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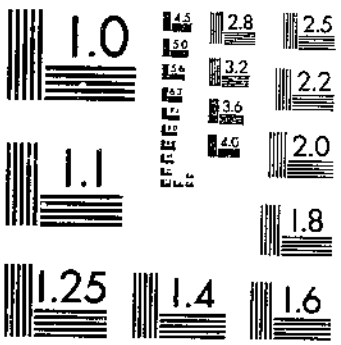

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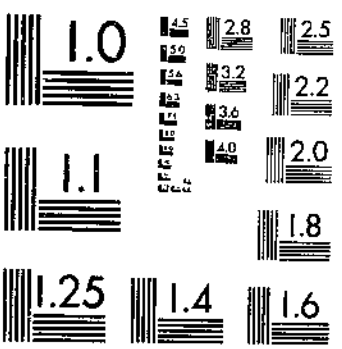

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Persistence of BHC, DDT, and Toxaphene in Soil and the Tolerances of Certain Crops to Their Residues

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INTRODUCTION

The accumulation of insecticides in the soil may have an important effect on the insects and other organisms present. It may also reduce or increase the yield of certain crops and affect the flavor or quality of others.

In 1947 an investigation to determine the tolerance of crops to BHC, DDT, and toxaphene in soils was undertaken at Florence, S. C., by the Bureau of Entomology and Plant Quarantine; the Bureau of Plant Industry, Soils, and Agricultural Engineering; and the South Carolina Pee Dee Agricultural Experiment Station. These insecticides are widely used for the control of cotton insects, and in South Carolina and a few other States some of the land that is used for cotton is rotated with tobacco. The experimental procedures and the results of the plant-tolerance experiments obtained during the first 3 years have been published (Allen *et al.* *1*)[2]. However, residue analyses were not made until 1951, after the investigation had been underway for 4 years. The results of these analyses and some of the relationships between the amount of insecticide and the growth and yield of crops grown in these soils are presented in this bulletin.

[1] The following persons assisted in this cooperative project: J. D. Early, C. E. Jernigan, and T. W. Graham of the Agricultural Research Service and Z. T. Ford, of the South Carolina Pee Dee Agricultural Experiment Station.

[2] Italic numbers refer to literature cited, p. 18.

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REVIEW OF LITERATURE

Insecticides may accumulate in the soil as a result of spraying and dusting the parts of the plants that are above ground (Chisholm *et al., 2;* Cooper *et al., 3*) or from applications to the soil for the control of soil-infesting insects (Fleming *et al., 7, 8, 9;* Howe, *14;* Muma *et al., 18*). Such accumulations may affect the micro-organisms (Wilson and Choudhri, *22;* Smith and Wenzel, *19*). Some of the insecticides may be translocated in the plants that grow in the soil and thereby prove toxic to certain insects that feed on these plants (Howe, *14;* Huffaker, *15;* and Starnes, *20*). They may also be toxic to certain plants that grow in the soil (Foster, *10;* Fleming, *8;* Grayson and Poos, *12;* Morrison *et al., 17;* Stitt and Evanson, *21;* Crowell *et al., 4;* Young and Gill, *23;* and Dorman *et al., 6*). On the other hand, some of them may actually increase plant growth and production (Allen *et al., 1;* Crowell *et al., 4;* Gould and Hamstead, *11;* and Dorman *et al., 5*).

In studying the persistence of chlorinated hydrocarbon insecticides in turf treated for control of the Japanese beetle (*Popillia japonica* Newm.) Fleming and coworkers (*9*) found that almost half the decrease in DDT residues occurred during the fourth and fifth years after application. After 6 years about 30 percent of the DDT remained, and the rate of decrease was then so slow that it was expected that some would be present for several additional years. Foster (*10*), in studying persistence of DDT 4 years after it had been applied to Chester loam, Sassafras sandy loam, Evesboro sand, and New Jersey muck soils, found that the DDT content was slightly less than the amount applied.

Fleming and coworkers (*9*) reported that 54 percent of the toxaphene applied to turf had been lost after 40 months. Foster (*10*), on the basis of work by Smith and Wenzel (*19*), considered toxaphene to be unstable in the soil and discontinued some of his exploratory tests with this material after 3 to 4 months.

