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SPLIT ALDICARB APPLICATION FOR PEST SUPPRESSION ON NAVEL ORANGE TREES IN FLORIDA

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Abstract. **A pest management program conducted for 3 years compared a single annual foliar miticide/insecticide treatment to applications of 5, 10, and 2 x 5 lb. a.i./acre rates (5.6, 11.2, and 2 x 5.6 kg a.i./ha) of granular aldicarb chiselled into the soil for control of mite and insect pests on young, bearing 'Navel' orange trees in Florida. Yields, fruit size, peel blemish, and pest populations were monitored each year.**

All aldicarb treatments suppressed citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), for 13 weeks or longer in the 2 years that rust mites were a problem. Significantly fewer russetted fruit were harvested from trees receiving the split applications than from all other treatments. Suppression of green scale, *Coccus viridis* (Green), and Texas citrus mite, *Eutetranychus banksi* (McGregor), was related to dosage and timing of application. Aldicarb treatment had little effect on yield the first year of application. However, aldicarb treatments significantly increased yield the second and third year and more large fruit was produced on aldicarb-treated trees in all years than on trees receiving foliar sprays only or no treatment.

The original ccommercial treatment rate and frequency recommended by the manufacturer for Temik aldicarb on citrus was a single annual application incorporating either 5 or 10 lbs. a.i./acre of a granular formulation into grove soil. While a number of investigations have been conducted in bearing groves to evaluate the performance of these commercially-applied single annual treatments, only seven (1-5, 8, 9) studies were more than a year in duration. These multi-year experiments, conduct in both round orange and grapefruit plantings, revealed uniformly high performance of aldicarb vs. citrus rust mite, *Phyllocoptruta oleivora* (Ashmead) (2, 3, 4, 5), efficacy vs. Texas citrus mite, *Eutetranychus banksi* (McGregor), citrus whitefly, *Dialeurodes citrifolia* (Morgan, and aphids, *Aphis citricola* Van der Goot, (1, 2, 3) and less consistent influence on fruit quality and sharpshooters *Homalodisca coagulata* (Say) and *Onocometopia nigracans* (Walker) (6, 8, 9).

A single annual aldicarb application was not intended to protect a citrus crop throughout a growing season, so some investigators used supplemental sprays to protect the crop until harvest (3, 4, 5, 6). Halving the 10 lb treatment rate and applying it twice was considered as an alternative to a control regime consisting of a soil treatment and foliar sprays. This split application method was investigated on grapefruit (2) to determine if it might extend the period of tree protection and eliminate the need for additional pesticide sprays.

The purpose of the present study was to determine the effectiveness of a 3-year program similar to the grapefruit experiment (2) but conducted at a test site planted to 'Navel' orange trees.

Materials and Methods

The experiment was conducted at the University of Florida IFAS AREC grove in St. Lucie county, FL, in a block of Navel orange trees on Carrizo rootstock planted in 1980 on double beds at a 15 x 22.5-foot spacing on the bed. The 4-tree plots were replicated 5 times.

Aldicarb was applied with a tractor-mounted applicator consisting of 4 chisels that opened the turf for delivery of granules into the furrow. A press wheel behind each chisel closed the furrow. A metering wheel controlled release of granules from a single hopper and a gasoline-powered blower delivered the granules through tubing to the chisels.

Miticide sprays were applied with a John Bean model Royalier JK-20T hydraulic sprayer operated at 300 psi and equipped with a double Boyce handgun. Trees were sprayed to 'run-off'.

In 1983, single 10 lb. a.i. applications of 15G and 20G aldicarb were compared with a split application of 15G and 2 foliar spray treatments in a randomized complete block design that included untreated controls. In 1984 and 1985, single 10 and 5 lb. a.i. applications of 15G were compared with the split application of 15G and 2 foliar spray treatments.

