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PRELIMINARY TESTS OF SYNTHETIC ORGANIC COMPOUNDS
AS INSECTICIDES. PART IV.

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This is the fourth report on preliminary tests with synthetic organic compounds, which were conducted at the insecticide-testing laboratories of this Bureau at Sanford, Fla., and Anaheim, Calif. The previous reports were published in E-621 (1944), E-634 (1945), and E-729 (1947).

Twenty-six compounds were tested against three or more species of leaf-feeding insects. The materials were supplied by the Division of Insecticide Investigations, most of them being received and tested during the first half of 1945. Equipment and certain methods employed have been described by Swingle, Phillips, and Gahan. ^{2/} The experimental procedures were the same as those followed in Part III (E-729).

The following insects were employed in testing these compounds and the standards:

American cockroach (Periplaneta americana (L.))
Armyworm (Cirphis unipuncta (Haw.))
Bean leaf roller (Urbanus proteus (L.))
Celery leaf tier (Phlyctaenia rubigalis (Guen.))
Cotton aphid (Aphis gossypii Glover)
Cowpea weevil (Callosobruchus maculatus (F.))
Cross-striped cabbageworm (Evergestis rimosalis (Guen.))
Hawaiian beet webworm (Hymenia recurvalis (F.))
Large milkweed bug (Oncopeltus fasciatus (Dall.))
Melonworm (Diaphania hyalinata (L.))
Rice weevil (Sitophilus oryza (L.))
Southern armyworm (Prodenia eridania (Cram.))

^{1/} Most of the materials tested were furnished by the Division of Insecticide Investigations. Technical assistance was given by E. R. McGovran, formerly of the Division of Control Investigations.

^{2/} Swingle, M. C., Phillips, A. M., and Gahan, J. B. Laboratory testing of natural and synthetic organic substances as insecticides. Jour. Econ. Ent. 34: 95-99. 1941.

Southern beet webworm (Pachyzancla bipunctalis (F.))
Squash bug (Anasa tristis (Deg.))
Sweetpotato weevil (Cylas formicarius elegantulus (Sum.))
Termites (Reticulitermes sp.)
Three-striped blister beetle (Epicauta lemniscata (F.))
Variegated cutworm (Peridroma margaritosa (Haw.))
Yellow-striped armyworm (Prodenia ornithogalli Guen.)

Thirteen of these species were reared in the laboratory in order to insure uniformity of population and continuous availability throughout the year. The cotton aphids, bean leaf rollers, three-striped blister beetles, and squash bugs were collected in the field.

Table 1 shows the effectiveness of nine common insecticides, including DDT, tested against various species of insects fed dusted foliage, to be used as standards for comparing results obtained with new compounds.

Table 2 presents the results of dust tests with 15 compounds that were found to be toxic to one or more species of insects.

The following compounds killed 85 to 100 percent of the insects in:

All species against which they were tested--

1-Benzoyl-2-phenylhydrazine
1-(m-Nitrobenzoyl)-2-phenylhydrazine
1-Phenyl-2-phenylsulfonylhydrazine
1-Phenyl-2-(p-tolylsulfonyl)hydrazine

At least 60 percent of the species tested--

1-Acetyl-2-phenylhydrazine
Bis(p-bromophenyl)methane
Bis(p-chlorophenyl)methanol
N,N-diisopropyl-m-nitrobenzamide
1-Isovaleryl-2-phenylhydrazine
1-Phenyl-2-valerylhydrazine

One or more species, but less than 60 percent of the species tested--

Benzylphenylnitrosoamine
1-Butyryl-2-phenylhydrazine
Chloro-bis(p-chlorophenyl)methane
1-Isocapropyl-2-phenylhydrazine
4-(alpha-Thiotoluy)l)piperidine

Of the second group only 1-acetyl-2-phenylhydrazine and N,N-diisopropyl-m-nitrobenzamide were effective when used as sprays. 1-Acetyl-2-phenylhydrazine caused severe foliage injury to five out of six varieties of plants treated, and bis(p-bromophenyl)methane caused moderate injury to Swiss chard leaves. Of the last-named group treatments of benzylphenylnitrosoamine and 1-butyryl-2-phenylhydrazine caused over 50 percent mortality against all species tested. 1-Isocapropyl-2-phenylhydrazine showed some toxicity against five species, and appreciable mortalities against three species. Contact treatments with benzylphenylnitrosoamine against the squash bug and termites caused mortalities of 81 and 89 percent, respectively. Mortality of 97 percent of the cotton aphids resulted from a treatment with 1-butyryl-2-phenylhydrazine.

