Proc. Fla. State Hort. Soc. 97: 62-66. 1984.

THE EFFECT OF ALDICARB ON NONTARGET ORGANISMS IN CITRUS GROVES

KIM H. HAAG AND DALE H. HABECK
IFAS, Department of Entomology and Nematology,
University of Florida,
Gainesville, FL 32611

Additional index words. Temik, citrus grove, insect fauna.

Abstract. **Pitfall traps were used to sample insect populations in citrus groves at Eustis and Clermont in Lake Co., Florida, from June to November of 1983. Groves were chosen based on the number of aldicarb applications (0-4) which had been carried out prior to 1983. Eight taxonomic groups were enumerated from the pitfall trap collections, whereas 5 taxa were identified and counted from flight trap collections. These insect groups, termed nontarget organisms, include earwigs, ground beetles, parasitic wasps and others, both predaceous and nonpredaceous, that are not citrus pests. Data obtained from pitfall traps and flight traps indicated that aldicarb apparently has no adverse long-term effects on nontarget insect populations. However, due to tremendous variation in the arthropod fauna, both between and within groves, it is difficult to accurately assess long-term effects of any pesticide on grove fauna.**

Aldicarb, manufactured by Union Carbide Agricultural Products Company, Inc., has been used extensively on citrus trees to control a variety of arthropod pests. The aldicarb literature deals primarily with its efficacy against these target organisms, including the spirea aphid [*Aphis spiraecola* (Patch)] (1), citrus red mite [*Panonychus litri* (Risso)] (7, 9, 10), citrus rust mite [*Phyllocoptruta oleivora* (Ashm.)] (2, 6), and brown soft scale (*Coccus hesperidium* Linnaeus) (4). Little data are available concerning the potential effects on other arthropod organisms commonly found in the citrus grove ecosystem.

In 1982, aldicarb was found in several drinking water wells in Florida. A University of Florida Task Force on aldicarb was formed later that year to analyze the fate of aldicarb applied to agricultural crops. Among the studies conducted was an assessment of the long-term effects of aldicarb on those nontarget, and potentially beneficial, organisms that comprise the nonpest arthropod fauna of citrus groves. The results of that study are presented here.

Materials and Methods

Insect populations were sampled in citrus groves at Eustis and Clermont in Lake Co., Florida, from June to November, 1983. Sampling methods included pitfall traps and insect flight traps.

Plots were established in each grove based on the number of annual aldicarb applications which had been carried out prior to 1983 (Table 1). Ten pitfall traps, in 2 groups of 5 traps each, were used per plot. Each pitfall trap consisted of a 24-oz plastic cup (6 inches deep and 3.6 inches in diameter) placed in the ground so that the rim was flush with the soil surface. Each cup was provided with 3 oz of antifreeze (ethylene glycol) which acted as a preservative. An aluminum pie pan was inverted and suspended above each cup by double-head nails. Pie pans rested 3-4 cm above the ground, thus effectively excluding rain from the cups but not interfering with arthropod access to the cup mouth. Each cup was left in the field for 7 days, and was replaced with a new cup at the end of each week. Samples were returned to the laboratory where the antifreeze was drained off and replaced with 70% isopropyl alcohol. Samples were then sorted into 8 taxonomic categories and counted.

[1]Florida Agricultural Experiment Stations Journal Series No. 6030.

Table 1. Summary of aldicarb treatment times to sample plots.

Location	Plot	Year treated 1979	1980	1981	1982	Treatments (no.)
Eustis	A			X	X	2
	B	X	X	X	X	4
	C		X	X	X	3
	D			X	X	2
	E					0
Clermont	A				X	1
	B				X	1
	C					0
	D					0

A single insect flight trap (Malaise trap) was installed near the middle of each plot. Each trap was placed in a tree row in an opening between 2 trees. Originally, insects were collected dry in a container with a no-pest strip. Later, insects were collected directly into 99% isopropyl alcohol, which resulted in better preservation of specimens. Samples were collected weekly and returned to the laboratory for sorting and identification. Counts were then made of selected groups of insects.

