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A comparison of nitrogen sources, rates and time of application on the yield of seed cotton

Haywood W. Luck

To the Graduate Council:

I am submitting herewith a thesis written by Haywood W. Luck entitled "A comparison of nitrogen sources, rates and time of application on the yield of seed cotton." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

L. N. Skold, Major Professor

We have read this thesis and recommend its acceptance:

W. L. Parks, D. M. Thorpe

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

March 7, 1958

To the Graduate Council:

I am submitting herewith a thesis written by Haywood W. Luck entitled "A Comparison of Nitrogen Sources, Rates and Time of Application on the Yield of Seed Cotton." 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.

I. V. Hold
Major Professor

We have read this thesis
and recommend its acceptance:

P. M. Thorpe

W. L. Parks

Accepted for the Council:

Dale Bentley
Dean of the Graduate School

A COMPARISON OF NITROGEN SOURCES, RATES AND TIME OF APPLICATION ON THE YIELD OF SEED COTTON

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

Haywood W. Luck

March 1958

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Haywood W. Luck

TABLE OF CONTENTS

CHAPTER PAGE

APPENDIX (continued)

LIST OF TABLES

CHAPTER I

INTRODUCTION

For a number of years inadequate nitrogen fertilization has been one of the main limiting factors in cotton production. Since the native soil nitrogen in Tennessee is very limited and the recovery of applied nitrogen is usually poor, cotton producers have begun only recently to approximate the needs of cotton for this nutrient. The use of nitrogen on cotton has become more general as the supply has become more plentiful. New information regarding the response that may be expected from nitrogen fertilization has encouraged producers to use higher rates. The investigation of nitrogen use on cotton must be continuous if progress is to be made concurrently with other phases of technology which are contributing to more efficient production.

The purpose of this experiment was threefold: first, to determine if there was any difference in the response of cotton to urea, ammonium nitrate, and sodium nitrate as sources of nitrogen; second, to determine the rate of nitrogen that would give optimum yield with present production methods; and third, to determine if the time of nitrogen application influenced the yield of cotton.

The three soils on which this experiment was conducted are representative of much of the land in West Tennessee on which cotton is grown.

CHAPTER II

REVIEW OF LITERATURE

Agricultural Experiment Stations of most southern states have conducted research on the nitrogen fertilization of cotton since about 1920. As the price of organic sources of nitrogen began to increase, comprehensive studies were made to compare organic sources of nitrogen with inorganic sources. Published information on this subject has been limited since World War II. Most studies since World War II have been made to determine optimum rates and methods of application.

Kelley (9)[1] stated that it is well established that crops are not always affected to the same degree by a given amount of nitrogen when applied in different forms. He further stated that reliable information concerning the practical value of nitrogen fertilizers can be obtained only by means of local experiments.

Skinner, et al. (24) found, in reviewing experiments with nitrogen fertilizers on cotton soils of the southeast, that there was not a wide variation in yield from different sources of inorganic nitrogen fertilizers. In a few instances sodium nitrate was slightly superior to other nitrogen fertilizers. Anders and Hull (1) found in a comparison of six sources of nitrogen fertilizers that on an average all sources except calcium cyanamid were about equal in value. A six year comparison of inorganic sources of nitrogen in Georgia on the yield of cotton

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[1] Numbers in parenthesis refer to literature cited.

(28) indicated very little difference among sources. Grissom (8) stated that a comparison of six sources of nitrogen for twenty-nine years at a thirty pound per acre rate indicated that sodium nitrate and ammonium nitrate were slightly superior to other sources. In another series of experiments begun in 1945 at Money and Onward, Mississippi, comparing five nitrogen fertilizers, no difference in yield of cotton due to sources of nitrogen fertilizers was obtained. Andrews, Edwards, and Hammons (2) found no difference in yield of cotton from the use of anhydrous ammonia, ammonium nitrate and nitrate of soda as sources of nitrogen. Nelson and Welch (15) reported no difference in the yield of cotton from the use of ammonium nitrate and sodium nitrate compared at three locations in 1948. Reynolds, Johnson and Langley (21) reported that at Nacogdoches, Texas, no difference was obtained between sources of materials but at Troup sulfate of ammonia was decidedly the best source of nitrogen.

