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Summer Control of the Apple Aphid in Ohio

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INTRODUCTION

The apple aphid, *Aphis pomi* DeGeer, is the most abundant aphid species on apples in Ohio. It is a serious pest of this crop in Ohio and many other areas of the United States and Canada. Its ability to cause severe problems in apple production by its feeding and by production of *honey dew,* on which a sooty fungus grows, has been discussed by many workers (2, 8, 11).

It has been suggested that insecticides applied at pre-bloom could effectively control the apple aphid because the aphids overwinter on apple twigs. However, the ability of aphids to overwinter on other host plants and to feed on many species of plants during the summer (13) can result in continuous reinfestation of apple trees, even if the aphid population has been eliminated (3, 7, 8, 10). It is, therefore, usually essential that insecticidal sprays be applied during the summer to control the apple aphid.

This circular presents the results of field tests conducted with insecticides from 1966 to 1972 in Ohio. Newer materials were compared with standard insecticides in knockdown and residual or overall efficacy under conditions of varying aphid densities. Low rates of insecticides were also tested for possible inclusion in integrated control programs.

MATERIALS AND METHODS

All experiments were conducted at Wooster, Ohio. The experimental design for Experiments 1-9 was basically a completely random design on one large Rome (Experiments 1 and 2) or on two small Red Delicious apple trees (Experiments 3-9). For Experiments 10-14, a randomized complete block design was utilized, with each block composed of a single apple cultivar. The cultivars in these tests were Golden Delicious, Jonathan, and Rome (Experiments 10 and 11), or Stayman (Experiments 12-14).

In Experiments 1 and 2, sprays were applied to drip with a 3-gal. compressed air sprayer to a peripheral area (ca. 2 x 2 ft.) of the tree. In all other tests, the insecticides were applied to entire trees as dilute

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sprays with hand guns and a hydraulic sprayer delivering 35 gallons per minute at 450-600 p.s.i. Except for the specific insecticides used for aphid control, all trees in each experiment were sprayed with the same pesticides for control of diseases and other insects. In Experiments 1-9, the check trees or areas were sprayed with water at the same time as the treatments. Trees in Experiments 10-14 were treated with full-season schedules of insecticides (from petal fall through early or late August), but only the pertinent pre-count dates of treatment are listed in the table. Check trees were sprayed with fungicides only, except as noted in Experiment 12.

In Experiments 1-9, five terminals were selected at a height of 3-7 ft. on the periphery of each tree or area. The total sample consisted of five or ten terminals per treatment per count date. After tagging these terminals, the numbers of apple aphids on the distal portions of the shoot were counted before treatment and at selected intervals following the sprays. The sampling unit consisted of the four distal, unfurled leaves, the growing tip, and the portion of the stem included between the tip and the fourth leaf (observations in the orchard indicated that apple aphids preferred these more succulent tissues). In situations where the population of aphids was large (more than 25 per terminal), the aphid number was estimated in multiples of five.

Data for Experiments 10, 11, and 12 were collected by making similar aphid counts on 10 randomly sampled terminals around the periphery of each tree. In Experiments 13 and 14, the data reflect the total number of aphid-infested terminals on each tree. Only those terminals with 20 or more aphids per terminal were counted as *infested* terminals.

In all tests except for Experiments 7, 8, 9, and 12, each set of counts taken on a particular date was analyzed with the analysis of variance procedure after a logarithmic transformation. For experiments subjected to an analysis, the mean values shown in the tables are based on the reconversion of the log means to aphids per terminal. Where analyzed, the treatment means on each sampling date were compared with Duncan's multiple range test at the 5% level.

Insecticides included in these tests and which do not have approved common names are:

Acarol, isopropyl 4, 4'-dibromobenzilate

Galecron, N'-(4-chloro-*o*-tolyl)-N,N-dimethylformamidine

Gardona, 2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate

Imidan, O-O-dimethyl phosphorodithioate S-ester with N-(mercaptomethyl) phthalimide

Omite, 2-(p-tert-butylphenoxy)cyclohexyl 2-propynyl sulfite

Phosvel, O-(4-bromo-2,5-dichlorophenyl) O-methyl phenylphosphonothioate

In Experiments 10, 11, 13, and 14, the insecticides were mixed with captan; in Experiment 12, with captan plus sulfur.

