1964

Cotton irrigation studies

Sherman A. Phillips

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COTTON IRRIGATION STUDIES

1. Effect of Irrigation on Response to Fertilization

2. The Influence of Water Regime and Plant Population on Cotton Yield

by Sherman A. Phillips

Louisiana State University and Agricultural and Mechanical College
Agricultural Experiment Station
Charles W. Upp, Director

Bulletin No. 579 March 1964
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## ACKNOWLEDGMENT

The author wishes to thank Dr. William H. Patrick, Jr., Professor of Agronomy, Louisiana State University, for his helpful suggestions in designing the experiments and in the preparation of this manuscript. Appreciation is extended to L. F. Curtis, former Assistant Professor of Agricultural Engineering, Louisiana State University, for obtaining physical data on the soils used in these experiments and to the Agricultural Engineering Department, Louisiana State University, for financial assistance for collection of soil samples for moisture determination.
Cotton Irrigation Studies

1. Effect of Irrigation on Response to Fertilization
2. The Influence of Water Regime and Plant Population on Cotton Yield

SHERMAN A. PHILLIPS*

Many environmental conditions as well as cultural practices affect the response of cotton to irrigation and fertilization. These include such things as physical and chemical properties of the soil, crop rotation, land forming, fertilizer rates, temperature, cloudiness, humidity, insect control, kind and amount of soil borne diseases, etc. However, soil moisture during the growing season appears to be the most important factor governing responses on Mississippi terrace soils. Uneven distribution and in some years inadequate amounts of rainfall during the growing season have caused some farmers to use supplemental irrigation as a means of balancing out unpredictable seasonal variations in natural rainfall.

To help answer questions which arose as the irrigated acreage increased, experiments were set up in 1957 at the Macon Ridge Branch Experiment Station, Winnsboro, Louisiana. Objectives of the experiments were: (1) to determine the yield response to irrigation, (2) to determine the effect of irrigation on the response of cotton to fertilization, (3) to follow moisture patterns and root penetration throughout the growing season on irrigated and non-irrigated cotton, (4) to determine the optimum moisture level for the production of cotton, and (5) to determine the effect of plant population on yield.

Review of Literature

In 1961, Brown et al. (2) reported that when approximately 100 pounds of nitrogen was used on Grenada soil the increased yields due to irrigation ranged from 0 to 1,521 pounds per acre, the 6-year average increase being 648 pounds of seed cotton per acre. A nitrogen rate between 80 and 100 pounds per acre was recommended for irrigated and non-irrigated cotton. Irrigation and nitrogen fertilization rates up to 264 pounds did not adversely affect the height of cotton plants nor significantly delay maturity of the crop.

Raney (7) reported more efficient response of cotton to nitrogen under irrigated than non-irrigated conditions. At the 120 pound level of nitrogen application the increased yield was 700 pounds for irrigated and 400 pounds for non-irrigated cotton.

Scarsbrook et al. (8) reported that high nitrogen content of the cotton plant was associated with high yields and that nitrogen also

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increased the efficiency of irrigation water. They also reported interaction of nitrogen and moisture on cotton yields in 1959. Under irrigated conditions in combination with 240 pounds of nitrogen per acre, 1,794 pounds of lint cotton was produced.

Marshall et al. (5) and Phillips (6) reported that cotton yields were increased on Lintonia, Richland and Olivier silt loam soils from the addition of phosphorus and/or potassium fertilizers.

Cowan et al. (3) stated that boll rot, boll shedding and lodging are associated with high nitrogen and water and are most pronounced under high plant population. Acala 4-42 and Deltapine Smooth Leaf were found to perform differently under varying amounts of nitrogen and water regimes. Lint yields of Acala 4-42 were highest when plants received only adequate supplies of nitrogen and water. When nitrogen fertility level is adequate for maximum yields, excessive irrigation can produce such rank cotton with large amounts of boll rot that resulting yields are lower than those obtained under nitrogen deficiency conditions. Deltapine Smooth Leaf variety also grew more rank when given extra amounts of water and nitrogen but boll rot was not severe and yields were not depressed.

Amemiya et al. (1) found that the peak period of soil water depletion occurred at early bloom. High soil water extended this period and increased the rate and amount of water depleted. Cotton roots may extract water below their primary root zone, but the rate of extraction may not be great enough to maintain optimum plant growth during the periods of peak demand.

