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Insecticide Residues in Certain Texas Soils

TEXAS AGRICULTURAL EXPERIMENT STATION
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IN COOPERATION WITH THE U. S. DEPARTMENT OF AGRICULTURE

Summary

Two field experiments were conducted during 1955-59 to determine the effects of large amounts of insecticides applied to soil on the germination, growth and yield of several crops. One test was on Miller soil type near College Station and the other was on Denton soil type near Denton, Texas.

A randomized block-plot design was used with four replications for each insecticide treatment and a check in each experiment. Insecticides applied to the soil plots at Denton were toxaphene, DDT, parathion, dieldrin and benzene hexachloride (BHC). Initial applications included two dosage-levels, the equivalent of the calculated amounts that would be applied for the control of insects attacking cotton over a period of 10 and 20 years, respectively. The above insecticides, except parathion, were included in the initial treatment of soil plots at College Station. However, the dosage was the equivalent of the amount of insecticides applied normally during 5 years for the control of cotton insects. No additional insecticide treatments were made to plants or soil in the Denton plots. Subsequent annual applications of each insecticide were applied to each successive crop grown on plots at College Station. No reduction occurred in the yield of cotton grown on plots at College Station that were treated with recommended yearly dosages of these insecticides. Grain sorghum was grown 1 year and alfalfa 2 years following cotton. Insecticide residues in the soil had no apparent effect on the yield of either of these crops.

The percentage of germination of cottonseed on BHC-treated plots at Denton during the first year, following initial application of the insecticide was significantly lower than that on untreated soil plots. The oat plant stand and yield of oat forage and grain obtained during 1956 from soil plots treated with DDT, toxaphene and BHC were significantly less than that from untreated plots. Germination, growth and yield of cotton on each of the insecticide treated plots at Denton during 1958, 4 years after the initial applications of insecticides, were not affected.

Based on chemical and biological analyses of soil from the experiments at Denton and College Station less than 20 percent of the insecticide residues was recovered 4 years after the initial applications of the insecticides.

Traces of DDT, toxaphene, dieldrin and BHC residues were found in oil and meal extracted from cottonseed produced on plots treated with each of the above insecticides. However, considering that the cotton was grown in soil that contained much higher concentrations of insecticides than result from normal spraying and dusting, there is little, if any, chance of translocation of dangerous amounts of any of the insecticides from the soil to the cottonseed.

Losses of insecticides during each succeeding year following the initial applications were greater than the amount of each insecticide applied annually for control of insects. Therefore, it appears to be unlikely that the insecticide residues will build up to injurious concentrations.

Contents

INSECTICIDE RESIDUES IN CERTAIN TEXAS SOILS

*Neal M. Randolph, Robert D. Chisholm, Louis Koblitsky and J. C. Gaines**

Organic insecticides are used widely in Texas for the control of field crop pests. The insecticides may be deposited in the soil from the spraying or dusting of crops, or they may be applied directly to the soil for control of soil-infesting pests. As a consequence, insecticide residues in amounts sufficient to affect seed germination or the yield of some crops may accumulate in the soil. Also, it is possible that insecticides may be translocated in hazardous amounts from the soil to the crop. The continued use of such insecticides during recent years intensifies the need for information on the rates of accumulation or the degrees of persistence of insecticide residues in soil, the effects of the residues on specific crops and hazards to man or animals caused by possible translocation of insecticides from soils to crops.

Growers and commercial processors of many agricultural crops are interested in the potential residue deposits that result from repeated applications of insecticides. Agricultural workers are concerned with the stability of many of the pesticides and the effects of these chemicals on phytotoxicity, germination, growth and yields of different crops.

Studies were planned based on early indications that chlorinated hydrocarbons were relatively persistent in certain types of soil and that some crops were more sensitive than others to the residues of this group of insecticides. It also was assumed that some farmers were applying pesticides at rates that might result in accumulations great enough to reduce stands and yields of some crops.

Tests were conducted at College Station and Denton in order to solve some of these problems, especially how to deal with the cropping systems in the South.

Experimental Methods

Tests Plots

LOCATION AND SOIL TYPES

Two field experiments were laid out in the fall of 1954 in widely separated areas. The test near College Station in South-Central Texas was located on Miller soils near the Brazos River. These soils have a chocolate-red calcareous surface soil merging below the surface with chocolate-red subsoils. The topsoil is less calcareous than most Miller clays and tends to crust over when it dries. The subsoil is predominantly clay and is very gummy. It is productive and well suited for growing general farm crops.

The other test was conducted at Substation No. 6, Denton, in North Texas on Denton soils. The land generally is rolling. The soil is brown, is underlain by brown to yellowish brown subsoils and is granular, crumbly and readily penetrated by water. It is suitable for growing cotton, small grains and grain sorghum; and fair yields are obtained when moisture conditions are favorable. The soil is not strongly resistant to drouth.

PLOT DESIGNS

A randomized block-plot arrangement was used with four replicates for each treatment and the check in each experiment. Plot size in the tests at College Station was 66 ⅔ feet by 72 feet. Each plot at Denton was 53 ⅓ feet by 60 feet but was further divided into subplots 26 ⅔ by 60 feet and each insecticide was applied at two-dosage levels.