Results and Discussion

Pitfall trap samples. The 8 taxa chosen for enumeration from pitfall trap collections were selected because they were the most abundant groups present, as indicated by preliminary sampling. Not all have a demonstrable impact on citrus pests. For example, spiders are general predators and citrus pests do not comprise a significant portion of their prey (8). Crickets, caterpillars and springtails are chiefly plant feeders or scavengers. Earwigs, however, are generally regarded as predators, especially in row crops. Many of the ants and beetles are predators, and could possibly exert a controlling influence on various citrus pests. Viewed broadly, all members of the faunal community interact in the food web, and all trophic levels are necessary for the maintenance of a balanced ecosystem. The pitfall sampling program was therefore designed to qualitatively and quantitatively assess the citrus grove arthropod fauna, and determine possible long-term changes in the community attributable to pesticide application.

Springtails (Collembola) were by far the most abundant insect group in both groves sampled (Tables 2, 3). Total numbers of springtails collected were not higher in the untreated groves or in groves treated less frequently than others. Ants were also quite numerous in both groves. At Clermont, there was an inverse relationship between numbers of ants collected and the number of aldicarb treatments. That is, more ants were found in both of the untreated groves than in either of the 2 treated groves. This inverse relationship was not evident in plots in the

Eustis groves. Adult beetles (Coleoptera) were relatively abundant in both Clermont and Eustis collections. Once again no relationship was evident between the number of aldicarb treatments and the number of adult beetles in groves at either site. Earwigs (Dermaptera) were quite abundant in the Eustis groves and were most numerous in the groves treated most often. Earwigs were not abundant in any of the plots at Clermont regardless of the frequency of pesticide treatment. Beetle larvae and spiders were both moderately abundant. No relationship between numbers of these organisms and number of aldicarb applications was observed. Crickets and caterpillars were the least numerous groups at both sites. Once again, no consistent relationship was found between the numbers of these insects collected and the number of aldicarb treatments in plots at either grove.

Table 2. Summary of selected arthropods collected in pitfall traps from Clermont, Lake Co., June through November, 1983.

	A(1)[z]	B(1)	C(0)	D(0)
Dermaptera (earwigs)	121	83	80	431
Formicidae (ants)	3,252	2,653	7,299	6,009
Lepidoptera larvae (caterpillars)	287	251	197	55
Coleoptera adults (beetles)	1,172	913	1,214	666
Coleoptera larvae (beetles)	666	354	139	134
Arachnida (spiders)	1,355	1,016	1,082	1,767
Collembola (springtails)	22,058	11,853	5,693	9,336
Gryllidae (crickets)	298	172	311	660

[z]Indicates number of aldicarb treatments received prior to 1983.

Table 3. Summary of selected arthropods collected in pitfall traps from Eustis, Lake Co., June through November, 1983.

	A(2)[z]	B(4)	C(3)	D(2)	E(0)
Dermaptera (earwigs)	7838	8,933	8,693	3,041	2,148
Formicidae (ants)	1,512	4,050	6,346	10,089	2,226
Lepidoptera larvae (caterpillars)	144	96	135	181	119
Coleoptera adults (beetles)	1,447	1,236	1,093	1,185	1,043
Coleoptera larvae (beetles)	506	255	268	356	120
Arachnida (spiders)	747	563	559	520	478
Collembola (springtails)	15,902	63,206	72,578	31,572	12,034
Gryllidae (crickets)	68	184	74	48	135

[z]Indicates number of aldicarb treatments received prior to 1983.

Even on the same sampling date, we typically observed large differences between the numbers of insects collected in individual pitfall traps within plots. As a result, at both Clermont and Eustis, we often found significant differences ($P = .05$) between mean numbers of insects collected in Plots 1-5 and Plots 6-10. This was consistently true for ants, spiders and springtails at Clermont, and for earwigs, ants, adult beetles and crickets at Eustis. This high variance within plots at both sites resulted in no significant differences between plots with respect to aldicarb treatments.

Flight trap data. Results of flight trap sample analyses are shown in Tables 4 and 5. The most numerous groups were moths, bees, wasps and flies. Although each sample typically contained 2,000 to 4,000 insects, only 5 taxonomic groups were sorted and counted. This subsampling was necessary since sufficient laboratory personnel were not available to completely analyze all of the material collected. The selection of these 5 families was based primarily on their potential as beneficial insects in citrus groves. The ground beetles (Carabidae), which live in the soil, are predaceous both as adults and larvae. The Dolichopodidae, or long-legged flies, are predaceous, and larvae also live in the soil. Braconids and ichneumonids are both families of parasitic wasps, which often parasitize other insects harmful to citrus. The click beetles (Elateridae), whose larvae live in the soil, are usually phytophagous and are frequently of economic importance.