Superiority of one source of nitrogen over another can sometimes be related to the content of accompnying elements. Tisdale (27) stated sodium in sodium nitrate may substitute partially for potassium in the nutrition of certain plants. Tidmore and Williamson (26) reported that nitrogenous fertilizers affect the availability of phosphate and potassium differently. Acid-forming fertilizers caused a decrease in phosphate availability and an increase in the amount of water-soluble potassium, whereas basic fertilizers caused an increase in phosphate availability and a decrease in the amount of water-soluble potassium. Paden (18) found that soil analysis from plots where

sources of nitrogen fertilizer studies have been in progress since 1928 show such acid forming sources of nitrogen as ammophos and ammonium sulphate had lowered the amount of exchangeable calcium and had resulted in corresponding increases in the amount of exchangeable hydrogen. Plots receiving sources containing calcium had high amounts of exchangeable calcium and low amounts of exchangeable hydrogen. Investigations by Grissom (8) revealed similar results. Paden (17) reported no difference in yield among fifteen different nitrogen fertilizers on limed soil. Newman and Sturgin (16) found that nitrogen fertilizers containing sodium and potassium or the non-basic carriers such as ammonium nitrate supplemented with dolomitic limestone were superior to non-basic carriers of nitrogen which were not supplemented with lime. Scarsbrook and Cope (23) stated that without neutralization, acid forming nitrogen fertilizers may cause low yields in a few years on coarse textured soils. However, on fine textured soils such as clays and loams it may take many years to effect yields. Kelley (9) stated that in general the economic value of nitrogen fertilization is related to the reaction of the soil and the efficiency of the different nitrogen materials is affected by soil acidity to very different degrees. Ammonium fertilizers usually produce their best effects in approximately neutral soil. The nitrates usually produce good results in a much wider pH range. Approximately the same yield may be expected from the various sources of nitrogen fertilizers if the soil acidity is corrected. Naftel (13) found, in investigating the absorption of ammonium ions and nitrate ions by cotton, that ammonium absorption

increased as the acidity of the culture solution decreased. The absorption of nitrate nitrogen was only slightly affected by the reaction of the solution used. The highest total nitrogen absorption usually occurred at pH 6.0.

The chemical form in which solid nitrogenous fertilizer materials are applied to the soil will determine the action of the material in the soil. Ammonium nitrate is acid forming. Urea also has an acid effect on the soil. Sodium nitrate has a basic effect on the soil. Tisdale (27) stated that the ammonium ion is held by the soil colloids until nitrified by soil bacteria. Urea is rapidly converted to ammonia by a process known as hydrolysis and the ammonia produced is converted to nitrates. The nitrate form of nitrogen remains in the soil solution until absorbed by the plant or removed by leaching. Frederick (6) found that the increase in the rate of nitrification with an increase in temperature was quite rapid, with the greatest change occurring between 7° and 15° Centigrade. Gibson (7) stated that urea is easily leached out of the soil but the rapidity with which it is converted to ammonia will preclude a loss of nitrogen in this way. Bates and Tisdale (3) reported the movement of nitrate nitrogen through any one soil to be closely related to the quantity of water added. Matthews (12) concluded that even under extremely wet conditions most of the nitrate nitrogen in Cecil sandy clay loam remained in the surface soil within easy reach of the roots of plants. There is very little if any loss of nitrate by leaching unless rainfall is fairly continuous.