Soil

TREATMENTS

Wettable powder formulations of insecticides were used for the initial treatment of the soil at College Station and Denton in March 1955. The pesticides used at College Station were as follows: 8⅓ percent dieldrin; 50 percent DDT; 40 percent toxaphene; and 12 percent gamma benzene hexachloride (48 percent BHC). Twenty-five percent parathion wettable powder, in addition to these four formulated insecticides, was applied to the soil in the experiment located near Denton. All materials were applied with a lawn fertilizer machine. The soil was turned to a depth of approximately 6 inches soon after treatment.

The initial application of each insecticide at College Station was equivalent to the total amount generally used by cotton growers during a 5-year period. It was estimated that farmers make an average of eight applications to cotton annually;

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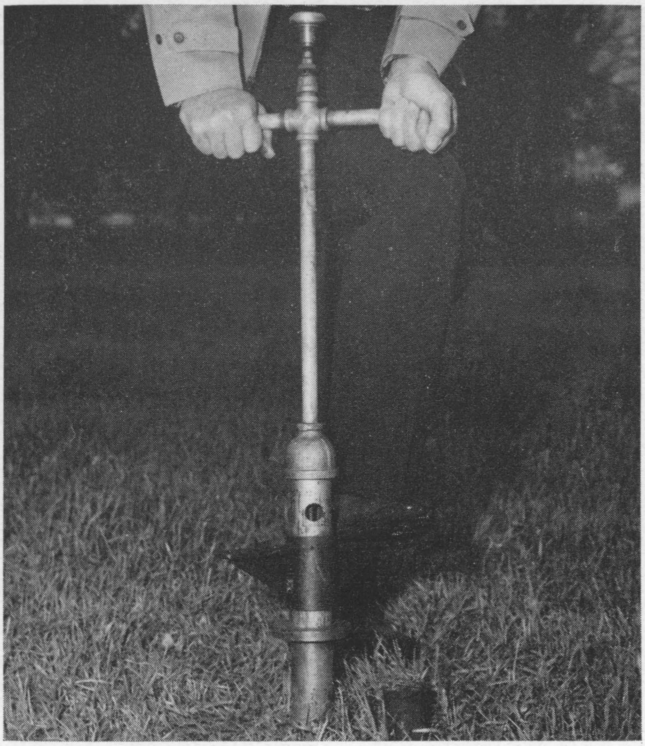

Figure 1. Soil sampler.

each of the first three treatments usually is an early season application of which the dosage is only one-half of each treatment made during the remainder of the growing season. Consequently, the total number of treatments annually would be 6½, and a total of 32½ applications would be made during a 5-year period.

The initial application of each insecticide at Denton was based on 10 and 20-year supplies. The number of applications made annually at this location was estimated at 4½ (3 early season applications at one-half dosage, and 3 late season treatments). Plots were randomized and each treatment was replicated four times but arranged in split-plots; one received a 10-year supply and the other a 20-year supply of insecticides. Therefore, total amounts equivalent to 45 and 90 applications of insecticides, respectively, were included in the initial treatments.

Each crop grown on the plots at College Station during the 4-year period received foliar applications, the amount equivalent to a 1-year supply (6½ treatments) of the respective insecticides included in the test, Table 1. The sprays, prepared from emulsifiable concentrates, were applied with a self-propelled spray machine equipped with hollow-cone nozzles and delivered at the rate of 6 gallons per acre at a pressure of 60 pounds per square inch.

SOIL SAMPLING

A soil sampler designed by V. A. Johnson and W. L. Caskey (5) but modified with a footpiece for forcing the tool into the soil was used to remove the soil samples, Figures 1 and 2. This soil sampler provides a means of taking cores of a known cross-sectional area and depth. It was constructed to take samples 2 inches in diameter. Thirty-six soil samples were removed from each plot at College Station at each of two levels, 0 to 3 inches and 3 to 6 inches. Cores from the lower

TABLE 1. INSECTICIDE RESIDUES DETERMINED AT INDICATED DEPTHS OF FIELD PLOTS BY CHEMICAL AND BIOLOGICAL ANALYSES, COLLEGE STATION, 1955-58

