margin of the decline area. Any attempt at controlling spreading decline by removal of the trees should also include at least four healthy trees ahead of the margin.

Rough lemon seedlings have made better growth when the decline soil was treated prior to planting with D-D, formaldehyde or ethylene dibromide in pot experiments. Field tests with D-D at 400 pounds per acre appear promising.

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THE PURPLE MITE AND ITS CONTROL

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During the past two years purple mite *Paratetranychus citri* McG. infestations have been general throughout the whole citrus area, and they have persisted even during the summer months. As a rule, purple mites are difficult to find in August and September but during these months in 1949 and 1950, light to medium infestations were observed in many groves. Purple mite populations were at a higher level during the summer of 1950 than during any other summer period on record.

Although no particular cause has been determined for the unusually heavy and widespread infestations, favorable weather conditions for mites have existed. Purple mites are often more numerous during and following periods of dry weather and it may be significant that in 1950 the rainfall at Lake Alfred was below normal each month from January to August inclusive.

Spray and cultural practices are factors of considerable importance in the development of purple mite infestations. Thompson (2) reported in 1938 that purple mites increased following copper sprays, and in 1942 Holloway (1) stated that the citrus red mite (purple mite) in California was more numerous following sprays containing compounds of copper, zinc and lime than where no sprays were applied. In 1944 Thompson (3) also reported that purple mites were more numerous following sprays containing lime-sulfur or compounds of copper or zinc, than where no sprays of any kind had been applied. In fact, the infestations were as heavy where lime-sulfur had been applied as a dormant spray as where either zinc or copper was used in the spray mixture.

Copper residues on the foliage bear a relationship to purple mite infestations as shown by the data in Table 1. The purple mite infestations were heavier in November where a neutral copper-oil emulsion combination was applied in April than where a neutral copper-wettable sulfur was applied at the same time. Analyses (5) of the copper residues* on the leaves showed that there was significantly more copper on the leaves where the copper-oil combination was applied and a higher mite population resulted. It should be emphasized here that the figures in the table represent only external copper. In the opinion of the authors, it is this external copper residue which influences purple mite infestations.

* Made by C. R. Stearns, Associate Chemist, Citrus Experiment Station.

TABLE 1.
A RELATIONSHIP OF COPPER DEPOSITS ON LEAVES TO PURPLE MITE INFESTATIONS SIX MONTHS AFTER THE COPPER APPLICATIONS.

Plots	Copper Spray Combinations Applied May 6	Dates of Summer Oil Sprays	Copper Deposit[3] on Foliage mcg/cm² Av.		Percent Leaves Infested with Purple Mites Av.	
5			1.6		10	
23	Copper-W. Sulfur[1]		1.9	1.8	6	8.0
2			3.7		67	
20	Copper-Oil[2]		3.0	3.4	51	59.0
8			1.7		23	
26	Copper-W. Sulfur	June 3	2.7	2.2	27	25
1			3.7		73	
19	Copper-Oil	June 16	4.3	4.0	55	64
12			2.5		2	
30	Copper-W. Sulfur	July 14	1.2	1.8	10	6.0
3			3.3		64	
21	Copper-Oil	July 14	4.1	3.7	63	63.5
13			2		1	
31	Copper-W. Sulfur	Aug. 4	1.8	1.9	1	1
4			5		11	
22	Copper-Oil	Aug. 4	4.7	4.8	11	11

[1] Neutral copper (34% metallic Cu) @ 3-100 + wettable sulfur 12½-100.
[2] Proprietary copper-oil emulsion @ 2 gallons-100.
[3] Copper analyses made by C. R. Stearns, Jr.

Parathion has been used as an insecticide for the control of scale insects and mealybugs during 1949 and 1950 and some growers are of the opinion that it is a factor in increases of purple mites. Following the summer sprays for scale control it was found that purple mites were more numerous after an application of parathion than after an oil spray. Parathion killed the active mites, but it did not kill the eggs nor did the residue on the leaves and fruit remain toxic long enough to kill the young mites as they hatched. By comparison, an oil emulsion spray killed the active mites as well as the eggs. Thus, if there is an infestation of purple mites in the grove when an application of parathion is made, it may be expected that mites will again be present within a week or two after the application.

The parathion situation may be further complicated by the use of almost all other sprays or dusts. In the summer of 1950, observations at seven locations in Polk County demonstrated some of the interactions to be expected when different spray programs are used. The data are presented in Table 2.

From these data and other data not shown here, it would seem that the use of copper, zinc and sulfur are major factors influencing summer and fall purple mite infestations and that parathion is a minor factor. The average purple mite infestations were highest in plots where copper, zinc, lime and wettable sulfur had been applied as a post-bloom spray and followed with sulfur in the summer. Where nothing but sulfur sprays or sulfur dusts were used throughout the season the mite populations were higher than where parathion was used and much higher than in the unsprayed trees. The lightest infestations were in the plots sprayed with oil emulsions and in the untreated plots. However, it should be

TABLE 2.
SUMMER PURPLE MITE INFESTATIONS FOLLOWING VARIOUS SPRAY PROGRAMS IN SEVEN GROVES.