RESULTS

Some difficulty was encountered in determining if the aphids present on the tagged terminals at 1 day following the sprays were dead or alive, primarily because of the slightly *abnormal* color of a few individuals. Fortunately, most situations were distinct and allowed utilization of the 1-day counts to understand more fully the knockdown qualities of the insecticides.

Another point concerns the use of the word *residual*. Not all of the data collected at intervals exceeding 2 or 3 days following treatment can be interpreted as an indication of a residual property. As suggested by Pielou and Williams (14), residual control is determined only by the efficacy of the residual deposit of the insecticide upon the aphids as they reinfest the trees. A prolonged absence of aphids following an insecticidal spray may be due to a very effective initial kill with a subsequent absence of immigrating aphids. An increasing hardening-off of leaves and cessation of terminal growth can also discourage aphid reinfestation on treated trees (11). In some situations, the residual property of an insecticide could be determined. Although reinfestation was observed in every test, in many of these situations a distinction could not be made between residual efficacy and other factors affecting recolonization or population increase. Therefore, unless stated specifically that an insecticide shows residual control, the control given at the sampling intervals after 2 days is considered indicative of overall effectiveness or persistence of control.

No phytotoxicity was noted in any of these tests.

Experiments 1, 2, and 3

In the experiments conducted in late June 1966, the populations of apple aphids were very high on June 22 and remained relatively stable through June 27 (Table 1). The severe drop in population levels for the check trees, as noted at the 2-day count in Experiments 1 and 3, may have been due simply to the force of the water spray. At this sampling time all insecticides, except superior oil and possibly tepp, gave very good control. Materials not giving significant control at 5 days following the treatments were diazinon, lindane, malathion, superior oil, and tepp Endosulfan and parathion were also somewhat less than satisfactory.

TABLE 1.—Control of Apple Aphid with Sprays on June 22, 1966.

Material	Pounds Active Ingredient per 100 Gal.	Av. No. Aphids per Terminal* Pre-spray June 22	Days After Treatment 2	5
Experiment 1				
Azinphosmethyl 25 WP	0.31	193.0 ab	2.6 d	10.6 c
Carbophenothion 25 WP	0.25	185.7 ab	7.9 cd	17.6 bc
Diazinon 50 WP	0.37	174.5 ab	5.1 cd	54.3 a-c
Ethion 25 WP	0.37	127.0 b	7.5 cd	16.1 bc
Lindane 25 WP	0.25	145.5 ab	9.1 cd	59.0 a-c
Superior oil 70-sec. vis.	1.5 %	142.4 ab	52.9 ab	43.6 a-c
Tepp 40 EC	0.17	205.5 ab	20.8 bc	86.4 ab
Water check		237.8 a	171.1 a	218.5 a
Experiment 2				
Imidan 50 WP	0.75	106.2 a	1.0 b	2.3 b
Oxydemetonmethyl 2 EC	0.25	95.0 a	0.8 b	0.5 b
Water check		132.1 a	119.9 a	97.3 a
Experiment 3				
Carbaryl 50 WP	0.75	213.9 ab	0.6 bc	26.6 bc
Demeton 2 EC	0.125	251.4 b	0.1 c	11.2 cd
Dimethoate 2.67 EC	0.25	254.3 b	0.1 c	4.8 de
Endosulfan 2 EC	0.5	249.2 b	0.8 bc	53.4 b
Malathion 25 WP	0.5	228.1 ab	1.9 b	128.4 a
Parathion 15 WP	0.15	163.5 a	2.3 b	46.4 b
Phosphamidon 8 EC	0.25	178.4 ab	0 c	2.7 e
Water check		163.5 a	67.3 a	158.4 a

*With each experiment, means in the same column flanked by the same lower case letter are not significantly different at the 5 % level. Means represent average values from five terminals per treatment.

It cannot be determined conclusively whether the control afforded at 5 days by some materials was due to residual activity or was simply a reflection of the initial effectiveness of an insecticide. However, an indication of reinfestation was noted in the phosphamidon treatment, where the aphid counts increased from 0 at 2 days to 2.7 at 5 days on the same terminals (Experiment 3). Other data in the same experiment indicate that very poor residual control was obtained with malathion compared to carbaryl, endosulfan, and parathion (the populations of aphids on trees treated with the last three insecticides were not statistically different from the malathion population at the 2-day count). If the pre-spray population for the ethion treatment had not been significantly lower than the pre-spray check population, it is possible that ethion would not have done as well.

TABLE 2.—Control of Apple Aphid with Sprays on July 7, 1966.

