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COMPARISON OF VARIOUS SPRAY OILS FOR CONTROLLING GREASY SPOT ON GRAPEFRUIT LEAVES AND FRUIT

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Abstract. **Oils with 435 (distillation temperature °F) specifications have long been used in Florida citrus groves to control greasy spot (*Mycosphaerella citri* Whiteside), as well as various pests. Now, because of improvements in the refining of spray oils, which may reduce risks of phytotoxicity, consideration is being given to the possible use of spray oils with higher distillation temperatures (heavier oils), to take advantage of their superior pesticidal action. In two out of five trials conducted in 1987 and 1988, 455 oil gave better control of greasy spot on leaves than 435 oil, but neither oil controlled greasy spot rind blotch (GSRB) effectively. A copper fungicide at 0.4 lb. Cu/100 gal (dilute application rate), applied either alone or mixed with 0.5 gal 435 oil/100 gal, controlled GSRB well, and provided better control of greasy spot on leaves than 455 or 476 oil alone at 0.5 gal/100 gal, and sometimes better control on leaves than 455 or 476 oils at 1.0 gal/100 gal.**

Emulsified petroleum oils have long been used in Florida citrus groves as insecticides and acaricides, as well to remove deposits of sooty mold and to reduce the severity of greasy spot, caused by *Mycosphaerella citri* Whiteside. In earlier years, spray oils often had adverse effects on the tree and fruit due to the variable quality of the oils then available. Unsuitable oils cause leaf and fruit drop, delayed coloring of fruit and poor internal fruit quality, and they render the tree more susceptible to freeze injury (3).

Research was begun at the Citrus Experiment Station, Lake Alfred, Florida in 1962 by Trammel and Simanton (1, 2, 3) to determine the relative effectiveness of different oils as pesticides and to define the properties needed for optimum pest control without adversely affecting the tree or fruit. The temperature at which 50% of an oil distills at 10 mm Hg was determined as the most reliable indicator of pesticidal efficiency and safety (1). Oils of higher distillation temperatures (DT) were referred to as being heavier than those of lower DT. Oils with a DT below 400°F were considered too inefficient for greasy spot control (2). Greasy spot control was best at the highest DT tested, which was 480°F. However, detrimental effects to tree and fruit were sometimes recorded with oils above 440°F DT (3).

In 1966, 2 types of spray oil were recommended and approved for use in Florida citrus groves (1). One type of oil, designated as FC 412-66 was a lighter oil for use in the fall or winter if a serious pest infestation should occur at this time of year. It was intended to minimize the risk of rendering the trees more prone to freeze damage or of affecting fruit quality. The other type of oil, designated as FC 435-66, was a heavier oil for normal summer use. More recently, it has been suggested that the 435 DT specification might be too rigid and that it might be possible to use oils of somewhat higher DT to utilize their superior pesticidal action without experiencing adverse side effects. Improvements in the refining techniques have increased the unsulfonated residue value of the oils available today, which should lower the risks of causing adverse physiological effects on the tree. R. F. Brooks (Univ. of Florida, personal communication) concluded that oils of 455 DT could be safely used on 'Valencia' orange trees, even if applied 3 times per year.

Oils with 435 DT specifications need to be supplemented with copper fungicides to provide a better assurance of greasy spot control, particularly when greasy spot pressure is heavy (6). Also, because 435 oil provides little or no control of greasy spot rind blotch (GSRB) (5), a copper fungicide is commonly added to the oil spray in grapefruit groves intended for fresh market fruit production. GSRB is generally too insignificant on other citrus cultivars to require the routine inclusion of copper fungicides in the summer oil spray to control this form of greasy spot (4). While heavier oils were known to provide better control of greasy spot on leaves (2), no information was previously available on the effect of heavier oils on GSRB.

This paper reports the results of spraying experiments on grapefruit trees to determine: 1) if heavier oils could control GSRB and 2) if the use of a heavier oil could dispense with the need for a copper fungicide to provide a better assurance of greasy spot control on leaves.

Materials and Methods

The experiments were conducted on 'Marsh' grapefruit trees at Lake Alfred and Davenport, Florida. In the

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Lake Alfred grove (Experiments 1 and 2), the trees were 10 ft high and spaced 25 × 15 ft, whereas in the Davenport grove (Experiments 3, 4 and 5), the trees were 15 ft high and spaced 25 × 25 ft. Spray treatments were applied dilute to drip off by handgun using 6 gal/tree (700 gal/acre) at Lake Alfred and 11 gal/tree (750 gal/acre) at Davenport. A randomized complete block design was used with single-tree plots replicated 8 times at Lake Alfred and 7 times at Davenport.

