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Cotton Irrigation In the Lower Rio Grande Valley

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Contents

Summary

Irrigation spacing experiments for cotton indicate that the water requirement of cotton is dependent upon the soil type which determines the rooting characteristic of the cotton plant. Moisture use on the Harlingen clay was restricted mainly to the surface 2 feet of soil because 90 to 99 percent of the roots were found to be in the surface foot of soil. Eighty percent of the roots of the cotton plants growing in Willacy loam soil were found to be in the top 2 feet of soil. However, moisture use on the Willacy loam occurred at lower soil depths because some root development was found to occur at 3 to 5 feet. Because of restricted root growth on Harlingen clay, cotton grown on this and similar soils must be irrigated more frequently than cotton grown on soils of the Willacy or Hidalgo series.

Maximum demand for moisture by cotton plants started during the early flowering stage and continued until most of the bolls were mature. Additions of water through irrigation or rainfall during this critical water demand period (during and immediately after bloom stage) increased cotton yields. Proper timing of irrigation to coincide with stages of maximum use and demand can reduce water use and produce higher yields.

Irrigation schedules for cotton have been proposed for Willacy loam and Harlingen clay soils. Satisfactory yields have been produced with a preplanting irrigation and an irrigation about 30 days after appearance of first bloom on the Willacy loam soil, but this schedule must be modified for a given farm situation. Satisfactory yields were produced on Harlingen clay when the cotton plants were irrigated at approximately 15-day intervals during the blooming and fruiting period.

Close spacing of cotton (3 to 6 plants per foot) increased yields when a high level of soil moisture was maintained.

Cotton Irrigation in Lower Rio Grande Valley

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COTTON ACCOUNTS for 40 to 50 percent of the farm cash income in the Lower Rio Grande Valley. As cotton is important to the economy of the area, research has been conducted at the Lower Rio Grande Valley Experiment Station since 1949 to find answers to some of the problems of soil and water management in cotton production and to find ways of making more efficient use of the limited supply of irrigation water.

Studies to determine the influence of moisture levels, plant spacings and date of planting on the yields and quality of cotton on coarse and medium-textured soils were conducted in 1949-50 and 1955-57. Results of these studies were reported previously (3, 4, 5, 7, 8).

Additional research was conducted on the Laredo clay loam and Willacy loam in 1958 and 1959, respectively, and on the Harlingen clay from 1960-62 (9). Research was conducted on Hidalgo sandy clay loam in 1961-62.

Objectives of the investigations were:

1. To determine the effects of moisture levels, plant spacings and date of planting on yield, growth and fiber characteristics of cotton.
2. To determine the water requirements of cotton as influenced by treatment and stage of plant growth.
3. To determine the best water management practices for the production of acceptable and/or economical yields of cotton with only a limited supply of irrigation water.

The purpose of this publication is to summarize the results of the studies and to propose irrigation schedules for coarse and medium-textured soils such as the Willacy and Hidalgo soil series and fine-textured soils such as the Harlingen clay.

Definition of Terms

Available soil moisture refers to the water retained in the soil between the limits of field capacity and the permanent wilting percentage. It is the moisture available to plants.

Field capacity is the quantity of water retained in the soil after gravitational water drains following an irrigation or heavy rain (1 to 3 days after an irrigation or rain).

Permanent wilting percentage refers to the soil moisture remaining in the soil after the plants have withdrawn all they can and wilt permanently.

Moisture percentage refers to the moisture in the soil based on the weight of the ovendry soil. Ovendry soil refers to a soil that has been heated at 110° C. for 24 hours.

Transpiration refers to the water absorbed by the crop or plants and evaporated from plant surfaces.

Evaporation refers to the moisture loss from a fallow or barren soil.

Evapotranspiration refers to the total moisture used in evaporation and transpiration.

Climate

The Lower Rio Grande Valley includes Cameron, Hidalgo, Willacy and Starr Counties and is located at the southern tip of Texas. The climate is subtropical. Weather records for 48 years at the Weslaco station show an average annual precipitation of 23 inches. However, the annual precipitation varies considerably from year to year. The highest recorded annual precipitation during this period was 40.4 inches in 1941; the lowest recorded was 7.8 inches in 1956. Variations in rainfall throughout the growing season emphasize the importance of irrigation to the agricultural economy of the area. The average monthly rainfall over a period of years indicates that the highest amount occurs from April through October. These average monthly rainfall data vary from 1 inch in February to about 4 inches in September.

The average relative humidity is approximately 75 percent. Open-pan evaporation is approximately 0.15 inch per day (55 inches per year). However, the average daily evaporation loss varies from approximately 0.08 inch per day in January and December to 0.25 inch per day in July and August. Wind velocity is extremely variable, but the average is 4 miles per hour. Prevailing wind direction is from the southeast.

A 48-year record at the Weslaco station shows an average maximum temperature of 84.5° F. and an average minimum temperature of 63.3° F. A 25-year period shows an average annual growing season of 330 days, with the average

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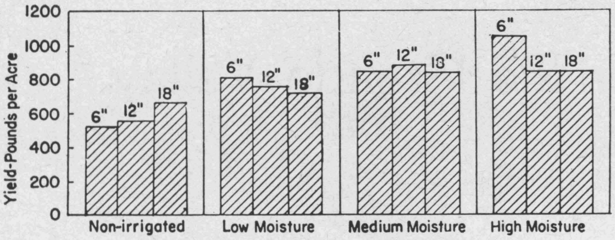

Figure 1. Yield of lint cotton as influenced by four moisture levels and three plant spacings on Willacy fine sandy loam, 1949.

date of the first killing frost on December 20, and the average date of the last killing frost on January 25.

Climatic conditions favor the planting of cotton from February 1 to March 31. Pink bollworm infestations make it necessary for the farmers to harvest and destroy green cotton stalks each year before September 1 to aid in the control of this pest. Such factors allow a growing period of 120 to 180 days for the cotton crop.

Location and Soils

Willacy Series (8)

Irrigation experiments were conducted on the Lower Rio Grande Valley Research and Extension Center (Field Station No. 15), two miles east of Weslaco, in Hidalgo County. The station is centrally located in the irrigated area of the Lower Rio Grande Valley.

The experiments were conducted on Willacy fine sandy loam and loam soils. The Willacy series is a deep, coarse to medium-textured, moderately permeable soil. The subsoil has a depth of more than 10 feet in places and usually is classed as a sandy clay loam or clay loam. Moderate to good drainage and a deep sandy clay loam subsoil enables this soil to hold a good reserve of soil moisture. The top 5 feet of this soil will hold 9 to 11 inches of available soil moisture. The organic matter content of the surface 6 inches varies from 1 to 1.5 percent.

Hidalgo Series

Irrigation studies designed to study the internal moisture stress within plants were conducted on Hidalgo sandy clay loam during 1961-62 on the Agricultural Research Service Farm 5 miles north of Weslaco, Texas. These soils resemble the Willacy soils except the Hidalgo series are calcareous on the surface; Willacy soils are not calcareous to a depth of at least 18 inches. The drainage, water-holding capacity and organic matter content are similar to the Willacy series.

TABLE 1. MOISTURE LEVELS USED AND PERCENTAGES OF MOISTURE AT WHICH IRRIGATION WATER WAS APPLIED TO COTTON ON WILLACY FINE SANDY LOAM SOIL

Moisture level	Percentage of available moisture	Percentage of soil moisture at maximum allowable stress	
		1949	1950
High	75	15.4	13.3
Medium	50	12.8	11.2
Low	25	10.1	9.1

Laredo Series

An irrigation-fertility experiment was conducted in 1958 a few miles southeast of Progreso, Texas about 1/4 mile from the Rio Grande river. The clay loam surface was underlain by sand. The sand usually was found at 2 to 3 feet but also was found at depths of from 1 to 5 feet at this particular location. Some of the soil at this location might be classified as a mixture of Laredo and Cameron soils. Laredo has slow surface drainage but excellent internal drainage; Cameron has slow surface drainage and slow internal drainage. The top 5 feet of this soil will hold 8 to 14 inches of available soil moisture. The organic matter of the surface 6 inches varies from 1.5 to 2 percent.