Material	Pounds Active Ingredient per 100 Gal.	Av. No. Aphids per Terminal* Pre-spray July 7	Days After Treatment 1	2
Experiment 4				
Azinphosmethyl 25 WP	0.31	55.3 a	5.5 bc	0.3 c-e
Carbaryl 50 WP	0.75	56.5 a	2.0 bc	0.3 c-e
Carbaryl 50 WP	1.0	76.4 a	1.6 c	0.1 de
Tepp 40 EC	0.17	56.1 a	5.5 bc	4.1 a
Carbophenothion 25 WP	0.25	77.2 a	6.0 bc	1.3 b-d
Demeton 2 EC	0.06	88.3 a	3.2 bc	0.3 c-e
Demeton 2 EC	0.12	97.1 a	3.8 bc	0.4 c-e
Diazinon 50 WP	0.37	92.8 a	4.6 bc	1.6 a-c
Ethion 25 WP	0.37	59.8 a	6.5 bc	2.0 ab
Imidan 50 WP	0.75	56.1 a	2.5 bc	0.1 de
Oxydemetonmethyl 2 EC	0.25	66.5 a	7.0 b	0 e
Phosphamidon 8 EC	0.12	78.9 a	4.7 bc	0.6 b-e
Phosphamidon 8 EC	0.25	121.6 a	4.3 bc	0.4 c-e
Tepp 40 EC	0.17	56.1 a	5.5 bc	4.1 a
Water check		98.1	23.1	3.9 a

*Means in the same column flanked by the same lower case letter are not significantly different at the 5% level. Means represent average values from five terminals per tree, ten terminals per treatment.

Experiment 4

Observations made on June 27 in the previous tests indicated that about 50% of the aphids were alatae (winged), which is possibly a forecast of imminent dispersal. In this experiment conducted July 7, the initial populations were generally less than 100 per terminal (Table 2). Subsequent samples showed that the check population was in a sharp, natural decline. However, since each of the pre-spray treatment populations was not statistically different from the check, a comparison of each mean with the check mean should provide satisfactory information on knockdown efficacy.

All insecticides gave significant control at the 1-day count. The higher rate of carbaryl provided more effective knockdown than oxydemetonmethyl. By July 9, the check population was very low, and there was no difference between the check and diazinon, ethion, or tepp. The other insecticides remained better than the water spray.

Experiment 5

The aphid population in 1967 was relatively low and stable, although there was an increase on the check terminals from July 7-11 (Table 3). Ethion did not provide an adequate knockdown of aphids,

TABLE 3.—Control of Apple Aphid with Sprays on July 5, 1967.

Material	Pounds Active Ingredient per 100 Gal.	Pre-spray July 5	Av. No Aphids per Terminal* — Days After Treatment: 1	2	6	14
Experiment 5						
Azinphosmethyl 25 WP	0.31	59.7 a	3.3 bc	0.2 de	1.2 b-e	16.9 a-c
Carbaryl 50 WP	1.0	43.5 a	3.0 b-d	0.8 cd	2.2 bc	14.0 a-c
Demeton 2 EC	0.06	45.1 a	2.7 b-e	0.2 de	0.3 c-e	6.9 b-d
Demeton 2 EC	0.12	53.1 a	0.2 g	0 e	1.3 b-e	3.3 b-d
Diazinon 50 WP	0.5	51.9 a	0.2 g	0 e	1.7 b-e	22.3 ab
Dimethoate 2.67 EC	0.25	68.1 a	0.8 d-g	0 e	0.3 c-e	1.4 d
Endosulfan 2 EC	0.5	46.0 a	0 g	0 e	0.4 c-e	2.2 cd
Endosulfan 50 WP	0.5	66.3 a	0.7 e-g	0 e	0.2 de	1.4 d
Ethion 25 WP	0.37	55.2 a	45.0 a	15.7 b	3.2 b	4.8 b-d
Imidan 50 WP	0.5	65.8 a	5.2 b	0.7 c-e	0.9 b-e	8.6 b-d
Malathion 25 WP	0.5	58.4 a	0.3 g	0 e	2.1 b-d	13.0 a-c
Oxydemetonmethyl 2 EC	0.25	64.0 a	0 g	0 e	0.1 e	1.1 d
Parathion 15 WP	0.15	63.2 a	2.3 b-f	0.4 c-e	0.7 b-e	2.3 cd
Phosphamidon 8 EC	0.125	51.8 a	0 g	0.1 de	0.3 c-e	5.1 b-d
Phosphamidon 8 EC	0.25	42.6 a	0.4 fg	0.1 de	0.6 b-e	5.4 b-d
Tepp 40 EC	0.17	54.7 a	0.9 c-g	1.2 c	1.5 b-e	5.3 b-d
Water check		60.9 a	63.5 a	81.8 a	115.0 a	65.0 a