In most studies of rates and time of application of nitrogen

fertilizers on cotton these variables have been conducted concurrently. Many investigators have found fifty to eighty pounds of nitrogen per acre to be the most effective rate on cotton. Rogers (22) reported the greatest yield increase from three hundred pounds per acre of sodium nitrate with one-fourth applied at planting time and three-fourths at chopping time. The second highest yield was with all the sodium nitrate applied at chopping time. Collins, Hall and Harrell (5) reported that an average of sixteen years data indicated forty-eight pounds of nitrogen applied as a sidedressing in addition to twenty-six to thirty pounds applied at planting produced the highest yield. The average increase in yield from nitrogen was seven hundred seventy-nine pounds of seed cotton per acre. Reynolds, Johnson and Langley (21) found three hundred pounds of sodium nitrate per acre, one-half of which was applied at planting and the remainder as a sidedressing, gave a higher yield of lint cotton than one hundred fifty pounds of sodium nitrate applied in the same manner.

Christensen, Boyles and Lyerly (4) investigated the use of ninety-one pounds and one hundred eighty-two pounds of ammonium nitrate applied at the time of planting and when cotton was six to twelve inches tall. There was an increase of three hundred to seven hundred pounds of seed cotton per acre due to rate but little difference due to the time of application. Nelson (14) obtained yield increases of seed cotton with nitrogen applications of up to sixty pounds per acre. Longenecker, Lyerly and Christensen (11) obtained a three hundred fifty to six hundred pound increase in seed cotton in the El Paso Valley in 1954 with

ninety-four pounds of nitrogen per acre. Long and Hazlewood (10) reported an average increase of three hundred twenty-three pounds of seed cotton in West Tennessee with an application of thirty-two pounds of nitrogen per acre. Smith (25) compared time of application of forty-eight pounds of nitrogen in four combinations. The highest yield was obtained when one-third of the nitrogen was applied under the crop and two-thirds was applied as a sidedressing at one application. Grissom (8) reported a response to nitrogen on cotton up to sixty pounds per acre. Sidedressing with nitrogen was not as satisfactory as pre-planting or split application. Ray and McGeorge (20) reported in a summary of fourteen nitrogen tests that the fifty pounds per acre rate was the most economical in the majority of the tests. In a few instances one hundred pounds per acre gave the highest yield of seed cotton. Reports from California (19) indicate a significant increase from fifty pounds of nitrogen but not from higher rates. Investigations in Texas (19) with sixty and one hundred twenty pounds of nitrogen per acre indicated that the one hundred twenty pound rate produced little or no more cotton than did the sixty pound rate. Information on many investigations with very high rates of nitrogen as the study at Thorsby, Alabama (19), have not been completed to date. The study at Thorsby includes rates of sixty, one hundred twenty, one hundred fifty and three hundred twenty pounds of nitrogen per acre with irrigation and without irrigation.

CHAPTER III

METHODS

This experiment was conducted at three locations in West Tennessee in the summer of 1957. Two of the tests were on private farms and the other was on Fort Pillow State Farm.

At the H. B. Willis and Son's farm in Haywood County near Brownsville, Tennessee, the test was on Memphis silt loam, a well drained upland soil formed from deep loess. It has a brown, friable, silt loam surface. The subsoil is a brown to reddish brown, friable to firm, silty clay loam.

At the W. B. Reeves farm in Tipton County near Covington, Tennessee, the test was on Falaya silt loam, a somewhat poorly drained bottom soil of young alluvium of loessial origin. The surface is a dark grayish-brown, friable, silt loam. The subsurface layers are grayish-brown, silt loam with mottles of black, dark brown and gray.

At the Fort Pillow State Farm in Lauderdale County near Henning, Tennessee, the test was on Olivier silt loam. Olivier silt loam is a somewhat poorly drained terrace soil formed from old alluvium from loess soils. The surface is a grayish-brown, friable, silt loam. The subsoil is pale yellow, friable, silty clay loam. The lower subsoil is mottled and there is a fragipan at shallow depths.

A split-split-plot experimental design was used including eighteen treatment combinations and was replicated four times. The main plots were time of application of nitrogen materials. Two additional treatments

receiving the same level of phosphorus and potassium but no nitrogen were included at each location. The first split was sources of nitrogen fertilizer and the second split was rates of application. This design allows a more critical evaluation of rates of nitrogen.