EXPERIMENTAL PROCEDURE

This study was conducted in Marlboro fine sandy loam on the farm of the Pee Dee Experiment Station, in a typical 3-year crop rotation. This rotation included tobacco followed by a winter cover crop of oats mixed with Austrian winter peas the first year, cowpeas followed by rye as a winter cover crop the next year, and cotton followed by rye the third year. Each experiment was started with a different crop and was continued with the 3-year rotation. In the spring of 1947 the plots in experiment A were planted to tobacco, those in experiment B to cotton, and those in experiment C to cowpeas. In the summer of 1951 the respective plantings were cowpeas, tobacco, and cotton, as in 1948.

In each experiment 0.02-acre plots were arranged in 4 randomized blocks. The treatments were identical for all three experiments. The insecticides were worked into the top 6 inches of the soil.

In the selection of soil treatments consideration was given to insecticides and dosages that were being used widely against various insects. BHC, DDT, and toxaphene were applied annually at about the maximum dosages required for insect control. These were in-

cluded in treatments 2, 3, 6, 8, and 10. In addition, single applications of BHC and DDT were made at not more than five times the normal annual dosage in an attempt to obtain in as short a time as possible quantities of residues that might eventually accumulate in practice. These were included in treatments 4, 5, 7, and 9.

INSECTICIDE RESIDUES IN THE SOIL

Samples of soil from the various plots were taken in the spring and fall of 1951 and analyzed for insecticide residues. Before the fall sampling, studies were made to determine the vertical distribution of the residues in the soil. The method of analysis of Koblitsky and Chisholm (*16*) for total organic chlorine was used, and the results were converted to equivalent amounts of the insecticide.

Spring Samples

The soil samples taken in the spring were obtained in March just before the winter cover crops were harvested. Twelve borings were made in each of 120 field plots. Each boring consisted of a core of soil 2 inches in diameter and 6 inches deep. The borings collected from a given plot were combined as a composite sample, screened once through a 16-mesh screen, thoroughly mixed, weighed, and spread out on a large tarpaulin. For analysis, a pint container was filled with soil taken from different parts of the sample. These soil samples were analyzed and the quantities of insecticides calculated after subtraction of the readings for the check plots. The results are shown in table 1.

The insecticide equivalents of the organic chlorine determined in the soils from check plots were within the range to be expected in untreated soils. Analyses of soils for BHC by the Hornstein (*13*) colorimetric method demonstrated that any movement of this insecticide from plot to plot due to cultivation, heavy rains, or other causes was of no consequence.

The percentage of DDT that remained in the soil was higher when DDT had been applied annually than when a single dosage had been in the soil for 4 years. However, the residues were at least 37 percent of the total quantities applied.

The percentage of BHC was below 15 percent whether it was applied as a single heavy dosage or as lighter dosages every year.

The percentage of toxaphene was about the same as that of DDT.

Vertical Distribution of Residues

To determine the vertical distribution of the insecticides in the soil, 5 borings were made in September in an untreated check plot and in all 4 replicates of treatment 5 of experiment B (table 1). Each boring consisted of a core of soil 2 inches in diameter and 10 inches deep. All cores were separated into 2-inch layers. A composite sample was prepared for each layer in each plot and analyzed as described previously. The results are given in table 2.

TABLE 1.—*Residues, found in the spring of 1951, of insecticides applied to the soil beginning in 1947*

Treatment No.	Insecticide applied per acre		Residue per acre in top 6 inches of soil				
	Applied in 1947	Total	Experiment A	Experiment B	Experiment C	Average	
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*
	DDT:						
2	10	40	18. 5	18. 6	18. 8	18. 6	46. 5
3	20	80	40. 1	40. 0	40. 6	40. 2	50. 3
4	40	40	14. 8	14. 3	15. 4	14. 8	37. 0
5	100	100	36. 6	37. 8	49. 8	41. 4	41. 4
	BHC (technical):						
6	16. 7	66. 8	4. 5	6. 5	6. 4	5. 8	8. 7
7	83. 3	83. 3	4. 6	13. 5	13. 3	10. 5	12. 6
10	Toxaphene 20	80	41. 1	42. 5	48. 8	44. 1	55. 1

Of the total DDT residues, 87 percent was found in the top 6 inches. The amounts found below this depth were in most cases below the limit of accuracy of the analytical method.