*Means in the same column flanked by the same lower case letter are not significantly different at the 5% level. Means represent average values from five terminals per tree, ten terminals per treatment.

as indicated by the early post-treatment counts. Azinphosmethyl, carbaryl, the lower rate of demeton, Imidan, and parathion gave very good control at 1 and 2 days following treatment, but the counts at 1 day indicated less knockdown with these materials than obtained with some of the other insecticides.

A sample taken 6 days following treatment showed significant control by all materials. However, reinfestation of terminals was apparently occurring, as indicated by a comparison of counts taken at 6 days with those made at 2 days on trees sprayed with insecticides such as diazinon and malathion (0 aphids on July 7 and 1.7 - 2.1 on July 11). The check population had dropped on July 19, but all of the insecticide-treated terminals showed further increases in aphid numbers.

If the 2-day counts are compared with those made at 6 and 14 days, some indication of residual action is possible. Less residual control was apparent with azinphosmethyl, carbaryl, diazinon, and malathion. These insecticides were not significantly different from the check treatment at 14 days. The data for materials such as dimethoate, endosulfan WP, and oxydemetonmethyl may simply reflect very low populations recorded on July 7. However, because of the similar situation for diazinon and malathion on July 7 and the resulting larger increase in aphid numbers by July 19, the excellent control by former materials is believed to be an indication of better residual effectiveness.

Experiment 6

The work in 1968 provided an opportunity to determine the efficacy of insecticides under conditions of a very high and rapidly increasing aphid population (Table 4). Counts made at each interval following treatments showed that all insecticides gave significant control. This conclusion would seem feasible under conditions of this test, even if an insecticide possessed only minor aphicidal properties.

Gardona gave the poorest control. If this insecticide is considered as a baseline, the least amount of knockdown (as indicated by the counts at 1 day) occurred with carbofuran, demeton, Imidan, and oxydemetonmethyl; the best was with carbaryl and diazinon. The data collected 2 days after treatment showed that all materials gave a significantly greater reduction in aphid populations than Gardona. The most effective insecticides at the 4-day count were carbofuran, oxydemetonmethyl, and phosphamidon; the other materials, however, gave significantly better control than Gardona. Similar results were obtained at the 6-day count, although there was some indication that certain treatments were allowing aphids to increase in numbers. By the time a sample was taken 8 days following treatment, it was apparent that aphid reinfestation (aphids averaged 0 per terminal on carbofuran-treated trees on July 9

TABLE 4.—Control of Apple Aphid with Sprays on July 5, 1968.

Material	Pounds Active Ingredient per 100 Gal.	Av. No. Aphids per Terminal*					
		Pre-spray July 4	Days After Treatment				
			1	2	4	6	8
Experiment 6							
Azinphosmethyl 25 WP	0.31	106.1 a	5.4 d-f	3.8 c	6.2 c	16.0 c	30.3 cd
Carbaryl 50 WP	1.0	110.1 a	2.5 f	1.5 cd	3.0 c	5.2 de	16.0 de
Carbofuran 75 WP	0.37	123.5 a	29.5 b	3.8 c	0 d	0.3 f	2.2 f
Demeton 2 EC	0.06	102.4 a	10.6 cd	2.6 cd	3.7 c	8.3 cd	25.2 c-e
Diazinon 50 WP	0.37	113.8 a	1.7 f	1.6 cd	5.7 c	17 0 c	47.0 bc
Diazinon 50 WP	0.5	123.8 a	2.8 ef	1.0 d	4.6 c	20 3 c	51.0 bc
Gardona 75 WP	0.56	146.2 a	24.5 bc	33.5 b	42.9 b	57.3 b	98.1 b
Imidan 50 WP	0.5	120.3 a	9.1 cd	4.6 c	2.5 c	8.5 cd	11.2 e
Oxydemetonmethyl 2 EC	0.18	126.1 a	13.3 b-d	3.2 cd	0.5 d	0.4 f	2.7 f
Oxydemetonmethyl 2 EC	0.25	136.5 a	23.4 bc	4.5 c	0.6 d	0.1 f	0.4 g
Phosphamidon 8 EC	0.12	145.9 a	8.1 de	2.8 cd	0.4 d	2.5 e	14.8 de
Water check		124.2 a	168.1 a	248.0 a	284.9 a	316.9 a	325.7 a

*Means in the same column flanked by the same lower case letter are not significantly different at the 5% level. Means represent average values from five terminals per tree, ten terminals per treatment.

and 2.2 on July 13) and heavier aphid population pressure (population had doubled in size from the 4 to 8-day count on the Gardona-treated trees) had occurred.