Single applications of granular were applied on 12 April 1983, 23 April 1984, and 4 April 1985. The second application in the split treatment was applied 28 July 1983, 23 July 1984, and 20 July 1985. The 15G high rate and split treatment were applied to the same trees all 3 years. The single low rate (5 lb. a.i.) was applied to the same trees in the last 2 years of the experiment, being substituted for the 20G high rate (10 lbs. a.i.) used in the first year (Table 1).

The miticide sprays of Oncol aminofuracarb, Advantage carbosulfan, and Orthene acephate were applied as post-bloom treatments within 10 days after aldicarb applications in 1983 and 1984. The 1985 miticide spray of Agrimek avermectin was applied in July when mite populations commenced to increase.

The experimental area received additional foliar sprays each year containing copper and nutritionals in the spring and copper in the summer. These were applied by airblast sprayer as concentrate sprays.

Texas citrus mite populations were determined on 25 randomly selected leaves per plot, collected while circling the 2 center trees. Leaves were placed in pint jars containing alcohol and brought to the lab. Each jar was vigorously shaken and then leaves removed separately and surfaces rinsed into the funnel of a Millipore filter system with a stream of 50% alcohol from a wash bottle The leaf-wash

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Table 1. Materials and rates used in the experiment.

Treatment	Formulation	Amt/Acre or 100 Gal		Year applied		
		a.i.	Product[z]	1983	1984	1985
Aldicarb	15G	5 + 5 lb	33 + 33 lb	X	X	X
Aldibarb	15G	10 lb	66 lb	X	X	X
Aldicarb	20G	10 lb	50 lb	X		
Aldicarb	15G	5 lb	33 lb		X	X
Aminofuracarb	20E	4 oz	19 fl oz	X		
Carbosulfan	2.5E	1 oz	3.2 fl oz	X	X	
Acephate	75SP	16 oz	20.8 oz		X	
Avermectin[y]	0.15E	0.2 oz	1 fl oz			X
Avermectin	0.15E	0.4 oz	2 fl oz			X

[z]Quantities of spray material sufficient for 100 gal batches.
[y]Applied in 0.2% oil emulsion spray.

and the liquid from the jar were drawn through the filter. Mites on the filter disc were counted with the aid of a binocular dissecting scope.

Whitefly populations monitored on summer flush leaves tagged during July and harvested in Septemer. Tagged leaves from the 2 center trees in each plot were picked, brought to the lab, and examined with the aid of a binocular dissecting scope for presence of live immatures as well as Aschersonia spots. Presence of the latter implied poor control by treatments.

Rust mite populations were monitored by examining two 1.2 cm^2 lens-fields at 2 sites on the shaded surface of 25 fruit randomly selected while circling interior trees of each plot. Percent infested and mean population density per lensfield were calculated from the recorded data.

Equatorial diameter of all fruit from all trees in each plot was measured with a caliper in January of each year. Yield was determined while fruit was being measured.

Peel injury was determined with the aid of a 2 ft^2 frame positioned at a height of 6 ft on the perimeter of the tree canopy. All the fruit within the square was rated for peel russet. For each treatment, a frame count was made in each quadrant of 20 trees.

The presence and population density of green soft scale was ascertained by examining 10 leaves in fruit-bearing twigs of the two center trees in each plot.

Data on insects, mites, peel blemish, and yield were subjected to analysis of variance and means separated by Duncan's multiple range test when F values were significant (P 0.05).

Results

Although rust mite population pressure during the 1983 season was not severe through the initial 15 weeks of the test, the foliar spray of carbosulfan was less effective than all aldicarb treatments (Table 2). Both sprayed materials, carbosulfan and aminofuracarb, were inferior to aldicarb treatments for rust mite control at 21 weeks posttreatment: a failure that contributed to significantly more russetted fruit on sprayed trees at harvest. The split application of aldicarb, equal to the single aldicarb treatments in control of rust mites, provided significantly less blemished fruit at harvest.

