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Agricultural Research Administration
Bureau of Entomology and Plant QuarantineINSECTARY AND FIELD-CAGE TESTS WITH DDT AGAINST WHITE-FRINGED BEETLE
ADULTS CONDUCTED AT FLORALA, ALA., DURING 1944

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Insectary and field-cage tests of DDT (1-trichloro-2,2-bis(p-chlorophenyl)ethane) were conducted against the adults of one species of white-fringed beetles (Pantomorus leucoloma (Boh.)) at Florala, Ala., during the summer of 1944. The results of these tests confirm those obtained in 1943,^{1/} which showed that DDT is the most potent insecticide ever tested against adult white-fringed beetles.

The DDT used in all the experiments reported was received from the manufacturers as a 10 percent DDT-pyrophyllite dust. A chemical analysis made by the Division of Insecticide Investigations of this Bureau showed that this material contained 8.9 percent of DDT. Lower concentrations were prepared by further diluting this dust with additional pyrophyllite. The 10 percent DDT-pyrophyllite was also used for preparing all sprays.

The adult white-fringed beetles were collected in the field, and all beetles used in any one series of tests were collected from the same host plant on the same date.

INSECTARY TESTS

Effectiveness of DDT as a Stomach Poison

In these tests a total of approximately 50 beetles in five cages were used in each replication, and each series of tests was replicated two or three times during the season. The mortality was recorded 96 hours after the beetles had been released on the treated foliage. In each test an appropriate number of untreated check cages were included in order to determine the natural mortality. The net mortalities have been calculated by Abbott's formula.

^{1/} Young, H. C. 1944. DDT against the white-fringed beetle and the velvetbean caterpillar. (Scientific Note) Jour. Econ. Ent. 37:145-147.

Dusts.--In the insectary tests against the adult beetles, peanut and chrysanthemum foliage held in 2-ounce wide-mouthed bottles embedded in soil in 5-inch azalea flower pots was treated in a settling chamber with predetermined dosages of dusts containing different percentages of DDT. The foliage was held in a position similar to that existing under field conditions. After the dusts had been allowed to settle for 3 minutes, the beetles were confined on the treated foliage in screen cages 9 inches high and $5\frac{1}{2}$ inches in diameter. Prior to the dust treatment the foliage was moistened with a fine water mist from a hand atomizer.

In two series of tests dusts containing different percentages of DDT were applied at a fixed rate equivalent to 11.6 pounds per acre on peanut foliage and 15.5 pounds on chrysanthemum. For comparison a synthetic cryolite dust (76.8 percent sodium fluoaluminate) in which 10 percent of wheat flour had been incorporated to improve its dusting quality was applied at the same rates. The results are shown in table 1.

In this series 0.13 pound of DDT per acre on peanut foliage and 0.16 pound on chrysanthemum foliage gave approximately the same mortalities as obtained with the cryolite dust at the same dosages of the dust mixture. From these results it is apparent that, when used as a stomach poison in dust form, DDT was 69 to 74 times as toxic to white-fringed beetle adults as sodium fluoaluminate.

Further tests were conducted to compare dusts containing various percentages of DDT when applied so as to give the same dosage of DDT regardless of the dilution. This dosage was 0.23 pound of DDT per acre on peanut foliage and 0.31 pound on chrysanthemum. The results are given in table 2.

These tests indicate that, when DDT dusts are used as a stomach poison, the quantity of DDT applied per acre is the important factor affecting mortality, and not the percentage of DDT contained in the dust.

Table 1.—Effectiveness of DDT as a stomach poison against the white-fringed beetle when applied as a dust to foliage at fixed dosages of dust. Insectary tests, 2 replications on each foliage

Concentration of DDT	Tests on peanut foliage		Tests on chrysanthemum foliage	
	Dosage of DDT	Net mortality	Dosage of DDT	Net mortality
Percent	Lb. per acre	Percent	Lb. per acre	Percent
0.25	0.03	1	0.04	0
.5	.06	4	.08	13
1.0	.12	36	.16	53
1.5	.17	50	.23	86
2.0	.23	83	.31	89
2.5	.29	73	.39	94
Check (cryolite dust) ^{1/}	—	39	—	55

^{1/} 76.8 percent Na₃AlF₆.