Year	Applications[1]		Cumulative applications determined					
			0-3 inches		3-6 inches		0-6 inches	
	Foliar, pounds per acre	Cumulative, pounds per acre	Chemical percent	Biological percent	Chemical percent	Biological percent	Chemical percent	Biological percent
				DDT				
1955	8.6	55.9	35.8		4.8		40.6	
1956	10.6	66.5	9.5	7.4	14.0	9.9	23.5	17.3
1957	9.2	75.7	8.2	7.1	7.8	4.9	16.0	12.0
1958	9.3	85.0	6.9	5.3	8.0	2.6	14.9	7.9
				Toxaphene				
1955	13.9	110.8	36.3		3.7		40.0	
1956	14.3	125.1	7.8	6.2	11.6	10.7	19.4	16.8
1957	16.4	141.5	6.2	6.8	8.0	5.5	14.2	12.3
1958	18.9	160.4	6.9	2.6	9.0	2.4	16.0	4.9
				Dieldrin				
1955	1.6	9.7	22.7		8.2		30.9	
1956	1.5	11.2	14.3	11.8	6.2	10.3	20.5	22.1
1957	1.8	13.0	5.4	10.0	20.8	12.3	26.2	22.3
1958	1.6	14.6	3.4	3.9	9.6	3.5	13.0	7.4
				BHC				
1955	5.6	61.0	10.5		2.3		12.8	
1956	5.5	66.5	2.7	2.0	2.0	1.6	4.7	3.6
1957	9.1	75.6	0.4	0.9	2.1	1.4	2.5	2.3
1958	6.7	82.3	.73	1.9	.73	1.2	1.5	3.1

[1]Includes 5-year supply preplanting application.
[2]Bioassay based on percent gamma BHC.

level, 3 to 6 inches, were taken by inserting the tool into the holes left after removal of the cores from the upper 0 to 3 inch layer, Figure 3. Special care was taken to keep the surface soil from falling into the holes.

Sampling areas were distributed within the plot in such a manner that one 0 to 3 inch and one 3 to 6 inch core were taken from each 100 square feet. Buffer zones of approximately 10 feet were allowed at the ends and sides of each plot. The same technique of soil sampling was used at Denton. However, since the plots were smaller, only 24 samples were taken at each level. Samples were taken from treated and check plots at Denton and College Station before and after the initial applications of the insecticides. Further samplings followed annually after subsequent crops were harvested.

Field soil samples were placed in metal containers and weighed immediately, but the time interval before screening varied. The soil cores were reweighed and were then grated by use of a special machine, Figures 4 and 5. The soil core fitted into a metal tube, mounted at a right angle to a rotating drum fabricated from food graters. Perforations on the drum cut the soil into small particles. The samples were weighed again after screening. A composite that consisted of four 1-quart subsamples was taken from the soil collected from each plot at College Station for chemical and biological analyses. Subsamples of the Denton soil were made from a composite sample taken from each group of four replicated plots. Grated soil samples were stored in plastic bags inside quart-sized cardboard containers, Figure 6.

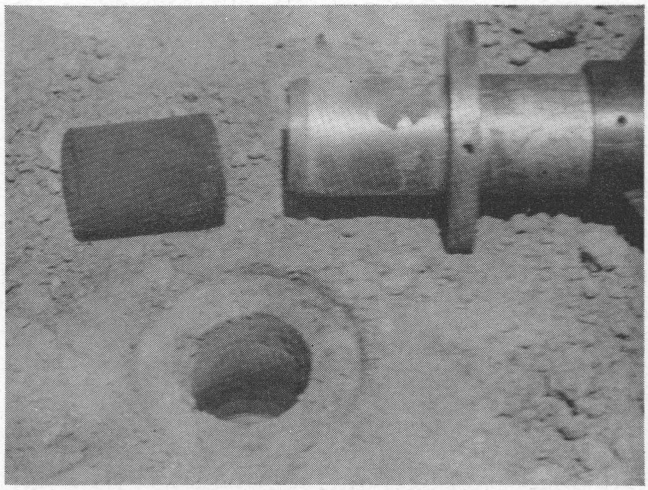

Figure 2. Three-inch soil core removed from soil sampler.

TABLE 2. SUMMARY OF CHEMICAL AND BIOLOGICAL ANALYSES OF SOIL SAMPLES, DENTON 1955-58

Insecticide[1] and year applied			Pounds per acre applied	Percent of total insecticide recovered					
				0-3 inches		3-6 inches		Total	
				Chemical[2]	Biological[3]	Chemical[2]	Biological[3]	Chemical[2]	Biological[3]
DDT	1955	L.	69.4						
		H.	140.0	11.6				25.9	
	1956	L.							
		H.							
	1957	L.		21.7	14.1	16.3	12.4	37.9	26.5
		H.		19.4	11.3	11.5	9.0	30.9	27.4
	1958	L.		14.1		8.9		23.0	
		H.		10.2		8.6		18.8	
Toxaphene	1955	L.	131.8						
		H.	264.7	6.8		9.7		16.5	
	1956	L.							
		H.							
	1957	L.		3.4	5.5	16.8	8.6	20.3	14.1
		H.		17.9	6.0	8.6	1.8	26.5	7.8
	1958	L.		13.0		9.0		21.9	
		H.		9.5		7.0		16.5	
Dieldrin	1955	L.	14.2						
		H.	23.1	18.2		24.7		42.9	
	1956	L.							
		H.							
	1957	L.		26.4	7.7	11.3	12.0	38.0	19.7
		H.		20.8	8.2	13.9	10.0	34.6	18.2
	1958	L.		16.9		6.3		23.2	
		H.		10.0		7.8		17.8	
BHC	1955	L.	69.2						
		H.	139.7	12.3		11.2		23.5	
	1956	L.							
		H.							
	1957	L.		2.9	2.2	0.43	3.0	3.3	5.2
		H.		2.5	2.9	1.2	1.3	3.7	4.2
	1958	L.		.87		.43		1.3	
		H.		.72		.93		1.7	

[1]"L" refers to low dosage (10-year supply of insecticide).
"H" refers to high dosage (20-year supply of insecticide).
[2]Chemical analyses were not made of soil in low dosage plots in 1955.
[3]Biological analyses were not made during 1955, 1956 and 1958.