TABLE 2.—*Vertical distribution of DDT in plots treated with 100 pounds of DDT in 1947 and sampled in September 1951*

Depth of sample (inches)	DDT residue per acre				
	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
0–2	10. 5	9. 0	8. 5	8. 5	9. 1
2–4	14. 5	9. 5	9. 5	10. 5	11. 0
4–6	7. 5	9. 5	7. 0	8. 5	8. 1
6–8	1. 5	5. 0	4. 5	2. 0	3. 2
8–10	. 5	2. 5	1. 5	. 0	1. 1
Total	34. 5	35. 5	31. 0	29. 5	32. 5

Fall Samples

The fall samples were taken during October and the first part of November. The summer crops had been harvested, and the soil had been disked thoroughly, harrowed, and packed lightly. Fifty borings were made in each of the plots. These borings were 2 inches in diameter and 10 inches deep, but the samples were collected and analyzed in the same manner as in March. The results of these analyses are given in table 3.

Comparison of Spring and Fall Samples

Since the soil samples obtained in the fall were taken to a different depth than those obtained in the spring, the data are not entirely comparable. Calculations made on the basis of comparable depths show that when the insecticides were applied annually the residues were greater in the fall, but the reverse was true when only one application was made. These results demonstrate that the insecticides accumulated in the soil with repeated applications.

For each treatment a study was made of the variability of the residues in spring and fall samplings. The standard deviation was greater in the fall than in the spring samples in 5 of the 7 treatments. The coefficient of variability was also greater in four of these treatments. Therefore, the increase from 12 borings per plot in the spring to 50 borings in the fall did not appreciably increase the accuracy of the work.

TABLE 3.—*Residues found, in the fall of 1951, of insecticides applied to the soil beginning in 1947*

Treatment No.	Insecticide applied per acre		Residue per acre in top 10 inches of soil				
	Applied in 1947	Total	Cowpeas	Tobacco	Cotton	Average	
	DDT: *Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*
2	10	50	24. 0	26. 3	28. 0	26. 1	52. 2
3	20	100	56. 8	51. 5	53. 3	53. 9	53. 9
4	40	40	14. 8	17. 8	17. 4	16. 7	41. 8
5	100	100	31. 6	31. 8	39. 4	34. 3	34. 3
	BHC (technical):						
6	16.7	83. 5	6. 1	4. 5	10. 5	7. 0	8. 4
7	83.3	83. 3	2. 0	4. 3	8. 9	5. 1	6. 1
10	Toxaphene 20	100	45. 1	48. 8	61. 8	51. 9	51. 9

RELATION BETWEEN RESIDUES AND DEPTH OF TOPSOIL

It was realized that the depth of topsoil in the test plots might have an important bearing on the quantity of an insecticide retained in the soil. Therefore, the depth of the topsoil was determined by taking 12 borings in each field plot and averaging them for the plot value.

There was considerable variation in the depth of topsoil among plots in a given experiment, as well as among the three experiments. The range was 8.6 to 14 inches in experiment A, 9.9 to 11.7 inches in experiment B, and 11.5 to 13.8 inches in experiment C. However, the depth of topsoil had no significant effect upon the persistence of the insecticides.

RELATION BETWEEN RESIDUES AND CROP PRODUCTION IN 1951–52

Tobacco

The DDT residue obtained from the tobacco plots receiving the different treatments (experiment B) was about the same as that obtained in the other experiments. The plants appeared to grow in a normal manner, and there was no evidence of phytotoxicity during the growing season.

The yield of salable tobacco was good except from the plots receiving the two heaviest dosages of DDT, treatments 3 and 5 (table 4). One of the replicates of treatment 3 was flooded during a downpour on July 1, and the yield considerably reduced; however, treatment 5 was not affected in this manner. The plots receiving these two treatments produced a higher percentage of trashy tobacco than any of the other treated plots. In these plots the residues were greater than from the other DDT treatments. However, almost as much DDT remained from treatment 2 as from 5, although the yield of trashy tobacco was much less. In 1949 and 1950 the yield was also lowest for plots receiving treatments 3 and 5, further indicating that the heavy dosages caused some damage to the tobacco.