Long-legged flies and braconid wasps were the most numerous groups in both Clermont and Eustis, whereas the ground beetles were typically the least abundant group at both sites. In the samples collected in Clermont groves, there was no clear relationship between the number of aldicarb treatments and the abundance of any of the five insect groups. That is, the untreated groves did not contain higher numbers of these insect families, either considered as 4 separate samples (Plots A, B, C, D) or replicates ($\bar{x}_{A+B}$; $\bar{x}_{C+D}$). Paired t-Tests ($P = .05$) showed no significant differences between mean abundance of insects collected in treated ($\bar{x}_{A,B}$) and untreated ($\bar{x}_{C,D}$) groves at Clermont.

In the samples collected in Eustis groves, there were no consistent relationships between the number of aldicarb treatments and the abundance of insects selected for enumeration. Ichneumonids and braconids tended to be the most numerous in Plot E (untreated); however, this relationship was not evident for the other 3 families. In addition, groves B (with 4 treatments) and C (with 3 treatments), did not produce collections with fewer insects when compared to groves A and D, which received two treatments each. At Eustis, it was not possible to find replicate groves with respect to the number of aldicarb treatments. An analysis of variance (ANOVA) using the data from all 12 sampling dates showed no significant treatment effects.

It is clear from our data that previous reports which state that aldicarb-treated groves are "devoid of life" are simply untrue. Our observations indicate that not only are insects abundant, but numerous birds as well as rabbits, lizards, and snakes are often present in the treated plots. Of the birds, cardinals, brown thrashers and mourning doves were most numerous at these two study sites.

There are few published studies of the effects of aldicarb on nontarget arthropod taxa. It has been reported that aldicarb has few acute and no observable long-term effects on "beneficial" populations in cotton and soybean systems (11). However, the taxonomic composition of these "beneficial complexes" was not specified. Gray and Coats (3) reported on a study of the effects of carbofuran and alachlor-cyanazine on carabids in a cornfield ecosystem. They found primarily that indirect effects of herbicide

Table 4. Abundance of selected insects in flight trap samples: Clermont, Lake Co., 1983.

	Plot A (1)[z]					Plot B (1)					Plot C (0)					Plot D (0)				
Date	Elateridae	Carabidae	Dolichopodidae	Braconidae	Ichneumonidae	Elateridae	Carabidae	Dolichopodidae	Braconidae	Ichneumonidae	Elateridae	Carabidae	Dolichopodidae	Braconidae	Ichneumonidae	Elateridae	Carabidae	Dolichopodidae	Braconidae	Ichneumonidae
28 Jun	46	19	64	253	37	25	1	34	125	21	51	12	38	77	7	31	29	60	133	18
12 Jul	31	3	172	222	43	27	2	156	153	50	58	2	44	52	20	8	0	87	114	18
26 Jul	16	3	186	91	24	35	1	266	144	35	46	3	43	42	19	3	1	59	73	26
09 Aug	10	16	20	24	5	29	1	27	46	17	23	7	13	24	7	1	1	6	32	9
23 Aug	23	1	104	33	15	16	0	37	25	13	6	0	41	11	13	2	2	4	24	2
06 Sep	78	1	274	61	6	22	2	88	41	10	19	1	20	29	7	1	1	11	24	6
20 Sep	39	0	43	49	10	15	1	106	52	19	9	1	7	65	19	0	2	10	63	3
04 Oct	23	1	14	46	17	4	0	89	156	34	4	1	21	86	30	0	1	23	113	13
18 Oct	17	1	6	18	12	8	3	60	55	18	10	0	27	42	19	0	1	8	42	13
01 Nov	2	0	3	9	13	1	1	42	79	48	1	0	23	46	37	0	1	9	25	20
16 Nov	1	1	9	26	17	0	0	33	130	35	1	0	11	71	29	0	1	16	77	76
30 Nov	2	1	16	73	21	1	0	41	113	27	0	0	9	53	31	0	1	16	53	22
Totals	288	47	911	905	220	183	12	979	1119	327	228	27	297	598	238	46	41	309	773	226

[z]Indicates number of aldicarb treatments received prior to 1983.

treatment (e.g. micro habitat removal) were responsible for some decrease in the numbers of some species sampled. The effect of the pesticides on overall community structure was thought to be minimal. Los and Allen (5) studying carabids in an alfalfa field, reported an overall decrease in species diversity and a decrease in number of taxa in fields treated with pesticides, when compared to untreated alfalfa fields.