Table 2.—Effectiveness of DDT as a stomach poison against the white-fringed beetle when applied as a dust to foliage at fixed dosages of DDT. Insectary tests, 2 replications on each foliage.

Concentration of DDT	Tests on peanut foliage		Tests on chrysanthemum foliage	
	Dosage of mixture	Net mortality	Dosage of mixture	Net mortality
Percent	Lb. per acre	Percent	Lb. per acre	Percent
0.25	93.0	65	123.9	96
.5	46.0	83	61.9	97
1.0	23.0	77	31.0	93
1.5	15.5	87	20.6	99
2.0	11.6	83	15.5	96
2.5	9.3	82	12.4	94
Check (cryolite dust) ^{1/}	11.6	50	15.5	42

^{1/} 76.8 percent Na₃AlF₆.

Sprays.--Sprays containing different quantities of DDT and 0.1 pound of a wetting agent per 100 gallons of water were applied outside the insectary with a hand sprayer to peanut and chrysanthemum foliage held in an upright position in wide-mouthed bottles. The spray was applied until it dripped from the foliage. When it was dry, beetles were confined on the treated foliage in the manner described for dusts. A spray containing 8 pounds of synthetic cryolite (85.4 percent sodium fluoaluminate) and 0.1 pound of a wetting agent per 100 gallons of water was used as a check. The results are given in table 3.

Table 3.--Effectiveness of DDT as a stomach poison against the white-fringed beetle when applied as a spray to foliage at different concentrations. Insectary tests, 2 replications on each foliage

Concentration of DDT	Net mortality on--	
	Peanut foliage	Chrysanthemum foliage
<u>Lb. per 100 gal.</u>	<u>Percent</u>	<u>Percent</u>
1/64	1	4
1/32	11	15
1/16	65	27
1/8	92	91
1/4	92	93
1/2	97	95
Check (cryolite) ^{1/} 8	93	89

^{1/} 85.4 percent Na₃AlF₆.

The sprays were about equally effective on peanut or chrysanthemum foliage. The sprays containing 1/8 pound or more of DDT per 100 gallons gave a net mortality in excess of 91 percent, and 1/8 pound of DDT gave the same mortality as 8 pounds of cryolite.

Effectiveness of DDT as a Contact Poison

Dusts applied to the beetles.--Dusts containing different percentages of DDT in pyrophyllite were also tested in the insectary as contact poisons. Adult beetles were placed in wooden-frame cages, 12 inches square and 1 inch high, covered on the top and bottom with 16-mesh screen wire. These flat cages were placed in a settling chamber, 1/4 inch above the bottom surface. After the dust had been injected and allowed to settle for 3 minutes, the beetles were immediately transferred to untreated foliage in clean test cages, and the mortality was recorded.

The results of one series of tests in which the rate of application was equivalent to 11.6 pounds of dust per acre are shown in table 4. Only the 5-percent dust gave any appreciable mortality. Treatments with cryolite and pyrophyllite were used as checks.

Table 4.—Effectiveness of DDT as a contact poison against the white-fringed beetle when applied as a dust to the beetles at a fixed dosage of dust. Insectary tests, 2 replications

Concentration of DDT	Dosage of DDT	Net mortality
<u>Percent</u>	<u>Lb. per acre</u>	<u>Percent</u>
0.25	0.03	2
.5	.06	2
1.0	.12	1
1.5	.17	3
2.0	.23	9
2.5	.29	7
5.0	.58	46
Checks:		
Cryolite dust ^{1/}	—	2
Pyrophyllite	—	0

^{1/} 76.8 percent Na_3AlF_6 .