Three oil products were included in each experiment. Two of them were supplied by Sun Oil Company, Philadelphia, PA. They were Sunspray 7N, which has a 435°F DT midpoint and Sunspray 9N, which has a 455°F DT midpoint. From hereon, these 2 products are referred to as 435 and 455 oils. Thompson Haywood T-MULZ-FLO emulsifier was added to both these oils at 30 ml/gal. A third oil, Volck Supreme Spray Oil, was supplied by Chevron Chemical Company, San Francisco, CA. It had a DT midpoint of 476°F and already contained an emulsifier. From hereon, it is referred to as 476 oil. The copper fungicide used in these studies was basic copper sulfate WP, which contained 53% copper, and was supplied as Tribasic copper sulfate by the Tennessee Chemical Company, Atlanta, GA. The only other spray materials applied to the trees were Ethion 4 EC in May, Kelthane 1.6 EC in July and Vendex 50 WP in late August or September, which were applied separately from the experimental treatments by airblast sprayer to all trees to control rust mites.

Greasy spot disease ratings were made only on the spring growth flush. In May, the shoots to be sampled were labeled with white plastic tags in groups at the same compass points on each tree. At Lake Alfred, 15 shoots were labeled at 2 locations on each tree and at Davenport, 8 shoots were labeled at 4 locations on each tree. In late winter, before the spring growth flush emerged, all the labeled shoots were cut from the tree and the remaining leaves were examined for greasy spot. A leaf was recorded as diseased even if it carried only 1 greasy spot lesion and even if the symptoms were confined to the petiole wings. All leaves that were missing were assumed to have abscised because of greasy spot. Therefore, the number of leaves lost was added to the number of remaining leaves with greasy spot symptoms to calculate the percent leaves diseased.

To determine the incidence and severity of GSRB, 100 fruit were picked randomly from around the tree canopy, and the percentage area covered by the symptoms was estimated for each fruit.

Results

One of the concerns about applying the heavier oils, 455 and 476, to citrus trees was that they might cause leaf drop. In none of the experiments reported here was any oil-induced defoliation observed.

Experiment 1 (1987-88). The spray treatments (Table 1) were applied on 22 July 1987 and disease severity was assessed on 7 Mar. 1988. Despite relatively heavy infection pressure, as indicated by the amount of disease on leaves of untreated trees, very little GSRB appeared on fruit. Therefore, no assessments were made on fruit. Differences in the percent leaves diseased between the 3 oils were not significant. Nor was there any difference between the full and half rates of 435 oil. Basic copper sulfate + 0.5% 435 oil controlled greasy spot better than any of the oils applied alone at 1.0% concentration.

Experiment 2 (1988-89). The spray treatments (Table 1) were applied on 27 July 1988 and disease severity was assessed on 28 Feb. 1989. As in Experiment 1, there was too little GSRB to assess. The 476 oil controlled greasy spot on leaves better than 435 oil and 455 oil appeared intermediate in effectiveness. Basic copper sulfate + 0.5% 455 oil gave better control of greasy spot than 0.5% 455 oil alone, but was not superior to 1% 455 oil.

Experiment 3 (1987-88). Spray treatments (Table 2) were applied on 17 July 1987 and GSRB was assessed on 2 Feb. 1988. Greasy spot severity on foliage was determined on 24 Feb. 1988.

Based on the percent leaves diseased, 476 oil was more effective than 455 oil, which in turn was more effective than 435 oil. Basic copper sulfate + 0.5% 435 oil gave better control of greasy spot on leaves than either 435 or 455 oils applied at 1%.

All 3 oils were inferior to basic copper sulfate for controlling GSRB. Only basic copper sulfate significantly reduced the average area of the rind on affected fruit covered by GSRB.

Experiment 4 (1988-89). Spray treatments (Table 3) were applied on 20 July 1988, and greasy spot on leaves and GSRB were assessed on 17 Jan. 1989 and 20 Feb. 1989, respectively.

There was less greasy spot-induced defoliation on trees

Table 1. Effect of different spray oils and basic copper sulfate on the control of greasy spot on 'Marsh' grapefruit leaves at Lake Alfred.

	Experiment 1		Experiment 2	
Treatment and rate /100 gal	% defoliation	% leaves diseased	% defoliation	% leaves diseased
435 oil 1 gal	4.8 a[z]	21.6 b	0.1 a	4.8 b
435 oil 0.5 gal	5.7 a	26.9 b	—	—
455 oil 1 gal	2.8 a	15.6 b	0.0 a	3.0 ab
455 oil 0.5 gal	—[y]	—	0.1 a	6.7 b
476 oil 1 gal	2.9 a	13.6 b	0.0 a	0.7 a
Basic copper sulfate 0.75 lb.	—	—	0.0 a	2.8 ab
Basic copper sulfate 0.75 lb. + 435 oil 0.5 gal	0.8 a	1.9 a	—	—
Basic copper sulfate 0.75 lb. + 455 oil 0.5 gal	—	—	0.2 a	0.2 a
Check (untreated)	28.5 b	68.7 c	5.1 b	39.1 c

[z]Mean separation within columns by Duncan's multiple range test at P = 0.05.
[y]Treatment not included in experiment.