The following compounds caused less than 85 percent mortality of the species against which they were tested:

<u>Compound</u>	<u>Insect 1/</u>
4(p-Bromo-alpha-thiotoluy1)morpholine $\text{BrC}_6\text{H}_4\text{CH}_2\text{CSN}(\text{CH}_2\text{CH}_2)_2\text{O}$	Melonworm Southern armyworm Southern beet webworm
Bromobis(p-chlorophenyl)methane $(\text{ClC}_6\text{H}_4)_2\text{CHBr}$	Melonworm Southern armyworm Southern beet webworm
5-Butyl-1-phenylsemioxamazide $\text{C}_6\text{H}_5\text{NHNHCOCONHC}_4\text{H}_9$	Melonworm Southern armyworm
1-Cinnamoyl-2-phenylhydrazine $\text{C}_6\text{H}_5\text{NHNHCOCH-CHC}_6\text{H}_5$	Melonworm Southern armyworm Yellow-striped armyworm
p-(1,2-Dibromoethyl)toluene $\text{CH}_3\text{C}_6\text{H}_4\text{CHBrCH}_2\text{Br}$	Melonworm Southern armyworm Southern beet webworm
sym-Di-o-tolylthiourea $(\text{CH}_3\text{C}_6\text{H}_4\text{NH})_2\text{CS}$	American cockroach (3/4 grown) Bean leaf roller (fifth instar) Blister beetle (adult) Hawaiian beet webworm (fifth instar) Melonworm Southern armyworm (fifth instar) Southern beet webworm (fifth instar)

1/ All fourth instars unless otherwise indicated.

<u>Compound</u>	<u>Insect</u>
alpha, alpha, alpha', alpha'- 4,4'-Hexachlorobibenzyl $\text{ClC}_6\text{H}_4\text{CCl}_2\text{CCl}_2\text{C}_6\text{H}_4\text{Cl}$	Melonworm Southern armyworm Southern beet webworm
5-Isobutyl-1-phenylsemioxamazine $\text{C}_6\text{H}_5\text{NHNHCOCONHCH}_2\text{CH}(\text{CH}_3)$	Melonworm Southern armyworm Yellow-striped armyworm
1-Phenyl-2-phenylacetylhydrazine $\text{C}_6\text{H}_5\text{NHNHCOCH}_2\text{C}_6\text{H}_5$	Melonworm Southern armyworm Yellow-striped armyworm
1-Phenyl-5-propylsemioxamazine $\text{C}_6\text{H}_5\text{NHNHCOCONHC}_3\text{H}_7$	Melonworm Southern armyworm Yellow-striped armyworm
Tetrakis(p-chlorophenyl)ethylene $(\text{ClC}_6\text{H}_4)_2\text{C}-\text{C}(\text{C}_6\text{H}_4\text{Cl})_2$	Melonworm Southern armyworm Southern beet webworm

The results of spray tests on 15 compounds are presented in table 3. Of these compounds 13 were reported in the dust tests. Of the 4 most effective compounds in the dust tests, 1-phenyl-2-phenylsulfonylhydrazine and 1-phenyl-2-(p-tolylsulfonyl)hydrazine, when tested as sprays, were effective against at least two-thirds of the species to which they were toxic as dusts. 1-(m-Nitrobenzoyl)-2-phenylhydrazine was effective as a spray only against the southern beet webworm. Mortalities of less than 60 percent resulted against the melonworm and the southern armyworm from spray treatments of this material. Spray treatments of 1-benzoyl-2-phenylhydrazine caused appreciably lower mortalities than dusts against all species tested, and this was the only one of the 4 most toxic compounds which caused more than very slight injury to tender foliage. Swiss chard leaves showed moderate injury from spray treatments. 1-Phenyl-2-(p-tolylsulfonyl)hydrazine lost 56 percent of its weight during 7 days' exposure to warm air. The other 3 materials lost less than 50 percent of their weight during similar exposure. None of the 4 materials showed any appreciable toxicity when tested as fumigants against the southern armyworm. Negative results of contact tests of 3 of the compounds indicate further that these materials act as stomach poisons. 1-Benzoyl-2-phenylhydrazine was not tested as a contact insecticide.