Harlingen Series

Irrigation-spacing experiments on cotton were conducted about a mile northeast of Progreso, Texas. This soil is a clay to a depth of at least 5 feet. The clay mineral is predominantly montmorillonite. The Harlingen clay exhibits high swelling and shrinkage, severe cracking when dry and very poor surface and internal drainage. This soil is highly calcareous and usually contains over 2 percent organic matter. The top 5 feet of soil will hold about 7 to 8 inches of available moisture.[1]

Discussion of Yield Data

Moisture Level-Spacing-Planting Date Studies[2] on Willacy Series

The influence of moisture level-spacing studies in 1949-50 are indicated in Figures 1 and 2 (5). Description of treatments are listed in Table 1; the amounts of water applied to the different treatments and amount of water supplied by rainfall are indicated in Table 2. Cotton yields were significantly increased by irrigation in 1949 but not in 1950. Heavy rainfall after blooming caused an increase in the yields of cotton on the nonirrigated and low moisture treatments in 1950.

Cotton thinned to 6-inch spacings (8) produced higher yields than cotton spaced 12 and 18 inches apart when a high level of moisture was maintained, Figures 1 and 2.

[1]Field capacity was approximately equivalent to 0.8 atmosphere percentage as determined on a disturbed sample in the laboratory.

[2]Procedures used in conducting experiment and detailed information of these studies are described in Texas Agricultural Experiment Station Bulletin 916 (8).

TABLE 2. AMOUNTS OF WATER APPLIED, EFFECTIVE RAINFALL, AND NUMBER OF IRRIGATIONS ON MOISTURE LEVEL AND PLANT SPACING EXPERIMENT IN 1949 AND 1950 ON WILLACY FINE SANDY LOAM SOIL

Moisture treatments	Number of irrigations: Before bloom stage	During bloom stage	Water applied, inches	Rainfall, inches	Total water applied, inches
		1949			
High	1	4	17.0	3.6	20.6
Medium	0	3	8.5	3.6	12.1
Low	0	2	5.5	3.6	9.1
Non-irrigated	0	0	0	3.6	3.6
		1950			
High	2	3	16.4	10.9	27.3
Medium	1	3	13.6	10.9	24.5
Low	0	2	7.5	10.9	18.4
Non-irrigated	0	0	0	10.9	10.9

The influence of soil moisture treatments and planting dates on yields was evaluated from 1955 through 1957 and is indicated in Figure 3 (8). Descriptions of treatments are indicated in Table 3; the amount of water applied to different treatments and rainfall for 1955-57 are indicated in Table 4. Cotton yields were generally increased by irrigation during the blooming and fruiting period, especially in 1955-56 because the cotton was grown under relatively dry conditions. The yield of cotton grown on treatment D, planted on March 15, 1956, was low because it failed to receive one scheduled irrigation late in the season. Cotton grown on treatment E, which received a preplanting irrigation and an irrigation 30 to 40 days after first bloom, averaged over 2 bales per acre during 1955-57. This practice produced high yields and made efficient use of water which is often limited.

Yield differences between planting dates in 1955-56 were insignificant. However, yields of March-planted cotton in 1957 were higher than February-planted cotton.

Some factors which may favor delaying cotton planting until March 1 to 15 are: (1) cotton planted in late March requires less water than cotton planted in early February; (2) March-planted cotton may be exposed to less cold, damp weather which often reduces growth and yield; (3) results seem to indicate that March-planted cotton produces as much or more cotton than February-planted cotton; and (4) planting cotton in March will often reduce production cost, notably in fewer irrigations. The need for reseeding March-planted cotton probably is less frequent than for February-

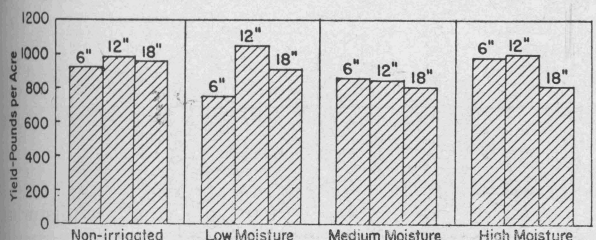

Figure 2. Yield of lint cotton as influenced by four moisture levels and three plant spacings on Willacy fine sandy loam soil, 1950.

TABLE 3. IRRIGATION TREATMENTS FOR COTTON GROWN ON WILLACY LOAM SOIL, 1955-57, 1959 AND LAREDO CLAY LOAM, 1958

Moisture level	Irrigation differential treatments	Years in which specific treatments were evaluated	Percentage of soil moisture at maximum allowable stress[1]
A	Irrigated when the average available moisture content of the top 2 feet of soil reached 65 percent at any time before bloom stage. Cut off irrigation water after blooms appeared.	1955-59	16.4 Early season
B	Irrigated when the average available moisture content of the top 2 feet of soil reached 35 percent before bloom stage. Cut off irrigation water after blooms appeared.	1955-57	12.8 Early season
C	Irrigated when the average available moisture content of the top 2 feet of soil reached 35 percent before bloom stage. From bloom stage until most of the bottom bolls were mature and open, irrigated when the average available moisture content of the top 2 feet of soil reached 65 percent.	1955-59	12.8 Early season to 16.4 late season
D	Irrigated when the average available moisture content of the top 2 feet of soil reached 35 percent until the bottom bolls were hard and firm. From this boll maturity stage until approximately three-fourths of the bolls were mature, irrigated when the average available moisture content of the top 2 feet of soil reached 65 percent.	1955-59	12.8 Early season to 16.4 late season
E	Irrigated throughout the season when the average available moisture content of the top 2 feet of soil reached 20 percent.	1955-59	11.0 All season
F	No irrigation after preplanting irrigation.	1957	

[1]Average soil moisture percentage in top 2 feet of soil, which was used as the moisture control zone.

TABLE 4. AMOUNTS OF WATER APPLIED TO DIFFERENT MOISTURE LEVEL TREATMENTS AND AMOUNTS OF RAINFALL DURING THE COTTON SEASON ON WILLACY LOAM SOIL, 1955-57

Treatments	Inches of Water: Feb. 15 planting date 1955	1956	1957	March 15 planting date 1955	1956	1957	Average number of irrigations for each treatment
A	6.0	8.1	10.4	6.2	6.1	5.0	2
B	4.7	5.0	6.0	3.0	4.2	5.6	1
C	21.6	21.1	23.3	16.2	17.3	24.0	4
D	22.4	15.5	17.8	14.6	10.7	17.6	3
E	6.9	7.7	7.4	7.0	5.7	7.8	1
F			0.0			0.0	0
Total rainfall	3.5	4.3	13.5	3.3	4.0	9.6	

planted cotton. However, February-planted cotton matures 7 to 10 days earlier, which usually makes the problem of boll weevil and bollworm control less serious than with the March-planted cotton. Cotton planted in February, on the average, can be harvested completely before the possible occurrence of tropical storms and heavy rains late in August, thus reducing the likelihood of field losses and poor grades.

The influence of irrigation treatments A, C, D and E[3] on cotton yields and moisture use was evaluated in 1959 as shown in Table 5. The amount of water applied, number of irrigations for each treatment and rainfall also are indicated in Table 5. Yields were significantly influenced by treatments. Cotton on treatment E, which received two irrigations after first blooms produced the highest yields. Cotton on treatment A which received three irrigations before first blooms produced the lowest yields. Insect infestation late in the season and boll rot were probably responsible for the difference in yields between treatments C, D and E.

Cotton quality varied slightly with moisture treatments and planting dates, but irrigation generally decreased strength and increased fiber length (8). Lint percent and boll size were greater in the February-planted cotton

[3]Treatments described in Table 3.