Figure 3. Soil sampler replaced in hole made when 0-to-3-inch soil core was removed before taking a core from the 3-to-6-inch section.

CHEMICAL ANALYSES

The soil samples were analyzed for organic chlorine by the method (with modifications) described by Koblitsky and Chisholm (6). A moisture determination was made on each sample. The results after correction for similar determinations on check samples were calculated in terms of pounds of insecticide per 3-inch acre of air-dried soil.

BIOASSAY

Two bioassay tests were conducted by W. G. Bodenstein (2) and were made on cottonseed oil extracted from cotton grown on dieldrin-treated plots at College Station and BHC-treated plots at Denton during 1955. House flies were used as test animals. Other biological analyses were conducted at College Station. Insecticidal residues were removed from the soil samples by stripping with a 4:1 mixture of Skellysolve B and acetone, Figures 7 and 8. Soil extract in acetones were used to prepare test suspensions. A bioassay method (3) employing the use of second instar larvae of the yellow fever mosquito, *Aedes aegypti (L.)*, was followed to determine the insecticidal residues in the soil samples. This technique is based on the negative phototactic response of the larvae, Figures 9 and 10 (1).

Eight suspensions (containing insecticidal residues, four standards and four unknowns) were tested simultaneously, using groups of mosquito larvae taken from the same rearing batch.

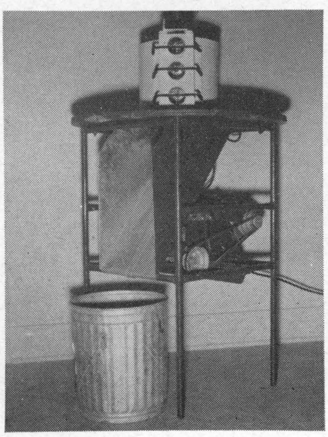

Figure 4. Soil grater used in the preparation of soil samples to extract insecticide residues.

TEMPERATURE MEASUREMENTS

A multipoint recording potentiometer, Figure 11, with storage batteries as sources of power, was used to measure temperatures at the following locations in the College Station grain sorghum plots during the growing season of 1956:

1. Three inches down in the soil.
2. At the soil surface within the row of the crop grown.
3. At the soil surface between the rows.
4. Atmospheric, 5 feet above the soil.

The machine was operated from 10 a. m. to 4 p. m. 3 days each week in June and July, and during the first, third and fifth weeks in August, and the second week in September 1956. The temperature at each point was recorded at 2 minute intervals but only those temperatures registered on the hour were used to obtain weekly averages of minimum, mean and maximum temperatures. Temperatures at point 3 were not recorded during the first 3 weeks in June because of the difficulty encountered in the adjustment of the machine.

Cropping System

CROPS PLANTED

Crops normally planted in the Denton and College Station areas were grown at these locations, Tables 3 and 4.

PEST CONTROL

Pest control practices were followed throughout the experiment at College Station. Weekly records of insect infestation were made during the growing season of each crop to determine the need for the application of additional insecticides. In several cases, the annual supply of chlorinated hydrocarbon insecticides included in the tests did not control certain insects but in other instances the application of an insecticide resulted in good control of some insects. Also, crops grown in the check plots had no initial or annual applications of insecticides. Consequently insecticides of the phosphate group and/or calcium arsenate were applied to the crops in order to maintain comparable insect control; otherwise the yield records would have been of no value in the overall experiment. Calcium arsenate and organic phosphates were used in order to avoid interference with chemical analyses.

PESTICIDE RESIDUES IN CROPS

A summary of the procedure for subsampling for chemical analyses is given below:

Green vegetation: Three replicates, 1000 grams each of a composite, cut into small pieces from each crop and representing each treatment

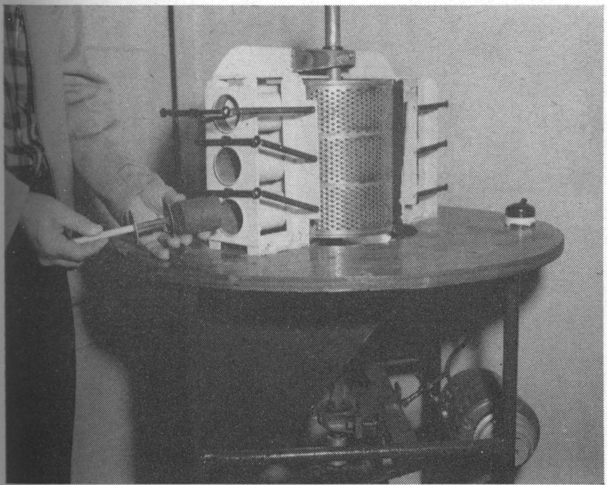

Figure 5. A soil core being placed in cylinder section in front of plunger before grating sample.