SUMMARY

The results of preliminary tests to determine the toxicity to insects of 26 synthetic organic compounds are reported.

Dust treatments of 4 of the 26 materials tested caused mortalities of 85 to 100 percent of all leaf-feeding insects against which they were tested. Alphabetically arranged these four most toxic compounds, all phenylhydrazines, were 1-benzoyl-2-phenylhydrazine, 1-(m-nitrobenzoyl)-2-phenylhydrazine, 1-phenyl-2-phenylsulfonylhydrazine, and 1-phenyl-2-(p-tolylsulfonyl)hydrazine. Only the first compound caused more than very slight injury to tender foliage. Results of contact and fumigation tests indicated that these materials acted as stomach poisons. The last two compounds were effective as sprays as well as dusts.

Two compounds, 1-acetyl-2-phenylhydrazine and N,N-diisopropyl-m-nitrobenzamide, were effective against most species of insects tested both as dusts and sprays, but caused moderate to severe injury to tender green foliage.

Table 1.--Effectiveness of nine common insecticides tested against various species of insects fed dusted foliage in laboratory, to be used as standards for comparing results obtained with new insecticidal compounds

Compound and insect	Stage <u>1/</u>	Foliage	Average deposit per square centimeter <u>Micrograms</u>	Feeding <u>2/</u>	Average mortality in 3 or 4 days <u>3/</u> <u>Percent</u>
DDT, technical, in pyrophyllite:					
0.5% Armyworm	Fourth	Corn	100	2	83
Bean leaf roller	Fifth	Bean	120	1	82
Celery leaf tier	Fourth	Swiss chard	95	1	85
Melonworm	do.	Pumpkin	137	2	87
Melonworm (contact)	do.	do.	260	3	45
Southern beet webworm	do.	Pigweed	133	2	83
Variegated cutworm	do.	Cabbage	115	1	100
Yellow-striped armyworm	do.	do.	180	2	67
1% Southern armyworm	do.	Collard	150	2	73
Southern armyworm (contact)	do.	do.	250	2	75
3% Sweetpotato weevil	Adult	Sweetpotato	295	0	96
10% Large milkweed bug	Nymphs	Milkweed seed	215	-	50
Derris root, powdered, 4.2-4.8% rotenone					
Cross-striped cabbageworm	Fourth	Collard	255	1	43
Hawaiian beet webworm	do.	Pigweed	108	1	71
Melonworm	do.	Pumpkin	240	0	88
Calcium arsenate					
Cowpea weevil	Adult	Treated peas	1:1000 ^{4/}	-	100
Rice weevil	do.	Treated wheat	1:1000	-	97

1/ Numbers refer to instar.

2/ Feeding: 0, none; 1, slight; 2, moderate; 3, normal.

3/ Records on all DDT treatments made at end of 3 days.

4/ Proportion by weight.

Table 1 -- (Continued)

Compound and insect	Stage ^{1/}	Foliage	Average deposit per square centimeter <u>Micrograms</u>	Feedings ^{2/}	Average mortality in 3 or 4 days ^{3/} <u>Percent</u>
Cryolite					
Blister beetle	Adult	Swiss chard	215	1	56
Lead arsenate					
Bean leaf roller	Fifth	Bean	170	2	100
Southern armyworm	Fourth	Collard	98	1	95
Southern beet webworm	do.	Pigweed	128	2	67
Nicotine, 0.125% in fuller's earth					
Cotton aphid	All	Cotton	270	-	88
<u>o</u> -Dichlorobenzene					
Melonworm	Fourth	Pumpkin	(1 cc.in petri dish)	0	100
Southern armyworm	do.	Collard	do.	0	100
Pyrethrum: Pyrethrin I, 0.33%					
Blister beetle	Adult	Swiss chard	185	1	72
Large milkweed bug	Nymph	Milkweed seed	215	-	100
Squash bug (contact)	do.	Squash	215	-	100
Termites (contact)	do.	(Treated soil)	1:1000 ^{4/}	-	100
Sodium fluoride					
American cockroach	Adult	-	(1/4 gr. per 50 sq. in.)	-	100