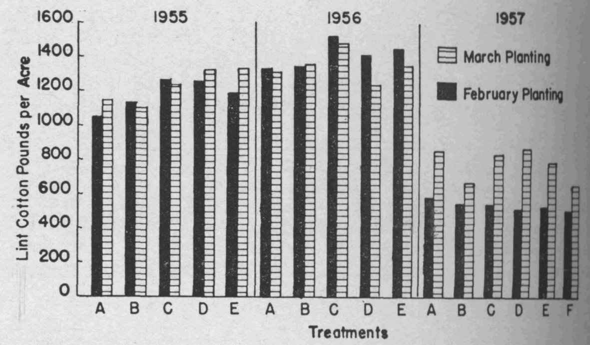

Figure 3. Effect of soil moisture levels and planting dates on cotton yields on Willacy loam soil, 1955-57.

than in the March-planted cotton (8). Completion of harvesting usually was delayed approximately 7 to 10 days by planting on March 15 rather than on February 15. Applications of water during fruiting (treatments C, D and E) delayed maturity.

Moisture Level Studies on Hidalgo Series

Irrigation treatments based on the relative turgidity[4] of the cotton leaves on Hidalgo sandy clay loam were investigated during 1961-62. The treatment descriptions are listed in Table 6; the yield and moisture use data are indicated in Table 7. Treatments based on relative turgidity did not have any influence on yields in 1961, but they significantly influenced yields in 1962. Differential responses in 1961-62 were probably caused by climatic factors.

Relative turgidity of the cotton plants grown on treatment B fell below 70 percent only three times in 1961. Timely rainfall and mild evapotranspiration conditions caused no great differences to occur in plant moisture stress among the treatments in 1961. It is important to note that 4.8 inches of rain fell on the plots from first bloom until 40 days after first bloom in 1961.

The yield data in 1962 sharply contrasted with the 1961 data. Marked differences in the

[4]Relative turgidity $(RT) = \frac{FW - DW}{TW - DW} \times 100$ where FW = fresh weight of cotton leaves; TW = weight of cotton leaves at full tugor or after leaves are floated on distilled water; DW = ovendry weight of cotton leaves.

TABLE 5. YIELD AND MOISTURE USE BY COTTON ON WILLACY LOAM IN 1959

Treatment[1]	Yield pound lint cotton per acre[2]	Soil moisture depletion, inches[3]	Rainfall, inches	Water applied, inches	Total water used, inches	Number of irrigations before blooming	after blooming
A	1200	6.5	3.9	9.0	19.4	3	0
C	1385	4.7	3.9	23.9	32.5	2	4
D	1320	4.8	3.9	21.3	30.0	2	3
E	1480	5.1	3.9	12.1	21.1	0	2

[1]Treatments did not receive a preplanting irrigation in 1959. Treatments are described in Table 3.
[2]L.S.D. (0.05) = 160 pound per acre.
[3]Available soil moisture on March 11 minus available soil moisture on August 6.

TABLE 6. DESCRIPTION OF PLANT MOISTURE STRESS TREATMENTS

Treatment number	Treatment description
1.	Irrigated when relative turgidity values were in the 70 to 72 percent range.
2.	Irrigated when relative turgidity values were in the 64 to 66 percent range.
3.	Irrigated approximately 7 days after relative turgidity values reached the 60 to 62 percent range.

relative turgidity of the cotton plants were observed between treaments in 1962. It is noteworthy that less than 1 inch of rain fell on the plots during a period of 40 days after the appearance of first bloom in 1962. Cotton grown on treatment B was severely stressed before irrigation. Cotton plants having relative turgidity values below 70 percent for extended period of time produced substantially less cotton. The period of time from the first bloom to the irrigation of treatment B was 38 days. Results of the studies have indicated that relative turgidity measurement of the cotton leaves could be used as a basis or guide to determine when to irrigate.

Moisture Level Studies on Laredo Series

Yield, irrigation and moisture use data for studies conducted on Laredo clay loam soil in 1958 are presented in Tables 8 and 9, respectively. Cotton yields of treatment A on replications 3 and 4 were different from yields on replications 1 and 2 as indicated in Table 8. The cotton plants on treatment A (replications 3 and 4) were evidently able to obtain moisture from the water table late in the season. Moisture sampling data[5] late in the growing season indicated that free water was present at about 3 feet in the 3 and 4 replications at this site. The response to irrigation on this soil was similar to the yield response on the Willacy loam soil. However, the response of cotton to irrigation on these soils would probably vary from location to location because soils bordering the Rio Grande river are often extremely variable.

TABLE 7. MOISTURE USE AND YIELD OF COTTON ON HIDALGO SANDY CLAY LOAM, 1961-62, WESLACO, TEXAS

Moisture treatments	Number of irrigations	Soil moisture depletion[1]	Irrigation water applied	Rainfall	Total use	Yield lint cotton[2]
		Inches	Inches	Inches	Inches	Pounds per acre
1961						
A	3	4.9	14.9	7.9	27.7	1050
B	1	5.9	6.8	7.9	20.6	1120
C	0	6.5		7.9	14.4	1040
1962						
A	3	3.6[3]	17.7	5.4	26.7	990[4]
B	1	4.1	8.0	5.4	17.5	700
C	0	6.7		5.4	12.1	600

[1]Available soil moisture on March 29 minus available soil moisture on July 25.
[2]No significant difference in yields in 1961.
[3]Available soil moisture on March 20 minus available soil moisture on July 27.
[4]Moisture level LSD (0.01) = 108 pounds per acre.

TABLE 8. YIELD OF COTTON AS INFLUENCED BY DIFFERENT MOISTURE TREATMENTS ON LAREDO CLAY LOAM SOIL IN 1958

Moisture treatments[1]	Average yield pounds lint cotton per acre replications 1 and 2	Average yield pounds lint cotton per acre replications 3 and 4	Average yields
A	960	1310	1135
C	1210	1155	1185
D	1260	1245	1250
E	1055	1035	1045
LSD (0.05)	130 pounds per acre	A significantly higher in yield than E	N.S.

[1]Description of treatment in Table 3.

Moisture Level - Spacing Studies on Harlingen Series

Moisture and spacing treatments are described in Table 10. A summary of cotton yields in 1960-61 as influenced by moisture and spacing treatments is shown in Table 11. Cotton yields ranged from about 300 pounds under treatment A to about 1,000 pounds of lint cotton per acre under treatments B and C. There were no significant differences in yield between treatments B and C. However, treatment D produced significantly less cotton than treatments B and C and significantly more cotton than treatment A. High soil moisture stress conditions during the blooming and fruiting period were responsible for the low yields of cotton under treatments A and D.

[5]Unpublished data.

TABLE 9. NUMBER OF IRRIGATIONS, RAINFALL AND MOISTURE USE DATA FOR MOISTURE LEVEL TREATMENTS ON LAREDO CLAY LOAM SOIL IN 1958

Moisture level treatments[1]	Number of irrigations before bloom stage	Number of irrigations after bloom stage	Soil moisture depletion, inches[2]	Water applied, inches	Rainfall, inches	Total water used, inches
A	2	0	5.7	5.4	7.3	18.4
C	0	3	3.9	10.7	7.3	21.9
D	0	2	4.5	7.7	7.3	19.5
E	0	1	6.4	6.5	7.3	20.2

[1]Treatment descriptions are in Table 3.
[2]Available soil moisture on February 17 minus available soil moisture on August 11.