Taylor et al. (9) and Vasquez et al. (10) postulated that soil water extraction by plants is a function of the actively growing roots only when the soil is uniformly moist throughout the profile. More water is removed from the shallow depths, where root activity is greatest, and the distance water must move is the least when the soil profile is uniformly moist throughout. As the surface soil moisture is decreased a greater water suction is required thereby resulting in a decreased volume which can be removed from shallow depths. For the water demand of the cotton to be met, greater amounts of water have to be extracted from deeper depths where root activity is lower but the volume of water is greater. Then equal or greater amounts of water are removed from deeper depths at a given time interval. After an irrigation or rainfall, larger amounts of water are removed each day from progressively lower depths.

Marani et al. (4) studied the effects of a single irrigation on the production of cotton and concluded that cotton irrigated at the beginning of flowering was found to be the most advantageous, increasing the yield of lint more than the other treatments. This irrigation increased the number of bolls and also boll size. An irrigation applied at the initiation of flower bud formation was less effective in increasing the number of bolls. This was because of an excessive rate of shedding of young bolls
during the peak of flowering in July. A late irrigation applied at the peak of flowering was the least effective in increasing boll number. It did improve boll size, staple length, and fiber maturity.

Experimental Methods

The experiment, "Effect of Irrigation on the Response of Cotton to Fertilization," was located on Richland silt loam soil that was land-formed for row irrigation in 1955. After being leveled, the soil was limed with one ton of dolomitic limestone per acre. In 1959 an additional ton per acre was applied. The experimental design used was a split plot with irrigation treatments as the main plot. The irrigated and non-irrigated subplots were four 40-inch rows measuring 85 feet in length. Four replications were used. The two center rows were harvested for yield measurements. The cotton plots received nitrogen at the rate of 0, 60, 120, and 180 pounds per acre in all possible combinations with 60 and 90 pounds of P₂O₅ and K₂O. Ammonium nitrate was the source of nitrogen, superphosphate the source of P₂O₅, and muriate of potash the source of K₂O. Gated pipe was used to flood the irrigated plots with water until the soil reached field capacity. Soil samples were taken at 6-inch increments to a depth of 30 inches throughout the growing season, and when the available soil moisture dropped to approximately 50 percent the irrigated plots were watered to bring the moisture level to field capacity. The available soil moisture was determined to the effective depth that plant roots were extracting soil moisture. The moisture content of the 0- to 30-inch depth was determined by oven drying soil samples for 24 hours at 110° Centigrade. The moisture was expressed on an oven dry weight basis.

Stardel cotton was used throughout the years of testing. The cotton was planted by hill-dropping on a 12-inch spacing and thinned to leave two to three plants per hill. Planting was done at the earliest opportunity in May of each year. Karmex DL pre-emerge herbicide, post emergence oil, and flaming were used as conditions warranted. Except in 1962, the cotton was hand harvested for yield. This experiment was rotated each year with another experiment. The nitrogen fertility levels were the same for both experiments. They were held in the same plots throughout the years of testing.

Experimental methods for the study, "Yield of Cotton as Influenced by Water Regime and Plant Population," were the same as the above experiment except that this experiment was on Olivier silt loam soil and was fertilized at the rate of approximately 130 pounds of nitrogen and 72 pounds each of P₂O₅ and K₂O per acre.

The following moisture regime and plant populations were studied:

A. Water regime.
1. Not irrigated.
2. Irrigated when available moisture reached 25 percent level.
B. Plant populations.
1. One plant per hill 12 inches apart in the drill (13,100 plants per acre).
2. Three plants per hill 12 inches apart in the drill (39,200 plants per acre).
3. Six plants per hill 12 inches apart in the drill (78,400 plants per acre).

The experimental design was a split plot with the water regime as the main plot and plant populations as the subplot. The main plots were 12 rows 200 feet long; the subplots were four rows 200 feet long. The two inside rows of the subplot were harvested for yield. A buffer zone was maintained between irrigated and non-irrigated plots. Soil samples were taken at 6-inch increments to a depth of 30 inches throughout the growing season. When the available soil moisture reached the designated level these plots were irrigated to bring the moisture level to field capacity.