Table 2. -- Compounds found to be toxic to various insects fed dusted foliage in the laboratory

Compound	Insect	Stages <u>1/</u>	Foliage	Average deposit per square centimeter	Feedings <u>2/</u>	Average kill after 2 or 3 days
				Micrograms		Percent
1-Acetyl-2-phenylhydrazine $C_6H_5NHNHCOCH_3$	Cotton aphid	All	Cotton plants	225	0	100
	Melonworm	Fourth	Pumpkin	250	3	50
	Southern armyworm	do.	Collard	225	1	100
	Southern beet webworm	do.	Pigweed	225	0	100
	Sweetpotato weevil	Adult	Sweetpotato	215	1	58
1-Benzoyl-2-phenylhydrazine $C_6H_5NHNHCOC_6H_5$	Melonworm	Fourth	Pumpkin	280	1	92
	Southern armyworm	do.	Collard	400	1	100
	Southern beet webworm	do.	Swiss chard	250	1	87
Benzylphenylnitrosoamine $C_6H_5N(NO)CH_2C_6H_5$	American cockroach	3/4 grown	-	$\frac{1}{4}$ gr. <u>3/</u>	-	0
	Bean leaf roller	Fifth	Bean	125	2	53
	Blister beetle	Adults	Swiss chard	215	1	56
	Cowpea weevil	do.	Cowpeas	1:1000 <u>4/</u>	-	26
	Cross-striped cabbage-					
	worm	Fifth	Collard	310	1	100
	Hawaiian beet webworm	do.	Swiss chard	200	2	66
	Melonworm	Fourth	Pumpkin	125	0	57
	Rice weevil	Adult	Wheat	1:1000 <u>4/</u>	-	3
	Southern armyworm	Fourth	Collard	310	1	100
	Southern beet webworm	Fifth	Swiss chard	200	1	70
	Squash bug	Second	Pumpkin stems	280	-	81
	Termites	Adult		1:5000 in soil <u>4/</u>	-	89

1/ Number refers to instar.

2/ Feeding: 0, none; 1, slight; 2, moderate; 3, much.

3/ Dusted on bottom of battery jar.

4/ Proportion by weight.

Table 2. -- (Continued)

Compound	Insect	Stages 1/	Foliage	Average deposit per square centimeter <u>Micrograms</u>	Feedings 2/	Average kill after 2 or 3 days <u>Percent</u>	
Bis(p-bromophenyl)methane $(\text{BrC}_6\text{H}_4)_2\text{CH}_2$	Melonworm (contact)	Fourth	Pumpkin	310	3	13	
	Melonworm	do.	do.	230	2	100	
	Southern armyworm	do.	Collard	320	3	0	
	Southern beet webworm	do.	Swiss chard	340	1	92	
1-Butyryl-2-phenylhydrazine $\text{C}_6\text{H}_5\text{NHNHCOC}_3\text{H}_7$	Cotton aphid	All	Cotton plants	250	0	97	
	Melonworm	Fourth	Pumpkin	200	2	63	
	Southern armyworm	do.	Collard	230	1	100	1
	Southern beet webworm	do.	Pigweed	270	0	100	2
	Squash bug	Nymphal	Pumpkin stems	215	0	67	1
	Sweetpotato weevil	Adult	Sweetpotato	265	0	79	
Bis(p-chlorophenyl)methanol $(\text{ClC}_6\text{H}_4)_2\text{CHOH}$	Melonworm	Fourth	Pumpkin	230	2	92	
	Southern armyworm (contact)	do.	Collard	215	3	4	
	Southern armyworm	do.	do.	280	2	52	
	Southern beet webworm	do.	Swiss chard	295	1	88	
Chloro-bis(p-chlorophenyl)- methane $(\text{ClC}_6\text{H}_4)_2\text{CHCl}$	Melonworm	do.	Pumpkin	265	2	88	
	Southern armyworm	do.	Collard	220	3	22	
	Southern beet webworm	do.	Swiss chard	215	3	33	