Part of the difficulty in making an evaluation is that it has not been well established whether or not natural predators and parasites exert a significant controlling influence on citrus pests. Sufficient baseline data on their abundance and ecology is not available. Therefore it is difficult to determine the effects of pesticides on the predator-pest interactions in citrus groves.

Simanton (8) reported a summary of 16 yr of extensive monitoring of pests and predators in Florida citrus groves. He stated that pesticides had little if any direct effect on the occurrence of certain species of predators of citrus pests. These include the little black lady beetle [*Delphastus pusillus* (Leconte)], the little black and white lady beetle (*Nephaspis amnicola* Wingo) the white-tailed lady beetle (*Scymus partitus* Casey), and the big-headed mite [*Hemicheyletia wellsi* (Baker)], none of which were very numerous even in untreated groves. A second group of predators seemed to be reduced acutely (within 30 days) in abundance following pesticide application. These included *Chrysopa* spp. (Neuroptera), the twice-stabbed lady beetle [*Chilocorus stigma* (Say)], the blood red lady beetle [*Cycloneda sanguinea* (Linnaeus)] and the mealywing [*Semidalis vicina* (Hagen)], all of which were typically numerous in the groves. Finally, a third group of predators were found to be at least 50% less abundant within 30 days after pesticide application and always much less numerous in the sprayed groves than in groves seldom if ever sprayed. These include the strawberry mite (*Agistemus floridanus* Gonzalez, the shiny button mite [*Iphiseiodes quadripilis* (Banks)], the yellow mite [*Typhlodromalus peregrinus* (Muma)], the tan mite [*Galendromus floridanus* (Muma)], brown and yellow thrips [*Aleurodothrips fasciapennis* (Franklin)], black thrips [*Leptothrips mali* (Fitch)] and the Chinese lady beetle [*Leis dimidiata quinquidecimaculata* (Hope)]. He pointed out that no attempts were made to determine the direct effects of pesticide application, or to segregate these effects from those of weather, crowding, and other variables.

This continues to be a problem in environmental studies. Projects such as ours, which attempt to assess long-term (4-5 yr) changes in populations, are frequently funded for a relatively brief sampling season (6-8 months). Many interacting factors, such as seasonal population variability, aberrant temperature and precipitation cycles, unreported or poorly documented pesticide application, and changing management practices inevitably interfere with the primary interaction of interest.

In addition, there is a great variation in the arthropod fauna between and within groves, and many insects appear to be distributed nonrandomly. For example, Plot E (untreated) at Eustis, which was chosen as the control, generally had the lowest numbers of all taxonomic groups enumerated. Because it was not possible to find replicates for the category of "untreated grove" at Eustis, we cannot determine if plot E is typical or if fundamental habitat differences are responsible for these low values, masking any pesticide effects. In view of these numerous interacting factors, even if a statistical correlation is found between insect population densities and frequency or intensity of pesticide application, one must be very cautious in interpreting this as a cause and effect relationship. A large grove of uniform topography completely surrounded by other citrus, planted to one variety and under uniform management practices, except for pesticide treatment, will be needed to produce conclusive results. This type of study would also provide a data base that would be useful in coping with future pesticide regulatory problems. In view of the importance of citrus to the economy of Florida, and the expectation of further controversy on the efficacy and safety of pesticides, the grove fauna should be investigated to provide reliable baseline data for use in future studies.

Acknowledgements

This study could not have been completed without the expert field assistance and careful laboratory work of Judy Gillmore. V. Eric Beckner also aided in the sorting of specimens and computer analysis of data. The cooperation and assistance of Mr. Dixie Royal, Umatilla, Florida in

Table 5. Abundance of selected insects in flight trap samples: Eustis, Lake Co., 1983.