Post-Bloom Application	Summer Application	Percent Infested Leaves							Averages
		1 Aug. 23	2 Aug. 15	3 July 26	4 July 26	5 Sept. 16	6 July 2	7 July 13	
Copper, zinc, lime, sulfur	Oil emulsion	2	6	2	0	2			2.4
Copper, zinc, lime, sulfur	Parathion[1]	36	24	26	32	10			25.6
Copper, zinc, lime, sulfur	Sulfur	53	23				66	90	58.0
sulfur	Parathion[1]	24							24.0
sulfur	Sulfur			39	46		37	28	37.5
No sprays or dusts		16	5	2	10	0	2	1	5.0

[1] Wettable sulfur 10-100 was combined with parathion.

noted that during the spring, all plots, including the untreated ones, were heavily infested.

Although spray residues may affect purple mite infestations, the type of weather still appears to be the dominant factor in influencing widespread mite populations. Lime-sulfur, wettable sulfur, sulfur dust and compounds of copper and zinc have been used over wide areas in the state for many years and generally heavy infestations have been the exception rather than the rule.

Miticides

If purple mites continue to be a problem during the spring and summer months it will be desirable to have a miticide that can be used safely during periods when succulent foliage is present and during warm weather. This problem will be intensified by the substitution of other scalicides for oil emulsion. During the past two years several new insecticides have been tested for the control of purple mites and they, along with the DN compounds, are discussed in the following paragraphs.

DN Dry Mix which contains 40% dinitro-o-cyclohexyl phenol, is still one of the most satisfactory miticides on the market but it is not safe to use when there is succulent foliage present or when the weather is hot.

DN-111, a preparation containing 20% dinitro-o-cyclohexyl phenol, dicyclohexylamine salt applied at 1¼ pounds per 100 gallons is as effective as DN Dry Mix at 2/3 of a pound. It can be combined with the same type of spray materials that are used with DN Dry Mix and is not so toxic to young foliage as DN Dry Mix. DN-111 is slightly more expensive than DN Dry Mix per 100 gallons of dilute spray but it is within the economic range for grove use.

In 1947, Thompson (4) reported that Neotran, which contains 40% bis-(p-chlorophenoxy)-methane, was effective in killing purple mites. Repeated tests have been made with this material and it has been found to be effective at 1½ to 2 pounds per 100 gallons of spray. It appears to be compatible with all of the materials, including lime-sulfur, now used as sprays on citrus in Florida. It is one of the few miticides on the market at the present time that is effective when mixed with highly alkaline solutions. No foliage injury has been observed with this material when it was applied in the spring on succulent foliage or during the summer months. The limiting factor of Neotran is the cost, which at the present time is approximately 80 cents per pound. Thus, at two pounds per 100 gallons the cost

of 100 gallons of dilute spray would be $1.60 or $8.00 per for a 500 gallon tank.

Another promising material, designated here as K-6451, is a wettable powder containing 50 percent chlorophenyl, p-chlorobenzene sulfonate. This material does not result in a high initial kill, but 7 to 10 days after the application, very satisfactory control has resulted. The period of control with this material was somewhat longer than that obtained with DN Dry Mix. However, the period of control with K-6451 was not as long during the warm spring and summer months as it was during the cool months from November to February. The minimum concentration for good control has not been determined but it will probably be 1½ to 2 pounds per 100 gallons. It appears to be similar to DN in its compatibility with spray materials. To date no injury has been observed where it was applied to succulent foliage or when it was applied during the summer months. Taste tests of the fruit as well as further experimental work on compatibility and control will be needed before this material is released for the public use. At the present time there has been no information released on the probable cost of this material.

Aramite, a 15 percent mixture of beta-chloroethyl-beta-(p-tertiary butyl phenoxy)-alpha-methyl ethyl sulfite, has shown some promise as a safe miticide to use during the spring and summer months. On an average this material has not been as effective as DN, Neotran or K-6451. Aramite, like all other materials tested, was not as effective during the summer months as it was during cooler weather. It was found to be compatible with most materials used as sprays on citrus, but it was not tested with highly alkaline materials. No injury has been observed on succulent foliage where this material was used nor has there been any injury following sprays applied during June, July or August. The present cost of Aramite is also comparatively high.

Other materials tested in a limited number of experiments included a 50 percent mixture of p-chlorophenyl phenyl sulfone and EPN, a material containing 27 percent of ethyl para, nitrophenol, thionobenzenephosphonate. Both of these materials appeared safe to use on succulent foliage and during warm weather but further tests are necessary to determine their effectiveness as a miticide.