Effect of Irrigation on the Response of Cotton to Fertilization

Data for 1958

Yield Response: Yield increases from nitrogen on irrigated plots in 1958 (Fig. 1) were not significant above the 60 pound per acre rate

FIGURE 1.—Response of cotton to irrigation and nitrogen fertilization, 1958.
of nitrogen application. There were no significant yield increases of seed cotton at any nitrogen level on plots that did not receive irrigation. At the 60 pound rate of nitrogen application, irrigated cotton produced 1,940 pounds of seed cotton per acre while plots that did not receive any irrigation water produced 1,415 pounds of seed cotton per acre, 525 pounds less than the irrigated plots. Use of 90 pounds of phosphate and/or potash did not produce yields significantly higher than 60 pounds of these nutrients under either irrigated or non-irrigated conditions.

**Rainfall:** Total rainfall (20.2 inches) and distribution were adequate during April, May, June, and through July 29 (Fig. 2). Two inches of irrigation water was applied July 31 in order to maintain soil moisture at the 50 percent level. Irrigation was necessary again on August 11, but it was followed by 2.1 inches of rain, nullifying possible beneficial effects of the last irrigation. During the latter part of August and September large amounts of rainfall caused a considerable amount of boll rot.

**Soil Moisture Trends:** The soil was at field capacity July 9 when soil moisture determination was begun. By July 22 the cotton roots were definitely extracting moisture to a depth of 18 inches (Fig. 3) with the greater amount being extracted from the shallower depth and decreasing as depth increased. On August 11, at the 0- to 6-inch depth, the available soil moisture was 12 percent. For the remainder of the growing season the soil moisture was at or approaching field capacity.

![Figure 2: Rainfall distribution by 10-day periods, and irrigation water applied to cotton, 1958.](image-url)
FIGURE 3.—Soil moisture trends for irrigated and non-irrigated cotton from 0- to 30-inch depth, 1958.

Data for 1959

Yield Response: Cotton yields were increased by nitrogen applications up to 120 pounds per acre (Fig. 4) on irrigated and non-irrigated plots. Although irrigation did increase yields by 305 pounds of seed cotton per acre the difference was not significant. There was an interaction between irrigation and nitrogen application. Nitrogen with irrigation produced larger yields than nitrogen without irrigation. Use of 90 pounds of phosphate and/or potash did not produce yields significantly higher than 60 pounds of these nutrients under either irrigated or non-irrigated conditions.

Rainfall: During the month of May and through June 9 (Fig. 5) 11.5 inches of rain fell, which was above average for this period. For the 12-day period from June 10 through June 21 there was no rainfall. The total rainfall and distribution for the remainder of the growing season was adequate except for a 12-day period from August 8 through August 19. Two inches of irrigation water was applied to the designated
FIGURE 4.—Response of cotton to irrigation and nitrogen fertilization, 1959.

FIGURE 5.—Rainfall distribution by 10-day periods, and irrigation water applied to cotton, 1959.

plots on July 9. After application of the water, .8 inch of rain fell, possibly eliminating some benefits of the irrigation. A second irrigation was required on August 12. Rainfall was adequate for the remainder of the growing season.
Soil Moisture Trends: Non-irrigated plots had one extended dry period of 8 days from August 15 to August 23 (Fig. 6) at which time available soil moisture was almost completely depleted down to a depth of 24 inches. For the remainder of the growing season soil moisture was adequate. This appears to be the reason irrigated plots yielded only 305 pounds more seed cotton than non-irrigated plots.

Data for 1960

Yield Response: Yield of cotton on irrigated plots was very high—3,806 pounds of seed cotton per acre at the 120 pound level of nitrogen application (Fig. 7). Non-irrigated plots at the same rate of nitrogen application yielded 1,869 pounds, a difference due to irrigation of 1,937 pounds per acre. Cotton on irrigated plots responded to nitrogen applications up to the 120 pound level. On non-irrigated plots there was no yield response to nitrogen fertilization. There was an interaction between irrigation and nitrogen application. Use of 90 pounds of phosphate
and/or potash did not produce yields significantly higher than 60 pounds of these nutrients under either irrigated or non-irrigated conditions.

