5-1-1955

Crop response to irrigation in the Yazoo-Mississippi Delta

Perrin H. Grissom

W.A. Raney

Peter G. Hogg

BULLETIN 531 MAY, 1955

Crop Response to IRRIGATION In the Yazoo-Mississippi Delta

MISSISSIPPI STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
CLAY LYLE, Director
STATE COLLEGE MISSISSIPPI

DELTA IRRIGATION SUMMARY

1. On sandy loam soils, during the 1952-54 periods, irrigation increased the yield of cotton an average of approximately 750 pounds of seed cotton per acre, increased corn yields 26 bushels per acre, and increased soybean yields 8 bushels per acre.

2. On clay soils, irrigation increased corn yields 30 bushels per acre, increased soybean yields 10 bushels per acre, increased alfalfa yields 1½ tons per acre, and failed to increase cotton yields in 1954, under the conditions tested.

3. Irrigated Dallis, Johnson, and Coastal Bermuda grass pastures produced over 300 pounds of beef cattle per acre in the period from July 26 to November of 1954.

4. On a hardpan soil, there was very little benefit from irrigating cotton.

5. Where cotton and corn were allowed to wilt severely before applying water, the yields response varied from a reduction to a slight increase and it was apparent that water must be applied earlier for practical benefits..

6. Insect control was more difficult on irrigated cotton than on non-irrigated cotton.

7. Irrigation increased the grass and weed problem.

8. The fiber of irrigated cotton was longer and weaker than non-irrigated. Irrigation corrected deficiences created by drought but apparently had no other effect on the fiber properties.

9. Irrigation had no significant influence on nep count, yarn strength, or other spinning qualities of cotton.

10. A permanent place for irrigation in agricultural production in the Yazoo-Mississippi Delta is indicated by the weather records and the crop response data.

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CROP RESPONSE TO IRRIGATION IN THE YAZOO-MISSISSIPPI DELTA

By PERRIN GRISSOM,[1] W. A. RANEY,[2] and PETER HOGG[3]

The purpose of irrigation is to keep the soil supplied with readily available moisture for plant growth and development. In the Mississippi Delta area where the total rainfall normally exceeds the amount necessary for optimum crop production, the purpose of irrigation can be limited to correcting soil moisture deficiencies created by poor rainfall distribution, excessively high temperature, and poor moisture intake and storage conditions within the soil.

This bulletin reports the results of supplemental irrigation experiments conducted at the Delta Branch Experiment Station in the period 1952-54 and discusses some of the factors which affect the need for and response to artificially applied water.

Factors Affecting Crop Response to Irrigation

The response to irrigation is influenced by the crop, the climate, and by the soil on which the crop is grown. The degree of response varies from year to year because of differences in total rainfall and rainfall distribution. Within a given year, the rainfall distribution will have a greater influence on response to irrigation than the total annual rainfall. Table 1 shows the average monthly rainfall at eight locations in the Mississippi Delta, which will serve to illustrate the differences in rainfall distribution. There is little difference in the amount of rainfall in different parts of the Delta but there is considerable variation between months. The rainfall is lowest when the crop needs are greatest.

Crop needs for water are not constant throughout the growing season. For most crops, the needs increase to a maximum in late summer and then decrease in the fall. Crop needs can be considered as the amount of water that is lost by transpiration through the plant and by evaporation from the soil. The water requirement for optimum crop growth is lower on a cloudy day than on an extremely hot day with full sun. More water is required per day for a long period of high temperature than for a short period at the same temperature.

The amount of water that is needed for optimum plant growth where there are no other restrictions can be calculated. Table 2 shows these calculated values for eight locations in the Mississippi Delta. These data show very small differences between locations but do show marked differences during the growing season.

The annual rainfall exceeds the total crop needs, but the distribution of the rainfall does not coincide with crop needs. There is an excess of precipitation in the winter months when crop requirements are at a minimum. During the summer, however, there are frequently a number of days or even weeks during which crop needs for water far exceed rainfall.

Fortunately, the soil acts as a buffer to climate. During periods of excess rainfall, the soil can act as a reservoir and store water for use during those periods when crop requirements exceed rainfall.

Soil stores moisture because there is an attraction between the soil and water and not because the soil acts as a water-tight vessel. To be available to plants, the attraction between the soil and water must not exceed the attraction which plants themselves can exert. When the soil has just reached the moisture content below

[1] Agronomist, Delta Branch of the Mississippi Agricultural Experiment Station.

[2] Soil Scientist, Soil and Water Conservation Research Branch, ARS, USDA.

[3] Assistant Superintendent, Delta Branch of Mississippi Agricultural Experiment Station.

ACKNOWLEDGEMENT. — Credit is due the Stoneville Laboratory of the Cotton Ginning Investigations, ARS, United States Department of Agriculture, for the cotton fiber analyses and spinning tests reported herein.

Table 1. Average monthly rainfall (inches) at 8 locations in the Mississippi Delta.

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Clarksdale	4.04	4.18	5.56	4.73	4.89	3.77	3.24	3.36	2.62	2.87	4.01	5.62	48.89
Scott	4.35	3.99	4.65	4.83	5.12	3.18	3.66	3.09	2.92	2.96	3.96	5.65	48.36
Belzoni	5.29	4.19	5.13	4.19	4.34	3.12	3.43	2.11	1.99	2.31	4.43	5.86	46.39
Greenville	4.78	4.48	5.53	5.03	5.02	3.31	3.35	3.86	3.47	2.69	4.13	6.57	52.22
Greenwood	5.09	4.77	5.82	5.70	4.88	3.76	4.34	3.36	2.58	2.88	4.09	6.50	53.77
Moorhead	4.86	4.09	5.33	5.18	4.58	3.86	4.12	3.29	2.55	2.50	3.80	6.40	50.56
Stoneville	4.71	4.28	4.68	4.76	5.02	3.09	3.52	3.45	3.11	2.43	3.72	6.08	48.85
Yazoo City	5.16	4.68	5.90	5.29	4.61	3.59	4.46	4.08	2.54	2.66	3.61	5.75	52.33
Mean	4.79	4.33	5.33	4.96	4.81	3.46	3.77	3.32	2.72	2.66	3.97	6.05	50.14

Table 2. Calculated monthly water requirements for optimum plant growth (inches) at 8 locations in the Mississippi Delta.

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Clarksdale	.35	.51	1.50	2.70	4.58	6.42	7.01	6.33	4.91	2.60	.97	.44
Scott	.42	.61	1.54	2.53	4.31	6.20	6.72	6.34	4.66	2.60	.97	.54
Belzoni	.45	.71	1.57	2.91	4.68	6.42	7.01	6.61	4.90	2.60	1.11	.54
Greenville	.45	.70	1.28	2.53	4.59	6.42	7.01	6.61	4.90	2.60	1.10	.44
Greenwood	.35	.64	1.54	2.70	4.59	6.42	7.01	6.61	4.83	2.60	1.10	.44
Moorhead	.45	.64	1.50	2.70	4.59	6.42	7.01	6.34	4.66	2.60	1.04	.51
Stoneville Exp. Sta.	.45	.64	1.50	2.70	4.59	6.19	7.01	6.34	4.90	2.60	1.04	.51
Yazoo City	.48	.64	1.87	2.96	4.68	6.40	6.61	6.53	4.86	2.63	1.07	.61
Mean	.43	.64	1.54	2.72	4.58	6.36	6.92	6.46	4.83	2.60	1.05	.50

which the water is unavailable to plants the soil is at the "permanent wilting percentage."

Soil moisture must also be retained against the force of gravity. Following a rain the soil remains moist after the downward movement of water has ceased. The term "field capacity" has thus been used to denote the moisture percentage that has thus been retained by soil against gravitational forces. The available water holding capacity is the difference between the amount that is retained against gravity and the amount that is retained at "permanent wilting percentage."