Treatment B was irrigated when the surface 2 feet of soil approached 50 percent of available moisture in 1961 as compared to 75 percent of available moisture in 1960. Treatment C was changed to 25 percent in 1961 as compared to 50 percent in 1960; treatment D was changed to 0 percent in 1961 as compared to 25 percent in 1960. Even with these changes, the 1960 and 1961 yields were almost identical. This may have been because the cotton was planted on March 7 in 1961 as compared to April 11 in 1960. However, the number of days between irrigations in 1961 for treatments B, C and D were almost identical to the number of days between irrigations in 1960. The average number of days between irrigations for treatment B was 13 days in 1960 and 11 days in 1961. The average number of days between irrigations for treatment C was 16 in 1960-61. The average number of days between irrigations for treatment D was 18 in 1960 and 19 in 1961. Treatments B and C were first irrigated when the first blooms were noted in 1960-61. In the case of treatment D, the first irrigation in 1960 occurred 13 days after the first blooms, as compared to 19 days after the first blooms in 1961. This would suggest the following: (1) little or no difference in the treatments during 1960-61 and (2) the possible critical need of the cotton plant for moisture during the early blooming stage. High soil moisture stress for a few days after the appearance of first bloom may cause marked reduction in yields on the Harlingen clay soil. Attempts were made to evaluate this hypothesis in 1962.

TABLE 10. DESCRIPTION OF MOISTURE LEVEL AND SPACING TREATMENTS ON HARLINGEN CLAY, 1960-62

Soil moisture (main treatments)[1]	Percent of moisture at maximum allowable stress 1960	1961	1962
Before the bloom stage, cotton in all moisture treatments was to be irrigated when the moisture content of the top 2 feet of soil was depleted to 25 percent of the available moisture. Moisture treatments B, C and D were initiated after the bloom stage.			
A. No water was applied after the bloom stage.			
B. Irrigation brought to field capacity the top 5 feet of soil when the average moisture content of the top 2 feet approached 75-50 percent[2] of the available moisture.	28	25	25
C. Irrigation brought to field capacity the top 5 feet of soil when the average moisture content of the top 2 feet approached 50-25 percent[2] of the available moisture.	25	23	23
D. Irrigation brought to field capacity the top 5 feet of soil when the average moisture content of the top 2 feet approached 25-0 percent[2] of available moisture.	25	21	21
Plant spacing (subplots)[3]			
1. Unthinned. (Approximately five plants per linear foot).			
2. Spaced 6 inches.			
3. Spaced 12 inches.			

[1]All moisture levels received a preplanting irrigation and were irrigated on the basis of changes in average available moisture of the top 2 feet under all spacing treatments. Field capacity is approximately 31 percent; 15-atmosphere tension is approximately 21 percent.

[2]First percentages were used in 1960; second percentages were used in 1961 and 1962.

[3]Plant spacing treatments were not investigated in 1962.

The data from 1960-61 indicated that cotton on the Harlingen clay will need water every 15 days during the blooming and fruiting period. The irrigation schedule should begin at first bloom. Such a schedule apparently will produce about 2 bales of cotton per acre on Harlingen clay soil provided soil management, insect control practices and climatic factors are satisfactory. This means that March-planted cotton will require four to five irrigations depending upon rainfall. Light rains such as occurred in 1960-61 often only wet the top few inches of the Harlingen clay soil. This moisture is usually lost by evaporation and not used by the plants.

Moisture level C was the most efficient treatment with respect to pounds of cotton produced per inch of water; treatment A was the least efficient. High moisture level treatments delayed maturity and decreased lint percentage.

A summary of cotton yields in 1962, as influenced by moisture treatments, is indicated in Table 12. Cotton yields ranged from approximately 725 pounds of lint cotton per acre under treatment B to about 500 pounds under treatment A. Factors such as climate, cropping system (continuous cotton) and use of poor quality water probably contributed to poor stands and low yields in 1962. Cotton planted on March 6 and 26 and on April 11 for the purpose of evaluating the influence of moisture levels and plant spacings on yields failed to emerge to a satisfactory stand. However, the stand from the April 11 planting was used to study the influence of moisture level on yields. Cotton yields under treatments A, C and D were not significantly different.

Because treatments B and C produced approximately the same yields during 1960-61, treatment C was changed in 1962 to evaluate the importance of irrigation at bloom stage. Treatment B was irrigated when the first bloom appeared; treatment C was irrigated 10 days after the appearance of first blooms. Yields of cotton under treatment C may have been influenced by high intensity rains which followed the first irrigation in 1962. However, the difference in yield between treatments B and C was probably due to the delay in irrigation at bloom stage, suggesting that it is important to initiate irrigation soon after the appearance of the first blooms.

Observations indicate that early application of water to small cotton on this soil often delays the growth of the plants and subsequently lowers yields. This is probably a function of soil temperatures. Low night temperatures in the spring and summer were probably responsible for marked reduction in yields and retarded growth of cotton plants in the Lower Rio Grande Valley in 1962. Treatment A was higher in yield in 1962 than in previous years because of heavy rains (5.8 inches) from June 23-26.

High moisture level treatments increased boll size, decreased lint percentage, decreased the pounds of cotton produced per inch of water and delayed maturity in 1962. Cotton fiber length was increased but fiber strength was decreased by the application of water during the fruiting period.

Plants grown under a low level of moisture were about 20 inches tall; plants under a high level of moisture were about 30 to 36 inches tall. Cotton grown on moisture treatment D was only slightly taller than cotton grown on treatment A.

Closely spaced cotton produced significantly higher yields, as indicated in Table 11, especially under treatments B and C. It seemed to mature earlier on treatments A, B, C and D in 1960 and A, C and D in 1961 but delayed maturity in the case of treatment B in 1961. It produced a smaller boll, Table 11, greater total tonnage of plant material and smaller plants, which had a tendency to lodge in 1960 but not in 1961.[6]

[6]This may have been due to a difference in variety.

TABLE 12. SUMMARY OF DATA FOR COTTON IRRIGATION EXPERIMENT CONDUCTED IN 1962 ON HARLINGEN CLAY SOIL[1]

Irrigation treatments	Average yield pounds of lint per acre[2]	Pounds of cotton per inch of water	Bolls per pound	Percent lint
A	500	37	99	35.8
B	725	31	96	33.4
C	555	27	98	34.0
D	520	36	97	35.5

L.S.D. (0.05) = 75 pounds per acre.
L.S.D. (0.01) = 110 pounds per acre.

[1]Average of four replications.
[2]These yield values were corrected to eliminate skips in the row.

Cotton grown under moisture level treatments B and D did not defoliate as well as under other treatments possibly because of moisture stress of plants at time of application. However, closely spaced cotton did not defoliate as well probably because the lower leaves of the cotton plant did not receive adequate concentration of defoliant. This was also probably true of moisture level treatment B which produced high plant tonnage. However, the defoliation response of cotton grown on moisture level treatment D was probably due to moisture stress of plants or physiological stage of plant growth.

Inadequate coverage of the row middles by cotton plants in treatment D resulted in a high weed population late in the season. Modification of the soil moisture regime causes tremendous changes in the plant growth which would influence the management of the cotton crop.

TABLE 11. SUMMARY OF DATA FOR COTTON IRRIGATION-SPACING EXPERIMENT CONDUCTED IN 1960-61 ON HARLINGEN CLAY[1]

Irrigation treatment	Plant spacing treatment	Average yield pound of lint per acre		Pounds of cotton per inch of water		Bolls per pound[2]		Percent lint	
		1960	1961	1960	1961	1960	1961	1960	1961
A	1	322	342	34	31	106	104	36.6	38.4
A	2	330	334	34	30	93	102	36.0	37.3
A	3	314	349	32	31	92	89	36.5	37.2
Average		325	341	33	31	97	98	36.3	37.6
B	1	898	1093	41	44	82	90	35.6	36.3
B	2	861	1067	39	43	78	85	36.0	36.5
B	3	824	977	38	39	77	82	36.2	36.1
Average		860	1045	39	42	79	86	36.0	36.3
C	1	1037	1127	48	51	82	91	36.9	36.3
C	2	936	1083	44	49	77	85	36.5	36.9
C	3	919	996	43	45	76	83	37.4	36.8
Average		963	1068	45	49	78	86	36.9	36.3
D	1	729	772	37	39	88	94	36.3	37.2
D	2	704	794	36	40	82	85	36.3	37.0
D	3	749	752	38	38	81	85	36.5	36.8
Average		727	772	37	39	84	88	36.3	37.0

[1]Moisture level L.S.D. (0.01) = 109 (1960), 72 (1961) pounds of lint cotton per acre.
Moisture level L.S.D. (0.05) = 72 (1960), 47 (1961) pounds of lint cotton per acre.
Linear component of spacing significant at (0.05).
[2]Boll size at time of first picking.