Each plot consisted of five rows, 38 inches apart and 35 feet long, or 1/78.62 of an acre. Border rows of cotton were planted on the sides of each test and the ends contained approximately twenty feet as a buffer strip.

On one of the main plots, all of the nitrogen was applied at planting time. On the other main plot, 25 pounds of nitrogen was applied at planting time and the remainder as a sidedressing.

The nitrogen fertilizers used were urea (45 per cent nitrogen), ammonium nitrate (33.5 per cent nitrogen), and sodium nitrate (16 per cent nitrogen). The rates of application were fifty, one hundred, and one hundred fifty pounds of nitrogen per acre.

A soil test was made at each location. The Olivier soil had a pH of 5.8. The available P_2O_5 was high (35) and the available K_2O was medium (160). Cotton had been grown on this area in 1956. The Falaya soil had a pH of 6.8. The available P_2O_5 was medium (16) and the available K_2O was very low (80). Corn and sorghum silage was the previous crop. The Memphis soil had a pH of 5.0. The available P_2O_5 was medium (18) and the available K_2O was high (190). Three tons of lime per acre was added to reduce the acidity. Grain sorghum was the previous crop.

Seedbed preparation was done by the operators of the respective farms. In each case the land was turned, disked several times and listed.

At planting all plots received an application of two hundred fifty pounds per acre of 0-20-20 in the row. While the furrows were open, the plots were marked off and the nitrogen fertilizer applied by hand at the rates designated for each plot.

The variety of cotton planted was Pope. The seeding rate was twenty-five pounds per acre of mechanically delinted and treated seed. Dates of plantings were: April 29 on the Olivier soil, April 30 on the Memphis soil, and May 6 on the Falaya soil. After the cotton came up to a good stand it was thinned to a stand of twenty to thirty thousand plants per acre.

Operators of the farms cultivated only when necessary to keep the cotton free of weeds.

The sidedressing was applied June 18 on the Memphis soil, June 19 on the Olivier soil, and June 21 on the Falaya soil. The nitrogen fertilizers were applied by hand to the side of the row and plowed in with a cultivator.

Insect control was not adequate at any of the locations. The cotton on the Willis farm was dusted four times with an airplane using 3-5-0. One other treatment was made by tractor using Dynatox. The cotton on the Reeves farm was dusted one time with 3-5-0. At Fort Pillow, the test was sprayed twice with Malathion and Toxaphene.

Yield determinations were made by harvesting and weighing the seed cotton from the three center rows of each plot. Harvesting began early but was not completed until late fall due to inclement weather. It was necessary to make three pickings at each location.

CHAPTER IV

RESULTS AND DISCUSSION

Rainfall in 1957 was very heavy in the area where this experiment was conducted. Distribution of the rainfall during the growing season is shown in Appendix D. Maturity was delayed at all locations by the over-supply of moisture. The cotton plants grew very large on most of the plots at all locations. High boll weevil infestation reduced yields at each location. Insect injury may have been greater on cotton fertilized with nitrogen than on unfertilized check plots which matured earlier. Check plots on the Memphis and Falaya soils began to show nitrogen deficiencies when the cotton started "squaring".

Yields of seed cotton were obtained at each of the locations. These data were subjected to analysis of variance to evaluate the influence of nitrogen sources, rates, and time of application on the yield of seed cotton at each location.

A summary of the results at each location is presented in Table I. A summary of all treatment effects on the yield of seed cotton per acre at all three locations is presented in Table II. More detailed plot yield data are given in Appendix A, B and C.

There were highly significant differences among certain treatments on the Memphis and Falaya soils. No response to nitrogen was obtained on the Olivier soil.

