8 August 1956

To the Graduate Council:

I am submitting to you a thesis written by Elmer W. Counce entitled "Control of Weeds in Cotton with Pre-Emergence Application of Herbicides." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science with a major in Agronomy.

Laurence V Stold
Major Professor

We have read this thesis
and recommend its acceptance:

Eric Winters

R F Richards

Accepted for the Council:

C. A. Waters
Dean of the Graduate School

CONTROL OF WEEDS IN COTTON WITH PRE-EMERGENCE APPLICATION OF HERBICIDES

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

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by

Elmer W. Counce

August 1956

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ACKNOWLEDGMENT

The writer wishes to express his gratitude to: Dr. J. K. Leasure for his help in designing the study, Professor L. N. Skold for directing the study, and other members of the Agronomy Staff who have so kindly given help during the conduct of this study.

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CHAPTER I

INTRODUCTION

The following study was designed to evaluate the effectiveness of certain chemicals at various rates of application in controlling weeds in cotton and to determine if the chemicals had injurious effects on the cotton.

Research in pre-emergence chemical weed control in cotton began as recently as 1946. Since that time a great deal of work has been done in the field, and many advances have been made which promise to reduce the amount of labor and expense involved in cotton production.

CHPATER II

REVIEW OF LITERATURE

Ahlegren, Klingman, and Wolf (1)[1] mentioned the use of copper salts to control weeds in grain crops as early as 1897. Robbins, Crafts, and Raynor (21) mention that in 1908, Bolly in North Dakota completed twelve years of research on weed control. By 1933, dinitro-o-cresol was developed in France as a chemical spray material that had selective herbicidal properties (15). Sinox[2], was released by the French workers in 1938.

In 1944, widespread intrest in selective weed control developed when it was discovered that 2, 4-D was highly effective in controlling broadleaf weeds in grass crops (14).

Until 1945, weed control in row crops was accomplished almost entirely by mechanical and cultural techniques. In 1946, Anderson and Wolf (5) reported effective control of weeds when applying two and seven tenths pounds per acre of 2, 4-D acid, as a pre-emergence treatment for corn at the New Jersey Station.

Ennis (11) mentioned that Leonard, Harris, and Arle made preliminary studies in Mississippi with the use of dintro compounds as pre-emergence herbicides for cotton in 1947. These workers first suggested spraying the chemicals in a band about twelve inches wide, centered over the drill row.

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[1]Numbers in parenthesis refer to "Literature Cited".

[2]Refer to Appendix for "List of Chemicals Cited".

McMurray, Leasure, Epps, and Jones (16) conducted four preliminary experiments in Tennessee in 1949, using DNOSBP, PCP, IPC, and 2, 4-D as pre-emergence weed control treatments for cotton. DNOSBP was found to be the safest and most effective. These workers reported that cotton injury occurred when extended periods of dry weather followed treatment with DNOSBP. The injury to cotton caused by DNOSBP during dry seasonal conditions was substantiated by Albert, Powers, and Bland (3) in South Carolina.

Cantwell (7) mentions that the first research work on cotton weed control using CIPC was done in 1949, by Leonard at Mississippi State College, and that excellent results were obtained without extensive injury to the cotton. In 1953, approximately 125,000 acres were treated with CIPC and excellent field results were observed (7). Leasure (13) also found that CIPC gave week control comparable to DNOSBP without risk of cotton injury, in Tennessee. The Research Committee of the Southern Weed Conference in January 1955, unanimously agreed that CIPC was at that time the most satisfactory pre-emergence cotton herbicide (13), this recommendation was also included in the report of the Research Committee of the Southern Weed Conference for 1956.

Shaw and Lovvorn (22) stated that "Three of the most important developments in weed control in the past decade were the discovery of the herbicidal properties of 2, 4-D, the introduction of pre-emergence weed control, and the development of the technique of low gallonage application".

The introduction of substituted ureas has greatly stimulated the study of soil sterilization. Two substituted ureas, CMU -- now called Karmex W -- and Karmex DL, are highly potent and have shown excellent promise for controlling weeds in cotton (17). These organic chemicals have residual effects in the soil (22). Weed, Welch, Sutton, and Hill (25) reported that Karmex W and Karmex DL at low rates gave control of weeds for four to ten weeks.

In 1954, Rea (19) reported that twelve pounds per acre of CIPC and one and one-half pounds per acre of Karmex W liquid were the most promising pre-emergence chemical treatments studied in Texas tests. Rea also used post-emergence lateral applications of herbicides in water.