Discussion of Water Requirements of Cotton

Angus (2) referred to the water use by crops as an energy-controlled process which is modified by plant, soil and atmospheric factors. In discussing the role of atmospheric factors in the physics of evaporation, it was indicated that the physical requirements to cause water to vaporize are a source of heat (solar energy) and diffusion of the water vapor from greater to lower concentrations. In plants the diffusion is from the surface of the plant leaves (greater concentration) to the turbulent atmosphere (lesser concentration).

Water requirement of cotton, as used in this publication, will refer to the amount of water needed to produce a satisfactory yield of cotton.[7] The discussion will not include conveyance losses from the source to the farm or field. It is impossible to give the water requirement of cotton for every farm or field in the Valley because this is dependent upon many factors. However, it is important that the grower understand some of the factors which contribute to the water requirement of cotton. Such an understanding should place the grower in a better position to make more efficient use of his soil and water resources.

[7]A satisfactory yield will refer to 1.5 to 2.0 bales per acre.

TABLE 13. AVERAGE DAILY EVAPOTRANSPIRATION RATES IN INCHES BY COTTON AS INFLUENCED BY MOISTURE LEVEL TREATMENTS AND PLANTING DATES ON WILLACY LOAM, 1955-57

	February 15 — Planting date[1]					
Treatment	Feb.	March	April	May	June	July
A	0.05	0.07	0.13	0.25	0.10	0.11
Average irrigation dates — April 18 and May 6						
B	0.04	0.08	0.09	0.21	0.11	0.08
Average irrigation date — May 10						
C	0.04	0.07	0.08	0.22	0.48	0.36
Average irrigation dates — May 10, June 2, 16 and 27						
D	0.04	0.07	0.08	0.11	0.48	0.32
Average irrigation dates — June 1, 18 and 26						
E	0.04	0.09	0.08	0.06	0.20	0.20
Average irrigation date — June 10						
F[2]	0.05	0.11	0.10	0.09	0.12	0.12
	March 15 — Planting date[1]					
A		0.04	0.06	0.20	0.16	0.12
Average irrigation dates — May 7 and 25						
B		0.06	0.06	0.14	0.17	0.09
Average irrigation date — May 20						
C		0.05	0.06	0.16	0.42	0.36
Average irrigation dates — May 21, June 8, 18 and July 3						
D		0.04	0.04	0.12	0.27	0.35
Average irrigation dates — June 10, 30 and July 7						
E		0.05	0.05	0.09	0.19	0.23
Average irrigation date — June 25						
F[2]		0.08	0.08	0.08	0.17	0.07
Average evaporation from open pan[3]	0.13	0.17	0.18	0.20	0.23	0.27

[1]Average dates of first blooms for February and March-planted cotton were May 3 and 19, respectively.
[2]One-year average (1957). Other treatments show averages for 1955-57 .
[3]From Class A standard weather bureau type.

In the discussion of research data on the water requirement of cotton, recommendations to growers will be separated into a discussion of: (1) Willacy and related coarse and medium-textured soils and (2) Harlingen clay soils. Research findings on Hidalgo and Laredo soils have indicated that cotton grown on these soils responded similarly to cotton grown on Willacy soil. However, cotton grown on Laredo soils would be expected to vary considerably from location to location because of soil variability.

Water Requirement of Cotton on Willacy

The approximate daily evapotranspiration rates by cotton plants as influenced by time throughout the growing season, planting dates and moisture levels, are shown in Table 13. These data are the average evapotranspiration, with the exception of treatment F, for cotton grown in 1955-57. The average daily evaporation from an open pan for the corresponding periods is also shown in Table 13. Each irrigation caused a marked increase in evapotranspiration because the applied water is held at low tension by the soil and more easily removed or "pumped" from the soil by plants. The energy the growing plants must exert to remove moisture from the soil increases as the available soil moisture decreases. Therefore, a decrease in available moisture causes a corresponding decrease in evapotranspiration.

Treatment A received an average of two irrigations, treatment B only one irrigation, treatments A and B were irrigated before blooming, treatment C received an average of four irrigations and treatment D received an average of three irrigations. Treatments C and D were irrigated when soil moisture stress was high early in the season and when soil moisture stress was low late in the season. Treatment E received one irrigation late in the season; treatment F received no irrigation water. The evapotranspiration data indicated that maximum use and demand for soil moisture by cotton plants begin just before or during bloom stage and continue until most of the bolls are mature.

The importance of available moisture during the first 40 days after appearance of the first blooms was evaluated by determining the correlation between maximum increase in yield of cotton due to irrigation and rainfall during this stage of plant growth. The maximum increase in yield due to irrigation could be evaluated only in 1949, 1950, 1957[8], 1961 and 1962 because a nonirrigated treatment was included in the experiments in these years and not in other years. The correlation coefficient (r = -0.917) indicated a high inverse relationship between rainfall during these 40 days and maximum increase in yield due to irrigation, Figure 4. The relationship between total rainfall during the cotton season and maximum increase due to irrigation was not nearly as good (r =

[8]Cotton planted in February and March was evaluated in 1957.

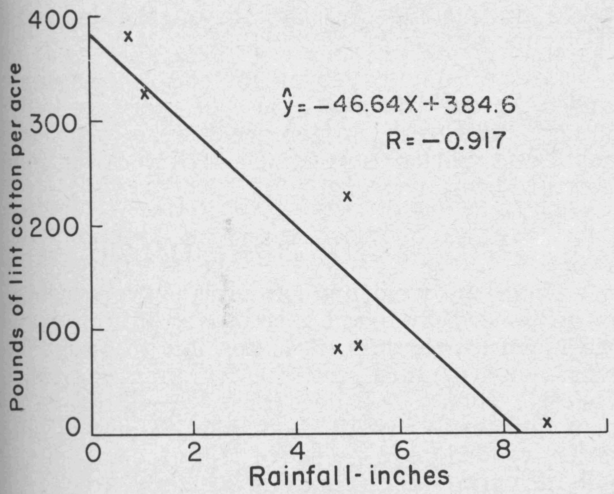

Figure 4. Relationship between maximum increase in yield due to irrigation on Willacy and Hidalgo type soils and rainfall during the first 40 days after appearance of first bloom.

-0.762). On the Willacy and Hidalgo soil, the cotton plant should receive water during the period of 30 to 40 days after first blooms appear, if satisfactory yields are to be made.[9] This would help explain the satisfactory yield response obtained from one irrigation 30 to 40 days after first bloom during 1955-57, and the lack of response due to irrigation during certain years when timely rains occurred during this critical moisture demand period. This does not mean that in certain years and locations factors such as insect infestation, high water table and other climatic factors are not important and do not influence the response of cotton to irrigation. However, the relationship between rainfall during this growth stage and maximum increase in yield is amazingly high, particularly since years, soil type, locations and planting date must have contributed somewhat to the observed yield responses.

Typical root development and distribution by cotton plants under different moisture levels on Willacy loam soil are reported in Table 14. Soil cores for root distribution studies were obtained with a Kelley soil sampling machine (10). Eighty percent or more of the cotton roots were in the top 2 feet of soil, regardless of the moisture level imposed. Cotton on treatments A and B, which grew under high moisture levels during the early part of the season and were permitted to "dry out" during fruiting stages, seemed to develop shallower root systems. The most extensive root system occurred in treatment E and was followed by treatments D and C.