Table 2. -- (Continued)

Compound	Insect	Stages 1/	Foliage	Average deposit per square centimeter	Feedings 2/	Average kill after 2 or 3 days
				Micrograms		Percent
N,N-Diisopropyl-m-nitrobenzamide $C_6H_4(NO_2)CON(C_3H_7)_2$	Large milkweed bug	Adult	Milkweed seed	280	-	12
	Melonworm	Fourth	Pumpkin	265	0	100
	Melonworm	do.	do.	285	0	100
	Southern armyworm	do.	Pigweed	215	2	67
	Southern beet webworm	do.	do.	285	0	100
1-Isocaproyl-2-phenylhydrazine $C_6H_5NHNHCO(CH_2)_2CH(CH_3)_2$	Celery leaf tier	do.	Swiss chard	28	3	24
	Melonworm	do.	Pumpkin	310	2	79
	Southern armyworm	do.	Collard	265	1	88
	Southern beet webworm	do.	Swiss chard	225	2	17
	Yellow-striped armyworm	do.	Cabbage	300	1	96
1-Isovaleryl-2-phenylhydrazine $C_6H_5NHNHCOCH_2CH(CH_3)_2$	Celery leaf tier	do.	Swiss chard	230	3	33
	Melonworm	do.	Pumpkin	225	1	100
	Southern armyworm	do.	Collard	215	1	92
	Southern beet webworm	do.	Swiss chard	225	2	96
	Yellow-striped armyworm	do.	Cabbage	250	1	100
1-(m-Nitrobenzoyl)-2-phenyl- hydrazine $C_6H_5NHNHCOC_6H_4NO_2$	Large milkweed bug	Adult	Milkweed seed	170	-	0
	Melonworm	Fourth	Pumpkin	288	0	100
	Southern armyworm	do.	Pigweed	340	0	100
	Southern beet webworm	do.	do.	295	1	100

Table 2. -- (Continued)

Compound	Insect	Stages 1/	Foliage	Average deposit per square centimeter	Feedings 2/	Average kill after 2 or 3 days
				Micrograms		Percent
1-Phenyl-2-phenylsulfonyl- hydrazine $C_6H_5NHNHSO_2C_6H_5$	Melonworm	Fourth	Pumpkin	215	1	96
	Southern armyworm(contact)	do.	Collard	265	2	17
	Southern armyworm	do.	do.	295	1	100
	Southern beet webworm	do.	Swiss chard	265	0	100
1-Phenyl-2-(p-tolylsulfonyl)- hydrazine $C_6H_5NHNHSO_2C_6H_4CH_3$	Melonworm	do.	Pumpkin	230	2	100
	Southern armyworm(contact)	do.	Collard	215	3	0
	Southern armyworm	do.	do.	230	1	100
	Southern beet webworm	do.	Swiss chard	225	1	100
1-Phenyl-2-valerylhydrazine $C_6H_5NHNHCO(CH_2)_3CH_3$	Celery leaf tier	do.	Swiss chard	225	2	27
	Melonworm	do.	Pumpkin	295	2	96
	Southern armyworm	do.	Collard	225	1	92
	Southern beet webworm	do.	Swiss chard	295	2	100
	Yellow-striped armyworm	do.	Cabbage	200	1	100
4-(alpha-Thiotoluy1)piperidine $C_6H_5CH_2CSNC_5H_{10}$	Melonworm	do.	Pumpkin	215	2	63
	Southern armyworm	do.	Collard	215	1	24
	Southern beet webworm	do.	Swiss chard	255	1	100

Table 3.--Effectiveness of laboratory spray tests of compounds most of which were found to be toxic to insects in preliminary dust tests