The yield from all BHC treatments was considerably higher than from any of the other treatments or from the untreated check. All BHC treatments except 9 also gave some reduction in severity of attack by the root knot nematode, and this was at least partly responsible for the increase in yields. However, cigarettes made from tobacco grown on these plots in 1950 and 1951 had an undesirable flavor and aroma, according to tests made by specialists in the tobacco industry.

The yield from the plots that had received annual dosages of 20 pounds of toxaphene per acre was about equal to that from the untreated check. The recovery of toxaphene from this treatment was high, averaging 48.8 pounds. Although the yield did not appear to be reduced, the quality of the tobacco was affected. Cigarettes made from the tobacco that grew on the toxaphene-treated plots in 1950 and 1951 were inferior in flavor and aroma to those from the check plots but superior to those from the BHC plots.

TABLE 4.—*Tolerance of tobacco (experiment B) to insecticide residues in the soil, 1951*

Treatment No.	Insecticides applied per acre		Residue per acre in top 10 inches	Root knot disease index	Salable tobacco per acre	Income per acre	Trash lug tobacco
	Applied in 1947	Total					
	Pounds	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Dollars*	*Percent*
1	Untreated check			41.4	1,118	622	13.5
	DDT:						
2	10	50	26.3	35.2	1,191	655	13.2
3	20	100	51.5	33.7	841	448	18.5
4	40	40	17.8	39.9	1,155	638	13.5
5	100	100	31.8	44.3	1,036	565	18.0
	BHC (technical):						
6	16.7	83.5	4.5	18.2	1,431	860	10.0
7	83.3	83.3	4.3	30.6	1,275	718	11.0
8	12.5+DDT 2.5	62.5+12.5		26.8	1,388	797	10.0
9	50+DDT 10	50+10		38.7	1,295	733	13.2
10	Toxaphene 20	100	48.8	39.9	1,115	600	14.5
Difference required for significance at 5 percent level				9.3	204	130	5.2

Cotton

The insecticide residues in the cotton plots (experiment C) were a little greater than those in tobacco and cowpea plots, but it is doubtful whether this difference was a factor in the results obtained on cotton. The residues and the stand, growth, and yield of the cotton plants are given in table 5.

As soon as the plants were up to a good stand, it was apparent that there were more plants on some plots than on others. A count on May 16 showed that the numbers of plants on the plots receiving four of the treatments were significantly greater than on the untreated check plots. These 4 treatments were the 10- and 20-pound dosages of DDT repeated annually, the 100-pound dosage of DDT applied in 1947 only, and the 16.7-pound dosage of BHC repeated annually.

Plant-height measurements were made as the season advanced, but there was no evidence that any of the treatments adversely affected the cotton plants.

The boll-weevil infestation on July 27 showed no significant difference between treatments.

The yield of seed cotton was determined by picking and weighing all the cotton that was produced on each plot. The yield from plots given the 50-pound dosage of BHC plus 10 pounds of DDT was lower than for the check plots, but the difference was not significant. The 10-pound dosage of DDT and the 20-pound dosage of toxaphene produced significantly more cotton than the check, but since the yields were positively correlated with the number of plants per treatment, it is doubtful whether the treatments were responsible for the difference. A high boll-weevil infestation reduced the yields for all treatments, and made it difficult to determine the effect of the insecticides in the soil.

Cowpeas

Studies were made on the stand of cowpea plants and their growth, as well as on the yield of hay and peas in the hull. The relationship of the yields to the quantity of the insecticides that remained in the soil is shown in table 6.

The 20-pound dosage of DDT repeated annually and the 100-pound dosage applied only in 1947 reduced the stand, retarded plant growth, and reduced the yield of cowpea hay. The 20-pound dosage also reduced the yield of peas in the hull. The soil residues from these two treatments were greater than from any other DDT treatments. However, the residue from the 100-pound dosage applied only in 1947 was not much greater than that from the 10-pound dosage that had been repeated annually, and yet the 100-pound dosage caused considerably more damage to the cowpeas. The 40-pound dosage of DDT applied only in 1947 did not seem to affect the cowpeas even though an average of 14.8 pounds of DDT remained in the soil.

An increase in the yield of cowpea hay was noted where 83.3 pounds of BHC and 50 pounds of BHC plus 10 pounds of DDT were applied in 1947 only. The latter treatment also gave a good yield of peas in the hull, but it was not significantly greater than the check. Although more cowpea hay and peas in the hull were produced in the plots receiving the two BHC treatments where the least amount of residue was found in the soil, this doubtless was not responsible for the increase in the yields.