TABLE I

A SUMMARY OF THE YIELDS OF SEED COTTON AS INFLUENCED BY NITROGEN SOURCES, RATES AND TIME OF APPLICATION ON MEMPHIS, FALAYA, AND OLIVIER SOILS

	Memphis Pounds per Acre	Falaya Pounds per Acre	Olivier Pounds per Acre
Nitrogen Sources:			
Urea	2738	1736	2214
Ammonium Nitrate	2888	1941	2598
Sodium Nitrate	2738	2118	2264
L.S.D. (.05)	N.S.	N.S.	N.S.*
Nitrogen vs. No Nitrogen:			
Nitrogen	2786	1931	2358
No Nitrogen	2260	1022	2174
L.S.D. (.05)			N.S.
Nitrogen Rates:			
50 pounds	2807	1683	2474
100 pounds	2777	2046	2351
150 pounds	2773	2065	2251
L.S.D. (.05)	N.S.	207	N.S.*
(.01)		292	
Time of Application:			
All N at planting	2703	1943	2160
N as split application	2869	1920	2557
L.S.D. (.05)	160	N.S.	N.S.*

* No response was obtained to nitrogen, therefore other comparisons are not valid.

TABLE II

AN AVERAGE OF THE YIELDS OF SEED COTTON PER ACRE AS INFLUENCED BY NITROGEN SOURCES, RATES AND TIME OF APPLICATION ON MEMPHIS, FALAYA AND OLIVIER SOILS

	Pounds per Acre
Nitrogen Sources:	
Urea	2229
Ammonium Nitrate	2476
Sodium Nitrate	2373
Nitrogen vs. No Nitrogen:	
Nitrogen	2358
No Nitrogen	1818
Nitrogen Rates:	
50 pounds	2321
100 pounds	2391
150 pounds	2363
Time of Application:	
All N at planting	2268
N as split application	2448

Sources of Nitrogen

At the five per cent level of probability there was no significant difference in yield among sources of nitrogen fertilizers at any of the locations. These results are in agreement with those of other investigators (2, 15, 6, 17, 23, 19) who have found no difference among sources of nitrogen fertilizers when properly applied, with an adequate supply of other nutrients in proper proportion and when the soil pH is approximately 6.0 to 6.5.

In selecting a nitrogen fertilizer the farmer should select on some basis other than anticipation of a greater response from any particular source (19). Tisdale (27) and Scarsbrook (23) state that if one material is just as effective as another, then the selection of a material should presumably be governed by its cost and supply.

Rates of Nitrogen

The response to nitrogen on the Memphis and Falaya soils was highly significant. There was not a significant response to nitrogen on the Olivier soil.

On Memphis soil the 50 pound per acre rate of nitrogen produced a yield of 2,807 pounds of seed cotton per acre while the no nitrogen check yielded only 2,260, an increase of 547 pounds. There were no further significant increases from additional nitrogen above the 50 pound per acre rate. The fact that cotton did not respond to more than fifty pounds of nitrogen may be due to the high rainfall leading to

efficient use of nitrogen and to the previous fertilization program at this location. Rather high rates of fertilizer had been applied to this field in previous years.

The nitrogen fertilized plots on the Falaya soil produced 1,931 pounds of seed cotton per acre, or 909 pounds per acre more than the no nitrogen check. The 50 pound per acre rate of nitrogen produced a yield of 1,683 pounds of seed cotton per acre, which was 661 pounds more than the no nitrogen check. The 100 pound rate of nitrogen produced a yield of 2,046 pounds of seed cotton per acre which was a significant increase of 363 pounds over the 50 pound per acre rate. There was very little difference between the yields produced by the 100 pound rate and 150 pound rate of nitrogen. The significant increase in yield from the 100 pound rate of nitrogen at this location was probably due to the low fertility level of the soil. A very small amount of fertilizer had been used in previous years.

On the Olivier soil the 50 pound per acre rate of nitrogen produced a yield of 2,474 pounds of seed cotton per acre while the no nitrogen check yielded 2,174 pounds, however, this difference was not significant.