Studies on Willacy loam soil in 1959 by Amemiya *et al.* (1), indicated that the pattern of soil moisture depletion by cotton was a function of the pattern of active root development as well as of the relative wetness or dryness of the soil. It was apparent during the early stages of growth that most of the moisture depletion occurred in the upper 2 feet of the profile. As the plant continued to grow and as a deeper root system became established, successively greater amounts of moisture were utilized by the plants from the third and fourth feet. However, the moisture data indicated that significant amounts of water were not removed from the fourth foot until the moisture in the third foot was under a suction of approximately 1 bar, which in this case was when 45 percent of the available water was depleted. When this occurred, moisture in the first and second feet of the profile was under a suction of approximately 3 to 1.5 bars, which represented depletions of 90 and 60 percent, respectively. As soil moisture depletion continued and as the moisture suction in the first 3 feet became greater, more water was removed from the fourth and fifth feet. During the critical period, which began about the first week in June, cotton in treatments A, D and E showed a relative decline in growth. An examination of the soil moisture data showed that this growth decline during this critical stage was during a time when the soil was allowed to become relatively dry. Consequently, the plants extracted much of their water from depths below the third foot. This occurred in spite of the fact that moisture suction in the third foot was less than 2 bars and only 65 percent of the available moisture had been depleted. Although moisture below the third foot was at a suction of less than 0.8 bar, cotton plants were unable to extract sufficient moisture to maintain optimum growth. Cotton plants may extract moisture from depths below their primary root zone (0 to 3 feet) but may not be able to extract an amount sufficient to maintain optimum growth during the critical period, even at relatively low suction values.

[9]Satisfactory yields for this area would be 1½ to 2 bales per acre.

Water Requirement of Cotton on Harlingen

The amount of water applied, number of irrigations and water use data for 1960-62 are indicated in Table 15. Moisture level treatments had a marked influence on evapotranspiration. Water loss caused by evapotranspiration was high during the blooming and fruiting period of the cotton plants under low moisture stress conditions. Evapotranspiration was high be-

TABLE 14. EFFECT OF SOIL MOISTURE DIFFERENTIALS ON ROOT DEVELOPMENT AND DISTRIBUTION BY COTTON PLANTS ON WILLACY LOAM SOIL

Soil depth, feet	Percentage of total roots by treatments[1]				
	A	B	C	D	E
0-1	67.2	74.0	57.5	58.0	53.6
1-2	19.3	18.3	25.5	24.1	27.0
2-3	6.7	4.9	6.6	9.5	11.6
3-4	4.8	2.8	6.2	5.9	4.9
4-5	2.0	0.0	4.0	2.5	2.9

[1]Treatments described in Table 3.

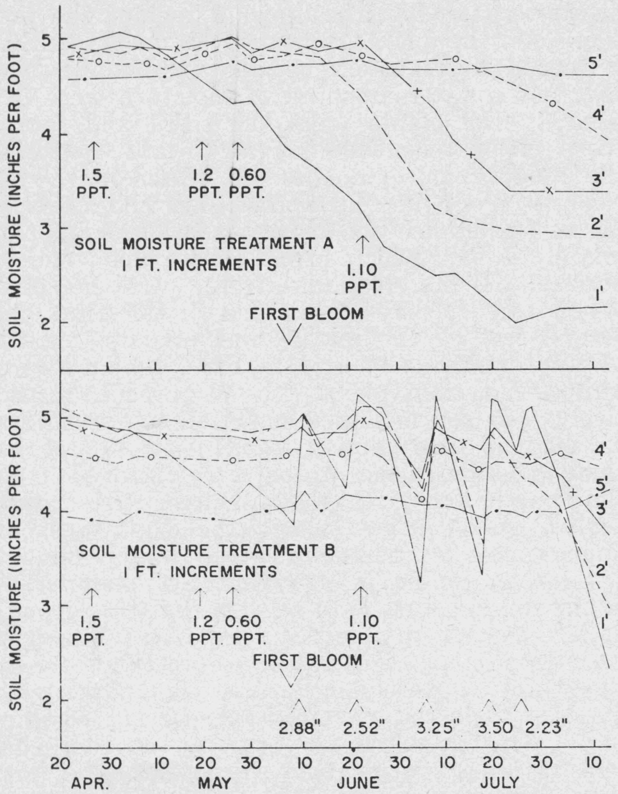

Figure 5. Seasonal soil moisture changes for a 5-foot profile as influenced by soil moisture treatments A and B and cotton plant spacing treatments on Harlingen clay, 1960. Dates and amounts of rainfall indicated by ppt. Irrigation dates and amount under symbol.

cause the soil moisture is easily available to plants at low moisture stress, potential evapotranspiration is high in the Lower Rio Grande Valley and quantities of evaporative surfaces are high when the cotton plants are relatively large. During this period, the evapotranspiration data often showed losses which ranged between 0.2 and 0.4 inch per day after an irrigation.

Typical soil moisture-use curves for different soil depths and for treatments A and B are indicated in Figure 5. Moisture use throughout the season was restricted largely to the top 2 feet of soil. This may have been caused by plant root distribution in the Harlingen clay. Ninety to 99 percent of the roots were found to be in the first foot of soil as indicated in Table 16. With the exception of treatment A, reduction in soil moisture from the third foot was not noticeable until late in the season. Loss of water at lower depths under treatment A occurred after cessation of plant growth; moisture loss probably was caused by soil evaporation. Moisture use at different soil depths under treatments C and D was similar to moisture use under treatment B with greater moisture depletion in the top 2 feet of soil before irrigation.

The amounts of water in the soil under soil moisture treatments A and B and spacing treatments during the growing season are indicated in Figure 6.

Cotton plants grown under close spacing tended to use the available soil moisture more rapidly. However, differences were relatively small and varied somewhat with location and moisture-level treatment.

Irrigation Schedules[10]

From the yield and evapotranspiration data, as influenced by plant spacings, planting dates and moisture regimes, it is possible to formulate irrigation schedules for the Lower Rio Grande Valley. Such schedules must be modified by local farmers to suit their particular soil and water conditions. Some of the factors which will influence the irrigation schedule are: type of soil, available water-holding capacity of soil, amount and quality of available water for irrigation, soil depth, plant spacing, presence of water table or restricting layers in the soil, soil fertility, cropping history, infiltration rate, slope and length of the irrigation run and insect infestation during the growing season. Bloodworth (6) has discussed the influences of some of these factors on the proper irrigation of crops. The exact influence of the individual factors on the irrigation schedule is not known, but a knowledge of them will help to formulate a more intelligent irrigation schedule for a specific farming situation. The county agricultural agent or Soil Conservation Service technician can help form-

[10]Much of these data were obtained from Bulletin 916 (8).

TABLE 15. SUMMARY OF RAIN AND IRRIGATION WATER APPLIED TO MOISTURE LEVEL TREATMENTS ON HARLINGEN CLAY FROM 1960-62

Moisture treatments	Number of irrigations[1]	Soil moisture depletion[2]	Irrigation water added	Rainfall	Total water use	Days between irrigations
		——— Inches ———				
			1960			
A	0	6.8	0.0	2.9	9.7	
B	5	4.6	14.4	2.9	21.9	13
C	5	3.6	15.0	2.9	21.5	16
D	3	4.2	12.4	2.9	19.5	18
			1961			
A	0	4.6	0.0	6.5	11.1	
B	5	2.1	16.3	6.5	24.9	11
C	4	3.3	12.2	6.5	22.0	16
D	3	1.9	11.5	6.5	19.9	19
			1962			
A	1[3]	5.5	0.0	8.1	13.6	
B	5	1.6	13.6	8.1	23.3	13
C	4	+0.2	12.6	8.1	20.5	17
D	3	+1.2	7.5	8.1	14.4	18

[1]A preplanting irrigation was applied to all treatments. The numbers of irrigations refer to the irrigations applied after first blooms.
[2]Refers to the difference in the soil moisture depletion at defoliation from the initial soil moisture at about the 4-leaf stage of plant growth.
[3]In 1962, a high intensity rain from June 23-27 is considered equivalent to one irrigation (5.75 inches of rain).

ulate an irrigation schedule by identifying the soil and furnishing information on its available water-holding capacity (11, 12).