TABLE 5.—*Tolerance of cotton in 1951 (experiment C) to insecticides applied to the soil beginning in 1947*

Treatment No.	Insecticide applied per acre		Residue per acre in top 10 inches	Plants per acre	Average height of plant	Boll weevil infestation	Yield of seed cotton per acre
	Applied in 1947	Total					
	Pounds	*Pounds*	*Pounds*	*Number*	*Inches*	*Percent*	*Pounds*
1	Untreated check			4, 200	11. 4	49. 2	670
	DDT:						
2	10	50	28. 0	6, 963	12. 4	48. 7	1, 060
3	20	100	53. 3	6, 413	12. 9	49. 2	910
4	40	40	17. 4	5, 388	11. 5	49. 7	845
5	100	100	39. 4	6, 075	11. 4	49. 2	905
	BHC (technical):						
6	16.7	83. 5	10. 5	5, 888	11. 3	49. 2	835
7	83.3	83. 3	8. 9	4, 975	12. 2	50. 0	850
8	12.5+DDT 2.5	62. 5+12. 5		4, 650	12. 1	49. 7	850
9	50+DDT 10	50+10		4, 200	10. 2	48. 5	540
10	Toxaphene 20	100	61. 8	5, 275	12. 5	49. 5	965
Difference required for significance at 5-percent level				1, 488	(1)	(1)	245

[1] Not significant according to the *F* test.

TABLE 6.—*Tolerance of cowpeas in 1951 (experiment A) to insecticides applied to the soil beginning in 1947*

Treatment No.	Insecticide applied per acre		Residue per acre in top 10 inches	Average height per plant	Yield per acre	
	Applied in 1947	Total			Cowpea hay	Cowpeas in hull
	Pounds	*Pounds*	*Pounds*	*Inches*	*Pounds*	*Pounds*
1	Untreated check			6. 6	9, 992	791
	DDT:					
2	10	50	24. 0	4. 1	5, 999	852
3	20	100	56. 8	3. 5	1, 271	310
4	40	40	14. 8	5. 7	8, 449	844
5	100	100	31. 6	3. 7	4, 619	757
	BHC (technical):					
6	16. 7	83. 5	6. 1	6. 7	7, 904	719
7	83. 3	83. 3	2. 0	6. 8	11, 471	848
8	12.5+DDT 2.5	62. 5+12. 5		5. 8	6, 951	668
9	50+DDT 10	50+10		7. 0	12, 415	1, 057
10	Toxaphene 20	100	45. 1	6. 3	9, 374	764
Difference required for significance at 5-percent level				1. 2	3, 939	(1)

[1] Not significant according to the *F* test.

An explanation has not been found, but an increase in pod production in these plots was noted during the summer of 1951 (fig. 1). It seems reasonable to suppose that differences in pod production could account for some of the differences noted in the yield of peas in

FIGURE 1. Stand and growth, of cowpeas in 1951 in plots of soil receiving different treatments in 1947: *1*, Untreated; *5*, DDT; *7*, BHC; *9*, BHC plus DDT.

the hull. In general, BHC has appeared to increase the growth and yield of cowpeas every year. A search has failed to show any differences in the numbers of insects or other pests that could account for the differences in the growth and yield of the crop. The variety of cowpeas grown, Brabham, is partially resistant to nematodes, and this resistance plus the control exerted by the insecticide may

FIGURE 1. Continued.

have accounted for the difference observed; however, no proof of this deduction was obtained.

The 20-pound dosage of toxaphene repeated annually did not appear to affect the cowpeas, even though the residue amounted to 45.1 pounds per acre when samples were taken to a depth of 10 inches.