Comparing the counts on the last three sampling dates, it was found that populations on all treated trees, except on those treated with oxydemetonmethyl and possibly carbofuran, had shown a distinct increase. This could be explained if the insecticides possessed inadequate residual qualities. Diazinon apparently did not exhibit much residual activity. There is also an indication that phosphamidon was less effective in residual activity than carbofuran and oxydemetonmethyl, and azinphosmethyl and diazinon were somewhat inferior to Imidan.

Experiment 7

A high initial aphid population characterized this test in 1969 (Table 5). However, the population generally decreased from June 30 to July 9. The rapid drop in aphid numbers on check trees noted at 1 day following treatment may have been due to the force of the water spray. This situation was noted in two tests in 1966, but it was not obvious in any of the other tests.

Although these data were not statistically analyzed, it would appear that diazinon and endosulfan provided the quickest knockdown. Data collected at the 2-day sampling period showed that oxydemetonmethyl and phosphamidon also possessed some knockdown value. Carbaryl and the lower rate of demeton did not give satisfactory population reductions at this time or at the later count dates. Other than these two insecticides, all materials gave good control at 7 days following treatment.

By July 10, the check population had stabilized, but populations on other trees were showing increases. Reinfestation had occurred, as exhibited by a comparison of counts on the oxydemetonmethyl and phosphamidon-treated trees (0 aphids on July 8 and 2.8 - 4.9 on July 10). It is not known, however, if the increases are significant indications of lesser residual activity by the insecticides, simply a reflection of increases in existing populations, or counts of random, immigrant aphids which had not yet shown the effects of the residual insecticide.

Experiment 8

In a second test in 1969 in which treatments were made on July 15, the aphid populations were very small and remained relatively stable, with only a slight increase and subsequent decrease in numbers evident (Table 6). All of the insecticides gave some evidence of knockdown activity. Although all insecticides were at least commercially effective for a low aphid population, it appeared that carbofuran and demeton

TABLE 5.—Control of Apple Aphid with Sprays on July 1, 1969.

Material	Pounds Active Ingredient per 100 Gal.	Av. No. Aphids per Terminal*				
		Pre-spray June 30	Days After Treatment			
			1	2	7	9
Experiment 7						
Azinphosmethyl 50 WP	0.25	194.5	31.8	18.8	1.8	5.0
Carbaryl 50 WP	1.0	195.0	41.0	35.3	18.7	33.2
Demeton 6 EC	0.04	207.5	49.5	69.7	9.7	15.8
Demeton 6 EC	0.14	199.5	31.0	18.9	2.6	3.6
Diazinon 50 WP	0.5	206.0	11.5	2.8	0.4	1.5
Endosulfan 50 WP	0.5	189.0	6.6	0.7	0.7	3.9
Imidan 50 WP	0.5	198.5	25.3	10.0	0.6	7.0
Oxydemetonmethyl 2 EC	0.18	192.5	44.4	1.0	0	4.9
Phosphamidon 8 EC	0.12	210.0	25.0	1.1	0	2.8
Water check		182.0	80.0	112.5	56.9	56.1

*Means represent average values from five terminals per tree, ten terminals per treatment.

TABLE 6.—Control of Apple Aphid with Sprays on July 15, 1969.

Material	Pounds Active Ingredient per 100 Gal.	Av. No. Aphids per Terminal*					
		Pre-spray July 14	Days After Treatment				
			1	2	6	8	10
Experiment 8							
Carbofuran 75 WP	0.37	28.0	14.5	0.2	0.6	0.4	0.3
Demeton 6 EC	0.09	31.9	5.1	0.9	0.3	0.4	0.3
Mevinphos 4 EC	0.16	28.6	13.4	1.6	3.0	5.4	2.1
Phosalone 3 EC	0.47	27.9	9.9	0.7	0.3	1.1	1.8
Water check		29.1	40.5	56.0	40.8	38.8	22.9

*Means represent average values from five terminals per tree, ten terminals per treatment.