	Plot A (2)[z]					Plot B (4)					Plot C (3)					Plot D (2)					Plot E (0)				
Date	Elateridae	Carabidae	Dolichopodidae	Braconidae	Ichneumonidae	Elateridae	Carabidae	Dolichopodidae	Braconidae	Ichneumonidae	Elateridae	Carabidae	Dolichopodidae	Braconidae	Ichneumonidae	Elateridae	Carabidae	Dolichopodidae	Braconidae	Ichneumonidae	Elateridae	Carabidae	Dolichopodidae	Braconidae	Ichneumonidae
28 Jun	11	3	108	99	6	30	15	110	77	6	32	41	102	26	7	23	241	32	65	34	14	7	8	85	25
12 Jul	28	0	174	27	5	23	4	134	25	2	35	27	282	27	7	23	33	134	59	30	7	1	114	139	21
26 Jul	109	0	129	24	2	23	1	58	6	4	26	14	224	18	24	40	89	224	73	65	36	1	106	122	29
09 Aug	35	1	90	22	5	3	4	16	9	4	13	56	35	16	11	21	118	71	121	39	3	1	22	78	32
23 Aug	48	2	56	19	5	9	1	29	10	3	30	34	54	18	22	18	36	44	51	29	5	4	31	183	67
06 Sep	9	0	111	77	7	3	0	31	32	3	1	8	64	62	16	6	2	6	39	16	1	0	82	154	17
20 Sep	9	2	23	63	8	1	1	23	23	14	2	2	41	120	44	3	6	59	349	142	2	2	71	79	31
04 Oct	26	3	50	36	9	2	1	28	28	20	11	2	70	99	27	1	2	298	261	60	4	6	99	208	60
18 Oct	5	1	31	48	23	1	0	18	14	20	3	3	52	82	55	2	2	41	89	88	0	1	49	179	59
01 Nov	0	0	19	37	21	1	0	24	20	22	0	1	42	39	18	0	1	57	117	55	0	0	6	52	23
16 Nov	1	1	10	28	9	1	1	15	17	44	2	0	39	43	31	0	1	61	160	61	0	0	16	36	33
30 Nov	0	1	21	11	8	1	0	23	12	13	0	1	54	24	24	3	0	94	85	60	0	1	88	97	62
Totals	281	14	822	491	108	98	28	509	273	155	155	189	1059	574	286	140	531	1120	1469	679	72	24	692	1412	459

[z]Indicates number of aldicarb treatments received prior to 1983.

providing access to the groves utilized in this study was greatly appreciated.

Literature Cited

1. Brooks, R. F. 1968. Control of aphids on Florida citrus. Proc. Fla. State Hort. Soc. 81:103-108.
2. Bullock, R. C. 1980. Temik aldicarb for control of pests on Florida citrus. Proc. Fla. State Hort. Soc. 93:44-47.
3. Gray, M. E. and J. R. Coats. 1983. Effects of an insecticide and herbicide combination on nontarget arthropods in a cornfield. Environ. Entomol. 12:1171-1174.
4. Hart, W. G. and S. J. Ingle. 1967. The effect of UC-21149 on infestations of brown soft scale on potted citrus. J. Rio Grande Valley Hort. Soc. 21:49-51.
5. Los, L. M. and W. A. Allen. 1983. Abundance and diversity of adult Carabidae in insecticide-treated and untreated alfalfa fields. Environ. Entomol. 12:1068-1071.
6. Selhime, A. G., C. R. Crittenden, and R. F. Kanavel. 1972. Systemic activity of aldicarb against citrus rust mites and citrus red mites on young orange trees. Fla. Entomol. 55:93-96.
7. Shaw, J. G., R. Espinosa, and R. B. Hampton. 1970. Tests with three formulations of aldicarb for control of the citrus red mite. J. Econ. Entomol. 63:1631-1632.
8. Simanton, W. A. 1976. Populations of insects and mites in Florida citrus groves. Fla. Agr. Expt. Sta. Monogr. Ser. No. 7. Inst. Food Agr. Sci., Univ. Florida, Gainesville. 141 pp.
9. Tashiro, H. and J. B. Beavers. 1967. Residual activity of the systemic UC-21149 against the citrus red mite. J. Econ. Entomol. 60:1187-1188.
10. Tashiro, H., D. L. Chambers, J. G. Shaw, J. B. Beavers, and J. C. Maitlen. 1969. Systemic activity of UC-21149 against the citrus red mite, citrus thrips, California red scale, and spirea aphid on nonbearing orange trees. J. Econ. Entomol. 62:443-447.
11. Union Carbide Agr. Products Co., Inc. 1983. Temik aldicarb pesticide: a scientific assessment. Union Carbide Agr. Products Co., Inc., Research Triangle Park, NC. 71 pp.