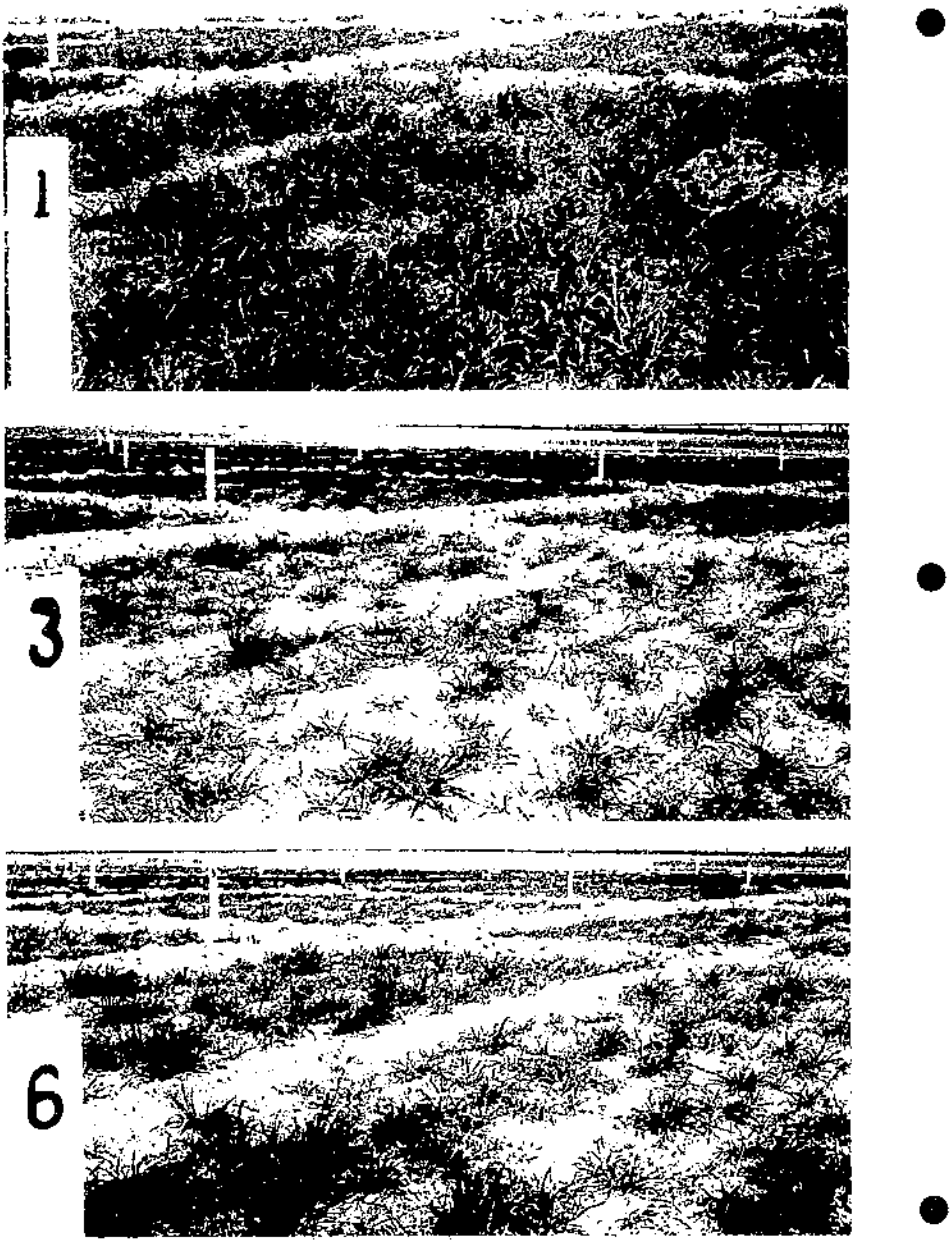

FIGURE 2.—Stand and growth of rye in experiment B in 1952 on plots receiving different soil treatments: *1*, Untreated; *3*, DDT; *6*, BHC; *7*, BHC; *9*, BHC plus DDT; *10*, toxaphene.

Winter Cover Crops

The yields of the cover crops, rye and oats and Austrian winter peas, in relation to the insecticide residues are given in table 7. The stand and growth of rye on an untreated check plot and on some of the treated plots are illustrated in figure 2.