All soil moisture between "the permanent wilting percentage" and field capacity is not equally available to plants even though it is considered available water. As the soil moisture content decreases it becomes increasingly difficult for plants to obtain water from the soil. In general, best plant growth is obtained when the soil moisture reservoir is about half full. At this moisture level both adequate aeration and adequate moisture are assured.

Sandy soil has a low available water holding capacity. When it rains, very little of the water is retained. Clay soils, on the other hand, retain a large amount of water at field capacity. Even though clay soils retain an appreciable quantity of water at the "permanent wilting percentage," the amount of available water is greater in clay soil than in sandy soil.

Table 3 is a rough guide to the available water that can be stored by different textured soils per foot of depth.

Table 3. Average available moisture holding capacity of soils in inches per foot of soil.

Soil texture	Avaliable water inches per foot
Sandy soil	0.75
Sandy loam	1.30
Loam and silt loam	2.00
Clay loam and clay	2.00

The total profile storage capacity is the product of the available moisture holding capacity and the depth of the root zone. The capacity of the soil profile to store water largely determines whether or not that soil is considered droughty.

When the soil moisture reservoir is maintained one-fourth to three-fourths full at all times, there is a greater loss of moisture through evaporation and transpiration than when the soil is occasionally allowed to reach the "permanent wilting percentage." When an abundance of soil moisture is available during the period of maximum use, as much as .4 acre inches of water per day may be lost. The average daily requirement is nearer .2 acre inches. If the storage capacity of the soil is 2 acre inches, the soil can hold only enough water to last 10 days under average summer conditions.

By taking into consideration the soil storage capacity for water, the losses through evaporation and transpiration, and the rainfall distribution, it is possible to calculate the monthly water deficiency.

Table 4 shows that the average monthly water deficit in the Delta is influenced by the profile storage capacity during June and July. During August and September there is an average deficiency of 5.25 acre inches regardless of the storage capacity of the soils.

Certain vegetable crops are shallow rooted and will exhaust soil moisture reserves quickly within the limited area occupied by their roots. Supplemental irrigation is needed much more frequently than for deep rooted crops. Young plants require more frequent irrigation than old plants for the same reason. When the entire plant is to be harvested, the time of

Table 4. Average monthly water deficiency in Yazoo-Mississippi Delta (inches).

Available Moisture Storage Capacity	June	July	August	September
1	.90	3.16	3.14	2.11
2		3.06	3.14	2.11
3		2.06	3.14	2.11
4		1.06	3.14	2.11

irrigation may not be too important as long as adequate amounts of moisture are supplied. When the fruit of a crop, which depends upon the proper balance between vegetative growth and fruit set, is to be harvested, the timing of irrigation assumes much greater importance.

Moisture is generally critical during periods of fruit set and early growth of fruit. A drought between silking and tasseling of corn and the early milk stage of the kernels will severely decrease yield. A drought before or after this period will have less effect. These same trends hold for cereals and for cotton. The response to irrigation will be much greater during these critical periods.

Different crops are grown at different times of the year. A drought in September would not affect corn yield in most places, but a drought in September could severely hinder establishment of pastures.

Factors Affecting Time of Applying Water

Soil characteristics which affect intake, storage, availability, or removal of water have a direct influence on irrigation practices. Soils with a low intake rate are not capable of absorbing much of the rainfall. Such soils are difficult to irrigate. Irrigation water must be applied at a low rate over a long period of time, thereby increasing the cost of irrigation.

The size of the soil particles, their arrangement, and the slope of the land are major factors which affect the rate that water will be taken in. In general, the finer the soil particles and the steeper the slope, the slower the water intake rate. Sandy soils will absorb water more rapidly than silt or clay soils. An exception to this occurs in the Delta where clay soils crack when they dry out. These cracks permit rapid penetration of water until the soil reaches field capacity. After these soils reach field capacity, the absorption of water almost ceases.

Soils which have a compacted layer in the soil profile that restricts the movement of water and roots also have a low absorption rate. Eradication of such a hardpan increases the efficiency of an irrigation system and reduces cost.

Infiltration rates are usually measured by applying water to a plot at an excessive rate, measuring the runoff, and calculating the intake rate as the difference between the two. An alternate method is to measure the rate of application which, if exceeded, would produce runoff. The reliability of both of these methods increases with plot size. A small plot might, by chance, occur on an isolated spot with an extreme intake rate that would not represent the field as a whole. The method of applying water to the plot has an effect on the measured intake rate.

Measurement of intake rate should be made with the type of irrigation system that is to be used and at about the moisture content at which irrigation will occur. Even then, some adjustment in application rates during the growing season might be required. The beating action of water drops usually reduces intake rate. If a sprinkler irrigation system is used to apply water, the intake rate is less than where a furrow or border method is used. Neither method will exactly simulate rainfall. Infiltration rates are also influenced by soil moisture content, stability of structure, crop residue management, and soil cover.

Factors Affecting Time of Irrigation

Generally, it will prove practical to start irrigating when about 50 per cent of the available moisture has been used up. Under farm conditions, the time to irrigate may best be determined by observing the plants or by examining the soil. There is also a possibility of calculating the time that water should be applied.

Most plants undergo changes in plant appearance when less than 50 percent of available moisture remains in the soil. There may be slight wilting or changes in leaf color, leaf arch, or other changes which farmers may use as indicators after they have some experience with irri-

Table 5. Soil moisture as related to soil.

Available moisture remaining	Feel or appearance of soils		
	Sandy loam soil	Loam and silt loam	Clay loam and clay
0	Dry, loose, flows through fingers	Powder dry, sometimes slightly crusted but easily breaks down into powdery condition	Hard, baked, cracked, sometimes has loose crumbs on surface
50% or less (Begin irrigation)	Still appears to be dry, will not form a ball*	Somewhat crumbly but will hold together under pressure	Somewhat pliable, will ball under pressure*. Cracks appear
50% to 75%	Tends to ball under pressure but seldom will hold together	Forms a ball* somewhat plastic, will sometimes slick with pressure	Forms a ball, will ribbon out between thumb and forefinger
75% to field capacity	Forms weak ball, breaks easily, will not slick	Forms a ball and is very pliable, slicks readily if relatively high in clay	Easily ribbons out between fingers and has a slick feeling
At field capacity	Upon squeezing no free water appears on soil but wet outline of ball is left on hand	Same as sandy loam	Same as sandy loam
Above field capacity	Free water will be released with kneading	Can squeeze out free water	Puddles and free water form on surface

*Ball is formed by squeezing a hand full of soil very firmly with fingers.

gation. Soil characteristics may also serve as a guide for the time to irrigate. The soil should be examined in the center of the root zone or at a depth of one foot, depending upon the extent of the root system. Table 5 lists some of the soil characteristics at different moisture levels.

Under most Mississippi conditions for most crops the time lapse between irrigations, where no rain occurs, can be expected to vary from ten to fifteen days. Crops with shallow root systems will probably require more frequent applications of water.

An approximation of the time to irrigate may be calculated from rainfall data and from water requirement data by a simple bookkeeping procedure. The credits are rainfall and irrigation water and debits are evaporation and transpiration. Table 6 illustrates the procedure where profile storage capacity is four acre inches of available water. Since irrigation should begin when one half of the available water is exhausted, a two-inch irrigation is added whenever the balance is down to two acre inches. Table 7 shows a deficit by this means of 18 acre inches of water during 1954. This procedure over-emphasizes water requirement for cotton early in the growing season and over-emphasizes requirement for corn in the late summer.

Weather Data

Tables 7, 8, and 9 report the daily rainfall, maximum and minimum temperatures for the period April 1 through September 30 for each of the three years, 1952-54, that irrigation tests have been conducted at the Delta Station. The information presented in these tables is helpful in interpreting the crop response data.