Table 2. Effect of different spray oils and basic copper sulfate on the control of greasy spot rind blotch (GSRB) on 'Marsh' grapefruit trees at Davenport (Experiment 3).

Treatment and rate/100 gal	% defoliation	% leaves diseased	% fruit with GSRB	% area of *GSRB on* fruit[z]
435 oil 1 gal	2.1 a[y]	22.4 c	5.4 b	10.3 b
455 oil 1 gal	1.0 a	10.5 b	9.1 bc	8.8 b
476 oil 1 gal	0.7 a	2.5 a	5.4 b	6.8 b
Basic copper sulfate 0.75 lb.	0.4 a	5.3 ab	0.2 a	0.7 a
Basic copper sulfate 0.75 lb. + 435 oil 0.5 gal	0.8 a	2.3 a	0.0 a	0.0 a
Check (untreated)	18.4 b	69.8 d	16.3 c	9.6 b

[z]Numbers in this column represent the average percent area of GSRB for only those fruit with symptoms.
[y]Mean separation within columns by Duncan's multiple range test at P = 0.05.

Table 3. Effect of different spray oils and basic copper sulfate on the control of greasy spot rind blotch (GSRB) on 'Marsh' grapefruit trees at Davenport (Experiment 4).

Treatment and rate/100 gal	% defoliation	% leaves diseased	% fruit with GSRB	% area of GSRB on fruit[z]
435 oil 1 gal	2.1 c[y]	16.9 d	18.3 b	18.1 b
435 oil 0.5 gal	1.8 bc	20.1 d	26.3 bc	20.1 b
455 oil 1 gal	1.2 abc	4.9 bc	21.4 bc	23.3 b
455 oil 0.5 gal	1.2 abc	14.3 cd	17.8 b	17.5 b
476 oil 1 gal	0.1 ab	3.4 ab	19.3 bc	16.8 b
476 oil 0.5 gal	0.4 abc	6.1 bc	19.6 bc	18.3 b
Basic copper sulfate 0.75 lb.	0.2 abc	1.4 ab	0.1 a	0.4 a
Basic copper sulfate 0.75 lb. + 435 oil 0.5 gal	0.0 a	0.1 a	0.4 a	2.6 a
Basic copper sulfate 0.75 lb. + 455 oil 0.5 gal	0.1 ab	0.5 ab	0.4 a	1.5 a
Check (untreated)	14.8 d	65.4 e	28.3 c	25.4 b

[z]Numbers in this column represent the average percent area of GSRB for only those fruit with symptoms.
[y]Means separations within columns by Duncan's multiple range test at P = 0.05.

sprayed with 1% 476 oil than on those sprayed with 1% 435 oil. Based on the percent leaves diseased, 476 and 455 oils were more effective than 435 oil at a 1% rate. At concentrations of 0.5%, only 476 oil provided better control than 435 oil. Basic copper sulfate + 0.5% 435 oil was more effective than any of the oil treatments alone, except for the 1% 476 oil.

While some control of GSRB was provided by 1% 435 oil and 0.5% 455 oil, only those treatments which contained copper substantially reduced GSRB.

Experiment 5 (1988-89). Spray treatments (Table 4) were applied on 15 Aug. 1988, fruit samples were picked for assessment of GSRB on 13 Jan. 1989, and greasy spot on leaves was assessed on 7 Feb. 1989.

All treatments controlled greasy spot relatively well on leaves and there were no significant differences between treatments in this respect.

Only those treatments that contained copper reduced GSRB.

Discussion

In terms of reduced defoliation, there were no significant differences in efficacy between treatments, except in Experiment 4 where defoliation was less with basic copper sulfate + 0.5% 435 oil than it was with 1% 435 oil alone. If disease pressure had been heavier, more differences in defoliation might have been evident between treatments, as

Table 4. Effect of different spray oils and basic copper sulfate on the control of greasy spot rind blotch (GSRB) on 'Marsh' grapefruit trees at Davenport (Experiment 5).