Weed, Welch, Sutton, and Hill (25), recorded excellent weed control at Raleigh, North Carolina, using one-half pound per acre of Karmex DL compound. They found that Karmex BL was safer to use than Karmex W, resulting in less reduction in cotton populations in tests at Eagle Pass, Texas, Raleigh, North Carolina, and Baton Rouge, Louisiana.

Nearly perfect control of grasses was obtained with CIPC by Albert and Anderson (2) at Clemson. They found that rates of one pound per acre of Karmex W, Karmex DL, and Karmex M, controlled broad-leaved weeds such as ragweed and morning glory better than CIPC, but were less effective than CIPC in narrow-leaved weed control using pre-emergence applications.

Foy (12) at Missouri, found that two pounds per acre of Karmex W would significantly reduce cotton yields. Foy further showed that one

pound of Karmex W per acre was the upper limit of safety and that the best rates of CIPC and DNOSBP lie between six and nine pounds per acre.

According to the Mississippi Agricultural Experiment Station, safe limits on most soils vary between one-fourth and one-half pound per acre on a twelve inch band, when using Karmex W and Karmex DL (9).

Efficient control of weeds for the first three weeks after planting was obtained in North Carolina by Upchurch (24), who found DNOSBP least effective, when comparing Karmex D, Karmex M, CIPC, and DNOSBP.

Elder, Porterfield, and Dreessen (10), reported that Karmex W gave excellent kill of weeds and grass when used at one-third pound per acre in Oklahoma. They observed some yellow discoloration on young cotton at this rate and one and one-third pounds per acre killed much of the small cotton.

Antognini and Day (6) at the Geigy Agricultural Chemicals Research Laboratory, Bayonne, New Jersey, found Geigy 444 to be a promising selective pre-emergence and non-selective post-emergence herbicide. Pre-emergence treatments as low as eight pounds per acre gave good weed control and post-emergence treatments at rates as high as twenty-four pounds per acre when the weeds were well established resulted in no injury to the cotton.

Several investigators have suggested the possible advantage of mixing CIPC and DNOSBP together. It has been demonstrated in tests that CIPC was less harmful to the germination cotton and gave more effective crabgrass control than DNOSBP. On the other hand DNOSBP was more effective in the control of certain other weeds, as pigweed. Davis

and Searcy (8) at Auburn concluded in 1955, experiments that mixtures of DNOSBP and CIPC were little, if any, better than an equal rate of DNOSBP alone. Richards of Tennessee (20) in 1955, found that mixtures of DNOSBP and CIPC had no advantage over equal rates of either herbicide alone. Porter, Thomas, and Stamper (18) at the Louisiana Experiment Station concluded that there was no evidence to indicate any synergistic effect from any combination of CIPC, DNOSBP, and Karmex DL, used in their 1954, season experiments.

Satisfactory early season weed control was obtained in 1955, at Clemson by Albert, Hall, Balk, and Ried (4), when using CIPC, Karmex DL, Geigy 444, and #5520. Plant stands and yields showed no significant differences between treatments. Other chemicals such as BP-III and BP-IV types A and B, significantly reduced cotton stands although the weed control was better than with the CIPC treatments.

CHAPTER III

EXPERIMENTAL PROCEDURE

An experiment was initiated at Martin, Tennessee, in the growing season of 1955, on a Grenada silt loam soil, to evaluate the effeciency for the control of weeds in cotton, of several chemicals used alone and in certain combinations.

The experimental design selected was a randomized block with four replications of nine treatments. The range area was ninety-six feet in length, providing for four blocks, with alleys four feet wide between the blocks. Each block was twenty feet by sixty; each plot in the block consisted of two rows twenty feet in length, spaced forty inches apart.

The range area had been under a rotation of corn, cotton, followed by four years in lespedeza. A cover crop of ryegrass and vetch was planted after corn in the rotation and plowed under the next spring for cotton.

The land was prepared by disking, plowing, disking, and harrowing in April. Two days before planting, the soil was disked and harrowed twice. A well pulverized seed bed was obtained.

The cotton was planted on May 18, with standard equipment, on a slightly raised bed made by tractor cultivators. Stoneville 2B was the variety used. Acid delinted seed were drilled at a rate of twelve pounds per acre. Fertilization was made according to soil test recommendations from the Department of Agronomy at the University of Tennessee, Knoxville, Tennessee.

Immediately after planting, the rows were rolled with a smooth roller and the plots were lined off, staked, and treated.