**Rainfall:** Total rainfall and distribution was very inadequate throughout the entire growing season (Fig. 8). For the months of April and May and through June 24 rainfall was considerably below normal, the total amount being 7 inches. There was a period from July 20 through August 9 that received only .4 inch of rain. In order to maintain moisture at the 50 percent level on irrigated plots, 2 inches of water was applied on July 14 and August 1. The latter part of August was extremely wet, the total amount of rainfall being 9.2 inches.

**Soil Moisture Trends:** Soil moisture data indicate that cotton roots were extracting some moisture from a depth of 30 inches in the soil (Fig. 9). The greater amount of the moisture was extracted from the upper zone of soil and decreased with depth. From the 0- to 12-inch depth most of the soil moisture was extracted approaching the 0 percent available moisture level.
FIGURE 8.—Rainfall distribution by 10-day periods, and irrigation water applied to cotton. 1960.

FIGURE 9.—Soil moisture trends for irrigated and non-irrigated cotton from 0- to 30-inch depth, 1960.
Data for 1961

Yield Response: Ample rainfall in 1961 made it unnecessary to water plots that were to have been irrigated. As a consequence, yields were substantially the same at each nitrogen level (Fig. 10). There were no increases from nitrogen application above the 60 pound per acre rate, nor were there any increases from the addition of 90 pounds of phosphate and/or potash in comparison with the 60 pound level of these nutrients.

Rainfall: During the first part of the growing season, May 2 through June 14, .7 inch of rain fell, (Fig. 11). For the remainder of the season there was ample rainfall and the distribution was good. As a consequence it was unnecessary to water plots that were to have been irrigated.

Soil Moisture Trends: Soil moisture was adequate for maximum crop yields throughout the growing season (Fig. 12). From June 12 through August 1 soil moisture was at or approaching field capacity. During the middle of August plant roots were extracting moisture from a depth of only 12 inches.
FIGURE 11.—Rainfall distribution by 10-day periods, and irrigation water applied to cotton, 1961.

FIGURE 12.—Soil moisture trends for irrigated and non-irrigated cotton from 0- to 30-inch depth, 1961.
FIGURE 13.—Response of cotton to irrigation and nitrogen fertilization, 1962.

Data for 1962

Yield Response: Irrigation significantly increased cotton yields at each nitrogen level (Fig. 13). The yield increase ranged from 204 pounds of seed cotton where no nitrogen was added to 907 pounds for the 120 pound rate. The average yields for all nitrogen treatments were 1,418 and 2,211 pounds for the non-irrigated and irrigated cotton, respectively.

The interaction of nitrogen and irrigation was highly significant. The yield of cotton fertilized with nitrogen under irrigation was significantly increased while the non-irrigated cotton responded very little to nitrogen rates. Yield increases under irrigation were similar for all rates of nitrogen from 60 to 180 pounds per acre, the average increase from these nitrogen rates being 877 pounds of seed cotton. Use of 90 pounds of phosphate and/or potash did not produce yields significantly higher than 60 pounds of these nutrients under either irrigated or non-irrigated conditions.

Rainfall: Rainfall was very erratic throughout the growing season (Fig. 14). For the month of April more than an average amount of
FIGURE 14.—Rainfall distribution by 10-day periods, and irrigation water applied to cotton, 1962.

FIGURE 15.—Soil moisture trends for irrigated and non-irrigated cotton from 0- to 30-inch depth, 1962.
rain fell, a total of 7.5 inches. The month of May was very dry with .5 inch of rain. June was an extremely wet month with a very uniform rainfall pattern. The remainder of the growing and fruiting season was very dry, and the small amount of rain that fell was very irregular. From June 29 through July 9 there was no rainfall. On July 10, July 24, August 10, and August 27 the cotton was irrigated, with 2 inches of water being applied at each irrigation. Through the important growing and fruiting season, from June 29 through September 17, only 3.5 inches of rain fell. There was an excellent harvesting season with extremely little lodging and boll rot.