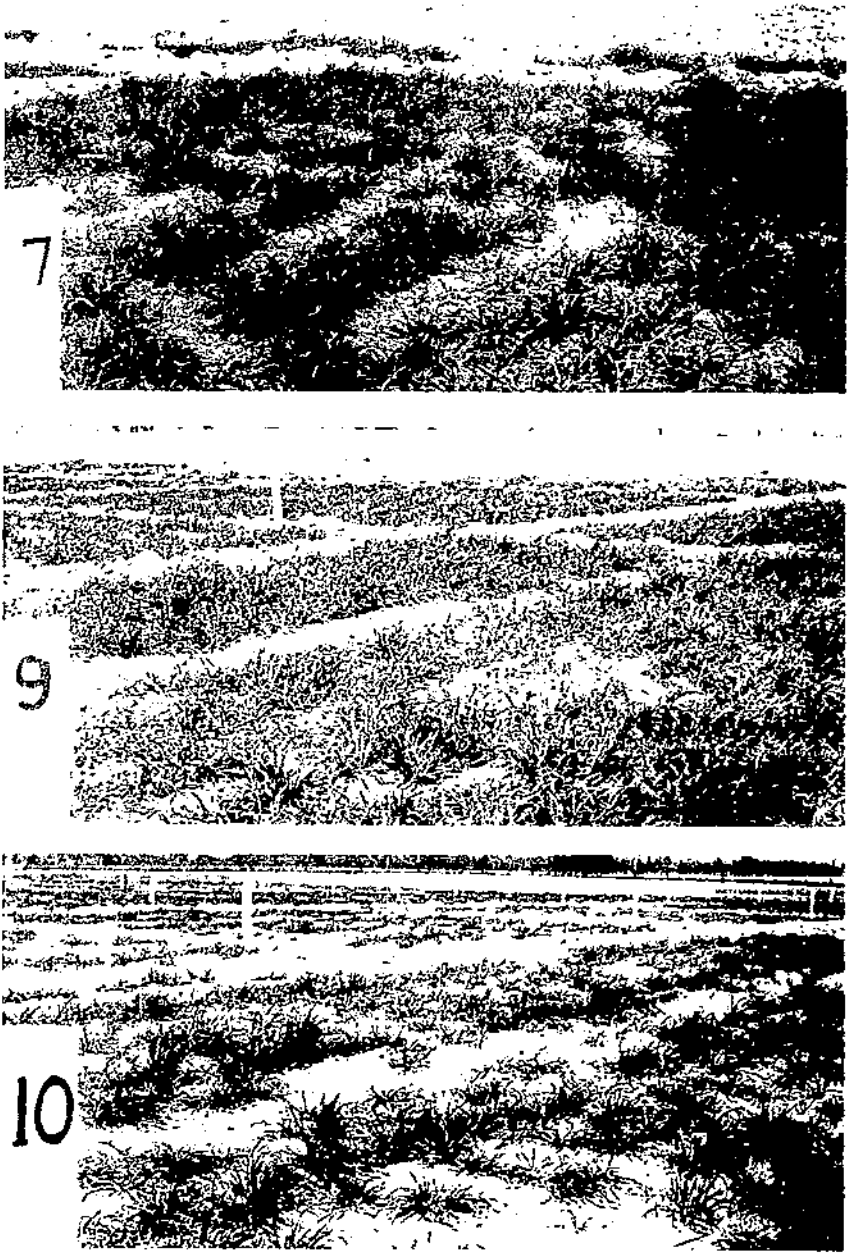

FIGURE 2. Continued.

TABLE 7.—*Tolerance of cover crops during the winter of 1951–52 to insecticides applied to the soil beginning in 1947*

Treatment No.	Insecticide applied per acre		Rye following cowpeas		Oats and peas following tobacco		Rye following cotton	
	Applied in 1947	Total	Residue per acre in top 10 inches	Yield [1]	Residue per acre in top 10 inches	Yield [1]	Residue per acre in top 10 inches	Yield [1]
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1	Untreated check			6.6		6.0		5.6
	DDT:							
2	10	50	24.0	2.6	26.3	4.8	28.0	2.9
3	20	100	56.8	1.3	51.5	4.0	53.3	2.1
4	40	40	14.8	4.7	17.8	5.2	17.4	4.7
5	100	100	31.6	2.9	31.8	4.6	39.4	3.2
	BHC (technical):							
6	16.7	83.5	6.1	3.3	4.5	4.4	10.5	4.4
7	83.3	83.3	2.0	4.2	4.3	5.3	8.9	4.2
8	12.5+DDT 2.5	62.5+12.5		2.4		4.1		3.8
9	50+DDT 10	50+10		7.0		7.1		6.2
10	Toxaphene 20	100	45.1	2.3	48.8	4.0	61.8	3.2
Difference required for significance at 5-percent level				[2]		[2]		1.8

[1] Total weight of roots and foliage on 144 square feet.
[2] Not significant according to the *F* test.