It is interesting to note that where the sprays were applied in April or May the period of control was not so long as where the same materials were applied in November. It is quite possible that one of the factors which shortened the period of control was reinfestation of mites from adjacent properties. The plots sprayed in April and May were adjacent to blocks that were heavily infested with mites and there were indications in some experiments that adult mites migrated into these plots within 5 to 6 days after the applications. In one experiment no living mites were observed 3 days after a thorough application of an effective miticide. In comparison, the untreated plots were 100 percent infested. Four days later another examination was made and an average of 9 percent of leaves on the sprayed trees were infested with adult mites. It would thus appear that migration of adult mites took place because mites cannot develop from the egg to the adult stage within four days. In two other experiments conducted during the spring months it was found that adult mites made their appearance 5 to 6 days following an effective miticide where no mites were found 3 days after the application.

In Table 3 are recorded some of the results obtained with the most promising materials tested. It is desirable

TABLE 3.

COMPARISONS OF CONTROL OF PURPLE MITES WITH VARIOUS MITICIDES.

Materials and Concentrations in Pounds per 100 Gallons		Figures Express Percent Infested Leaves					
		Pre-Spray	Nov. 12	Dec. 1	Dec. 30	Jan. 19	Feb. 10
Sprayed November 7							
DN Dry mix	.66 lbs.	92	0.2	0.0	0.0	1.4	9.5
K-6451	1.50 "	94	4.1	0.0	0.1	0.0	6.5
Neotran	1.50 "	94	0.0	0.0	0.4	2.1	21.5
Aramite	1.50 "	77	0.0	1.2	4.8	12.2	81.5
		Nov. 1	Nov. 28	Dec. 22	Jan. 7	Feb. 10	
Sprayed November 11							
DN Dry mix	.66 lbs.	15	0.0	0.8	3.8	33.5	
K-6451	1.50 "	18	0.0	1.2	10.2	19.4	
Neotran	1.50 "	14	0.0	0.0	2.9	32.1	
Aramite	1.50 "	15	3.0	1.1	8.3	50.3	
		Jan. 5	Jan. 16	Feb. 4	Feb. 28		
Sprayed January 11							
DN Dry mix	.66 lbs.	32	0.0	6.2	5.0		
K-6451	1.50 "	42	13.0	1.9	1.5		
Neotran	1.50 "	34	0.0	13.8	22.5		
Aramite	1.50 "	48	0.6	19.0	10.5		
No treatment		36	28.1	40.0	26.0		
		March 30	April 7	April 13	April 27	May 5	May 23
Sprayed April 3							
DN Dry mix	.66 lbs.	33	1.7	1.0	0.0	19.1	60.0
K-6451	2.00 "	21	2.5	0.0	0.0	.4	2.5
Neotran	2.00 "	47	0.0	0.0	0.0	4.1	29.0
Aramite	2.00 "	4	6.0	1.0	1.2	27.1	61.0
No treatment		5	5.0	15.0	15.0	30.0	57.0
		April 13	April 21	May 2	May 8	May 23	
Sprayed April 17							
K-6451	1.5 lbs.	10	0.0	2.0	18.0	45.0	
K-6451	2.0 "	12	0.0	0.0	0.0	53.0	
No treatment		33	45.0	77.0	88.0	97.0	

to do further experimental work with all of these new miticides, not only to test their effectiveness, but also to test their safety on foliage and fruit.

Timing and Application of Sprays

The period of control of purple mites does not depend entirely on the miticide used. One of the cardinal prerequisites to obtaining a long period of control is to apply the miticide before a high percentage of the leaves become infested. This is illustrated in the following discussion.

Although it is now well known that parathion is not an outstanding material for the control of purple mites, light infestations in four plots were kept at a low level for two months where parathion was included in a dormant spray at 1 pound of 15% material per 100 gallons of mixture.

When the application was made about 2 percent of the leaves were infested, whereas two months later an average of 8 percent of the leaves were infested in the parathion plots as compared to 32 percent infested leaves where parathion was omitted. The parathion had killed the few active mites, and since there were very few eggs present at that time, the mite population did not build up in those plots until May.

The intensity of the infestation at the time of spraying influenced the degree of infestations at a later date. Thus, in experiments where duplicate plots were used, and where there was a difference of 20 to 30 percent in the original infestation at the time of spraying that difference was still apparent at the conclusion of the experiment although the level of population had been substantially reduced by all treatments. This was true in 88 percent of the duplicate plots. For instance, on January 3, Plot A had 18 percent of the leaves infested and the duplicate, Plot B, had a 43 percent infestation. Three months after the application, Plot A had 4 percent of the leaves infested compared to a 35 percent infestation in Plot B. This comparison is made to stress the importance of treating groves in October or November when the mite population is at a low level, and treating again in January or February. Mite populations will thus remain at a low level through the late winter and spring months when grove conditions are likely to be unfavorable for spraying because of dry weather and the presence of succulent foliage.

If dusting is practiced it is especially important to make the application before the mite population reaches a high level. If a high percentage of the leaves are infested when a dust is applied, a second application should be made within a week or ten days to bring the numbers down to a point where a reasonable period of control can be obtained.

Thorough coverage is of prime importance. None of the miticides are considered fumigants and direct contact is necessary for satisfactory control. The type of coverage that is usually made for rust mite control is not thorough enough for purple mite control. Special care should be taken to cover the tops of the trees where the heaviest infestations are usually found.

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