Application of the herbicides was made with a three gallon "Hudson" hand sprayer. The materials for each treatment were formulated with water at a rate of twenty gallons per acre. Practice trials to determine the proper walking speed and the proper height of the nozzle above the soil, were made before any chemicals were applied.

By use of fan type nozzle ("Spraying Systems", number 730077) fitted to the sprayer, and by holding the spray nozzle about one foot above the soil surface, centered over the drill row, a band of the chemical spray materials fourteen inches wide was applied.

The treatments used were the following:

Treatment 1	DNOSBP[1]	6 lbs./acre
Treatment 2	DNOSBP	8 lbs./acre
Treatment 3	CIPC	6 lbs./acre
Treatment 4	CIPC	9 lbs./acre
Treatment 5	Karmex D[2]	3/4 lb./acre
Treatment 6	Karmex D	1 lb./acre
Treatment 7	DNOSBP CIPC	3 lbs./acre 3 lbs./acre
Treatment 8	DNOSBP CIPC	4 lbs./acre 4 lbs./acre
Treatment 9	Check	No treatment

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[1]These are the usual trade designation of the various chemicals used. The complete name of each chemical is listed in the appendix.

[2]Karmex D now has the trade designation of Karmex DL.

In commercial practice, weeds in the middles of the rows would be controlled by tillage. In this experiment, however, no cultivation of the plots was done thus providing a better appraisal of weed control by the chemicals applied.

Observations were made at one, two, three, four, six, eight, and ten weeks after planting. The number of weeds in each treated band was recorded by species at two, four, six, and eight weeks after planting. Total cotton population counts were made at one, two, three, four, six, and eight weeks after planting.

CHAPTER IV

RESULTS AND DISCUSSION

Table I records the number of weeds by species at two, four, six, and eight weeks after planting for each treatment. Analysis of variance was not made on weed counts due to the abnormal distribution of weed number and population. Actual weed counts indicate that none of the chemicals was effective in controlling Bermudagrass; however, all of the chemicals tested were effective in reducing crabgrass, yellow nutgrass, poor joe, morning glory, and ragweed populations when compared with the check.

Mixtures of DNOSBP and CIPC (treatments 7 and 8) at three pounds per acre of each and at four pounds per acre of each, gave the poorest weed control of all chemicals used in the test (Figures 1 and 2); however, the effectiveness of weed control was greatly increased at the higher rates. The data do not indicate synergistic effects, as inferior weed control resulted in these plots when compared with the control obtained by either CIPC or DNOSBP alone.

In Table II are shown the number of cotton plants in each treatment at the end of one, two, three, four, six, and eight weeks planting. There was a significant reduction, at the five per cent level, in cotton populations when using Karmex D at either rate. As can be readily seen in Figures 3 and 4, very little cotton remained in the Karmex D treatments after the second week.

TABLE I

NUMBER OF WEEDS EACH SPECIES GROWING IN THE TREATED FOURTEEN INCH BAND AT THE END OF THE PERIODS INDICATED. TOTAL OF FOUR REPLICATIONS. MARTIN, TENNESSEE, 1955.

Weed	Weeks After Planting	Treatments: 6 lbs. DNOSBP	8 lbs. DNOSBP	6 lbs. CIPC	9 lbs. CIPC	3/4 lb. Karmex D	1 lb. Karmex D	3 lbs. DNOSBP; 3 lbs. CIPC	4 lbs. DNOSBP; 4 lbs. CIPC	Check
Bermudagrass (Cynodon Dactylon Pres.)	2	16	6	3	5	2	3	3	11	11
	4	19	8	10	2	5	5	3	12	13
	6	19	8	11	5	8	4	5	13	17
	8	22	11	18	18	7	18	5	16	22
Crabgrass (Digitaria spp.)	2	0	0	0	0	5	0	0	1	16
	4	0	1	1	0	3	0	3	6	88
	6	0	0	0	0	0	1	14	30	94
	8	2	0	0	0	0	0	24	48	161
Yellow Nutgrass (Cyperus esculentus L.)	2	0	0	0	0	0	0	0	2	0
	4	1	0	0	0	0	0	0	1	28
	6	0	2	1	0	0	0	5	16	237
	8	1	0	2	0	0	0	6	10	266
Poor Joe (Diodia teres Walt.)	2	2	0	0	0	1	0	13	16	14
	4	20	4	1	0	2	4	47	51	57
	6	33	4	0	0	0	17	53	74	56
	8	33	4	0	0	0	13	60	75	84
Horsenettle (Solanum caroliness L.)	2	0	0	0	0	0	0	0	1	3
	4	0	1	0	0	0	0	1	3	0
	6	2	2	0	0	0	0	0	6	0
	8	3	3	0	0	0	2	0	7	0
Morning Glory (Ipomea purpurea Lam.)	2	3	3	1	2	1	3	4	7	14
	4	5	4	0	0	0	0	0	4	13
	6	6	3	0	0	0	0	0	1	13
	8	6	6	0	0	1	0	0	1	18
Ragweed (Giant) (Ambrosia trifida L.)	2	0	0	0	0	0	0	0	1	2
	4	1	0	0	0	0	0	0	1	1
	6	1	0	1	0	0	0	0	1	1
	8	0	0	5	0	0	0	0	2	10