Cotton

In recent years, it has been evident

that cotton is less tolerant of drought than was generally believed. Curtailed yields due to moisture deficiencies have been the rule rather than the exception. The use of supplemental irrigation to correct these deficiencies has been studied at the Delta Station since 1951 and previously from 1928 to 1932. The studies have been fruitful but the close interrelationship between irrigation and other production practices such as drainage, fertilizers, weed control, deep tillage, and insect control, tend to make efficient irrigation of cotton a complex problem. It appears likely that adjustments will be required on all of these practices for best results. The manner in which the cotton plant responds to irrigation must be considered also. For maximum production a balance between vegetative growth and fruiting is desirable. Too much water or too little water may affect the balance adversely. This problem is more acute in this area than in cotton growing areas where rain is improbable. If the vegetative growth is promoted excessively by irrigation, and wet, cloudy weather follows, reduced yields may be expected. The Delfos 7343 variety of cotton was used in all of the tests reported in this bulletin.

When To Irrigate. The timing of the irrigation of cotton, with respect to the level of soil moisture and stage of plant development, will likely be the key to

Table 6. Calculated irrigation requirements when profile storage capacity is 4.00 acre inches (1954) Stoneville, Miss.

	Credits		Evaporation + Transpiration		
Dates	Rainfall	Irrigation	Debits	Balance	Runoff
	April		Inches		
1-7	0.53		.57	3.96	
8-15	1.18		.64	4.00	.50
16-23	2.42		.72	4.00	1.70
24-30	2.19		.79	4.00	1.40
	May				
1-7	6.79		.98	4.00	5.81
8-15	3.22		1.08	4.00	2.14
16-23	0.07		1.20	2.87	
24-31	1.22		1.32	2.77	
	June				
1-7	.00		1.42	1.35	
8-15	.00	2.00	1.51	0.49	
16-23	.21	4.00	1.60	3.10	
24-30	.45		1.63	1.92	
	July				
1-7	0.00	2.00	1.70	2.22	
8-15	0.00	2.00	1.75	2.47	
16-23	0.57	2.00	1.75	3.29	
24-31	0.82		1.72	2.39	
	August				
1-7	.05	2.00	1.69	2.75	
8-15	.00	2.00	1.65	3.10	
16-23	2.26		1.59	3.67	
24-31	.10		1.52	2.25	
	September				
1-7	0.00	2.00	1.44	2.81	
8-15	.13		1.33	1.61	
16-23	2.04		1.13	2.52	
24-30	.03		.93	1.61	

Table 7. Weather data at Delta Branch Experiment Station, April-September, 1952

Day	April Rain (in.)	April Temp. (°F) Max.	April Temp. (°F) Min.	May Rain (in.)	May Temp. (°F) Max.	May Temp. (°F) Min.	June Rain (in.)	June Temp. (°F) Max.	June Temp. (°F) Min.	July Rain (in.)	July Temp. (°F) Max.	July Temp. (°F) Min.	August Rain (in.)	August Temp. (°F) Max.	August Temp. (°F) Min.	September Rain (in.)	September Temp. (°F) Max.	September Temp. (°F) Min.
1		71	56		91	55		90	60		99	73		95	71		98	72
2		68	45		92	60		91	62	T	97	73		96	70	.65	86	60
3		70	43	.01	94	60		94	62		98	71		99	72		80	50
4	.46	65	56		93	61		95	69	.41	95	71		98	73		81	50
5	.06	59	40		95	62		93	70		95	72		97	73		87	52
6		61	37	T	94	66		93	68		98	67	.52	91	69		89	60
7		75	40	.02	93	69	T	95	67	T	97	71		91	67		91	58
8		80	53		91	66	.31	96	69		95	70	.08	93	68		94	64
9		81	53		90	64	T	95	72	.03	87	65	.17	91	72		93	61
10	.20	78	45	.53	86	60		93	74		91	60	.46	94	71		89	59
11		66	44		66	48		96	74		94	61		95	72		92	57
12	1.25	65	53		78	45		97	73		96	69		96	74	.05	89	63
13	T	59	49		81	48		98	69		96	69	T	97	73	.70	86	65
14		62	43		84	56		98	68		98	73		99	73	.03	87	68
15		64	39		86	62		98	69	T	96	72		99	75		90	65
16		67	40		86	60		97	70	.05	91	74		101	76		90	61
17		71	43		91	64		99	72	T	96	75		103	75		93	58
18		77	47	.34	87	64		101	74	T	96	70		97	71	.04	87	63
19		80	53	.05	67	56	1.11	101	73	T	96	71	T	97	72		84	64
20		75	58		77	59		94	75		96	73	T	100	72		87	56
21	.24	80	63		83	53		95	76		100	72		98	71		82	58
22	T	83	58	.14	88	62		95	73		100	70	T	95	74		81	58
23	1.74	77	64		88	63		96	74		102	71		92	72		83	51
24	.24	75	57	1.01	83	63		97	75		103	69		91	65		82	48
25		82	44		84	65		96	76	T	102	71		91	64		85	49
26		72	40		83	60		96	75		101	71		93	64		85	51
27		77	41		87	61		100	74	T	102	72		92	63		88	48
28		83	54		80	63	T	102	75		102	73		92	57		91	48
29		87	56	.53	73	61		99	74	T	101	77		92	60		90	51
30		90	58		81	55		98	73	1.29	91	69		94	62		90	55
31					86	54				T	92	72		99	65			

Table 8. Weather Data at Delta Branch Experiment Station, April-September, 1953

Day	April			May			June			July			August			September		
	Rain (in.)	Temp. Max.	(°F) Min.	Rain (in.)	Temp. Max.	(°F) Min.	Rain (in.)	Temp. Max.	(°F) Min.	Rain (in.)	Temp. Max.	(°F) Min.	Rain (in.)	Temp. Max.	(°F) Min.	Rain (in.)	Temp. Max.	(°F) Min.
1	.03	78	53		83	56		96	69		96	74		93	71		98	65
2		74	49		86	59		91	65		95	75		93	72		96	70
3		77	44	.10	85	59		91	60		96	74	.09	93	71		94	67
4	.07	74	51	2.44	76	62		91	62		95	74		95	73	.74	97	69
5		76	45		70	58		93	69		96	75		98	72		81	56
6	.29	70	57	T	73	54		96	70		97	76	.35	94	74		86	54
7		72	48	.06	77	53	T	98	74		98	76		98	71		93	57
8		87	52		78	52		97	74	.01	92	75		97	73		91	59
9		88	66		84	56		98	75		95	75		92	65		92	56
10		84	55		86	61	.13	99	73		91	71		90	60		91	59
11		83	45	.26	84	64	T	100	72		87	60		92	60		93	62
12	.77	79	52	.72	85	63	T	99	72		85	64		96	63		98	65
13		62	40	.78	80	63		99	73		86	70		98	64		91	56
14		72	38	.73	77	53		98	76	.02	90	67		100	75		95	51
15	.13	73	54	1.36	66	55		97	76		89	66		94	70		94	62
16		72	40	.70	87	55		96	75	.47	87	69		96	71		96	60
17		79	42	1.10	82	68		99	76	T	88	69		94	70		98	59
18	.12	76	43	.04	81	65		99	77		92	69	.18	93	69		95	65
19		62	34	.27	81	63		101	75	T	93	72	T	87	70		90	57
20		61	38		85	63		100	72	.94	84	72		90	62	1.26	90	62
21		72	32		87	68	.84	102	69	.18	85	73	.26	90	63		84	61
22		81	50		90	72		98	71	.21	88	72	.27	84	70		77	50
23		84	60		91	71		97	73		91	70	T	82	67		83	47
24	1.77	78	60		92	71		96	73		91	69		87	61		87	54
25	T	77	59		90	69	.08	95	72		92	67		91	62		84	63
26		75	49		93	67		96	70		95	68		92	63		84	59
27		72	43		98	72	T	94	70		93	71		92	65		94	58
28		81	51		95	64	.34	85	72		95	69	.01	87	72		97	58
29	3.00	79	60		95	67		91	73		96	71	.41	91	71		96	55
30	.01	81	59		94	67		95	72		103	72		91	69		95	55
31					94	64					93	71		94	68			