Dusts containing 2.5 and 5 percent of DDT were also applied at different dosages in order to vary the quantity of DDT applied per acre. The results, which are given in table 5, show that, within the limits used, the mortality increased as the quantity of DDT per acre was increased. Treatments of 0.47 pound or more of DDT per acre showed more than 51 percent net mortality. The heaviest treatment, 0.93 pound of DDT per acre, gave 90 percent net mortality.

Further tests were conducted to compare dusts containing different percentages of DDT when applied so as to give the same dosage of DDT. This dosage was 0.31 pound per acre. There was considerable variation in the results with the different concentrations. The dusts containing 1.5 and 2 percent of DDT were the most effective, and both of them gave approximately 50 percent net mortality. The detailed results are given in table 6.

Table 5.--Effectiveness of DDT as a contact poison against the white-fringed beetle when applied as a dust to the beetles at different dosages of DDT and dust. Insectary tests, 3 replications

Concentration of DDT	Dosage of--		Net mortality
	Mixture	DDT	
<u>Percent</u>	<u>Lb. per acre</u>		<u>Percent</u>
2.5	9.3	0.23	13
	12.4	.31	25
	15.5	.39	36
	18.6	.47	52
5.0	12.4	.62	73
	15.5	.78	88
	18.6	.93	90
Check (cryolite dust) ^{1/}	15.5	—	0

^{1/} 88.9 percent Na₃AlF₆.

Table 6.--Effectiveness of DDT dusts as a contact poison against the white-fringed beetle when applied as a dust to the beetles at a fixed dosage of DDT. Insectary tests, 2 replications

Concentration of DDT	Dosage of mixture	Net mortality
<u>Percent</u>	<u>Lb. per acre</u>	<u>Percent</u>
0.25	123.9	37
.5	61.9	42
1.0	31.0	30
1.5	20.6	51
2.0	15.5	50
2.5	12.4	43
5.0	6.2	22
Checks:		
Cryolite dust ^{1/}	15.5	0
Pyrophyllite	23.2	0

^{1/} 76.8 percent Na₃AlF₆.

Dusts applied on the soil.—Dusts containing different percentages of DDT were tested by applying them directly on the soil surface. The soil was placed in 5-inch azalea flower pots, in each of which a wide-mouthed bottle was embedded, and exposed in the settling chamber for 3 minutes to predetermined dosages of the dusts. Clean foliage was then placed in the bottles. Newly collected beetles were introduced into screen cages and allowed to crawl on the wire before the cages were placed over the treated pots. This procedure avoided placing the adults directly in contact with the treated soil surface. The quantity of foliage used in these tests was approximately twice that used in other tests. The foliage touched the side of the cage at several points, permitting the adults to reach it without crawling on the soil. Under the conditions of this test most of the beetles moved from the foliage to the soil to oviposit or rest within 4 hours. Under field conditions adults are on the surface of the soil more hours during each day than on vegetation.

Dusts containing 2.5 and 5 percent of DDT were applied at different dosages, as in the tests where the applications were made directly to the beetles. The results, given in table 7, show that the lighter dosages gave greater mortality when applied to the soil than when applied directly to the beetles (table 5). Since mortality continued to occur for a longer period, the tests were continued for 3 additional days, or a total of 7 days. The two heaviest dosages gave slightly greater mortality at the end of 96 hours when applied to the beetles, but not at the end of 168 hours.

Table 7.—Effectiveness of DDT as a contact poison against the white-fringed beetle when applied as a dust to the soil surface at different dosages of DDT and dust. Insectary tests, 3 replications

Concentration of DDT	Dosage of—		Net mortality after—	
	Mixture	DDT	96 hours	168 hours
<u>Percent</u>	<u>Lb. per acre</u>		<u>Percent</u>	<u>Percent</u>
2.5	9.3	0.23	19	29
	12.4	.31	48	56
	15.5	.39	60	68
	18.6	.47	54	69
	12.4	.62	74	85
5.0	15.5	.78	72	88
	18.6	.93	84	94
	15.5	—	2	5
Check (cryolite dust) ^{1/}				

^{1/} 88.9 percent Na₃AlF₆.