TABLE 7.—Control of Apple Aphid with Sprays on July 11, 1972.

Material	Pounds Active Ingredient per 100 Gal.	Av. No. Aphids per Terminal			
		Pre-spray July 10	Days After Treatment		
			3	6	9
Experiment 9					
Diazinon 50 WP	0.5	62.1	0	4.8	8.7
Dimethoate 2.67 EC	0.33	56.7	0	0.3	2.5
Check		70.6	22.7	10.0	5.3

gave the best control at the later counting dates, and mevinphos gave the poorest.

Experiment 9

The data in Table 7 show that the aphid population was in a rapidly declining state. Both diazinon and dimethoate gave excellent control 3 days after treatment. By the 6-day count, reinfestation was occurring and diazinon was apparently showing less residual activity.

Experiments 10, 11, 12, 13, and 14

The results in Table 8 show the number of aphids or infested terminals counted after three to five applications. Counts were taken 7-11 days following a specific spray application, with the exception of the 1969 data where sprays were applied 1 day prior to the count.

The data indicate that all rates of carbofuran and phosalone provided highly effective aphid control. Azinphosmethyl and diazinon generally controlled aphid populations very well. In 1966, Imidan and the mixture of Imidan plus carbophenothion appeared to give adequate control. However, Imidan was not satisfactory in 1971 and 1972. Personal communications with representatives of Stauffer Chemical Co. revealed that some problems with Imidan in recent years may have been due to formulation and this may have been the cause of unsatisfactory control. Although Gardona may offer some potential as an aphicide, it did not appear to be very effective, especially in the 1969 test. Dialifor and Phosvel gave no obvious control of the apple aphid.

It is doubtful if the addition of Galecron in each diazinon spray in 1972 aided in controlling the aphid. The application of 1.5 pints of Acarol 2 EC and 1.25 lb. of Omite 30 WP as acaricide sprays in 1969 did not seem to change the performance of carbofuran and Gardona, respectively. One important point, however, concerns the use of 0.33 pint of mevinphos 4 EC on the fungicide check trees on June 25 and July 3. The count on these trees 7 days after the second spray indicated that mevinphos provided excellent aphid control. It also was noted

TABLE 8.—Control of Apple Aphid with Full-Season Sprays.*

Material	Pounds Active Ingredient per 100 Gal.	Av. No. Aphids per Terminal on Indicated Dates†				Aphid-infested Terminals per Tree on Indicated Dates†	
		1966		1968	1969	1971	1972
		June 24	July 8	July 1	July 10	July 14	June 27
Experiments		10		11	12	13	14
Azinphosmethyl 25 WP	0.25	11.1 b	0.1 c				
Azinphosmethyl 50 WP	0.25					3.4 cd	
Carbofuran 50 WP	0.5	0.7 c	0.4 c				
Carbofuran 75 WP	0.37			0.4 c	0 ‡		
Carbofuran 4 Flow.	0.25					0 e	
Carbofuran 4 Flow.	0.12					0 e	
Dialifor 50 WP	0.5				61.7		
Diazinon 50 WP	0.5					5.8 c	
Diazinon 50 WP + Galecron 4 EC	0.5 0.25						3.8 a
Gardona 75 WP	0.75	29.3 a	2.3 b				
Gardona 75 WP	0.56			1.4 b	90.0‡		
Imidan 50 WP	0.5	6.5 b	2.1 b			35.5 b	14.4 a
Imidan 70 WP	0.47						9.4 a
Imidan 50 WP + carbophenothion** 12.5 WP	1.0	7.0 b	1.5 b				
Phosalone 3 EC	0.46				0		
Phosalone 3 EC	0.37					0.6 de	
Phosalone 3 EC	0 18					0 e	
Phosvel 50 WP	0.5					132.2 a	
Fungicide check		261.0 a	22.4 a	3.9 a	0.7‡	53.7 ab	13.4 a

*The pertinent pre-count sprays were made on May 23, June 1, June 15, and June 29 in 1966; May 22, June 6, and June 20 in 1968; May 13, May 23, June 6, June 20, and July 9 in 1969; May 24, May 28, June 7-9, June 22, and July 6 in 1971; and May 23, June 2, and June 17 in 1972.

†Within each experiment, means in the same column flanked by the same lower case letter are not significantly different at the 5% level. Means represent average values from 10 terminals per tree.