Infiltration rate of the soil, slope of the irrigated field and the length of run will influence the amount of water which can be applied efficiently to the soil during any one irrigation. Land leveling is usually necessary in the Valley if efficient application and distribution of water is to be obtained. The farmer is often not able to distribute the water to the field uniformly because of these factors. Inefficient application and distribution of water may result in a reduction in yield caused by lack in uniformity in growth and yield of the cotton plants.

Irrigation Schedules for Cotton Grown on Willacy Loam

Irrigation schedules are outlined for what usually is considered a "low" supply and an "adequate" supply of irrigation water. The proposed schedules are made with the following assumptions: that the soil is deep (5 feet or more) with no water table or restricting zones and will hold 7 to 10 inches of available moisture; that good quality water is available;[11] that the cotton grower follows recommended fertilizer and insect control practices and plants seed of adapted varieties; that the soil profile is filled with a preplanting irrigation; and that the land topography is graded properly.

Low Water Supply—One Irrigation

With a limited supply of water, the grower should plant his cotton in March. Based on Table 17, the cotton grower should irrigate when approximately 7 inches of water have been removed from the soil. The irrigation will occur about 30 days after appearance of first blooms, according to the proposed schedule.

The average rainfall from March 15 to June 21 is approximately 5.80 inches. Some of the rains are light and relatively ineffective. However, rainfall will often reduce the need for irrigation water from about 7 inches in dry years to 3 or 4 inches in wet years. Growers may wish to delay the application of water to a later date when rainfall is relatively high. However,

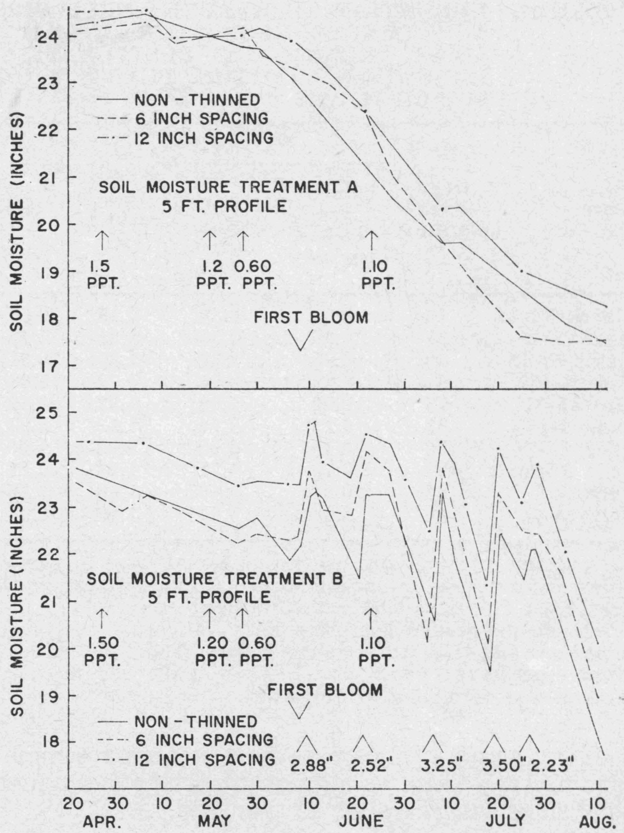

Figure 6. Seasonal soil moisture changes by 1-foot increments as influenced by cotton and irrigation treatments A and B, on Harlingen clay, 1960. Dates and amounts of rainfall indicated by ppt. Irrigation dates and amounts indicated under symbol.

many growers, because of unlevel land, long runs, insufficient labor and soil type may not be able to apply 6 to 7 inches of water to a cotton field without considerable waste, uneven distribution and sometimes damage to the cotton plants. The grower, by keeping a record of rainfall and using the moisture use data in Table 17 as a guide, can determine the best time to use his single postplanting irrigation.

Adequate Water Supply—Three irrigations

Since the cotton grower who operates under this condition has filled his soil profile with a preplanting irrigation and has three more irrigations to finish his crop, the time of planting is not as critical as in the former case. Plans for February and March-planted cotton are proposed.

[11] Good quality water refers to water containing less than 1,000 ppm of total salt and having a low sodium content.

TABLE 16. PERCENT ROOTS BY WEIGHT AS INFLUENCED BY MOISTURE LEVEL TREATMENT AND SOIL DEPTH ON HARLINGEN CLAY, 1960-61

Soil depth, feet	Treatments, 1960				Treatments, 1961			
	A	B	C	D	A	B	C	D
	Percent by weight							
0-0.5	76.4	82.0	81.5	94.0	91.3	91.3	65.3	84.0
0.5-1	23.0	15.6	17.5	5.4	7.5	8.2	34.2	14.7
1-2	0.5	1.8	0.8	0.3	0.5	0.4	0.5	1.0
2-3	0.1	0.5	0.3	0.3	0.2	0.1	0.1	0.2
3-4	0.1	0.2			0.3			0.2
4-5					0.3			

TABLE 17. IRRIGATION SCHEDULE PROPOSED FOR COTTON GROWN ON WILLACY LOAM WITH ONE POSTPLANTING IRRIGATION. COTTON PLANTED ON MARCH 15, 1956

Time	Days after planting	Moisture Use		Rain-fall, inches (B)	A-B
		Daily use, inches per day	Cumu-lative use, inches[1] (A)		
March 15-31	16	0.05	0.80	0.15	0.65
April 1-15	31	0.05	1.55	0.31	1.24
April 15-30	46	0.05	2.30	1.39	0.91
May 1-15	61	0.09	3.65	1.97	1.68
May 15-31[2]	77	0.09	5.08	1.97	3.12
June 1-15	92	0.19	7.94	1.97	5.97
June 15-21	98	0.19	9.08	2.02	7.06[3]
June 21-30	107	0.19	1.71	1.44	0.27
July 1-15	122	0.23	5.16	1.60	3.56
July 15-31[4]	138	0.23	8.84	1.94	6.90

[1]Cumulative use = daily use x number of days in period plus moisture use in earlier periods. Example for April = (0.05) (15) plus 0.80 = 1.55 inches.
[2]First blooms occurred on May 19.
[3]Approximate time to irrigate (June 21 or 22) with 7 inches per acre.
[4]Cotton was defoliated on August 2.

Tables 18 and 19 illustrate how cumulative moisture use can serve as a guide for irrigation under conditions where water is plentiful.

February-planted cotton should receive its first irrigation about 30 days after first blooms appear, but the March planting will need its first irrigation about 15 days after first blooms appear. Early-planted cotton should be irrigated when the cumulative water use, minus the rainfall, equals about 6 inches. However, March-planted cotton should be irrigated when this is equal to or near 5 inches. Daily use of water by cotton, as indicated in Tables 17, 18 and 19, is related directly to the amount of water available to the cotton plants. If a farmer has water for only two irrigations rather than three, it probably would be desirable to delay the first irrigation until the cumulative water use minus rainfall is about 6.5 to 7 inches as was the case on the February-planted cotton. The second irrigation could be applied when the cumulative water use minus rainfall is about 6 inches.

TABLE 18. IRRIGATION SCHEDULE PROPOSED FOR COTTON GROWN ON WILLACY LOAM WITH THREE POSTPLANTING IRRIGATIONS. COTTON PLANTED ON FEBRUARY 15, 1956

Time	Days after planting	Daily use, inches per day	Cumula-tive use, inches[1] (A)	Rain-fall, inches (B)	A-B
Feb. 15-28	13	0.04	0.52	0.29	0.23
March 1-15	28	0.07	1.57	0.38	1.19
March 15-31	44	0.07	2.69	0.52	2.17
April 1-15	59	0.08	3.89	0.68	3.21
April 15-30	74	0.08	5.09	1.76	3.33
May 1-15[2]	89	0.11	6.74	2.34	4.40
May 15-31	105	0.11	8.50	2.34	6.16[3]
June 1-13	118	0.48	6.24	0.00	6.24[3]
June 13-15	120	0.48	0.96	0.00	0.96
June 15-30	135	0.48	8.16	1.49	6.67[3]
July 1-15	150	0.32	4.80	0.16	4.64
July 15-26[4]	161	0.32	8.32	0.50	7.82

[1]Cumulative use = daily use x number of days in period plus moisture used in earlier periods.
[2]First blooms occurred on May 1.
[3]Approximate time to irrigate.
[4]Cotton was defoliated on July 26.