Sprays applied on the beetles.---Sprays containing different quantities of DDT and 0.1 pound of a wetting agent per 100 gallons of water were tested by applying the sprays directly to the beetles. The beetles were held in wooden-frame cages exactly like those used in the dust tests. The sprays were applied with a small hand sprayer until they dripped from the beetles. After the beetles had been allowed to dry, they were placed in clean cages and provided with untreated foliage for food. The results are given in table 8.

Table 8.--Effectiveness of DDT as a contact poison against the white-fringed beetle when applied as a spray to the beetles at different concentrations. Insectary tests, 2 replications

Concentration of DDT		Concentration of DDT	
Net mortality		Net mortality	
Lb. per 100 gal.	Percent	Lb. per 100 gal.	Percent
1/64	17	1/2	93
1/32	20	Checks:	
1/16	47	Cryolite $\frac{1}{8}$	45
1/8	64	Water	1
1/4	84		

$\frac{1}{85.4}$ percent Na_3AlF_6 .

Sprays applied on cages.---Two sprays were tested to study the mortality caused by contact with treated surfaces. The sprays contained 4 pounds of DDT and 0.6 pound of a wetting agent per 100 gallons of water, and 20 pints of fish oil was used in one of the sprays. The inner surfaces of the cages were sprayed until dripping. After the spray had dried, newly collected adults were placed in the cages for different periods of time and then transferred to untreated foliage in clean cages. The mortality records were made at 24-hour intervals for 96 hours, but since practically all the beetles affected died within 48 hours, the mortality was thereafter recorded at the end of 48 hours.

A few tests were begun within 24 hours after the cages had been treated, a second series was started after 2 to 7 days and before the treated cages were exposed outdoors to weathering, and a third series after 13 to 22 days and the cages had been exposed outdoors for 6 days, during which time 5.6 inches of rain fell.

The results are shown in table 9. In tests started within 24 hours after treatment, the two sprays were about equally effective when adults were confined in the treated cages for 1/2, 1, and 16 hours. In the second series the beetles confined for 1/4, 1/2, and 1 hour were much less affected by the spray containing fish oil than by the spray without fish oil, but both sprays were equally effective after 16 hours. The fish oil had dried and hardened at the time of this exposure. In tests conducted after the cages had been exposed outdoors, both sprays failed to kill beetles confined for 1 hour, but after 16 hours the spray containing fish oil was the more effective.

Table 9.--Effectiveness of DDT as a contact poison against the white-fringed beetle when applied as a spray, with and without fish oil, to the surface of cages

Time after treatment when tests were begun	Length of exposure	Tests	Net mortality	
			Without fish oil	With fish oil
<u>Days</u>	<u>Hours</u>	<u>Number</u>	<u>Percent</u>	<u>Percent</u>
<u>Before exposure to outside weathering</u>				
1	1/2	1	100	94
	1	1	96	98
	16	1	100	100
2-7	1/4	4	63	4
	1/2	3	89	11
	1	2	94	24
	16	1	98	98
<u>After exposure to outside weathering</u>				
13-22	1	1	0	0
	16	3	20	58

Toxicity of Plants Grown in DDT

In December 1943 DDT was thoroughly mixed with soil at the rates of 0.416, 1.04, 2.08, 4.17, and 10.41 grams per cubic foot, which is equivalent to incorporating 10, 25, 50, 100, and 250 pounds of DDT with the upper 3 inches of an acre of soil. In 1944 peanut plants were grown in this soil. Approximately 50 adult beetles were fed for 22 days on the foliage from each treated plot. In no case was the foliage toxic to the beetles.