Figure 1. Treatment 7 - DNOSBP and CIPC mixture at three pounds per acre of each, six weeks after emergence.



Figure 2. Treatment 8 - DNOSBP and CIPC mixture at four pounds per acre of each, six weeks after emergence. Note the weed growth in the treated band.

TABLE II

NUMBER OF COTTON PLANTS GROWING IN THE TREATED FOURTEEN INCH BAND AT THE END OF THE PERIODS INDICATED. TOTAL OF FOUR REPLICATIONS. MARTIN, TENNESSEE, 1955.

Weeks After Planting	Treatments								
	6 lbs. DNOSBP	8 lbs. DNOSBP	6 lbs. CIPC	9 lbs. CIPC	3/4 lb. Karmex D	1 lb. Karmex D	3 lbs. DNOSBP 3 lbs. CIPC	4 lbs. DNOSBP 4 lbs. CIPC	Check
1	179	164	336	263	381	378	141	256	349
2	348	231	409	349	119	232	207	322	378
3	367	241	341	293	66*	201*	209	322	387
4	343	226	191*	170*	64*	188*	204	315	374
6	337	220	181*	162*	60*	186*	202	314	374
8	332	220	162*	147*	59*	175*	200	312	370

*Significant difference between treatment means and check (treatment 9) at the five per cent level.



Figure 3. Treatment 5 - Karmex D at three-fourths pound per acre, six weeks after emergence. Note the excellent weed control, but the serious reduction in cotton stand.



Figure 4. Treatment 6 - Karmex D at one pound per acre, six weeks after emergence. Note the excellent weed control, but the serious reduction in cotton stand.

CIPC at either rate significantly reduced the stand of cotton beginning the fourth week and losses continued to occur through the eight week.

Karmex D at both rates and CIPC at both rates gave very good weed control for the duration of the experiment.

Field observations and notes recorded at emergence on May 25, indicate delayed emergence in all DNOSBP plots. By June 8, the cotton in treatments 1 and 2 had emerged to an even stand but the size of the plants varied greatly (see Figures 5 and 6).

The cotton in both CIPC treatments was slow in shedding the seed coat from the cotyledonary leaves, and the base of the hypoccotyl was larger than in any other treatments. In studies by Swanson, Shaw, and Hughes (23) of the USDA, a constricted region at the root-stem juncture was found in cotton when CIPC was used in a test of the effects of certain chemicals on cotton seedlings. A red coloration was present in the leaves but disappeared by the third week, at which time the growth of cotton was vigorous. At ten weeks these were the most vigorous, heaviest fruiting treatments in the test, with plants averaging twenty-four inches in height (see Figures 7 and 8).

The highest germination and also the highest cotton population losses occurred in treatments 5 and 6 (see Figures 3 and 4) with the use of Karmex D. At emergence the young plants had yellow, discolored leaves. Foy (11) at Missouri described similar effects in 1953 tests. Necrosis continued through the test although some plants recovered.



Figure 5. Treatment 1 - DNOSBP at six pounds per acre, six weeks after emergence. Note skips in the row and irregular sizes of plants.



Figure 6. Treatment 2 - DNOSBP at eight pounds per acre, six weeks after emergence. Cotton was similar to Figure 5.



Figure 7. Treatment 3 - CIPC at six pounds per acre six weeks after emergence.



Figure 8. Treatment 4 - CIPC at nine pounds per acre six weeks after emergence.

The recovered plants exhibited a forked-branched type of growth. The maximum height of the cotton in the Karmex D treatments was eighteen inches.

In treatments 7 and 8, using mixtures of DNOSBP and CIPC, (see Figures 1 and 2) emergence was delayed but was uniform. By the fourth week there was an evident increase in the growth rate of cotton. Some chopping would have been necessary to effect adequate weed control at the end of the third week after emergence. At ten weeks these treatments were vigorous and averaged twenty-one inches in height.