Compound	Insect <u>1/</u>	Foliage	Quantity per 100 gallons	Feeding <u>2/</u>	Mortality	Exposure
			<u>Pounds</u>		<u>Percent</u>	<u>Days</u>
1-Acetyl-2-phenylhydrazine	Melonworm	Pumpkin	4	3	100	3
			8	2	100	3
	Southern armyworm	Pigweed	8	2	100	3
			4	3	71	3
	Southern beet webworm	do.	8	2	96	3
1-Benzoyl-2-phenylhydrazine	Melonworm	Pumpkin	8	3	71	3
	Southern armyworm	Collard	8	2	25	3
			4	3	4	3
	Southern beet webworm	Swiss chard	8	2	54	3
			4	2	50	3
Benzylphenylnitrosoamine	Blister beetle <u>3/</u>	do.	4	2	54	4
	Melonworm	Pumpkin	4	2	91	4
	Southern armyworm <u>4/</u>	Collard	8	2	18	4
	Southern beet web- worm <u>4/</u>	Swiss chard	8	1	55	4
Bis(<u>p</u> -bromophenyl)methane	Melonworm	Pumpkin	8	3	4	3
	Southern armyworm	Collard	8	3	0	3
			4	3	0	3
	Southern beet webworm	Swiss chard	8	3	8	3
			4	3	17	3

1/ All fourth instar unless otherwise indicated.

2/ Feeding: 0, none; 1, slight; 2, moderate; 3, much.

3/ Adult.

4/ Fifth instar.

Table 3. -- (Continued)

Compound	Insect <u>1/</u>	Foliage	Quantity per 100 gallons	Feeding <u>2/</u>	Mortality	Exposure
			<u>Pounds</u>		<u>Percent</u>	<u>Days</u>
1-Butyryl-2-phenylhydrazine	Melonworm	Pumpkin	4	3	92	3
			8	2	100	5
	Southern armyworm	Pigweed	8	2	100	3
			4	1	70	3
	Southern beet webworm	do.	8	2	78	3
Bis(p-chlorophenyl)methanol	Melonworm	Pumpkin	8	3	0	3
	Southern armyworm	Collard	8	3	0	3
			4	3	0	3
	Southern beet webworm	Swiss chard	8	2	88	3
			4	2	88	3
p-(1,2-Dibromoethyl)toluene	Southern armyworm	Collard	8	3	0	4
			4	3	0	4
			4	3	0	4
	Southern beet webworm	Swiss chard	4	2	14	4
			4	3	17	4
			8	3	13	4
			8	3	21	4
N,N-Diisopropyl-m-nitrobenzamide	Melonworm	Pumpkin	8	0	100	3
	Southern beet webworm	Pigweed	8	2	71	3
			8	3	9	3
sym-Di-o-tolylthiourea	Southern armyworm <u>4/</u>	Collard	6	2	0	4
	Southern armyworm	do.	8	3	0	4

Table 3. -- (Continued)

Compound	Insect <u>1/</u>	Foliage	Quantity per 100 gallons	Feeding <u>2/</u>	Mortality Percent	Exposure Days
			<u>Pounds</u>			
1-Isocaproyl-2-phenylhydrazine	Armyworm	Barley	8	2	0	3
1-Isovaleryl-2-phenylhydrazine	Armyworm	do.	8	2	71	3
1-(<u>m</u> -Nitrobenzoyl)-2-phenylhydrazine	Melonworm	Pumpkin	8	2	58	3
	Southern armyworm	Pigweed	8	2	39	3
			4	2	46	3
	Southern beet webworm	do.	8	1	100	3
1-Phenyl-2-phenylsulfonylhydrazine	Melonworm	Pumpkin	8	2	100	3
	Southern armyworm	Collard	8	2	50	3
			4	2	25	3
	Southern beet webworm	Swiss chard	8	1	100	3
			4	1	100	3
1-Phenyl-2-(<u>p</u> -tolylsulfonyl)hydrazine	Melonworm	Pumpkin	8	2	25	3
	Southern armyworm	Collard	8	2	100	3
			4	3	63	3
	Southern beet webworm	Swiss chard	8	1	96	3
			4	2	83	3
1-Phenyl-2-valerylhydrazine	Armyworm	Barley	8	2	13	3