Table 9. Weather data at Delta Branch Experiment Station, April-September, 1954

Day	April			May			June			July			August			September		
	Rain (in.)	Temp. Max.	(°F) Min.	Rain (in.)	Temp. Max.	(°F) Min.	Rain (in.)	Temp. Max.	(°F) Min.	Rain (in.)	Temp. Max.	(°F) Min.	Rain (in.)	Temp. Max.	(°F) Min.	Rain (in.)	Temp. Max.	(°F) Min.
1		57	32	4.79	75	63		92	74		103	71		95	69		89	55
2		75	34		84	64		91	67		99	74		93	74		94	57
3		82	44	2.00	69	48		88	68		97	73		99	69		99	56
4		83	53		61	43		80	53		96	73		98	72		99	60
5		85	65		70	44		84	50		100	73		98	73		100	60
6		86	65		77	49		88	57	T	100	73		98	72		100	60
7		88	64	T	74	57		93	66		96	73	.05	98	72	T	96	71
8	.53	85	55		75	47		93	70		97	73		101	73	.09	94	64
9		76	45	.23	72	56		98	70	T	95	70		95	72	.04	97	64
10		74	60	.02	66	55		96	69		97	69		96	60		95	69
11	.60	79	63		71	54		97	67		98	64		102	67		82	58
12	.12	77	55		67	55		98	70		100	69		100	67		87	54
13	.37	69	54	2.97	69	54	T	95	68		99	74		99	67		94	49
14		87	56		73	50		94	69		98	76		100	67		97	57
15	.09	82	67		78	54		92	70		100	75		101	72		98	59
16	.86	69	52		81	53		91	72		104	75		102	74	T	95	63
17		77	43		83	58		93	71		97	74		100	74		89	68
18		80	50	.07	78	65	.17	94	70		99	75		99	71		95	69
19		80	51		81	60		94	69	T	98	70		94	72		97	70
20		83	54		73	50		93	67	.57	94	72		98	75		96	72
21		86	53		75	45		96	67		95	72	.78	93	69	2.04	79	65
22		85	59		82	50		97	70		96	75	1.48	94	67		77	----
23	1.56	86	57		85	54	.04	99	72		99	77		93	67		80	50
24		84	58		87	58		99	73		103	74	.10	95	71		90	52
25	T	84	60		84	63		101	70	.82	91	72		98	72		91	63
26		87	63	.40	82	66		100	75		93	69	T	98	72		94	66
27		85	63	.82	76	65		101	74	T	93	70		98	70		94	62
28	.27	82	----		87	63	T	103	75		93	67		100	73		91	65
29	1.92	85	64		88	67	.26	102	74	T	91	66		100	72	.03	91	71
30		85	69		93	66	.19	98	68	T	93	69		99	72		91	71
31					93	70					95	67		87	67			

successful irrigation. With this in mind, an experiment was begun in 1952 on a Dubbs fine sandy loam soil to study the effect of irrigating cotton at varying moisture levels.

The treatments used which will be referred to by number in the remainder of this discussion were as follows:

Treatment 1. No irrigation.

Treatment 2. Irrigation when the soil moisture reached the permanent wilting percentage, the soil was powdery dry, and cotton plants had wilted severely.

Treatment 3. Irrigation when soil moisture reached 50 percent of available capacity, soil appeared dry but would ball under pressure, and wilting occurred only in the afternoon.

Treatment 4. Irrigation when soil moisture had dropped to 75 percent of available capacity, soil was still moist, would ball up readily, no wilting to very slight wilting occurred.

In 1952 and 1953 special instruments, Bouyoucos blocks and tensiometers, were used to determine the soil moisture level. The variations within plots and between plots of similar treatment were so great that the reliability of the measurements was questioned. In 1954, plant appearance alone was used to determine the time for the various treatments. The water was applied by sprinkling with perforated pipe in 1952 and by the furrow method with gated pipe in 1953 and 1954. It should be pointed out that, due to the small plots and to the somewhat excessive rate of application, the efficiency of the water was probably lower than might be expected under farm conditions.

Table 10 presents a rather varied response to varying the frequency of irrigation. Some of this variation may be explained by the weather records. In 1952, on treatment No. 2 where the plants were severely wilted before applying irrigation water, the cotton was temporarily revived but was not sustained in that condition due to high temperatures and dry winds.

By August 18 the cotton was in a severely wilted condition and soil moisture measurements indicated the permanent wilting percentage had been reached again. As before, a vegetative response occurred but the temporary revival was inadequate to produce an increase in yield. In two other cases in 1952, one application of water to severely wilted cotton reduced the yields. In 1953, the cotton was planted nine days later than in 1952 thus making the peak moisture demands

Table 10. The influence of irrigation at different moisture levels on the yield of cotton on a Dubbs fine sandy loam soil, 1952-54.

Treatment	No. times irrigated	Total inches of water applied	Date of first irrigation	Date of last irrigation	Pounds of seed cotton per acre
			1952—Planted May 12		
1	0	0	0	0	2665
2	2	4	July 29	August 18	2590
3	5	10	June 25	August 14	3072
4	7	14	June 28	August 14	2954
			1953—Planted May 22		
1	0	0	--	--	3001
2	1	3	August 17	August 17	3542
3	3	6	July 16	August 17	3552
4	5	10	July 9	August 28	3724
			1954—Planted May 21		
1	0	0	--	--	2443
2	2	6	August 13	September 8	2959
3*	5	14	July 2	September 8	3437
4	7	14	July 2	September 8	3465

*Application of 2 inches on July 2 through error.

later and the application of water on August 17 was followed by a period of cool, cloudy weather with occasional light showers. Under these conditions one irrigation was definitely beneficial.

In 1954, it appeared that the results of 1952 would be repeated; however, 2.26 inches of rain fell ten days after the first irrigation of the severely wilted cotton thus providing a relative long period with nearly adequate moisture. Thus, one irrigation increased the yields. Based on these observations, it appears undesirable to allow cotton to reach a severely wilted condition before irrigating. However, even severely wilted cotton should respond favorably to irrigation if damp cloudy weather follows the first application of water or if a second application is made shortly after the first.

Treatment 3 approaches what appears to be an optimum moisture management practice for cotton. The yields were not different from those produced by Treatment 4 but fewer irrigations were required. Where the latter treatment was used, the first irrigation each year appeared to be wasted. There were also indications that the frequent irrigations as practiced with Treatment 4 favored vegetative conditions which might have proven harmful had rainy and cloudy weather occurred.

Taking all the data into consideration and considering observations in tests described here and in other tests, specifying accurately the optimum time to irrigate cotton is not possible at the present time. Plant characteristics and behavior seem to offer the best possibility for a practical definition of "when to irrigate cotton." Based on the present information this time can be roughly described on sandy loam and silt soils as "when the cotton begins to bloom near the terminals and not before the third week of blooming has been completed, the cotton begins wilting about noon, and the color changes to a dark green with a purplish cast."

The specifications for the time to irrigate cotton on sandy loam soils do not fit clay (buckshot) soils. The plants react to drought condition in a different manner on the two soils. On the clay soils, moisture deficiencies are manifest by reduced rate of growth rather than by marked changes in plant appearance. In one test, on a clay soil in 1954 approximately 4½ inches of water were applied on August 13 and again on September 12. Following each irrigation for a period of five to seven days the cotton suffered from lack of aeration. After recovering from the depressing effect there was a favorable plant response to the irrigation but the response was so late that no yield benefits were obtained. In another test on buckshot soil, one irrigation was applied to cotton on June 16 and no additional irrigations were made.