The poorest yield in all three experiments was obtained where the 20-pound dosage of DDT had been repeated annually, and more residue in the soil was obtained from this treatment than from any of the other DDT treatments. However, it should be noted that the yield for the 10-pound dosage of DDT repeated annually was also low, but that only about half as much DDT remained as from the 20-pound dosage. Residues from the 100-pound dosage applied only in 1947 were greater than from the 10-pound dosage repeated annually; but the yields for the 100-pound dosage were higher in two experiments. The DDT residues from the 40-pound dosage applied only in 1947 were heavy but, as in the past, yields for this treatment were comparatively good.

Light residues in the soil were obtained from all treatments with BHC. However, the yields from those treatments that had been repeated annually (treatments 6 and 8) were lower than from plots on which the same insecticide had been in the soil for 5 years (treatments 7 and 9). Attention is called to the fact that BHC plus DDT applied only in 1947 gave a greater yield than the untreated check in all three experiments.

Toxaphene residues were heavy and the yields for this treatment were low in all three experiments. This shows that the accumulation of toxaphene in some types of soil can be harmful to certain crops.

SUMMARY

A plant-tolerance experiment was initiated at Florence, S. C., in 1947. DDT, BHC, and toxaphene were incorporated in the top 6 inches of the soil, and studies were made to determine their effect on tobacco, cotton, and cowpeas grown in a typical 3-year rotation. DDT was applied at 10 and 20 pounds per acre each spring from 1947 to 1951, and at 40 and 100 pounds in 1947 only; BHC at 16.7 pounds each spring and at 83.3 pounds in 1947 only; BHC at 12.5 pounds with 2.5 pounds of DDT each spring and at 50 pounds with 10 pounds of DDT in 1947 only; and toxaphene at 20 pounds per acre each year. The tobacco was followed by a winter cover crop of oats and Austrian winter peas, and the cotton and cowpeas were followed by rye. Soil samples were taken from the plots at the end of the fourth year and again at the end of the fifth summer-crop season, and chemical anaylses made to determine the quantities of the insecticides that remained in the soil and their relationship to certain crop yields.

Four and a half years after single applications approximately 38 percent of the DDT and 6 percent of the BHC remained in the soil. Six months after the last of five annual applications 53 percent of DDT, 52 percent of toxaphene, and 8 percent of BHC remained. Approximately 87 percent of the DDT was found in the top 6 inches of the soil.

There appeared to be a definite relationship between the amount of DDT in the soil and the stand, growth, and yield of cowpeas, oats, and rye. In general, the greater the residue within the ranges found, the poorer were the stand and growth and the lower the yield. This was true for all treatments except the 40-pound dosage applied in 1947 only, which did not harm any of the test crops. On the other hand a 10-pound dosage repeated annually for 4 years harmed some of the test crops. The yield of salable tobacco was reduced by the two

heaviest dosages of DDT, but the lightest dosage did not cause any adverse effects. The yield of cotton did not appear to be affected by the quantity of DDT in the soil.

The BHC residues in the soil were light for all treatments. All dosages tested appeared to increase the yield of tobacco in 1951, but this increase was due, in part at least, to some reduction in the severity of attack by nematodes. Although there was an increase in the yield of tobacco, cigarettes made from the tobacco had an undersirable flavor and aroma. Cotton did not seem to be affected by BHC. The yields of cowpea hay, peas in the hull, and the winter cover crops were higher and the BHC residues in the soil were lower where this insecticide alone or in combination with DDT was applied in 1947 only.

The plots treated with a mixture of BHC and DDT in 1947 only produced more cowpea hay and peas in the hull in 1951, and all types of winter cover crops studied in 1951–52, than the checkplots. It is doubtful, however, whether the quantity of BHC that remained in the soil was responsible for the differences noted in the yields. In general, BHC increased the yield of cowpeas every year, but an explanation for this has not been found.

Toxaphene in the soil did not appear to be toxic to tobacco, cotton, or cowpeas. However, cigarettes made from the tobacco grown on the toxaphene plots were inferior in flavor and aroma to those from tobacco grown on check plots. This treatment reduced the stand and lowered the yields of oats and rye.

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