Figure 6. Plastic lined quart-sized container used for storage and shipment of soil samples.

and check. The forage was air-dried, packed in plastic bags and shipped to the chemical laboratory.

Mature vegetation: Three replicates, 200 grams of a composite, chopped into small pieces, representing each crop, treatment and check. Samples were packed in plastic bags for shipment.

Ground grain: 1000 grams of ground grain representing each crop, treatment and check, and also packed in plastic bags for shipment.

Cottonseed: Duplicate samples of approximately 500 grams of oil and 1000 grams of meal were prepared from composite cottonseed samples of both treated and check plots at College Station. Similar amounts of oil and meal were removed from composite cottonseed samples of only the BHC-treated plot at Denton. (Cottonseed oil and meal were extracted, refined and processed by the Texas Engineering Experiment Station.)

CHEMICAL ANALYSES

Products and methods used to determine insecticide residues by chemical analyses are as follows:

Cottonseed oil: The cottonseed oil samples were analyzed for organic chlorine by a combustion procedure followed by amperometric titration with standard silver nitrate (4). The results were calculated after correction for similar determinations on check samples in terms of parts of insecticide per million parts of oil.

Cottonseed meal: The cottonseed meal samples were extracted with hexane and the insecticide residues in concentrated extracts were determined by the same method used for cottonseed oil.

Grain sorghum: The samples of grain sorghum forage and crushed grain were extracted with Skellysolve B. The extract was concentrated and the total organic chlorine was determined

TABLE 3. CROP RESPONSES TO THE INITIAL APPLICATION OF A 5-YEAR SUPPLY OF INSECTICIDES TO SOIL PLUS NORMAL FOLIAR TREATMENTS MADE ANNUALLY TO EACH CROP AT COLLEGE STATION, 1955-58

Treatment	Cotton plants per acre, 1955	Average height cotton plant inches, 1955	Seed cotton yield pounds per acre, 1955	Average grain sorghum plants per acre, 1956	Grain sorghum forage yield including grain per acre, 1956	Sorghum grain yield in pounds per acre, 1956	Average alfalfa plants per acre, 1957	Average alfalfa plants per acre, 1958
DDT	9,451.3	5.29	1189.2	79,759.0	7,739.8	1901.9	947,430	1,646,568
Toxaphene	9,657.5	5.56	1184.5	74,722.8	7,740.0	1840.5	860,310	1,711,908
Dieldrin	9,121.0	5.30	1138.5	77,172.8	8,322.5	1899.2	830,363	1,637,856
BHC	8,154.3	5.39	1087.7	64,378.8[1]	7,146.8	1848.7	939,262	1,668,348
Check	8,599.8	5.42	1005.7	85,203.3	7,279.5	1778.1	850,152	1,372,140
LSD-5 percent level	N.S.	N.S.	N.S.	13,104.9	N.S.	N.S.	N.S.	N.S.

[1]Plants per acre in BHC-treated plots were significantly lower than in check plots.

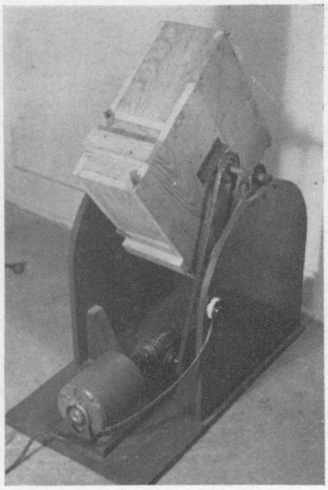

Figure 7. Stripping machine.

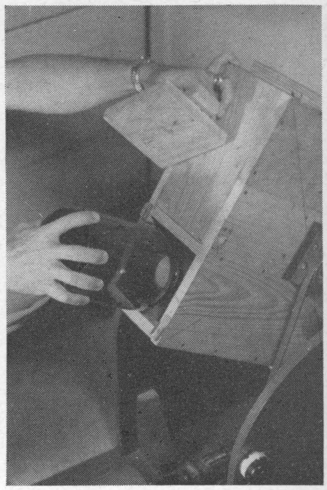

Figure 8. Tumbling portion of stripping machine used for extraction of insecticide residues from soil samples.

by combustion and amperometric titration with standard silver nitrate. The insecticide residues of the treated samples were calculated to a green weight basis after correction for similar determinations on check samples.

Oats: The oats were analyzed in the same manner as sorghum grain and forage.

Results

Chemical Analyses

The results of analyses of soil samples taken during the 4-year period from the College Station and Denton plots following the harvest of each crop are presented in Tables 1 and 2.