These results on the rates of nitrogen applications are in agreement with the findings of many investigations (22, 21, 10, 20, 19).

Time of Application

On the Memphis soil there was a significant difference in response to the time of application of nitrogen. With all the nitrogen applied at time of planting the yield of seed cotton was 2,703 pounds per acre while the split application yielded 2,869, an increase of 166 pounds of seed cotton per acre.

In some plots, using higher rates, where all the nitrogen was applied at time of planting, germination was affected. Leaching losses of nitrogen applied at time of planting must not have been important since there was very little difference in yield for the different rates when all the nitrogen was applied at planting.

On the Falaya soil there was no significant difference in yield due to time of application. Lack of response to sidedressing at this location may have been due to destruction of the late crop by insects.

There was no valid difference in time of application of nitrogen on the Olivier soil because of lack of response to nitrogen.

CHAPTER V

SUMMARY

A comparison of the influence of nitrogen sources, rates and time of application on the yield of seed cotton was made on Memphis, Falaya and Olivier soils. The nitrogen fertilizers compared were urea, ammonium nitrate and sodium nitrate. These materials were applied at the rate of 50, 100 and 150 pounds per acre. All of the nitrogen was applied at time of planting on one of the main plots and on the other main plot 25 pounds of each rate of nitrogen was applied at planting with the remainder applied as a sidedressing. The following results were obtained:

1. On the Memphis soil there were no significant differences among sources of nitrogen. Nitrogen gave a significant yield increase over the check plots. There was no significant response to nitrogen above the 50 pound per acre rate. Nitrogen applied as a sidedressing gave a significant increase in yield.

2. Nitrogen gave a significant yield increase in seed cotton over the no nitrogen check on the Falaya soil. There was no significant difference in yield among the different nitrogen sources. Yield increases from different nitrogen rates was highly significant. The 100 pound rate of nitrogen produced a yield of 2,046 pounds of seed cotton per acre which was a significant increase of 363 pounds over the 50 pound per acre rate. There was no significant difference in yield of seed cotton due to time of application of nitrogen.

3. There was no significant response to nitrogen on the Olivier soil.

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APPENDIX

APPENDIX

APPENDIX A

THE YIELD OF SEED COTTON PRODUCED ON A MEMPHIS SILT LOAM SOIL FERTILIZED WITH NITROGEN FROM VARIOUS SOURCES AND AT VARIOUS RATES AND TIMES OF APPLICATION

Treatment No.	Source of Nitrogen	Rate of N per Acre	Yield in Pounds per Plot					Average Yield Pounds per Acre
			Replication				Average	
			1	2	3	4		
1	Check		20.4	16.7	18.2	19.4	18.7	2450
2	Urea	50	22.3	21.0	18.8	22.5	21.2	2777
3	"	100	23.3	17.3	19.3	22.1	20.5	2686
4	"	150	21.9	14.4	26.6	23.7	21.6	2830
5	Amm. Nit.	50	25.0	21.8	19.3	17.5	20.9	2738
6	"	100	21.2	20.9	16.7	24.5	20.8	2725
7	"	150	20.9	24.5	16.2	23.6	21.3	2791
8	Sod. Nit.	50	20.7	19.4	18.3	22.2	20.2	2646
9	"	100	20.1	20.1	20.6	22.3	21.0	2751
10	"	150	20.4	16.2	18.1	18.1	18.2	2384
11	Check		20.3	15.4	12.5	15.2	15.8	2070
12	Urea	50*	23.1	23.7	19.7	26.3	23.2	3039
13	"	100*	24.4	20.9	17.6	19.8	20.7	2712
14	"	150*	19.7	21.6	11.9	19.5	18.2	2384
15	Amm. Nit.	50*	26.7	21.2	20.4	19.7	22.0	2882
16	"	100*	24.2	21.2	21.1	23.1	22.4	2935
17	"	150*	26.0	25.3	26.2	21.9	24.9	3262
18	Sod. Nit.	50*	25.5	18.6	18.8	21.6	21.1	2764
19	"	100*	22.3	20.2	23.4	21.4	21.8	2856
20	"	150*	21.2	20.8	26.7	22.6	22.8	2987

*25 pounds of nitrogen per acre applied at planting and remainder as sidedressing.