Again, in 1984, carbosulfan spray was less effective in suppression of rust mites 13 weeks after treatment application (Table 3). The split application of aldicarb, equal to the single aldicarb treatments in control of rust mites, provided less blemished fruit at harvest than all other treatments except acephate.

Table 2. Citrus rust mite control - 1983.

	Weeks posttreatment:			% Fruit russetted at harvest
	+11	+15	+21	
Aldicarb 15G 5 + 5	0.01[y]	1.20 cd[z]	0.7 b	2.6 c
Aldicarb 15G 10	0.01	0.01 d	3.2 b	12.1 b
Aldicarb 20G 10	0.00	0.30 d	4.8 b	24.9 b
Aminofurocarb 20E	0.30	5.30 abc	15.9 a	41.5 a
Carbosulfan 2.5E	0.90	7.60 ab	23.2 a	52.2 a
Control	1.10	8.50 a	22.9 a	65.8 a

[z]Mean separation within columns by Duncan's multiple range test, 5% level.
[y]Citrus rust mite population density per 1.2 cm^2 of fruit surface.

Table 3. Citrus rust mite control - 1984.

	Week posttreatment:			% Fruit russetted at harvest
	+6	+13	+20	
Aldicarb 15G 5 + 5	0.01 bc[zy]	0.3 b	0.01	3.2 c
Aldicarb 15G 10	0.01 bc	0.1 b	0.50	45.0 ab
Aldicarb 15G 5	0.00 c	0.3 b	1.10	54.0 ab
Acephate 75 SP	0.05 ab	6.7 ab	2.50	26.2 bc
Carbosulfan 2.5E	0.06 a	9.3 a	2.40	55.8 a
Control	0.07 a	6.7 ab	1.60	47.8 ab

[z]Mean separation within columns by Duncan's multiple range test, 5% level.
[y]Citrus rust mite population density per 1.2 cm^2 of fruit surface.

The citrus rust mite populations were at low levels in 1985 and russetted fruit was absent at harvest (Table 4).

Green soft scale was present in the experimental area during 1983. It is a minor pest of Florida citrus and is considered abundant if 5% of leaves are infested (7). Foliage of untreated trees in the experimental area was infested at a 39% level. The single aldicarb 20G application and the split application were intermediate to the single aldicarb 15G and both sprays in their suppression of this scale (Table 5). Since only half of the split treatment had been applied when the scale evaluation was conducted, trees receiving this treatment were being protected with 5 lbs. a.i. per acre.

A Texas citrus mite infestation occurred in 1985 and was surveyed near its peak in June prior to the application of avermectin foliar sprays and the second application of the split aldicarb treatment (Table 5).

All aldicarb treatments reduced the Texas citrus mite population below populations in the untreated trees but

Table 4. Citrus rust mite control - 1985.

	Weeks posttreatment:		
	+5	+12	+22
Aldicarb 15G 5 + 5	0[z]	0.3	0.4
Aldicarb 15G 10	0	0.2	1.0
Aldicarb 15G 5	0	0.3	1.1
Avemectin low rate		2.9	0.3
Avemectin high rate		7.4	0.1
Control	0	2.2	1.5

[z]Citrus rust mite population density per 1.2 cm^2 of fruit surface.

Table 5. Treatment effects on other canopy pests.

	Mean population per leaf:		
	Green soft scale	Texas citrus mite	White -fly
Aldicarb 15G 5 + 5	3.7 ab[z]	4.5 a	6.9 b
Aldicarb 15G 10	0.9 b	1.7 b	7.1 b
Aldicarb 20G 10	1.7 ab		
Aldicarb 15G 5		8.6 a	7.8 b
Aminofurocarb 20E	0.1 b		
Carbosulfan 2.5E	1.4 b		
Avermectin low rate			6.9 b
Avermectin high rate			12.6 b
Control	6.2 a	18.1 a	34.4 a

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

the single 10 lb. rate was statistically superior to the 5 lb. rates.