FIELD-CAGE TESTS

Insecticide Applied on Foliage

To determine how long DDT would remain effective against the white-fringed beetle under field conditions, 5 tests were made in which dusts and sprays were applied on peanut and chrysanthemum plants, 3 tests on potted plants and 2 on plants growing in the field. Either 3 or 4 field cages 24 by 24 by 30 inches were utilized for each treatment, and 25 to 35 beetles were exposed in each cage. The dusts contained either 2.5 or 1.5 percent of DDT in pyrophyllite, and were applied at the rates of 0.34 to 0.38 pound of DDT per acre. Two sprays were used, a concentrated spray applied with a paint sprayer and a dilute spray applied with an ordinary pressure sprayer. The dilute spray contained 0.2 pound of DDT, 2 pints of fish oil, and 0.1 pound of a wetting agent in 100 gallons of water. The concentrated spray contained 4 pounds of DDT, 20 pints of fish oil, 1.14 pounds of a wetting agent, and water to make 100 gallons. The quantity of DDT applied per acre was not determined for the sprays, but it is known to have been greater than for the dusts. The dilute spray was applied until it dripped from the foliage, and the concentrated spray by enveloping the plant in a light, fine fog.

In the tests on potted plants, after the treatments the pots were plunged in the soil outdoors, where the plants were exposed to weathering for different periods and then placed in field cages into which adult beetles, newly collected from the field, were introduced. In the tests on field-grown peanut plants, the plants were covered with cages immediately after treatment. Beetles were released immediately in some of these cages and at specified intervals thereafter in others. The mortality was determined 96 hours later.

The net mortalities and rainfall for the individual tests are given in tables 10 and 11. The dusts remained effective for a shorter period than the sprays. In the mortality tests begun immediately after treatment, the average net mortalities were 77, 96, and 94 percent, respectively, for the dust, the concentrated spray, and the dilute spray. After 5 days' exposure and an average rainfall of 3.12 inches the dust was only 39 percent as effective as initially, while the concentrated spray retained 93 percent and the dilute spray 64 percent of its initial killing power. After 10 days of exposure and an average rainfall of 5.07 inches, the dust gave 6 percent, the dilute spray 26 percent, and the concentrated spray 67 percent net mortality. In tests begun 15 days after treatment, and after an average rainfall of 7.95 inches, the dilute spray gave 13 percent and the concentrated spray 56 percent net mortality.

Table 10.--Duration of effectiveness of DDT against the white-fringed beetle when applied in different forms to potted plants under field conditions

Date of application	Interval between treatment and introduction of beetles	Rainfall		Net mortality after treatment with DDT in--		
		From treatment to introduction of beetles	During test period	Dust	Concentrated spray	Dilute spray
	<u>Days</u>	<u>Inches</u>	<u>Inches</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>
<u>Applied to peanut plants</u>						
July 21	0	0	Trace	100	97	97
	5	Trace	2.19	75	85	68
	10	2.19	2.77	22	40	14
	20	9.50	5.66	--	4	-
<u>Applied to chrysanthemum plants</u>						
July 26	0	0	2.19	80	95	94
	5	2.19	2.77	10	89	39
	10	7.45	1.01	1	50	1
	15	9.50	5.66	-	30	-
August 9	0	0	6.70	66	89	99
	5	6.70	0	0	93	82
	10	6.79	0.12	-	86	47
	15	6.91	0.81	-	62	23

Table 11.--Duration of effectiveness of DDT against the white-fringed beetle when applied in different forms to peanut plants under field conditions