APPENDIX A (Continued)

ANALYSIS OF VARIANCE

Sources of Variation	D.F.	Sum of Squares	Mean Square	F Value
Sources	2	21.79	10.90	1.51
Replications	3	86.14	28.71	3.97
Error (a)	6	43.46	7.24	
Rates	2	0.90	.45	.05
Rates x Sources	4	37.51	9.38	1.13
Error (b)	12	99.54	8.30	
Application	1	28.63	28.63	4.36*
Application x Sources	2	25.35	12.67	1.93
Application x Rates	2	1.69	.84	.13
Application x Sources x Rates	4	55.34	13.83	2.11
Error (c)	33	216.76	6.57	
Total	71	617.11		
Treatments	19	302.45	15.92	2.41**
Replications	3	109.45	36.48	5.53**
Error	57	375.73	6.59	
Total	79	787.63		
Nitrogen vs. no nitrogen	1	115.28	115.28	17.49**

APPENDIX B

THE YIELD OF SEED COTTON PRODUCED ON A FALAYA SILT LOAM SOIL FERTILIZED WITH NITROGEN FROM VARIOUS SOURCES AND AT VARIOUS RATES AND TIMES OF APPLICATION

Treatment No.	Source of Nitrogen	Rate of N per Acre	Yield in Pounds per Plot					Average Yield Pounds per Acre
			Replication				Average	
			1	2	3	4		
1	Check		10.6	8.2	2.0	7.3	7.0	917
2	Urea	50	12.0	16.7	11.9	7.4	12.0	1572
3	"	100	11.0	20.9	15.8	8.7	14.1	1847
4	"	150	12.0	14.7	14.4	13.0	13.5	1769
5	Amm. Nit.	50	16.9	18.3	12.8	11.9	15.0	1965
6	"	100	20.9	14.7	17.1	16.3	17.3	2266
7	"	150	13.7	15.1	9.6	12.4	12.7	1664
8	Sod. Nit.	50	20.0	14.5	10.7	12.7	14.5	1900
9	"	100	21.2	15.0	9.6	17.3	15.8	2070
10	"	150	18.5	17.7	17.8	20.3	18.6	2437
11	Check		7.5	7.5	8.8	10.4	8.6	1127
12	Urea	50*	8.0	9.0	10.0	13.2	10.1	1323
13	"	100*	11.4	14.0	16.1	14.0	13.9	1821
14	"	150*	12.6	15.9	18.2	17.0	15.9	2083
15	Amm. Nit.	50*	12.7	11.3	12.7	10.9	11.9	1559
16	"	100*	16.5	17.8	12.9	16.1	15.8	2070
17	"	150*	14.7	14.7	14.5	20.9	16.2	2122
18	Sod. Nit.	50*	14.1	14.3	15.1	10.8	13.6	1782
19	"	100*	16.9	19.6	16.0	14.8	16.8	2201
20	"	150*	20.0	18.6	14.7	17.5	17.7	2319

*25 pounds of nitrogen per acre applied at planting and remainder as sidedressing.

APPENDIX B (Continued)

ANALYSIS OF VARIANCE

Sources of Variation	D.F.	Sum of Squares	Mean Square	F Value
Sources	2	101.69	50.85	2.77
Replications	3	39.24	13.08	0.71
Error (a)	6	110.20	18.37	
Rates	2	131.23	65.62	10.36**
Sources x Rates	4	38.02	9.51	1.50
Error (b)	12	75.91	6.33	
Application	1	0.50	0.50	0.07
Application x Sources	2	0.55	0.28	0.04
Application x Rates	2	39.98	19.99	2.91
Sources x Rates x Application	4	31.02	7.76	1.13
Error (c)	33	226.77	6.87	
Total	71	795.11		
Treatments	19	695.28	36.59	4.60**
Replications	3	44.38	14.79	1.86
Error	57	452.91	7.95	
Total	79	1192.57		
Nitrogen vs. no nitrogen	1	347.63	347.63	43.73**