The efficacy of aldicarb vs. whitefly on spring flush has been documented by Bullock (1) and Childers (3). Its ability to protect summer flush vs. whitefly was examined in 1985 when the efficacy of the summer foliar-applied treatments of avermectin was being evaluated. All soil treatments of aldicarb and foliar sprays of avermectin were equivalent in performance and superior to controls (Table 3).

Table 6. Effect of aldicarb treatments on tree yield.

	Mean yield (fruit/tree)		
Treatment	1983	1984	1985
Aldicarb 15G 5 + 5	9.6	21.3 a[z]	55.4 a
Aldicarb 15G 10	15.8	15.8 ab	34.7 bcd
Aldicarb 20G 10	8.3		
Aldicarb 15G 5		10.3 bc	36.0 bcd
Aminofuracarb 20E	14.9		
Carbosulfan 2.5E	11.2	7.6 bc	
Acephate 75 SP		8.3 bc	
Avermectin 0.15E low rate			28.6 d
Avermectin 0.15E high rate			41.1 bc
Control	11.6	6.6 c	44.6 b

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 7. Effect of aldicarb treatments on fruit size.

	% Fruit > 3.5 inches in diameter		
Treatment	1983	1984	1985
Aldicarb 15G 5 + 5	38.4 ab[z]	30.8	12.2 a
Aldicarb 15G 10	46.0 a	32.8	9.6 ab
Aldicarb 20G 10	26.4 abc		
Aldicarb 15G 5		32.2	9.6 ab
Aminofuracarb 20E	23.2 bc		
Carbosulfan 2.5E	14.4 c	22.0	
Acephate 75 SP		24.0	
Avermectin 0.15E low rate			6.1 bc
Avermectin 0.15E high rate			8.4 bc
Control	14.0 c	26.0	5.8 c

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 8. Effect of aldicarb treatments on fruit size.

	Mean yield (fruit/tree) (sizes 48, 64, and 80)		
Treatment	1983	1984	1985
Aldicarb 15G 5 + 5	4.0	8.2	32.3
Aldicarb 15G 10	6.5	4.9	21.4
Aldicarb 20G 10	3.9		
Aldicarb 15G 5		4.1	18.1
Aminofuracarb 20E	9.0		
Carbosulfan 2.5E	7.4	4.3	
Acephate 75SP		3.7	
Avermectin 0.15E low rate			17.5
Avermectin 0.15E high rate			26.2
Control	7.1	3.8	30.9

Although average tree productivity more than tripled during the 3 years of the experiment (Table 6), the split application provided significantly more fruit than all materials and rates in the last 2 years except for the single 10 lb. treatment of 15G formulation in 1984.

As trees grew older, percent of large sizes (in access of 3.5 inches in diameter) diminished in all treatments, but the greatest percent of large fruit in the last year of the test were present on trees receiving the split treatment (Table 7).

Also, higher yields of the most desirable sizes (48's, 64's, and 80's) were being produced on trees receiving the split application of aldicarb (Table 8).

Conclusion

The split treatment significantly enhanced yield and % unblemished fruit and increased % of large fruit. High yields of fruit of desirable sizes were also recorded. While this treatment regime is not available to growers in Florida or the U.S.A., its performance as the sole material used during the growing season for arthropod pest control suggests its potential value for use in a minimum or reduced pesticide program for citrus production. The split treatment's control of citrus rust mite on developing fruit was sufficient for enough of the growing season to provide the highest % of clean fruit of all treatments in the experiment.

The single 5 lb. a.i/acre rate of aldicarb was statistically equal to the 10 lb. rate in fruit yield, % large fruit, and suppression of whitefly and citrus rust mite and was comparable in production of desirable-sized fruit.