Soil Moisture Trends: At the first soil moisture sampling, June 22, soil throughout the profile was at field capacity (Fig. 15). By July 9 at the 0- to 6-inch depth the soil moisture had been extracted down to 10 percent; at the 6- to 12-inch depth, 20 percent; at the 12- to 18-inch depth, 35 percent; at the 18- to 24-inch depth, 55 percent; and at the 24- to 30-inch depth, 65 percent. As the depth of sampling increased the percentage of soil moisture extracted decreased progressively with depth. The soil moisture had been extracted to the wilting point by August 10 down to a depth of 12 inches on plots that did not receive irrigation. From 12 to 24 inches, the available soil moisture had been extracted down to the 10 percent level. Due to extremely hot temperatures and low humidity more irrigation was required in 1962 than in the previous years.

Summary of Results

The amount of rainfall and irrigation supplied to cotton from 1958 through 1962 is given in Table 1. The total amount of rainfall supplied to the crop from April 1 through August 31 varied from 18.8 inches in 1962 to 34.1 inches in 1959. In 1959, the year with the largest amount of rainfall, two irrigations were required, while in 1961, which received 13.3 inches less rainfall, irrigation was not needed. This indicates that the distribution of rainfall is important, especially during the critical months of July and August. During these months the cotton plant requires more water for maximum production than at any other time. Two irrigations, one in July and one in August, were required in 1958, 1959, and 1960. In 1961 irrigation was not required due to the total amount and distribution of rainfall. In 1962 four irrigations were required, two each in July and August. The average amount of rainfall plus irrigation for July and August for the years 1958 through 1962 was 13.9 inches.

Supplemental irrigation increased cotton yields for the years 1958, 1960, and 1962. The amount and distribution of rainfall in 1961 made it unnecessary to irrigate. Yield increase due to supplemental irrigation for the 5 years of testing ranged from 0 to 1,937 pounds of seed cotton per acre.
TABLE 1.—Summary of Water Supplied to the Soil by Rainfall and Irrigation During Growing Seasons, 1958-1962, Winnsboro, La.

<table>
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<tr>
<td>April-August total</td>
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<td>July</td>
<td>11.1</td>
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<td>19.3</td>
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<td>Total water supplied, inches</td>
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Average yields for the 5 years at the 120 pound level of nitrogen were 2,602 and 1,852 pounds of seed cotton for the irrigated and non-irrigated plots respectively (Fig. 16). This is an average increase of 750 pounds of seed cotton per acre due to irrigation.

In 2 of the 5 years of testing under irrigated conditions, yield increases were obtained by nitrogen application up to the 120 pound per acre level. The other 3 years, 60 pounds of nitrogen produced yields comparable to higher rates of nitrogen applications. In 4 of the 5 years of testing, the 120 and 180 pound rates of nitrogen produced comparable yields. In 1961, the 180 pound rate of nitrogen decreased yields below that produced at the 120 pound rate. In all the years of testing there was no decrease in yield from the application of 120 pounds of nitrogen per acre, although in 3 of these years there was no increase in yields.

In 3 dry years of testing, 1958, 1960, and 1962, on non-irrigated plots there were very small increases in the yield of cotton by the application of nitrogen. Nitrogen applications up to the 120 pound rate resulted in yield increases in 1959, but in 1960 there were no increases above the 60 pound level.

Rainfall and distribution for the 5 years covering this study ranged from excellent to extremely poor. It appears that the distribution of rainfall is as important as the total rainfall during the growing and fruiting season.

The response of cotton yields to nitrogen fertilization is directly correlated to soil moisture. Under extremely dry conditions only small increases resulted from nitrogen application, while under favorable con-
ditions yields were increased by the addition of nitrogen up to the 120 pound level.

In years of inadequate or poorly distributed rainfall, cotton roots definitely extracted moisture from a depth of 30 inches in the soil. The greater amount of moisture was extracted from the 0- to 6-inch depth, and the amounts decreased progressively with greater depths. In wet years the plants' supply of water was supplied largely from the topsoil. For the water demand of the plant to be met during dry years, greater amounts of water had to be extracted from lower depths where there were fewer roots but more available water. It was evident that cotton plants extract water from below the 18-inch depth, but not enough for optimum growth during the critical period of blooming and boll development. After each watering by irrigation or rainfall, the same pattern of moisture depletion occurred.
Yield of Cotton as Influenced by Water Regime and Plant Population

Data for 1958

Yield Response: Irrigation increased cotton yields over plots that were not irrigated (Fig. 17). The average yield increase due to irrigation was 975 pounds of seed cotton per acre. As an average of all plant populations, there was no difference in yield between the plots that were maintained at the 25 percent and the 50 percent levels of available soil moisture.