APPENDIX C

THE YIELD OF SEED COTTON PRODUCED ON OLIVIER SILT LOAM SOIL FERTILIZED WITH NITROGEN FROM VARIOUS SOURCES AND AT VARIOUS RATES AND TIMES OF APPLICATION

Treatment No.	Source of Nitrogen	Rate of N per Acre	Yield in Pounds per Plot					Average Yield Pounds per Acre
			Replication				Average	
			1	2	3	4		
1	Check		13.0	14.7	14.2	15.6	14.4	1886
2	Urea	50	10.6	17.7	23.3	18.4	17.5	2293
3	"	100	9.4	16.5	18.0	12.8	14.2	1860
4	"	150	13.2	6.1	13.0	13.6	11.5	1507
5	Amm. Nit.	50	17.2	21.5	23.0	18.1	20.0	2620
6	"	100	18.4	13.6	22.9	16.5	17.9	2345
7	"	150	14.2	14.4	21.8	22.9	18.3	2397
8	Sod. Nit.	50	20.5	13.2	13.1	20.9	16.9	2214
9	"	100	8.1	23.4	19.3	16.0	16.7	2188
10	"	150	11.6	14.1	21.5	14.4	15.4	2017
11	Check		18.5	23.2	11.6	21.7	18.8	2463
12	Urea	50*	18.7	15.1	20.2	19.1	18.3	2397
13	"	100*	26.6	22.8	11.4	22.5	20.8	2725
14	"	150*	23.5	17.6	12.1	23.0	19.1	2502
15	Amm. Nit.	50*	22.5	15.4	23.5	25.1	21.6	2830
16	"	100*	21.0	19.2	19.3	22.1	20.4	2672
17	"	150*	23.3	22.5	15.9	21.6	20.8	2725
18	Sod. Nit.	50*	24.3	18.4	12.1	21.0	19.0	2489
19	"	100*	18.7	22.0	11.0	18.9	17.7	2319
20	"	150*	21.9	19.3	12.8	17.9	18.0	2358

*25 pounds of nitrogen per acre applied at planting and remainder as sidedressing.

APPENDIX C (Continued)

ANALYSIS OF VARIANCE

Sources of Variation	D.F.	Sum of Squares	Mean Square	F Value
Sources	2	123.13	61.57	5.20*
Replications	3	36.34	12.11	1.02
Error (a)	6	70.99	11.83	
Rates	2	34.64	17.32	0.36
Sources x Rates	4	15.67	3.92	0.08
Error (b)	12	572.61	47.72	
Application	1	165.32	165.32	14.71**
Application x Sources	2	35.36	17.68	1.57
Application x Rates	2	23.39	11.70	1.04
Application x Sources x Rates	4	34.72	8.68	0.77
Error (c)	33	370.88	11.24	
Total	71	1483.05		
Treatments	19	485.24	25.54	1.34
Replications	3	48.09	16.03	0.84
Error	57	1085.95	19.05	
Total	79	1619.28		
Nitrogen vs. no nitrogen	1	14.73	14.73	0.77

APPENDIX D

INCHES OF RAINFALL AT TWO LOCATIONS[1] IN WEST TENNESSEE DURING THE GROWING SEASON OF 1957

Month	Covington	Brownsville
April	6.81	5.86
May	7.95	8.38
June	5.87	7.60
July	4.17	5.94
August	7.42	3.99
September	2.77	4.55
October	4.08	4.50
Total	39.07	40.82

[1]The test, on Memphis soil was located approximately eight miles southeast of Brownsville, on Falaya soil was located approximately six miles southeast of Covington, and on Olivier soil was located approximately ten miles northwest of Covington.