Bioassay

Results obtained from a bioassay test of cottonseed oil extracted from cotton grown on BHC-treated plots at Denton was 2.88 p.p.m. BHC. The same test applied to the oil extracts from cottonseed produced on dieldrin-treated plots at College Station resulted in 2.0 p.p.m. dieldrin. Biological analyses of soil samples taken from the experiment at College Station during 1956, 1957, and 1958, and from the experiment at Denton during 1957 are included in Tables 1 and 2. Bioassays were run on soil samples from Denton in 1958 but were of no value because of the interference of an arsenical which resulted from the application of a desiccant for defoliation of the cotton.

TABLE 4. CROP RESPONSES TO LOW (10-YEAR SUPPLY) AND HIGH (20-YEAR SUPPLY) DOSAGES OF INSECTICIDES APPLIED TO SOIL, DENTON, 1955-56

Treatment		Cotton plants per acre 1955[1]	Seed cotton pounds per acre 1955[2]	Oat plants per acre 1956[3]	Oat forage pounds per acre 1956[4]	Oat grain pounds per acre 1956[5]	Cotton plants per acre 1958[6]
DDT	Low	28,764	384.5	60,330	970.0	507.7	43,317
	High	27,283	367.7	63,707	910.2	527.5	49,038
Toxaphene	Low	29,610	394.2	54,558	934.8	497.8	40,456
	High	27,865	409.2	45,629	908.2	499.1	49,855
Parathion	Low	30,509	405.2	68,389	1077.5	525.3	43,562
	High	28,129	397.7	73,399	975.6	462.1	46,177
Dieldrin	Low	31,196	397.7	78,517	1062.6	528.1	54,350
	High	30,617	403.2	71,765	934.8	487.9	49,855
BHC	Low	17,554	463.5	58,806	943.8	513.9	39,880
	High	6,821	431.5	39,204	699.3	433.1	43,970
Check		29,398	422.3	72,800	1060.9	491.8	43,235
L.S.D.	5% Level	6,166	N.S.	4,443	112.7	64.6	N.S.
L.S.D.	1% Level	8,527		6,145	155.8	89.3	

[1]Cotton plant stands in BHC-treated plots were significantly lower than those of check plots and also plots treated with any of the other insecticides.
[2]No significant difference in seed cotton yield.
[3]Oat plant stands in DDT, toxaphene and BHC-treated plots were significantly lower than stands in check plots as well as in dieldrin and parathion-treated plots. No significant difference occurred between stands in high and low dosages.
[4]Forage yields from toxaphene and BHC-treated plots were significantly lower than those produced on check plots. Yields obtained from high-dosage BHC-plots were significantly lower than those produced on parathion, DDT, toxaphene or dieldrin-treated plots. Difference in production of plots receiving high dosage of BHC was significantly lower than that on plots treated with the low dosage.
[5]A significant difference in oat grain yields was obtained between plots receiving high and low dosages of BHC, but no significant difference occurred between low-dosage treatments with different insecticides.
[6]No significant difference in cotton plants.

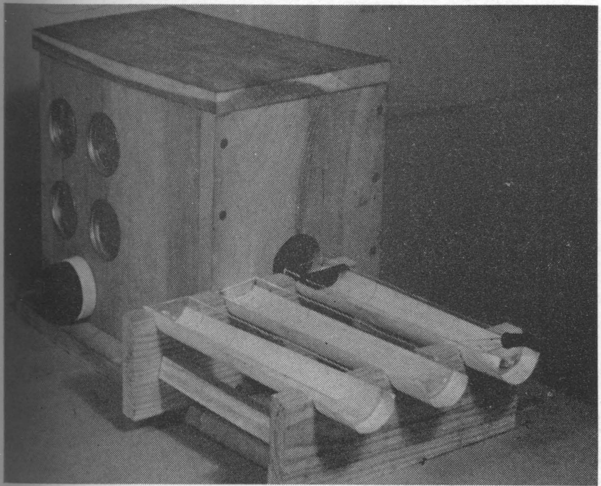

Figure 9. Photomigration chamber and glass troughs used to test the reaction of mosquito larvae, in the presence of intense lights, to extracts of insecticide residues.

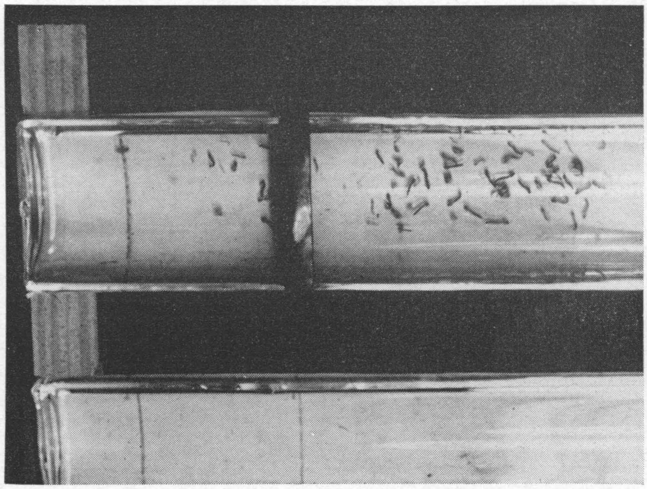

Figure 10. Mosquito larvae, left of trough partition, were affected by insecticide residue and unable to swim away from the intense light of the photomigration chamber.