Proc. Fla. State Hort. Soc. 97: 66-69. 1984.

DIFFERENT TECHNIQUES AND VIEWS CONCERNING LEAF TISSUE ANALYSIS

JAMES R. ILEY
Applied Agricultural Research, Inc.,
1305 East Main Street,
Lakeland, Florida 33801

Abstract. **The sampling period of the present leaf analysis system is oriented more toward applying corrections to next year's crop. A proposed system, still under investigation, is described to make corrections on the present crop by moving the sampling date back to approximately the first half of April. This month lies within a period of great leaf activity and is not normally sampled; however, an attempt has been made and shows promise. With the use of a fixed leaf surface area as a basis rather than dry weight, much of the laboratory work can be eliminated and sampling can be simplified. At the same time, sample transportation to the laboratory is made easier and laboratory turn-around time is greatly reduced. The ideas, techniques and data are presented since others may have interest in this system or parts thereof.**

Most of the research work on leaf tissue analyses has been compiled and published (3, 6). These publications give instructions for sampling and standard values with which analytical results can be compared to determine if they are in a satisfactory range or not. Adaptions (5) have been made to fit local conditions and needs.

Leaf tissue analyses can be a very important tool but appears restricted by the present system of employment; therefore, this work is an exploration in ideas and techniques in search of a greater use that may reveal some of the unknown potential. The areas of exploration are:
1) To simplify the sampling procedure so that a selected field worker at the grove may be taught to sample with reliability.
2) To investigate different sampling periods where results may be more advantageous, so if needed, corrective action can be taken.
3) To simplify the laboratory techniques so that laboratory turn-around time is minimized and results can be readily obtained.

An underlying concept of these explorations is that the simplification will reduce sample cost which should induce more usage and result in a greater understanding of the use of a leaf tissue analysis. Leaf tissue analysis cannot replace soil analysis, nor was it intended to do so, but it can be used to develop a more efficient fertility program.

Sampling

Modifications of the sampling procedure includes the selection of trees, the number of leaves taken per sample, the selection of different age leaves and the removal of a portion of the leaf tissue to be analyzed by the laboratory.

Samples would be from 10 trees, in line, perpendicular to the direction in which the grove is fertilized rather than the recommended 20 randomly selected trees. If a tree is in poor condition, an adjacent tree in that row is used. The location of these trees should be within the grove, not on the very edge, and should be recorded since the same trees should be used in future sampling of the area. If trees are located in blocks or large beds, with deep ditches on each side, and there are only 10 rows per block, the outside rows are excluded and 5 rows are sampled, two trees per row.

From each of these trees, one dry leaf is collected from a non-fruiting terminal about chest high, and from the side of the tree exposed to sunlight for a total of 10 leaves per sample. Newly expanded leaves of a flush may appear to be uniform but in fact may be a complex of three flushes possibly a week apart and can only be separated through feeling the difference in the leaves. All the leaves of a sample should be of the same age, and comparable samples also should be of the same age. In sampling old leaves behind new flushes it is difficult to determine the age of the leaf; therefore, it has been assumed that leaves of this old age group react similarly with respect to new growth emerging.

From young leaves, just fully expanded, 3 disks are punched from each side of the leaf for a total of 60 disks. Some laboratories may be able to use 30 disks from the young leaves, but if 60 are used it should be stated so values can be converted back to a standard 30-disk sample. A 6.35-mm hand paper punch is used with the holes evenly spaced along the leaf, the initial hole being halfway up the leaf length. Details of the procedure and comparisons to the conventional procedure have been published (4). All paper punches are not the same, and some can be easily modified with a small plastic receptacle to collect the 30 small disks.