In this test the yields in pounds of seed cotton per acre were as follows: irrigated 1906, no irrigation 1820. Although the yields were only slightly different, there were definite indications that an early irrigation was beneficial; however, the June 16 date may have been too early for cotton planted May 23. In this test, the first favorable plant response was observed approximately one month after irrigating. Observations suggest that irrigation is needed somewhat earlier on buckshot than on sandy loam soils.

Rates Of Nitrogen and Irrigation. A study of the influence of irrigation on the response of cotton to different rates of nitrogen was conducted on a Dubbs fine sandy loam soil from 1952 to 1954. The irrigation water was applied by the furrow method using gated pipe. Approximately 2 inches of water were put on at each of the five irrigations. Anhydrous ammonia was used as the source of the nitrogen and was applied before planting at rates of 60, 90, and 120 pounds of nitrogen per acre in 1952 and 1953. During these two years it was apparent that the 60-pound rate was too low; therefore, a 150-pound rate was substituted in 1954. The three-year results of this test are shown in Table 11.

As indicated by the data, in 1952 and 1953 the yield of cotton increased as the

Table 11. The influence of irrigation on the yield response of cotton to different rates of nitrogen on a Dubbs fine sandy loam soil, 1952-1954.

Pounds of nitrogen per acre	Pounds of seed cotton per acre: No irrigation	Irrigated	Increase due to irrigation
	1952		
60	2317	2748	431
90	2465	3040	575
120	2727	3314	587
	1953		
60	2639	3426	787
90	2813	3529	716
120	3080	3708	628
	1954		
90	2224	3406	1182
120	2481	3477	996
150	2321	3476	1155

	1952	1953	1954
Date of planting	May 12	May 22	May 21
Times irrigated	5	5	5
Total water applied (inches)	10	10	10
Date of first irrigation	June 19	July 10	July 2
Date of last irrigation	August 18	September 1	August 16

rate of nitrogen increased and the effect of irrigation was fairly constant. There was no interaction between irrigation and rates of nitrogen. In 1954 the difference in yields between rates of nitrogen was small with no evidence that the 150-pound nitrogen rate was beneficial. It is of particular interest, however, to note that the high nitrogen rate with ample moisture had no significant adverse effect.

Although the results presented in Table 11 show no particular influence of irrigation on the response to nitrogen rates, the fact that approximately the same increase in yield was obtained at each level does point up the desirability of using a high rate of nitrogen under irrigated conditions. For economic reasons, a high level of production must be attained since the irrigation investment is the same regardless of the level of production.

The Relation Of Cotton Insect Control To Irrigation. Cotton insects thrive on healthy, succulent, rapidly developing cotton plants. Factors which promote such plant conditions can be expected to increase the insect problem. Since irrigation stimulates growth and development, it has an influence on insect control practices. An indication of the relationship between irrigation and insect control is illustrated by Table 12.

Table 12. The influence of rates of nitrogen and irrigation on the yield of cotton where insects were not controlled, 1953.

Pounds of nitrogen per acre	Pounds of seed cotton per acre: Irrigated twice	No irrigation
0	473	838
60	455	1224
90	490	1117
120	477	1056

The results in Table 12 show that cotton receiving no irrigation produced more than twice as much as the irrigated cotton. The reduced yields of the irrigated plots were attributed to insect damage. Under the conditions of this experiment where insect control measures were not practiced, the insect population was much higher on the irrigated plots than on the plots receiving no additional water. Contrary to normal expectations, the dry plots bloomed longer than the irrigated plots. This apparently resulted from fewer insects on the dry plots.

Under farm conditions in 1954, it was observed that irrigated cotton required four to six poison applications more than cotton receiving no irrigation. Although the number of insecticide treatments will vary with weather conditions, the need will be increased by irrigation.

The Relation Of Deep Tillage To Cotton Irrigation. The primary objective of deep tillage is to shatter hardpan conditions which restrict the movement of water in the soil. Deep tillage allows greater water intake and storage and permits more root development. It follows then that deep tillage should reduce the need for irrigation. Experiments conducted at the Delta Station in 1953 and 1954 have shown that moisture deficiencies were less severe where deep tillage was practiced on hardpan conditions. However, despite increases in yields ranging from 1,200 to 1,700 pounds of seed cotton per acre, there were indications that the moisture needs for cotton had not been satisfied by deep tillage alone. Severe wilting occurred during the month of August, and the yields obtained were lower than those produced on irrigated soils having no hardpan.

Considering the relation of deep tillage to irrigation from another viewpoint, a test was conducted in 1953 where water was applied to cotton growing on a soil with a severe hardpan. No deep tillage was practiced. The results are given in Table 13.

In the experiment reported in Table 13, the water was applied by sprinkling at the rate of two to three inches per irrigation. It was intended that the plots recieving five irrigations should have as much water as was needed. However, because of lack of penetration of the applied water, the cotton required irrigation every five days for favorable growth and fruiting. Because of the impracticability of applying water to cotton in 5-day intervals, the irrigation was stopped after the fifth watering. The results demonstrated the necessity for eradicating the hardpan condition before irrigation could be profitable.

Table 13. The influence of irrigation on the yield of cotton on a hardpan soil, 1953.

Times irrigated	Pounds of seed cotton per acre
0	823
1	807
2	967
5	1107

The Influence of Soil Type on Cotton Irrigation. Since soils vary in the amount of available water they will hold, irrigation practices can be expected to vary accordingly.

The results reported in Tables 10 and 11 were obtained from tests located on well drained sandy loam soils. In 1954, five irrigations providing 10 to 14 inches of water were required for maximum yields on these soils with the increase in yield due to irrigation averaging approximately 1050 pounds of seed cotton per acre.

In 1954 where cotton was planted on April 23 on a silty clay loam soil, the effect of irrigation was similar to the results on sandy loam soil. The yields in pounds of seed cotton per acre were as follows: no irrigation 2301, irrigated 3261 The water was applied on July 6, July 23, and August 17. Approximately 3 inches were added the first time and 4 inches in each of the other irrigations. It was indicated that the amount of water needed per irrigation on the silty clay loam soil was more than on the sandy loam soil but the intervals between irrigations were greater.

On clay soils, as was pointed out earlier, little or no benefit was obtained from irrigation under the conditions of the tests. The tests did indicate that more water per irrigation and fewer irrigations will be necessary than on other soils. Farm observations have indicated excellent response to irrigation on cotton and suggest that the Station tests were not representative with respect to increased yields.

In general, the tests and observations indicate that sandy loam soils will require less water per irrigation, but will require it more frequently than heavier soils; and that the finer the texture the more water will be needed per application, and the less frequent it will be needed.

Late Irrigation of Cotton. In determining the date to apply the last irrigation for cotton consideration must be given to insect control, boll rot, length of boll development period, temperature, and first date. Normally, 45 to 60 days are required for the development from bloom to open boll and the length of time will likely be greater during the late growing season. With an average frost date of November 4 at Stoneville, it appears doubtful that blooms occurring later than September 10 have much chance of developing into open bolls. Thus the primary reason for the last irrigation will be to provide moisture for the development of bolls already set rather than to set new ones. In one test in 1954 where cotton planted May 19 had been irrigated uniformly twice, a third application of water was made on September 8 on alternate 12-row plots replicated four times. The cotton showed moisture deficiencies at the time the last irrigation was made. The cotton yields in pounds of seed cotton per acre obtained were as follows: no late irrigation 2379, late irrigation 2633.