Temperature Measurements

The average minimum, mean and maximum temperatures at four points obtained weekly during June and July, biweekly during August and for the first week in August 1956, are given in Table 5. The average mean temperature of the soil 3 inches below the surface was 97° F. (daily maximum 123° F.). On the surface in rows of grain sorghum it was 103° F. (daily maximum 137° F.). Between the rows it was 121° F. (daily maximum 149° F.). The average mean air temperature 5 feet above the soil surface was 97° F. (daily maximum 113° F.).

Crop Responses

Results of crop responses to the initial application of the insecticides to the soil and of the insecticides applied during the growing season are given in Tables 3 and 4.

Pesticide Residues in Crops

The results of analyses of cottonseed oil and meal from the crops grown during 1955 on treated plots are presented in Table 6.

The results of analyses of grain sorghum forage and grain from crops grown on treated plots in College Station during 1956 are presented in Table 7.

Discussion

Insecticide Residues

Starting in the spring of 1955, amounts of DDT, toxaphene, dieldrin and BHC equivalent to the respective dosage applied to cotton for insect control during 5 years were worked into the soil plots at College Station. During successive summers, crops grown on the plots received amounts equivalent to a 1-year supply of insecticides. When the plots were sampled in the fall of 1955, it was found in all cases that the amounts of the several insecticides lost during the first growing season that followed initial applications were greater than the amounts applied for insect control during the first summer. It also was found that losses of insecticides during each succeeding year were greater than the amounts applied annually. The sums of the amounts of residues in the soil at the start of the respective crop

TABLE 5. AVERAGE MINIMUM, MEAN AND MAXIMUM TEMPERATURES (FAHRENHEIT) AT FOUR POINTS DURING WEEKLY PERIODS, COLLEGE STATION, 1956

Month	Week	3 inches below soil surface			Soil surface in row			Soil surface between rows			5 feet above soil surface		
		Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum
June	1	80	83	89	91	94	96				91	93	94
	2	79	84	88	80	87	93				81	88	95
	3	79	84	91	82	85	90				83	90	97
	4	83	90	94	93	97	101	112	129	146	92	97	100
July	1	87	98	106	98	108	114	100	122	135	94	101	107
	2	85	95	102	97	104	109	99	113	125	92	99	104
	3	91	106	114	100	112	119	107	125	135	94	102	108
	4	93	110	118	104	115	123	103	126	140	94	102	108
August	1	100	108	116	106	118	132	105	115	125	92	98	105
	3	100	112	119	99	113	123	108	127	140	94	104	110
	5	88	95	98	91	102	109	92	108	115	88	98	102
September	2	87	98	105	95	103	107	102	122	137	87	96	103

TABLE 6. CHEMICAL ANALYSES OF INSECTICIDES IN COTTONSEED OIL AND MEAL FROM SEED HARVESTED FROM COTTON GROWN IN PLOTS TREATED BEFORE AND DURING CROP SEASON WITH INSECTICIDES, 1955

Insecticide	Average of insecticide			Residue determined		
	Pre-planting pounds per acre	Foliage pounds per acre	Total pounds per acre	Oil p.p.m.	Meal p.p.m.	Cotton-seed p.p.m.[1]
	— — — — —		College Station	— — — — —		
DDT	47.3	8.6	55.9	.16	.01	.02
Toxaphene	96.9	13.9	110.8	.40	.13	.10
Dieldrin	8.1	1.6	9.7	1.45	.00	.20
BHC	55.4	5.6	61.0	.10	.09	.05
	— — — — — —		Denton	— — — — — —		
BHC	139.7	[2]	139.7	2.85	.47	.52

[1]Calculated on basis that cottonseed contains 50 percent of meals.
[2]No insecticide applied to foliage.

seasons plus the amounts of insecticides applied during the season are used as bases to compute the percentages of the total residues lost during each year. These are shown in Table 8.

Since in all cases the losses of the several insecticides were far greater than the amounts applied for insect control, the evidence points strongly to an eventual very low level of residue accumulation caused by normal spraying or dusting programs. It is suggested that the very high soil temperatures, especially near the soil surface, may have contributed to the rapid decrease in residue concentration. The average annual losses of DDT, toxaphene and dieldrin were approximately 50 percent. For BHC, it was 83.3 percent, Table 8. The results proved that accumulations of these insecticides following normal applications are not likely to occur in amounts sufficient to cause damaging effects to the growth of these crops.

Cottonseed

The insecticide residues found in cottonseed oil and meal were below presently established tolerances for DDT, toxaphene and BHC in other crops, Table 6. However, the dieldrin residue in cottonseed oil was above that established for any crop. No residue of dieldrin was found in cottonseed meal. Using data supplied by the Texas Engineering Experiment Station and also the fact that cottonseed contains an average of 50 percent of meats, the residues of DDT, toxaphene and BHC were calculated to be less than those permitted in any raw agricultural crop. Dieldrin was less than that tolerated for many crops and more than that allowed for others. No tolerances have been authorized for dieldrin residues in cottonseed, cottonseed oil, or cottonseed meal. Considering that the cotton was grown in soil containing much higher concentrations of the several insecticide residues than may be expected from normal spraying or dusting, it is indicated that there is little chance of translocation of dangerous amounts of BHC, DDT, dieldrin and/or toxaphene mixed with soil to cottonseed.