TABLE 19. IRRIGATION SCHEDULE PROPOSED FOR COTTON GROWN ON WILLACY LOAM WITH THREE POSTPLANTING IRRIGATIONS. COTTON PLANTED ON MARCH 15, 1956

Time	Days after planting	Moisture use		Rain-fall, inches (B)	A-B
		Daily use, inches per day	Cumula-tive use, inches[1] (A)		
March 15-31	16	0.04	0.64	0.15	0.49
April 1-15	31	0.04	1.24	0.31	0.93
April 15-30	46	0.04	1.84	1.39	0.45
May 1-15	61	0.12	3.64	1.97	1.67
May 15-31[2]	77	0.12	5.56	1.97	3.59
June 1-5	82	0.27	6.91	1.97	4.94[3]
June 5-15	92	0.27	2.70	0.00	2.70
June 15-30	107	0.27	6.75	1.49	5.26[3]
July 1-15	122	0.35	5.25	0.16	5.09[3]
July 15-31[4]	138	0.35	5.25	0.34	4.91

[1]Cumulative use = daily use x number of days in period plus moisture used in earlier periods.
[2]First blooms occurred on May 19.
[3]Approximate time to irrigate.
[4]Cotton was defoliated on August 2.

Assuming that only two irrigations are available, it probably would be desirable for the farmer to delay his planting date. For March-planted cotton, it would be desirable to delay the two irrigations until the cumulative water use minus rainfall is equal to 6 inches. The daily water use in inches per day would be slightly less for two than for three irrigations. An average of the daily use for the respective periods in Tables 18 and 19 probably would be closer to the actual losses and could be used as a guide of moisture use. For example, the daily loss for a schedule of two irrigations for June would be approximately 0.23 inch per day.[12]

Schedules for four irrigations could be patterned from Table 18 or 19, depending on whether the cotton is planted in February or March. The additional irrigation could be used 20 to 30 days before the irrigation dates listed in Table 18 or 19. The daily use in inches per day for four irrigations could be obtained from the column listed as treatment C in Table 13.

Soils possessing low water-holding capacity, shallow top soil, restricted zones or a high water table would need more frequent irrigations of lesser amounts each time. However, the evapo-

[12]0.19 = evapotranspiration rate for one irrigation (March-planted cotton). 0.27 = evapotranspiration rate for three irrigations (March-planted cotton). (0.19 + 0.27) (½) = 0.23 inch per day.

TABLE 20. IRRIGATION SCHEDULE PROPOSED FOR COTTON GROWN ON HARLINGEN CLAY WITH FOUR POSTPLANTING IRRIGATIONS. EXAMPLE FOR MARCH 15 PLANTED COTTON[1]

Time	Days after planting	Moisture use	
		Daily use, inches per day	Cumulative use, inches
March 15-31	16	0.05	0.80
April 1-30	46	0.05	2.30
May 1-20	66	0.05	3.30[2]
May 20-June 5	82	0.20	3.20[2]
June 5-June 20	97	0.20	3.00[2]
June 20-July 5	112	0.20	3.00[2]

[1]This example does not include rainfall.
[2]Approximate time to irrigate.

transpiration data could be used as a guide in setting up irrigation schedules for such conditions.

Irrigation Schedule - - Harlingen Clay Soil

Because of a high water-holding capacity, these soils remain relatively cold in the spring. The specific heat[13] of this soil, mainly because of its high water-holding capacity, is considerably higher than the medium and coarse-textured soils. Temperature conditions in the Harlingen soil generally favor a delay in cotton planting until March. An irrigation schedule for the Harlingen clay is proposed with similar assumptions as provided for the Willacy loam. Irrigation should begin at or immediately after the appearance of the first blooms. Earlier irrigation when temperatures are cold or cool often retard plant growth and cause a reduction in yield of cotton. Applications of four irrigations about every 15 days after the appearance of the first blooms will usually produce from 1.5 to 2.0 bales of cotton per acre on this soil. Cotton planted on March 15 would bloom about May 20 and should be irrigated on or about May 20, June 5, June 20 and July 5. Soil moisture use by plants growing in this soil is generally restricted to the surface 2 feet because the concentration of plant roots is restricted to the surface foot of soil. Applications of 3 to 3.5 inches of water at each irrigation is usually sufficient to replenish the soil moisture in the depleted zone. Water use during the blooming and fruiting period amounts to approximately 0.2 to 0.3 inch per day. Small rains generally do not supply available water to the plant roots but may help reduce the evapotranspiration rate. Table 20 can be a guide for the proper irrigation of cotton on Harlingen clay soil. By keeping a record of rainfall, the irrigation schedule could be modified for each specific situation.

[13]Specific heat of a substance or material is the ratio of its thermal capacity to that of water at 15° C.

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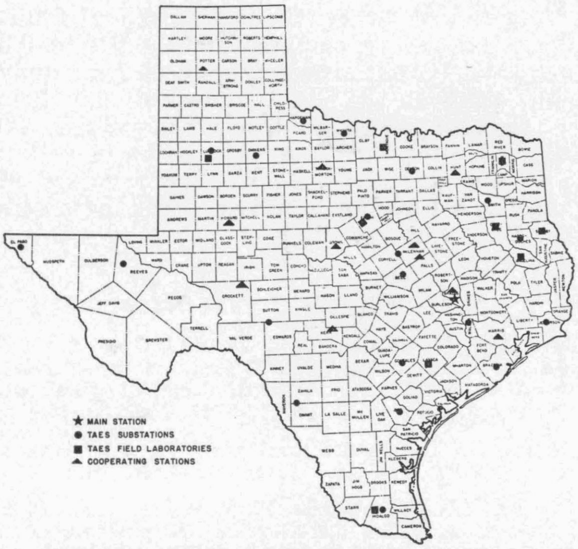

Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

State-wide Research

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The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of the parts of Texas A&M University.

ORGANIZATION

IN THE MAIN STATION, with headquarters at College Station, are 13 subject-matter departments, 3 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 20 substations and 10 field laboratories. In addition, there are 13 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

OPERATION

THE TEXAS STATION is conducting about 450 active research projects, grouped in 25 programs, which include all phases of agriculture in Texas. Among these are:

- Conservation and improvement of soil
- Conservation and use of water
- Grasses and legumes
- Grain crops
- Cotton and other fiber crops
- Vegetable crops
- Citrus and other subtropical fruits
- Fruits and nuts
- Oil seed crops
- Ornamental plants
- Brush and weeds
- Insects
- Beef cattle
- Dairy cattle
- Sheep and goats
- Swine
- Chickens and turkeys
- Animal diseases and parasites
- Fish and game
- Farm and ranch engineering
- Farm and ranch business
- Marketing agricultural products
- Rural home economics
- Rural agricultural economics
- Plant diseases

Two additional programs are maintenance and upkeep, and central services.

Research results are carried to Texas farmers, ranchmen and homemakers by county agents and specialists of the Texas Agricultural Extension Service

AGRICULTURAL RESEARCH seeks the WHATS, the WHYS, the WHENS, the WHERES and the HOWS of hundreds of problems which confront operators of farms and ranches, and the many industries depending on or serving agriculture. Workers of the Main Station and the field units of the Texas Agricultural Experiment Station seek diligently to find solutions to these problems.

Today's Research Is Tomorrow's Progress