On non-irrigated plots one stalk per hill produced higher yields than three or six plants.

On plots that contained one and three plants per hill 12 inches apart in the drill and where soil moisture was maintained at 25 percent and 50 percent availability, there were no differences in yield. With a plant population of six plants per hill there was a reduction in yield where the soil moisture was maintained at the 25 and 50 percent levels.

Rainfall: The total amount of rainfall (Fig. 18) during the cotton growing season was ample for maximum production but the distribution was poor. There were two periods from June 29 to July 9 and from July 29 to August 8 in which only .5 inch of rain fell. During the remainder of the growing season the distribution of water was good,

**FIGURE 17.—Response of cotton to levels of soil moisture and plant population, 1958**
FIGURE 18.—Rainfall distribution by 10-day periods, and irrigation water applied to cotton, 1958.

FIGURE 19.—Soil moisture trends for irrigated and non-irrigated cotton from 0- to 30-inch depth, 1958.
with the latter part of the growing season receiving too much rainfall. On July 21 and August 7 the plots that were maintained at the 25 percent level of available soil moisture were irrigated. Plots kept at the 50 percent level were irrigated July 18, July 30, and August 7.

Soil Moisture Trends: When sampling for moisture determination was begun July 8 (Fig. 19) the cotton roots were already extracting moisture down to the 30-inch depth. By August 5, on plots that were not irrigated all available soil moisture had been depleted to the 18-inch depth. The soil moisture on non-irrigated plots was nearly depleted down to 30 inches until the last of August, when more than average amounts of rain fell, thereby partially recharging the soil with moisture to the 30-inch depth.

Due to times of irrigation and rainfall, there were times when the plots that were to be irrigated when the soil moisture reached the 25 percent level contained more moisture than the plots which were irrigated when the soil moisture reached the 50 percent level.

Data for 1959

Yield Response: Due to the amount and distribution of rainfall (Fig. 20) there were no significant differences among irrigations or plant populations. On plots that had a plant population of six plants per hill and were irrigated at the 50 percent level there was a reduction in yield which approached significance.

Rainfall: From April 20 through May 10, a period of 20 days, .6 inch of rain fell (Fig. 21). May 11 through June 9 was very wet with a total of 11 inches of rain. From June 10 through June 19 was a period of 10 days that did not receive any rain. For the remainder of the growing season, small but consistent amounts of rain fell every 10 days ranging from .3 inch to 3.3 inches. During this period when the designated plots were irrigated, rain fell immediately following irrigation, which possibly minimized the effect of irrigation. The plots that were to be irrigated at the 25 percent available moisture level received irrigation July 9 and August 11. At the 50 percent level, plots were irrigated July 2, July 20, August 7, and August 14.

Soil Moisture Trends: Sampling for soil moisture was begun June 14 (Fig. 22), at which time soil moisture was at or approached field capacity. By July 13 on non-irrigated plots the soil moisture was approaching wilting point down to the 24-inch depth with the 6-inch depth having more moisture than the lower depth. For the remainder of the fruiting season the soil moisture from the 6-inch to the 24-inch depth was at the wilting point. The 0- to 6-inch depth contained small amounts of available soil moisture, thereby reflecting the small but uniform distribution of rainfall. Soil moisture on the plots irrigated at 25 and 50
percent levels had been extracted down to the 30-inch depth with the greater amount of moisture being extracted from the 0- to the 24-inch depth.
Data for 1960

Yield Response: Irrigation increased yields by 1,762 pounds of seed cotton per acre (Fig. 23). One plant per hill every 12 inches outyielded 3 and 6 plants per hill at all moisture levels. Under irrigated conditions, six plants per hill significantly reduced yields. Cotton on these plots had more lodging and boll rot, which probably accounts for the reduction in yield. There was a significant irrigation and plant population interaction. Under irrigation, as plant populations increased there was a reduction in yield.

Rainfall: The distribution of rainfall was very inadequate for the production of cotton (Fig. 24). The latter half of May through the middle of June was very dry. The last half of June through July 9, ample rain fell for optimum production. In order to maintain soil moisture at the 50 percent level, designated plots were irrigated July 11, July 28, and August 4. The 25 percent moisture level was maintained by irrigating July 25 and August 4. The last half of August was very wet with conditions conducive to boll rot.
FIGURE 23.—Response of cotton to levels of soil moisture and plant population, 1960.