TABLE 7. INSECTICIDE RESIDUES DETERMINED IN GRAIN SORGHUM FORAGE AND GRAIN GROWN ON COLLEGE STATION PLOTS, 1956[1]

Insecticide	Average insecticide applications				Average residue	
	Pre-planting pounds per acre	1955 pounds per acre	1956 pounds per acre	Total pounds per acre	Forage p.p.m.	Grain p.p.m.
DDT	47.3	8.6	10.6	66.5	1.0[2]	0
Toxaphene	96.9	13.9	14.3	125.1	0	0
Dieldrin	8.1	1.6	1.5	11.2	0	0
BHC	55.4	1.6	5.5	66.5	0	0

[1]Analyses by R. H. Carter, Beltsville, Maryland.
[2]A definite confirmatory colorimetric test for DDT was obtained on one of these samples.

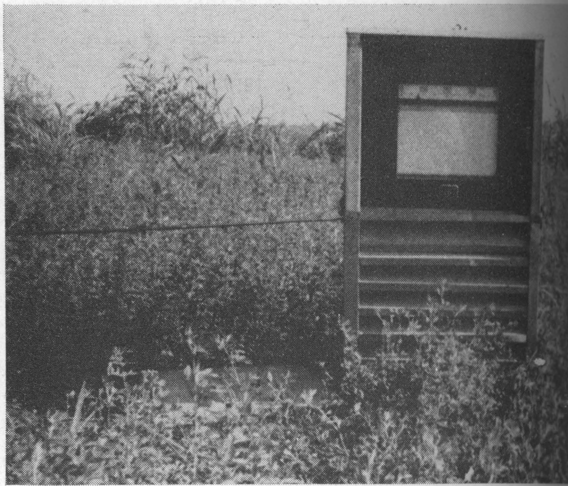

Figure 11. Multipoint recording potentiometer.

Grain Sorghum

With the exception of one sample of grain sorghum forage, none of the insecticides were translocated to the forage or to the crushed grain, Table 7. The single exception was in one DDT plot. It is possible that this residue may have resulted from contamination of the crop during application of the DDT to the soil. This residue was below that of any presently established tolerance for DDT.

Oats

None of the samples of crushed oats prepared from oats produced on the plots near Denton contained any insecticide residue.

Crop Responses

The number of grain sorghum plants per acre grown on the College Station plots having received BHC was significantly lower than in the

TABLE 8. LOSSES[1] OF INSECTICIDES FROM FIELD PLOTS AT COLLEGE STATION, BASED ON CHEMICAL ANALYSES

Insecticide	1955	1956	1957	1958	Average
			Percent		
DDT	59.3	53.2	51.2	40.7	51.0
Toxaphene	60.1	58.5	50.6	34.1	50.8
Dieldrin	69.1	48.9	17.1	62.0	49.3
BHC	87.2	75.9	84.5	85.7	83.3

[1]Based on the sums of the amounts of residues in the soil at the start of each crop season plus amounts of insecticides applied during respective seasons.

check plots. There was no significant difference between the number of cotton or alfalfa plants per acre between treatments or between the treatments and the check. Alfalfa plant stand records were taken approximately 2 months following plantings. No significant difference in grain sorghum yields of forage and grain or grain only was found between the treatments or between the treatments and the check.

The reduction of oat forage yield per acre on Denton plots which were treated with the high dosage of BHC and dieldrin was much greater than that harvested from plots treated with low dosages. The forage yields from toxaphene and BHC-treated plots were significantly lower than those on the check plots. Yield from high-dosage BHC-treated plots also was significantly lower than each of the yields obtained from parathion, DDT, toxaphene and dieldrin-treated plots. Differences in oat grain yields among plots that received high and low dosages of insecticides between treatments or between treatments and check were not significant. There was very little rainfall during the growing seasons of 1955 and 1956, and it is probable that the sparse stand of cotton and oats responded to the drouth and ultimately produced yields equivalent to those of plots with dense plant stands, Figures 12 and 13. Cotton plant stands in BHC-treated plots in 1955 were significantly lower than stands of the check

Figure 12. Center: Poor stand of cotton on BHC-treated soil, Denton, Texas, 1955.

Figure 13. Foreground: Poor stand of oats on toxaphene-treated soil, Denton, 1956.

plots and plots treated with other insecticides. DDT, toxaphene and BHC-treated plots contained significantly lower numbers of oat plants than were present in the check plots and in the dieldrin and parathion-treated plots. Records of oat plant stands were not obtained during 1957 because of the presence of irregular volunteer oat plants in all of the plots. No significant difference occurred between cotton plants on treated and untreated plots during 1958.

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Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

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