The cotton in the no treatment plot emerged earliest of all treatments and maintained a uniform stand through the test. Chopping would have been necessary by the second week after emergence. By the third week after emergence, weed infestation had become severe and the vigor and growth rate was greatly reduced (see Figure 9). At ten weeks the cotton had reached only an average of twelve inches in height due to weed competition.

The weed infestation in the border rows and alleys confirm that the soil was heavily infested with weeds in the experimental area. The season was favorable for the germination and growth of plants. Rainfall data (Table III) show that there was adequate moisture for plant growth and chemical response.



Figure 9. Treatment 9 - No chemical treatment, six weeks after emergence. Note the dense weed infestation.

TABLE III

RAINFALL FOR MAY, JUNE, JULY, 1955.[1]

Month	Rainfall (inches)	Month	Rainfall (inches)	Month	Rainfall (inches)
May 1		June 1		July 1	
2		2		2	
3		3		3	
4		4		4	
5	.12	5	.73	5	
6		6	.27	6	
7		7		7	1.43
8	.24	8	.22	8	
9		9		9	
10		10	.33	10	
11		11	.66	11	
12	.85	12	.11	12	
13	.30	13		13	
14		14		14	.12
15		15		15	.73
16		16		16	
17		17		17	
18		18		18	
19		19		19	.12
20	.30	20	.30	20	1.09
21	1.40	21		21	.03
22	.10	22		22	.06
23		23	.52	23	
24	.30	24		24	1.54
25		25	.32	25	.95
26		26		26	
27	.70	27		27	
28	.14	28		28	
29		29		29	
30		30	.02	30	.02
31				31	
total	4.54		3.48		6.06

[1]Data obtained from weather station University of Tennessee Martin Branch, Martin, Tennessee.

CHAPTER V

SUMMARY AND CONCLUSIONS

An experiment was carried out at Martin, Tennessee, in 1955, to determine the effectiveness of certain chemicals for weed control in cotton when applied as pre-emergence sprays.

DNOSBP applied at rates of six pounds per acre and eight pounds per acre resulted in good weed control but emergence was delayed and the growth rate of cotton was reduced.

CIPC applied at rates of six pounds per acre and at nine pounds per acre provided the most satisfactory results of all the chemical treatments used, even though significantly reducing cotton populations. The surviving cotton plants in the CIPC treatments were judged to be the least affected by the chemicals.

Karmex D applied at rates of three-fourths of a pound per acre and one pound per acre gave excellent weed control but seriously reduced the cotton population and growth. It was observed that the plots in these treatments remained almost free of weeds to harvest time (Figures 3, 4, 10, and 11).

Mixtures of CIPC and DNOSBP at three pounds per acre and at four pounds per acre of each, gave the poorest weed control but did not adversely affect the cotton population.

The results of this experiment, and of other experiments in Tennessee and in other cotton producing states of the humid region, provide sufficient evidence that chemical weed conrtol is feasible.



Figure 10. Over-all view of the range, six weeks after emergence. Note the excellent weed control but the adverse effects on the cotton in the Karmex D treatments in the foreground.



Figure 11. Over-all view of the range, later in season.

However, further investigation should be made. New chemicals and new techiniques should be developed to make chemical weed control in cotton safer and more convenient for general use on the farm.

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LITERATURE CITED

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APPENDIX

APPENDIX

LIST OF CHEMICALS CITED

1. Sinox; sodium dinitro ortho cresolate.
2. 2, 4-D; 2, 4-dichlorophenoxyacetic acid.
3. DNOSBP; dinitro ortho secondary butyl phenol.
4. PCP; pentachlorophenol.
5. IPC; isopropyl N-phenyl carbamate.
6. CIPC; isopropyl-N (3-chlorophenyl) carbamate.
7. Karmex W; 3-(p-chlorophenyl)-1, 1-dimethyl urea.
8. Karmex DL; 3-(3,4-dichlorophenyl)-1, 1-dimethyl urea.
9. Karmex M; 1-(3,4-dichlorophenyl)-3 methyl urea.
10. Geigy 444; 2-chloro-4, 6-bis (diethylamine)-S-triazine.
11. #5520; 2 chloroethyl N-(3-chlorophenyl) carbamate.
12. BP-III; alpha carbo 2, 4-dichlorophenoxy ethoxy-N-phenyl carbamate.
13. BP-IV Types A and B alpha carbo 2, 4-dichloro phenyl ethoxy-N-(3 chlorophenyl) carbamate.