While single, early-season sprays did not prevent peel russetting at harvest, acephate and aminofuracarb were intermediate in citrus rust mite control at 13 and 15 weeks posttreatment, respectively, and showed promise as candidates for further evaluation vs. rust mite. Both aminofuracarb and carbosulfan sprays were effective in suppression of green soft scale. Both rates of avermectin were effective in control of summer whitefly populations.

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DICOFOL: THE INFLUENCE OF APPLICATION METHOD ON SNOW SCALE POPULATION AND SEX RATIO

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Abstract. **Post-bloom and summer sprays of dicofol were made to mature grapefruit trees infested with citrus snow scale, *Unaspis citri* (Comst.) in 1986 to compare the effects of hand gun sprays with typical speed sprayer applications on the citrus snow scale population. The hand gun sprays, where the foliage, tree trunks, and scaffold limbs were directly sprayed to run-off resulted in increased citrus snow scale population. The influence of dosage rates on the population increase was not statistically significant. The typical speed sprayer applications, using 220 gallons per acre in the post-bloom spray and 777 gallons per acre in the summer spray, did not result in a significant increase in the citrus snow scale population. Neither the hand gun sprays nor the speed sprayer applications resulted in a statistically significant increase in the female to male ratio of the citrus snow scale population in this study.**

This study was initiated by Rohm & Haas Company to determine the influence of the miticide difocol (Kelthane MF) and the relation of application methods on the citrus snow scale population in a snow scale infested citrus grove in Florida.

Studies conducted at the Citrus Experiment Station, Lake Alfred, Florida by Brooks and Whitney (2) showed that the use of dicofol in citrus snow scale infested groves resulted in increased snow scale population. It was later publicized that the population increases were the result of a shift in the sex ratio induced by dicofol, resulting in more females in the population.

The original studies were conducted with hand gun sprays. Spray practicies have since changed to speed sprayer applications, and some field observations now indicate that the citrus snow scale population increases do not occur following speed spray applications. The present study was designed to determine whether or not the current spray methods would result in population increases and an alteration of the sex ratio.

Materials and Methods

Following the inspection and evaluation of several groves on the Florida east coast, a grapefruit grove in good condition on Merritt Island was selected as the site for this study.

The selection was made based on the high populations of the citrus snow scale, and the relative uniformity in the infestation as compared to the other groves inspected. The test plots were marked, mapped and the treatments were randomly selected within each of eight replicates. Evaluation trees within each plot were selected on the basis of citrus snow scale population and tagged for easy reference.

The test was set up in a randomized complete block design with eight replicates per treatment. The treatments are shown in Table 1.

Two application methods were used. In one, a hand gun spray was used to thoroughly wet the tree, including the inside branches, to run-off using about 750 gallons per acre (11 gallons/tree) in both the post-bloom spray on 22 April and the summer spray on 20 July. In the other, a speed sprayer application was used with 220 gallons per acre in the post-bloom spray on 29 April, and 777 gallons per acre in the summer spray on 15 July.

The method described by Brooks in 1964 (1) was used in the evaluation of this trial. On each of the eight trees used in the evaluations, four one square inch bark patches were brushed clean of all scale insects, and other debris leaving a clean bark patch for reinfestation by the citrus

Table 1. Treatments reported in this study.

Treatments	Timing and Rates	Application Method
Nontreated		
Dicofol	post-bloom — 4.5 pts./acre	hand gun
	summer spray — 4.5 pts./acre	hand gun
Dicofol	post-bloom — 9 pts./acre	hand gun
	summer spray — 9 pts./acre	hand gun
Aldicarb	post-bloom — 33 lbs./acre	granular
Dicofol	summer spray — 4.65 pts./acre	speed sprayer
Dicofol	post-bloom — 3.96 pts./acre	speed sprayer
	summer spray — 4.65 pts./acre	speed sprayer

NOTES:
1. Spray oil at 0.5% was added to all treatments in the summer spray.
2. Difocol formulation: Kelthane MF (9-7683) Form XF85018, Lot #3-1556R.
3. Aldicarb formulation used was Temik 15G.