In this case the September 8 irrigation was definitely beneficial. The favorable results can be attributed to filling out the bolls already set since tagged bolls indicated that where the blooms occurred later than September 10, the bolls failed to open. In this test, the cotton had already begun to open when the last irrigation was applied and no yield differences occurred in the first picking with all of the increase showing up in the second picking. From a practical standpoint, the increased yield was partially offset by the increased insect control measures necessary. The maintenance of the plants in a healthy vegetative state can be expected to make additional poison applications necessary. The same conditions also will likely delay the opening date of cotton and will create conditions favorable to boll rot. Thus, determining the time to apply the last irrigation becomes one of compromise and early September is indicated.

Grass and Weed Problems In Irrigated Cotton. No studies have been made at the Delta Branch Experiment Station to determine the effect of irrigation on the weed and grass population and growth in irrigated cotton, nor has any special control work been done. Observation of irrigated fields show that irrigation does create a late grass and weed problem that is particularly harmful in the harvesting operation and especially so when mechanical harvesting is practiced. Cultivation after the first irrigation has proven helpful. A perfect stand of cotton probably provides the best means of minimizing the weed and grass problem. Under conditions where skips occur in the cotton, grass and weeds fill in while a good stand of cotton tends to shade them out.

Fiber Properties and Spinning Qualities of Irrigated Cotton. In an effort to determine the effect of irrigation on the quality of cotton, samples were drawn from each of the treatments in the tests previously described and fiber determinations made in cooperation with the U.S. D.A. Cotton Ginning Investigations Laboratory at Stoneville.

In the experiments where the moisture level was varied, (results reported in Table 10) the fiber properties were determined on samples from each field plot for the two years 1952 and 1954. The average results of like treatments are reported in Table 14.

These data show that as the water was increased, there was an accompanying increase in length of staple, a slight decrease in strength and no effect on fineness, uniformity or maturity.

The replicate samples were composited for the spinning tests. The spinning data are shown in Table 15. Although some variation occurs, there were no uniform differences and no trends indicated despite the differences shown in the fiber

Table 14. The influence of different moisture levels on the fiber properties of cotton, grown on a Dubbs fine sandy loam soil, 1952 and 1954.

Treatment[1]	Fiber length (UHM—inches) 1952	1954	Ave.	Strength Pressley 1000 lb. sq. inches 1952	1954	Ave.	Fineness micrograms per in. 1952	1954	Ave.	Uniformity ratio—index 1952	1954	Ave.	Maturity index 1952	1954	Ave.
1	1.08	1.04	1.06	84	88	86.0	3.9	3.6	3.75	76	75	75.5	78	75	76.5
2	1.09	1.06	1.075	84	86	85.0	3.8	3.7	3.75	78	75	77.5	78	76	77.0
3	1.10	1.07	1.085	82	85	83.5	3.7	3.9	3.80	76	75	75.5	77	76	76.5
4	1.11	1.13	1.12	81	84	82.5	3.4	3.7	3.55	74	77	75.5	74	76	75.0

[1]See Table 10 for information on number of irrigations and total quantity of water applied.

Table 15. The influence of different moisture levels on the spinning qualities of cotton grown on a Dubbs fine sandy loam soil, 1952 and 1954.

Treatment[1]	Neps in card web No. per 1000 sq. in. 1952	1954	Yarn strength (lbs.) carded 22's 1952	1954	Yarn strength (lbs.) carded 50's 1952	1954	Yarn appearance carded 22's 1952	1954	Yarn appearance carded 50's 1952	1954	Average yarn appearance index 1952	1954
1	8	9	118.8	123.7	41.2	42.6	B	C+	C+	C	105	95
2	10	10	120.6	122.2	41.3	42.9	B	B+	C+	C+	105	110
3	10	12	117.9	124.7	40.7	43.2	B	B	C+	B	105	110
4	13	8	120.1	124.0	41.3	43.7	B	C+	C	C+	100	100

[1]See Table 10 for information pertaining to number of irrigations and and total quantity of water applied.

tests. There was no indication that irrigation increased the nep count or had any other adverse effect.

Where rates of nitrogen and irrigation were varied (the yields are reported in Table 11) the fiber determinations were made on samples from each plot. Like treatments are averaged and reported in Table 16. Again the staple length was slightly longer and slightly weaker on the irrigated plots. Irrigation had no effect on fineness, uniformity or the maturity index. None of the fiber properties were affected significantly by varying the rate of nitrogen.

The replicate samples were composited and spinning tests run on the 1952 cotton only. There were some variations in the spinning data but no significant differences due to irrigation or varying rates of nitrogen.

The influence of irrigation on the fiber properties of cotton grown on different soil types is shown in Table 17. The data shown are averages of the respective irrigation treatments. The samples from the Sharkey clay soil do not fit the usual pattern of longer staple and lower strength but there was no yield response to the irrigation in this test.

An evaluation of all of the fiber and spinning data shows that where irrigation was applied, the fiber was approximately .04 inches or slightly over 1/32 inch longer, the fiber strength was 3000 pounds per square inch less based on Pressley determinations, other fiber properties were not affected and irrigation had no significant influence on the spinning qualities.

Irrigation tended to correct abnormalities created by the drought, but apparently had no other effect. This can be substantiated by examining data from selected plots which received no irrigation but where the drought had a differential effect as indicated by plant appearance and yield. The drought differences were due to difference in the soil. These data are shown in Table 18.

Table 16. The influence of irrigation and rates of nitrogen on the fiber properties of cotton grown on a Dubbs fine sandy loam soil, 1952 and 1954.

Year	Pounds of N per acre	Irrigation[1] treatment	Fiber length UHM (in.)	Strength—Pressley 1000 lb. per sq. in.	Fineness micrograms per inch	Uni-formity ratio	Maturity index
1952							
	60	No irrigation	1.07	84	4.0	76	78
	90	No irrigation	1.06	85	4.0	77	78
	120	No irrigation	1.08	85	4.0	75	77
	60	Irrigated	1.10	80	3.8	73	75
	90	Irrigated	1.13	83	3.7	74	75
	120	Irrigated	1.11	82	3.8	73	76
1954							
	90	No irrigation	1.07	87	3.8	74	75
	120	No irrigation	1.08	86	3.9	74	75
	150	No irrigation	1.07	86	3.6	74	74
	90	Irrigated	1.11	84	4.0	72	75
	120	Irrigated	1.09	84	4.1	75	77
	150	Irrigated	1.12	83	4.1	74	77

[1] See Table 11 for information on number of irrigations and quantity of water applied.

Table 17. The influence of irrigation on the fiber properties of cotton grown on different soil types, 1954.

Soil type	Irrigation treatment	Number of irrigations	Total inches of water applied	Fiber length UHM inches	Strength—Pressley 1000 lbs. per sq. in.	Fineness micro-grams per inch	Uniformity ratio	Maturity index
Sandy loam								
	No irrigation	0	0	1.10	84	3.8	76	77
	Irrigated	5	10	1.14	83	3.8	76	78
Silty clay loam								
	No irrigation	0	0	1.08	88	3.6	76	76
	Irrigated	3	11	1.12	85	3.8	75	77
Sharkey clay								
	No irrigation	0	0	1.12	87	3.6	78	78
	Irrigated	2	8	1.14	89	3.6	77	78

Table 18. The influence of drought on fiber length and fiber strength of cotton, 1954.

Degree of drought damage	Fiber length UHM (inches)	Strength Pressley 1000 lbs. per sq. in.
Severe	.90	84
Moderate	1.01	85
No apparent damage	1.14	83

Although no irrigation was applied on any of the plots, the fiber was as long where no drought injury occurred as on any of the nearby irrigated plots. The fiber length varied more in those plots receiving no irrigation than it did in the tests where irrigation and no irrigation were compared.

Corn

Moisture has long been thought to be a limiting factor in corn production in the Mississippi Delta and frequently good corn prospects fail to materialize due to lack of water during the silk and tassel stage.