‡On June 25 and July 3, Acarol was applied to the carbofuran plot, Omite to the Gardona plot, and mevinphos 4 EC at 1/3 pint to the fungicide check plot. Endosulfan 50 WP at 1 lb. per 100 gal. was applied to the Gardona plot at the pink stage (April 30, 1969).

**A formulated mixture.

that the use of 1 lb. of endosulfan 50 WP at the pink stage of apple bud development (April 30) on the Gardona-treated trees in 1969 did not appear to prevent aphid reinfestation of the trees. No physical incompatibility was observed in the spray tank when Galecron was mixed with diazinon or a fungicide was mixed with the insecticides listed in Table 8.

DISCUSSION

Various types of apple aphid populations were present in these tests. There did not seem to be any obvious correlation between aphid density or population trends within the orchard and insecticide effectiveness, at least with the procedures and analyses used. One potential correlation could have involved the check aphid populations, which increased slightly from a low density and then decreased again (Experiments 5 and 8). Counts and analyses made when the population returned to a low level could indicate less effective control with insecticides which ordinarily may show good residual activity.

Some insecticides were tested more extensively than others in this series of tests; i.e., in three or more experiments. Of these materials, the best overall control was given by carbofuran, demeton, dimethoate, endosulfan, Imidan, oxydemetonmethyl, phosalone, and phosphamidon. These insecticides also generally gave very good knockdown at 1 and 2 days following treatment.

In experiments designed specifically for aphid control, carbofuran was tested only at 0.375 lb. of active ingredient (AI) per 100 gallons and performed very well. Rates as low as 0.125 lb. AI also appeared to be very effective when the insecticide was used in a seasonal program. These data are in general agreement with work by Asquith (1) and Rammer *et al.* (16), who indicated that carbofuran provided excellent control of the apple aphid at a rate of 0.25 lb. AI.

The rate of 0.047 lb. AI of demeton used in 1969 (Experiment 7) did not give adequate control of the apple aphid. The effective minimum rate appeared to be in the range of ca. 0.06 to 0.09 lb. AI per 100 gal., where very good knockdown and control were found. Cutright (3) and Glass and Chapman (7) reported that ca. 0.12 to 0.5 lb. AI of demeton provided excellent aphid kill at 2 days and the latter also indicated effective control for 2 weeks. At lower rates of ca. 0.01 to 0.06 lb., knockdown was very good but the persistence was not as great (7).

Tests with dimethoate were at a minimum rate of 0.25 lb. AI and showed good control. At a higher rate, dimethoate was found to give very good control (9, 10).

No residual activity was noted with endosulfan (15), although others concluded that ca. 0.5 lb. AI provided good aphid control (5, 9, 16). This rate was used with very good results.

In a recent paper by Asquith (1), Imidan at 0.5 lb. AI gave 86-93% reduction in aphid numbers. Tests by the authors, which were designed specifically for aphid control, revealed that this same rate provided very good control, although the knockdown at 1 day was generally poor. In full-season tests, control with Imidan at similar rates gave variable results; a possible reason for this variation was mentioned in the section on results.

Meta-Systox (0, 0-dimethyl 0-2-ethylmercaptoethyl thiophosphate) used at 0.125 lb. AI per 100 gal. gave excellent knockdown and control (7). Findings by the authors generally support these results with rates of 0.18 and 0.25 lb. AI of only oxydemetonmethyl. There was some indication that, although the knockdown was very good at 2 days with the lower rate, oxydemetonmethyl did not perform as well at the 1-day count.

The application of phosalone from 0.18 to 0.46 lb. AI, primarily in full-season tests, generally resulted in excellent aphid control. Similar results were reported by Asquith (1) and Danguy *et al.* (5).

Phosphamidon at rates as low as 0.125 lb. AI provided very good knockdown and long-term control.

Azinphosmethyl, carbaryl, and diazinon were also tested extensively. They usually provided effective knockdown, but the residual or overall control did not seem to be consistently effective or long-lasting. The results indicated that control of the apple aphid with these insecticides generally began to show signs of being less effective at ca. 6-10 days.

Tests with azinphosmethyl were conducted with rates of 0.25 and 0.31 lb. AI and it generally provided good suppression of aphids in full-season tests. Although Madsen and Bailey (9) determined that azinphosmethyl generally provided good knockdown and control, others concluded that it gave poor persistent or residual control (15). Fair control has also been reported for a rate of 0.125 lb. (1).