Date of application	Interval between treatment and introduction of beetles	Rainfall		Net mortality after treatment with DDT in--		
		From treatment to introduction of beetles	During test period	Dust	Concentrated spray	Dilute spray
	<u>Days</u>	<u>Inches</u>	<u>Inches</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>
July 21	0	0	Trace	99	100	83
	5	Trace	2.19	71	83	25
	10	2.19	2.77	8	58	5
	18	8.42	2.75	-	34	-
	23	15.16	0	-	20	-
August 8	0	0	2.75	39	99	95
	5	6.74	0	1	97	87
	10	6.74	0.19	-	99	61
	15	6.95	0.66	-	98	28
	20	7.61	0.26	-	55	7
	25	8.09	0	-	40	-

Insecticide Applied in Soil

In July 1944 beetles were introduced into outside rearing chambers 15 inches in diameter by 30 inches deep, in some of which DDT had been mixed into the upper 3 inches of soil a month previously at rates of 25, 50, and 100 pounds per acre. Upon examination in August the mortality was much higher in the treated than in the untreated chambers. Accordingly, a series of tests was set up to study the mortality of beetles caused by DDT when mixed in the soil.

On August 21 field cages 24 by 24 by 30 inches were placed over soil treated with DDT in the upper 3 inches at rates of 5, 10, 50, and 100 pounds per acre. In these tests potted chrysanthemum plants grown in untreated soil were placed in the cages as food for the beetles. Two cages were used for each treatment, and 25 to 35 beetles were exposed in each cage. Tests were started in these cages on August 22, August 30, and September 11. The first test was continued for 7 days, and the other two tests for 12 days. The average net mortality for the three tests was 31 percent for the 50-pound and 61 percent for the 100-pound dosage, and for the two lower dosages approximately the same as in the untreated checks.

EFFECT OF DDT ON PLANT FOLIAGE

During 1944 field plots of cotton, peanuts, and corn intercropped with velvetbeans were treated with a number of applications of DDT. The DDT was applied in three ways--as a 2.5 percent dust in pyrophyllite, as a dilute spray, and as a concentrated spray. The sprays were of the same composition as those used in the field-cage tests. During the summer each plot received three or more applications at the rate of approximately one-third pound of DDT per acre-application. No foliage injury to these crops was observed.

SUMMARY

Insectary tests were conducted at Florala, Ala., in 1944 to determine the effectiveness of DDT against the adults of one species of white-fringed beetles (Pantomorus leucoloma (Boh.)). DDT dusts and sprays were effective both as stomach and contact poisons.

When used as a stomach poison DDT in dust form was 69 to 74 times as toxic as sodium fluoaluminate, and a spray containing 1/8 pound of DDT per 100 gallons of water was about as effective as a spray containing 8 pounds of synthetic cryolite (85.4 percent sodium fluoaluminate). These tests indicate that, when used as a stomach poison, the quantity of DDT applied per acre is the important factor affecting mortality and not the percentage of DDT contained in the dust.

As a contact poison DDT in dust form was effective when applied directly to the beetles or on the surface of the soil. Dilute sprays containing 1/8 pound or more of DDT per 100 gallons applied directly to beetles produced net mortalities in excess of 60 percent. Adults can accumulate a lethal dose of DDT from contact with surfaces treated with sprays or dusts. The use of fish oil as an adhesive in a DDT spray increased the period adults must remain in contact with a treated surface to accumulate a lethal dose when the treated surfaces were not exposed to weathering. Fish oil, when used in a spray, increased the adhesion of DDT on surfaces exposed to outside weathering.

The foliage of peanut plants grown in soil containing DDT was not toxic to the beetles.

In field-cage tests DDT was applied as a dust, a dilute spray, and a concentrated spray to study the duration of effectiveness of these methods of application under different weather conditions. The concentrated spray remained effective longest, and the dilute spray was effective longer than the dust. Applications of 50 and 100 pounds of DDT per acre in the upper 3 inches of soil gave appreciable mortality of beetles caged on the treated soil.

No foliage injury was observed on cotton, peanuts, corn, and velvetbeans in field plots that received repeated applications of DDT as a 2.5 percent dust, a dilute spray, and a concentrated spray.