Treatment and rate/100 gal	% defoliation	% leaves diseased	% fruit with GSRB	% area of GSRB on fruit[z]
435 oil 1 gal	3.2 a[y]	26.2 a	15.7 b	15.0 cd
455 oil 1 gal	2.2 a	27.3 a	17.0 b	15.6 cd
476 oil 1 gal	0.5 a	13.9 a	14.3 b	12.3 bcd
Basic copper sulfate 0.75 lb.	1.5 a	22.4 a	3.1 a	5.2 ab
Basic copper sulfate 0.75 lb. + 435 oil 0.5 gal	1.6 a	13.3 a	1.9 a	3.2 a
Basic copper sulfate 0.75 lb. + 455 oil 0.5 gal	1.2 a	12.4 a	1.7 a	5.0 ab
Check (untreated)	19.1 b	66.5 b	15.0 b	19.5 d

[z]Numbers in this column represent the average percent area of GSRB for only those fruit with symptoms.
[y]Mean separation within column by Duncan's multiple range test at P = 0.05.

indicated by the differences in percentage leaves diseased. In terms of percent leaf diseased, greasy spot control improved overall with increasing DT of the oil applied. Nevertheless, only in Experiment 3 were distinct differences in efficacy exhibited between all oils. The 455 oil was significantly more effective than 435 oil in reducing the percent leaves diseased in Experiments 3 and 4, but not in Experiments 1, 2 and 5.

If a copper fungicide is not applied to grapefruit trees in the summer, there might be some incentive for using an oil of higher DT than 435 oil to enhance greasy spot control on leaves, provided that the heavier oil imposed no adverse physiological effect on the trees or fruit. It should be noted, however, that basic copper sulfate alone or mixed with 0.5% oil was more effective in reducing greasy spot on leaves than 1% 435 or 455 oils in Experiments 1, 3 and 4.

Most grapefruit groves are managed with the intention of producing a high packout of fruit for the fresh market, which means ensuring adequate control of GSRB. Because the heavier oils do not adequately control GSRB, it would still be necessary to include a copper fungicide in the summer oil spray mix when the fruit is intended for the fresh market, even if a heavier oil is used. Where copper is needed anyway, there would be little incentive for using a heavier oil such as the one with 455 DT specifications, unless it is considered essential for enhanced control of various insects or mites.

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EFFECTIVENESS OF FUNGICIDE SUPPLEMENTS TO SPRAY OIL FOR IMPROVING GREASY SPOT CONTROL ON GRAPEFRUIT LEAVES AND FRUIT

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Abstract. **An oil spray in the summer provides the mainstay for control of greasy spot (*Mycosphaerella citri* Whiteside) in Florida citrus groves. For grapefruit trees, a copper fungicide is commonly added to the spray mix to improve control, particularly on the fruit. Copper fungicides are highly effective for greasy spot control but darken scar tissue on the rind, which further detracts from the appearance of fruit intended for the fresh market. Copper fungicides have another disadvantage in that if their application is delayed from July to August to protect more summer growth flush, their effectiveness in controlling greasy spot on the spring growth flush may be reduced. One of the more promising materials studied in recent years was an experimental triazole derivative and ergosterol biosynthesis inhibitor, CGA 169374. It controlled greasy spot well and provided a bright fruit finish. However, despite some curative kickback action, as demonstrated on inoculated plants in the greenhouse, it still controlled greasy spot on the spring growth flush better when it was applied in July than when it was delayed until August.**

The multipurpose oil spray that is commonly applied to Florida grapefruit groves in the summer is useful for reducing the severity of greasy spot, caused by *Mycosphaerella citri* Whiteside, on leaves, but it has little or no value for preventing the development of greasy spot rind blotch (GSRB) (5). When control of GSRB is needed, as on grapefruit grown for the fresh market, it is necessary to add a fungicide to the spray mix to protect the rind from this blemish. Applications of oil alone can also be relatively poor sometimes for controlling greasy spot on leaves, particularly when disease pressure is heavy (6).

Little is known about the mode of action of oil in controlling greasy spot or of the factors that influence its effectiveness. Oil has little direct effect on *M. citri* or on the infection process. Rather, oil prevents the symptoms of greasy spot developing mainly through some alteration of the host physiology (2). Because oil has little or no effect on the greasy spot pathogen, spray timing with oil is less critical than it is with fungicides. Most fungicides have to be applied before major infection occurs, whereas oil can still be effective if applied long before or after infection (5).

Currently, many grapefruit growers include a copper fungicide in the summer oil spray when greasy spot control on leaves needs to be enhanced and when GSRB has to be controlled (1). No other material has proven as reliable as copper for greasy spot control (6). However, when the fruit is intended for the fresh market, copper fungicides can have an undesirable side effect: they emphasize existing injuries, such as those caused by wind scar and melanose, thereby causing further downgrading of fruit.

In the 1970's, when benomyl became available to citrus growers, it seemed this material would be a useful and safe alternative to copper fungicides for greasy spot control. However, control failures soon began to occur because of fungal tolerance to benomyl. In some groves, benomyl failed to provide significant control of greasy spot after it was applied once a year for only 4 consecutive yr (4).

The search has continued over the years for safer alternatives to copper fungicides, but without much success.

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