The corn irrigation tests at the Delta Station have been designed to study the influence of irrigation on yields, to investigate the effect of irrigation on fertilizer practices, and to study irrigation frequency. Dixie 22 corn was used in all of the tests.

When to Irrigate. The influence of frequency of irrigation on the yield of corn has been studied on a well drained, sandy loam soil. The test was fertilized uniformly each year with anhydrous ammonia at the rate of 120 pounds of nitrogen per acre before planting. In 1952, the water was applied by sprinkling with perforated pipe and in 1953 and 1954 irrigation was done by the furrow method with gated pipe. The experiment was designed to study the following moisture variables: (1) No irrigation, (2) irrigation when the soil moisture had reached the permanent wilting percentage, (3) irrigation when soil moisture had dropped to 50% of available capacity and (4) irrigation when the soil moisture had dropped to 75% of available capacity. The determinations of the varying moisture levels were attempted during 1952 and 1953 with Bouyoucos blocks and tensiometers. The tremendous variations of moisture readings within plots and between plots of similar treatment caused the reliability of the measurements to be questioned. In 1954, the time to irrigate was determined by plant appearance. The entire test was irrigated by sprinkling in 1953 for germination. The 3-year results of this test are shown in Table 19.

In each of the three years, the more frequent irrigations produced the highest

Table 19. The influence of irrigation at different moisture levels on the yield of corn on a Dubbs fine sandy loam soil, 1952-54.

Moisture level when irrigated	No. times irrigated	Total inches of water applied	Date of first irrigation	Date of last irrigation	Bushels of corn per acre
			1952—Planted May 13		
1	0	0			68.6
2	2	2	July 9	July 29	85.0
3	5	10	June 25	August 14	91.0
4	7	14	June 18	August 14	97.7
			1953—Planted June 2		
1	0	0			69.9
2	1	2	August 17	August 17	70.5
3	3	6	July 16	August 17	86.7
4	5	10	July 9	August 28	93.0
			1954—Planted April 19		
1	0	0			73.0
2	1	3	July 12	July 12	77.1
3	3	8	June 16	July 12	94.9
4	4	8	June 16	July 12	98.9

Table 20. The influence of irrigation on the response of corn to different rates of nitrogen on a Dubbs fine sandy loam soil, 1952-54.

Pounds of nitrogen per acre	Bushels of corn per acre		Increase due to irrigation
	No irrigation	Irrigated	
	1952		
120	62.5	93.6	31.1
180	61.8	92.2	30.4
240	64.6	92.4	27.8
	1953		
120	77.4	92.9	15.5
180	74.6	90.3	15.7
240	71.5	90.7	19.2
	1954		
120	64.4	96.2	31.8
180	61.6	91.8	30.2
240	63.3	93.1	29.8

	1952	1953	1954
Date of planting	May 13	June 2	April 19
Times irrigated	5	4	3
Total water applied (inches)	10	8	6
Date of first irrigation	June 19	July 9	June 16
Date of last irrigation	July 29	August 18	July 16

yields. However, Treatment 3 gave the greatest return for water applied. Remaining unanswered is the question whether heavier rates of watering at less frequent intervals may have been just as satisfactory as the best treatment used.

Rates of Nitrogen and Irrigation. A study of the influence of irrigation on the response of corn to different rates of nitrogen was conducted from 1952 to 1954. The rates of nitrogen chosen for comparison were 120, 180 and 240 pounds of nitrogen per acre. The 120-pound rate had been found to be optimum under dry conditions and for that reason, the higher rates seemed to offer more promise in the test. Anhydrous ammonia was used as the source of nitrogen each year and was applied before planting. The water was applied by the furrow method using gated pipe. Dixie 22 corn was used and was spaced 12 inches apart. Results of this test are shown in Table 20. The 3-year results show no difference in yield as a result of varying the rates of nitrogen.

An increase in yield was obtained each year from irrigation but the response to nitrogen was not affected.

In a test located on Sharkey clay (buckshot) soil, nitrogen was applied at rates varying from 60 to 180 pounds per acre in 30-pound increments. Due to a winter legume history on the land, the nitrogen level was rather high at the beginning of the test. The stand of corn was poor in both 1952 and 1953 with the spacing averaging one plant every 24 inches. The irrigation was done with gated pipe.

Table 21 shows the influence of rate of nitrogen and irrigation on the yield of corn on a buckshot soil. In this test the corn was planted on May 16 in 1952 and May 28 in 1953. The water was applied on July 3 and July 25 in 1952 and on July 8 and August 5 in 1954 at the rate of approximately four inches per irrigation.

In 1952 increasing the rate of nitrogen failed to increase corn yields where no irrigation was used. With irrigation, 60 pounds of nitrogen per acre was beneficial but no yield increases were obtained from higher nitrogen rates. In 1953, where no irrigation was used, the 60-pound rates of nitrogen increased the corn yield over the check but higher rates had no effect. Under irrigation there were slight increases in yield as the rate of nitrogen increased. During the two years, the average increase in yield by irrigation of the fertilized plots was 30.5 bushels per acre.

The effect of irrigation on the lodging of corn has been questioned and, although detailed information was not collected, observations indicate that the severity of the lodging depends on the time lapse between the date of irrigation and the date windy conditions occur. When high winds occur immediately following an application of water, the lodging has been more severe than where no water was applied. On the other hand, if two to three days elapse before high winds occur, the irrigated corn stands much better than the dry corn. This is due, at least in part. to the increased root development following irrigation.

Soybeans

A test was initiated in 1952 on a Dubbs fine sandy loam soil to study the influence of irrigation at various moisture levels on the yield of soybeans. The treatments planned were the same as those described previously for cotton. It developed that the plants were affected less by drought than cotton or corn. The time to irrigate was determined by Bouyoucos blocks in 1952 and by the soil-feel method in 1954. The 1953 test was abandoned because of poor stands. The Ogden variety was used in 1952 and the Lee variety in 1954. The water was applied by sprinkling in 1952 and by the furrow method in 1954. The 2-year results are shown in Table 22.

Since the yield of the unirrigated beans was so high, the results of these tests may not have application under most farm conditions. It is of particular interest to note, that although the soybean test was located between the similar tests for cotton and corn, the soybean response was considerably less than was true with the other crops. It was indicated that the peak need for water was during fruit set. The wettest treatment produced largest plants, the beans were set slightly higher on the plants, and more lodging occurred.

The results of another test conducted on buckshot soil in 1952 are as follows:

Table 21. The influence of irrigation on the response of corn to varying rates of nitrogen on a Sharkey clay soil, 1952 and 1953.

Pounds of nitrogen per acre	1952		1953	
	Bushels of corn per acre			
	No irrigation	Irrigated	No irrigation	Irrigated
0	8.3	31.4	12.4	19.8
60	9.7	48.6	21.8	38.7
90	11.7	49.5	19.8	39.4
120	11.4	48.0	17.3	42.5
150	10.7	47.0	21.4	44.4
180	10.5	49.6	20.1	52.5

Table 22. The influence of irrigation at different moisture levels on the yield of soybeans on a Dubbs fine sandy loam soil, 1952 and 1954.

Moisture level when irrigated	No. of irrigations	Inches of water applied	Date of 1st irrigation	Date of last irrigation	Bushels per acre
1952—Planted May 14					
1. No irrigation	0	0	———	———	24.5
2. Permanent wilting percentage	1	2	Aug. 25	Aug. 25	29.3
3. 50% of available capacity	5	10	June 25	Aug. 25	31.7
4. 75% of available capacity	7	14	June 18	Aug. 25	30.9
1954—Planted May 25					
1. No irrigation	0	0	———	———	37.4
2. Permanent wilting percentage	1	3	Sept. 8	Sept. 8	44.3
3. 50% of available capacity	4	12	July 16	Sept. 8	44.5
4. 75% of available capacity	7	14	July 2	Sept. 8	40.6

No irrigation 29.1 bushels per acre, irrigated 38.7. In this test the water was applied by sprinkling with perforated pipe on August 19 and September 13. Accompanying the increased yield was an increase in the size of the seed.