Carbaryl at 0.75 and 1.0 lb. AI per 100 gal. exhibited slightly better residual control than obtained with azinphosmethyl and diazinon. Some workers have stated that carbaryl provided long-lasting or residual control at ca. 0.5 lb. AI (12, 14). Madsen and Bailey (9) found that carbaryl gave a quick knockdown with a rate of 0.75 lb. but no persistent control. Results of these Ohio tests fall somewhere between these two extremes.

Slightly more persistent control was obtained with an 0.5 lb. rate of diazinon than with 0.375 lb. AI. It was also found that diazinon at

0.5 lb. in a full-season program seemed to provide good suppression of aphid populations. Pielou and Williams (14) did not obtain any residual control, but Madsen *et al.* (10) found adequate control with a rate of 0.5 lb. AI for ca. 2 weeks. Other workers have generally concluded that diazinon at a lower rate was inadequate for persistent aphid control (7, 9).

Less extensive tested materials which appeared to show some degree of control included carbophenothion, ethion, malathion, mevinphos, parathion, and tepp.

Carbophenothion at 0.25 lb. AI was included in two tests and good control of the apple aphid was obtained at 1, 2, and 5 days. Good control was obtained by Danguy *et al.* with ca. 0.4 lb., but not with a rate less than 0.3 lb. AI (5). In an earlier paper, Danguy *et al.* (4) said carbophenothion was good at 2 days but gave relatively incomplete control at 7 days. The use of this insecticide at 0.125 lb. with Imidan in a full-season test did not seem to add to the degree of control provided by Imidan alone. Asquith (1) found similar results.

Ethion has not generally been considered as an effective aphicide (6, 9). In tests by the authors, ethion at a rate of 0.375 lb. AI gave relatively poor knockdown, but there was an indication that there may have been some long-term effects. Danguy *et al.* (4) obtained variable results in a number of tests, but concluded that it was generally an inferior aphicide.

The authors obtained quick knockdown but relatively poor residual control with malathion at a rate of 0.5 lb. AI per 100 gal. These results are in agreement with Cutright (3) and Glass and Chapman (7), although Paradis (12) found generally good knockdown and some persistent control at 0.75 lb.

Mevinphos at 0.1 lb. AI generally provided good knockdown of the aphid population and fair persistent control. A double application (Experiment 12) provided excellent control at 7 days following the second spray. Paradis (12) recorded very good control with mevinphos at ca. 0.3 lb. AI at 2, 8, and 15 days.

Parathion at 0.15 lb. AI exhibited good knockdown and overall control in two tests. Cutright (3) and Glass and Chapman (7) also found that parathion provided knockdown at this same rate. However, data were presented by the latter authors to show that parathion was not very effective after 2 weeks.

Tepp did not consistently provide the degree of knockdown expected, or that Glass and Chapman (7) recorded at rates of ca. 0.1 to 0.2 lb. AI. These same authors reported usually poor persistent control. However, some long-term effects with tepp are indicated in Experiment 5 of these Ohio tests.

Other insecticides and rates included in these experiments were dialifor (0.5 lb. AI), Gardona (0.56 and 0.75 lb.), lindane (0.25 lb.), Phosvel (0.5 lb.), and superior oil. Except for some knockdown qualities exhibited by lindane, these materials performed rather poorly.

The data obtained by Asquith (1) generally support the authors' conclusions concerning dialifor, Gardona, and Phosvel. Glass and Chapman (7) reported that 0.25 lb. of lindane gave results similar to the authors, but Danguy *et al.* (4) said that lindane was superior to ethion and carbophenothion

CONCLUSIONS

The systemic insecticides (demeton, dimethoate, oxydemetonmethyl, and phosphamidon) were generally effective in the range of ca. 0.1 to 0.2 lb. AI per 100 gal. Although dimethoate was tested only at 0.25 lb., it is possible that a lower rate could be equally as effective. Carbofuran, parathion, and phosalone could also probably be placed in this same range of effective rates.

Most of the other insecticides with aphicidal properties appear to be effective at ca. 0.3 to 0.5 lb. AI. These would include azinphosmethyl, carbophenothion, endosulfan (which may show good control at a rate lower than 0.5 lb.), and Imidan. It may be possible that more effective overall control could be obtained with diazinon and malathion if the rates were increased to ca. 0.75 lb. AI per 100 gal., and with mevinphos or tepp to ca. 0.2 to 0.3 lb. Carbaryl appears to have an effective rate for aphids at ca. 1.0 lb. AI.

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