FIGURE 24.—Rainfall distribution by 10-day periods, and irrigation water applied to cotton, 1960.

Soil Moisture Trends: Soil moisture during the entire growing season (Fig. 25), with the exception of the last of August, was never at field capacity. This was due to the dry April and May. By July 18 and through August 9 the non-irrigated plots were at wilting point to a depth of 12 inches. The plant roots were extracting moisture to 30
FIGURE 25.—Soil moisture trends for irrigated and non-irrigated cotton from 0- to 30-inch depth, 1960.

inches but the amount was not enough to supply the requirement of the plants.

Data for 1961

Yield Response: Due to the amount and distribution of rainfall there were no yield differences among the irrigations or plant populations (Fig. 26).

Rainfall: With the exception of the last of May through the first half of June, rainfall and distribution was ample for cotton production (Fig. 27). Due to rainfall the plots that were designated to be irrigated at the 25 percent level did not require irrigation. The 50 percent available soil moisture plots were irrigated on August 16 and September 9. Rainfall immediately after each irrigation probably accounts for the lack of yield response to irrigation.

Soil Moisture Trends: Throughout the soil profile to a depth of 30 inches, soil moisture was ample for maximum production of cotton
FIGURE 26.—Response of cotton to levels of soil moisture and plant population, 1961.

![Graph showing cotton yield per acre vs. plants per acre with different levels of soil moisture and plant population (13,100, 39,200, 78,400) and varying moisture percentages (Non-irrigated, 25% average moisture, 50% moisture).]

FIGURE 27.—Rainfall distribution by 10-day periods, and irrigation water applied to cotton, 1961.

![Bar chart showing rainfall distribution with irrigation water applied to cotton (April 10 to September 27) with 25%, 50%, and 25 & 50% irrigation levels.]

(Fig. 28). Most of the soil moisture requirement was obtained from the 0- to 18-inch depth.
FIGURE 28.—Soil moisture trends for irrigated and non-irrigated cotton from 0- to 30-inch depth, 1961.

Data for 1962

Yield Response: Irrigated cotton yielded 1,337 pounds of seed cotton more per acre than non-irrigated (Fig. 29). There were no significant differences between the 25 percent or 50 percent moisture regimes or among the plant populations. Due to the extremely dry harvesting season there was a minimum of lodging and boll rot.

Rainfall: May was an extremely dry month with a total of .5 inch of rainfall from May 1 through May 28 (Fig. 30). From July 1 through August 24, the most critical time for cotton production, 2 inches of rain was received. During this time the 25 percent moisture regime plots were irrigated July 13, July 27, and August 14. The 50 percent moisture level plots were irrigated July 5, July 13, July 23, August 7, and August 14.

Soil Moisture Trends: Available soil moisture on non-irrigated plots was approaching wilting point at the 0- to 6-inch depth July 12 (Fig. 31). The available soil moisture progressively reached the wilting point to a depth of 30 inches by August 8. Throughout the remainder of the
fruiting season the soil moisture remained at the wilting point to this depth. The plants did not permanently wilt and die; therefore, moisture appeared to be extracted from below the depth of sampling. During the latter half of August the plants under the 25 percent and 50
percent irrigation regimes were definitely removing moisture to the 24-inch depth.

**Summary of Results**

Irrigation increased cotton yields in 3 of the 5 years of testing. Yield increases from irrigation ranged from 104 pounds of seed cotton per acre to 1,913 pounds, with an average increase of 823 pounds.

A 5-year average yield of 1,524 pounds of seed cotton has been produced without irrigation, 2,329 pounds where the moisture level was maintained at the 25 percent available soil moisture, and 2,366 pounds where soil moisture was maintained at the 50 percent level (Fig. 32). There were no significant differences in yield between the 25 percent and 50 percent available soil moisture levels in any of the years of testing.

The number of irrigations required to maintain the soil moisture at the 25 percent level ranged from none to three with an average of 1.8
irrigations per year. The number required to keep the soil at the 50 percent level ranged from two to five, with an average of 3.2.