One soybean irrigation test was conducted in 1953. It was located on a sandy loam soil and the Jackson variety was used. Approximately two inches of water were applied by sprinkling on August 4, August 17, and September 3, a total of 6 inches. The bean yields were as follows: No irrigation 12.9 bushels per acre, irrigated 23.2.

Summarizing the results of the soybean experiments: (1) Yields have been increased 6 to 10 bushels per acre, (2) irrigation before the fruiting stage began, apparently was not beneficial, (3) soybeans remained in an unwilted condition much longer than cotton or corn under drought conditions, and (4) the size of the soybean seed were increased by irrigation.

Pastures

In considering pasture irrigation in the Mississippi Delta, it is well to keep in mind the place of livestock in the average Delta farm operation. In most cases, land allocated to perennial pasture production is heavy clay or at best heavy mixed land. Lighter soils planted to pastures will likely be used in rotation with row crops. Here the pastures will usually be left in production from 2 to 4 years.

Most of the Delta pastures will be utilized for beef cattle. Because of the extensive nature of the beef production enterprise a relatively low gross return per acre may be expected. Where irrigation is to be used on pastures, it must be in conjunction with other good farming practices. The livestock program must be intensified as much as practical in order that maximum pasture utilization and high beef yields may be obtained.

Perennial summer grasses that offer opportunities for successful irrigation are: Johnson, Çoastal and Common Bermuda, and Dallis. Alfalfa is the only perennial legume that seems to have potentialities for irrigation. However, white clover, in association with Common Bermuda, may prove satisfactory where a good mixture is available. Where high levels of nitrogen are used on grass-clover mixtures, the clover will be quickly crowded out by the heavy growth of the grass. In most cases the grass will dominate the pasture during the irrigation season (June 15 to the end of October).

Due to the high water requirement of pastures as compared to row crops, it is more important to design pasture irrigation systems so that water may be applied as cheaply as possible.

In most cases sprinkler irrigation systems will be too costly to use for pasture irrigation. In the Mississippi Delta, a large percentage of the heavy clay pasture land is reasonably level and thus offers possibilities for some type of flood irrigation. The contour check system of flooding as used in rice production with some modification will prove satisfactory on many pastures. This system will particularly be suited to perennial pastures where ditches, levels, etc., may be used for several years, thus reducing the overhead expenses of the system.

When the land, type of pasture, and system of irrigation have been established, the next point to be considered is that of pasture management. It is essential to have a well established sod of an adapted summer grass in good condition if irrigation is to pay. Over-grazing must be avoided. The most common error made in irrigating pastures is that of waiting too long before applying water. Pastures require irrigation a considerable time before row crops. During a year of average rainfall, about 12 inches of water may be required. The first irrigation on Delta pastures will usually be required about the last week in June or, to put it another way, about two to three weeks after the last heavy rain.

Delta pastures require about 6 inches of water per month during the hot weather in late June, July, August, and September. When rainfall is about 3 inches short it will be time to start pasture irrigation.

Fertilization Under Irrigation. In order to get efficient use of irrigation water, a high level of soil fertility must be maintained. The minimum requirement of a grass pasture in warm weather is about one pound of nitrogen per acre per day. In order to have uniform pasture production throughout the summer, the nitrogen fertilizer should be applied just prior to irrigation at from 30 to 45 pounds of nitrogen per acre per application. Heavier less frequent applications will result in an excessively high level of protein in the forage for a short time and a subsequent deficiency. When the level of protein is too high (over 18 percent), the excess protein will not be used by the grazing animals to best advantage.

In addition, the dry matter consumed by the animals may be reduced as the palatability of herbage is actually reduced when the protein content is too high.

Another very important reason for frequent small applications of nitrogen is to level out the curve of pasture production so there will be a uniform amount of forage available throughout the summer. This is important in order that the pastures may be fully utilized with about the same number of cattle throughout the grazing season.

Management of Irrigated Pastures. The grazing of irrigated pastures presents special problems and opportunities not found in dry pastures. When the pasture has been grazed to from three to six inches in height and is in need of irrigation, cattle should be removed.

The pasture should be clipped if the grazing was not uniform or if there are weeds present. The fertilizer should be applied and in some cases the manure spread. After irrigation is completed, cattle should not be returned until the ground has become firm in order to prevent bogging and damage to the sod by the grazing animals. It will pay to keep the animals off the pasture until the grass has made a growth of from 8 to 18 inches in height, depending on the species of grass in the pasture. The best plan for managing irrigated pastures is to divide into at least two areas, and preferably four, and rotate the cattle from area to area. Thus with two pastures, each would be grazed one-half of the time. With four pastures, each would only be grazed one-fourth of the time.

Many experiments conducted in humid and irrigated areas, indicate that the four-field system of rotational grazing will increase yields by about 25 percent over continuous grazing.

Table 23 gives beef yields of newly established irrigated pastures on heavy clay soil at the Delta Branch Experiment Station in 1954, the grazing being done the year of planting.

These yields were obtained with two heavy irrigations totaling about 9 inches of water, one in mid-July and one in mid-August. One more irrigation was needed in late September, but the water was not available. This lack of water considerably reduced the October grazing. During the entire period of this test, dry land pastures were almost completely unproductive due to the extreme drought of the spring and summer of 1954. Based on the above study, on a properly fertilized irrigated pasture, rotationally grazed with young cattle, a beef production of 100 pounds

Table 23. Beef yields of Johnson, Dallis, and Coastal Bermuda grass pastures on Sharkey clay, irrigated twice with total of 9 inches of water, 1954.

	Type of pasture		
	Johnson	Dallis	Coastal Bermuda
Date grazing started	July 26	July 26	July 26
Total days grazed	63	70	101
Daily gain per animal	2.11	1.83	2.02
Total gain per acre	347	305	381

per acre per month should be expected.

Annual Grazing Crops. Sudan grass and millet respond well to irrigation. These crops may be handled practically the same as perennial crops except that growth should be about 2 feet in height prior to turning in the grazing animals. Also, the crops should be planted in rows and cultivated once to twice to reduce weed growth.

Winter Grazing Crops. Winter growing, grazing crops such as fescue, oats, wheat, ryegrass, etc., may be irrigated once in the fall, early in September, to germinate the seed and stimulate early fall growth. In the case of fescue, one heavy irrigation will normally be sufficient to supply the crop until fall rain. In the cases of annual crops, the fields may be flooded or sprinkled before or after seeding. On clay land, flooding after seeding will prove more satisfactory because of the difficulty of preparing and planting a seed bed on this type of soil.

Alfalfa

Alfalfa has been irrigated two seasons at the Delta Station. In 1953, a field of alfalfa growing on Bosket very fine sandy loam soil was irrigated twice by contour flooding. This soil had a hardpan condition which prevented good penetration of the irrigation water. The first irrigation increased the alfalfa yield by about 3/4 ton of hay. Subsequent irrigations promoted the growth of grass at the expense of the alfalfa and many plants died. The resulting hay crop was almost entirely crabgrass which replaced the dead alfalfa. In 1954, a second field of alfalfa on Sharkey clay was irrigated. The water was applied by perforated pipe immediately after cutting with a single irrigation per cutting. In this test, two irrigations increased the yields over the check by somewhat over 3/4 of a ton of hay per irrigation. In another case where only one irrigation was applied, regrowth following the next cutting was definitely faster, indicating that all the water (4 to 5 inches) of a single irrigation was not used on the growth of one cutting of hay. The stand of alfalfa on the clay land was not injured by irrigation. Alfalfa seems to offer possibilities for economical irrigation on heavy soils.