Yields for plant populations were significantly different in 2 of the 5 years of testing. These differences were for the years of 1958 and 1960. September of 1958 was extremely wet. Rain fell 13 days with a total amount of 11.9 inches. In August, 1960, rain fell 12 days with a total amount of 10.4 inches. During these 2 years of testing there were significant differences in yield due to population. Under all moisture regimes there was a decrease in yield as the number of plants per hill increased.

From the data it appears that in years having a wet late summer, as plant populations increase there will be a decrease in yield. For the years 1959, 1961, and 1962 there were no differences among the plant populations, which indicates that in years not having an extremely wet late summer population is not a factor in cotton production.

**Conclusions**

A study has been made to determine the effect of irrigation, fertilization, water regime, and plant population on the yield of cotton and moisture extraction patterns from the soil. Experiments were conducted at the Macon Ridge Branch Experiment Station, Winnsboro, on Richland and Olivier silt loam soil for a 5-year period, 1958 through 1962.

![FIGURE 32.—Response of cotton to levels of soil moisture and plant population, five-year average, 1958-62.](image-url)
Under the conditions which these experiments were conducted the following conclusions appear to be valid:

1. The response of cotton to irrigation must be evaluated over a period of several years. Yield increases due to supplemental irrigation on Richland silt loam soil ranged from 0 to 1,937 pounds of seed cotton per acre. Average yields at the 120 pound level of nitrogen were 2,602 and 1,852 pounds of seed cotton for irrigated and non-irrigated cotton respectively, with an average increase of 750 pounds of seed cotton per acre from irrigation.

2. Irrigation is made more effective by the use of nitrogen. With irrigation and no nitrogen on Richland silt loam soil the yield increase due to irrigation has ranged from 0 to 1,006 pounds per acre, with an average increase of 273 pounds. At the 120 pound rate of nitrogen the yield of cotton ranged from 100 to 1,937 pounds per acre, with an average increase of 750 pounds per acre.

3. The total rainfall and distribution was found to be extremely critical during the months of July and August. During the 5 years that the "Effect of Irrigation on the Response of Cotton to Fertilization" study was conducted, two irrigations, one in July and one in August, were required in each year 1958, 1959, and 1960. In 1961, irrigation was not required due to total amount and distribution of rainfall. In 1962, four irrigations were required, two each in July and August.

4. Although significant yield increases were obtained from the 120 pound nitrogen rate in 2 of the 5 years of testing, no reduction in yields occurred in the other 3 years. In 1 of the 5 years, 180 pounds of nitrogen reduced cotton yields. The interaction of irrigation and nitrogen rates was significant in 3 of the 5 years of testing.

5. From the data it appears that different nitrogen recommendations can be justified for irrigated and non-irrigated cotton. On Richland silt loam, and for other soils with similar physical and chemical properties, a nitrogen rate between 90 and 120 pounds per acre can be recommended for cotton grown under irrigated conditions and 60 to 80 pounds for non-irrigated cotton.

6. Due to limitations of the experimental design it was impossible to determine if yield increases were obtained by the addition of 60 pounds of phosphorus and/or potassium. There were no increases in yield under irrigated or non-irrigated conditions from the addition of phosphorus and/or potassium above the 60 pound level.

7. It appears that one plant per hill 12 inches apart in the drill on Olivier silt loam soil is equal to or better than the other plant populations studied. High nitrogen levels under irrigated
conditions coupled with a thick plant population and a wet late summer is more conducive to plant lodging and boll rot, thereby reducing cotton yields.

8. Irrigating at approximately the 25 percent available soil moisture level was as effective in increasing yields as irrigating at approximately the 50 percent available soil moisture level. On the average it would require approximately one irrigation more to maintain the soil at the 50 percent moisture level in the Macon Ridge area. Irrigation on Olivier silt loam soils increased yields by 823 pounds of seed cotton per acre.

9. Cotton roots will extract most of their moisture supply from the topsoil in years of ample rainfall. In dry years more of the moisture needs of the cotton plants will be met by extracting water from greater depths, but the amount which can be extracted will be progressively less as depth increases. In very dry years it is obvious that moisture is extracted from below the 24-inch depth, but not enough to maintain optimum growth during the critical period of blooming and boll development.
Literature Cited


