Use of Soil Moisture by Cotton

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FOR A LONG TIME cotton was considered a dry-weather plant by farmers in the South. Yet, cotton yields have been reduced in many areas nearly every year because of lack of moisture at critical times, and as a consequence, the income of farmers in the drouth areas was adversely affected. The economic risk to cotton growers is becoming increasingly serious because of mounting fixed overhead costs of farm operation, the higher rates of fertilizer input and the narrower margins between farm expenses and income.

Recent irrigation studies throughout the South show that since cotton yields are limited by the amount of available moisture at certain periods during the growing season (2), cotton should not be "stressed," i.e, undergo drought conditions, if optimum yields are to be obtained.

Sir E. John Russell of the Rothamstead Experiment Station in England explained the role of water in plant

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growth as follows: "Water is an essential nutrient for plant growth, and it is needed in much larger quantities than any other; but whereas a large proportion of every other nutrient absorbed by the plant is retained, the outstanding characteristic of the water is its continuous one-way flow from the soil through the roots, up the stems and into the leaf surface, where it is evaporated mainly inside the stomata, through which it diffuses into the air" (5). Russell also pointed out that the amount of water a crop transpires depends upon the amount of water available to the plants, the period of day in which the stomata of the leaves are open, and the solar energy falling on the crop.

Of the solar energy falling on a wet surface, part is reflected, part is re-radiated, part is used to heat up the absorbing material and the air around it; and the remainder evaporates water from the surface. Of the solar energy falling on plant leaves, the part used for photosynthesis is negligible since it is less than 1 percent of the total.

Bloodworth et al. (1) showed that water movement through the stem of a cotton plant is proportional to the availability of the soil moisture.

Experimental Procedures

Experiments have been underway at the Southern Piedmont Experiment Station at Watkinsville, Georgia, since 1952 to determine the rate and amount of moisture used by cotton. The studies were on an upland field of of Cecil sandy loam soil, and the cotton variety grown was Coker's 100 Wilt Resistant. Fertilizer was applied at the rate of 500 pounds per acre of 0-12-12 broadcast before planting, 500 pounds per acre of 4-12-12 in the row at planting, and nitrogen side dressing about 40 days after planting. Comparisons of nitrogen levels made in 1954 and 1955 showed no difference in yield between 60 pounds per acre of N and 120 pounds per acre of N. In 1956, 120 pounds per acre of nitrogen was applied.

Moisture level treatment varied from irrigation versus no irrigation during 1952 to 1954, to a comparison of several levels of soil moisture in 1956.

Results

The rate of moisture use for the different levels of soil moisture by years is given in table 1. These data show considerable difference in the peak rate and the average daily rate of water use each year. There were variations from one year to the next in both the peak and average rates of moisture used and between different moisture levels within the same year.

The peak rates were determined over short periods of only a few days duration. It is believed the average rate of 0.20 inch per day during the main growing season represents the moisture use requirement of cotton under the conditions of this experiment.

The amount of water used (transpiration and evaporation) from stored soil moisture, rainfall and irrigation are shown in table 2 for the different treatments in 1955 and 1956. Rainfall during the growing season was 6.99 inches in 1955 and 8.10 inches in 1956. In 1955, without irrigation, the cotton used 4.34 inches of moisture from the soil and a total of 11.33 inches of water. Without irrigation in 1956, the cotton used 3.05 inches of moisture from the soil and a total of 11.5 inches of water. The amount of stored water used from the soil was lessened markedly in 1955 where additional water was applied. However, irrigation treatments had little effect on the amount of water used from the soil in 1956.

The data indicate that 70 percent of the water was used from the top 1 foot of soil and 90 percent came from the top 2 feet. It was only toward the end of August that water was used extensively from the third foot of soil, regardless of the level of soil moisture. About half the available moisture was left in the 3 to 4-foot layer at the end of the growing season, indicating that plant roots were not using as much water from that layer of soil.

These data are at some variance from other data on the use of moisture by cotton on the deeper soils of the southwestern states. The pattern of use in that area was reported by Krantz et al. (4) to be:

TABLE 1

Average Daily Rate of Moisture Use by Cotton Under Various Levels of Available Water During the Growing Season of June, July and August at Watkinsville, Georgia, 1952-1956.

Year	Moisture Level at Irrigation in Top 2 Feet of Soil	Rate of Evapo-transpiration for Cotton			
		Irrigated		Not Irrigated	
		Maximum inches/day	Average inches/day	Maximum inches/day	Average inches/day
1952	10 percent AWC[1]	0.31	0.196		0.113
1953	10 percent AWC	0.34	0.213		No record
1954	30 percent AWC	0.31	0.216		0.184
1955	60 percent AWC	0.22	0.175	0.25	0.130
1955	30 percent AWC	0.30	0.180		....
1956	60 percent AWC	0.36	0.256		....
1956	30 percent AWC	0.32	0.218		....
1956	Observed wilt	0.27	0.177		....
1956	Observed wilt plus 5 days	0.26	0.173		....
1956	0 percent AWC	0.25	0.181		....
1956	Not irrigated	...	....	0.27	0.124
Average			0.199		0.146

[1]Available Water Capacity

Soil Depth *feet*	*Water Used* *inches*	*percent*
0-1	13.5	38.2
1-2	8.3	23.5
2-3	5.5	15.6
3-4	4.1	11.6
4-5	2.5	6.5
5-6	1.6	4.5
Total	35.5	99.9

The total of 35.5 inches of water used corresponds closely with data reported by Harris and Hawkins (3) where cotton near Mesa, Arizona, used a total of 36.4 inches of water during the entire season and water use by months was 1.0, 2.1, 4.0, 7.5, 8.3, 6.1 and 3.4 inches for April to October, inclusive.

The data in table 2 covers only the 90-day period from May 28 to August 25. Evapo-transpiration during the periods extending from planting (about April 15) to the first of June, and from August 26 until harvest was completed (about October 15) would require an additional estimated 6 or 8 inches of water. Assuming 7 inches of moisture were required for these two periods and using the data from table 2, the range of moisture requirements for cotton from planting to harvest at Watkinsville, Georgia, would be 18-30 inches.

The yields of cotton from the different levels of soil moisture in 1955 and 1956 are given in table 3. Insect control and other production factors were managed for maximum production in these studies.

Cotton yield increased in proportion to available moisture up to a level of about 18 inches during the 3-month growing season. With more than 18 inches of moisture there was a slight increase in yield.

The three low levels of irrigation did not affect the maturity date of cotton. The main effect of the two irrigations applied in these treatments was to develop bolls already set rather than to set new ones.

Vegetative growth was proportional to moisture use. The height of plants measured 18 to 24, 36 to 42 and above 60 inches respectively for the limited, optimum, and excessive quantities of water used.

TABLE 2

Source and Amount of Water Used by Cotton in 1955 and 1956 in Studies at Watkinsville, Georgia.

Moisture Level at Irrigation	Soil moisture 1955 inches	Soil moisture 1956 inches	Rainfall 1955 inches	Rainfall 1956 inches	Irrigation 1955 inches	Irrigation 1956 inches	Total 1955 inches	Total 1956 inches
None	4.34	3.05	6.99	8.10	0	0	11.33	11.15
0 percent AWC[1]	—	2.46	—	8.10	—	5.76	—	16.32
Observed wilt plus 5 days	—	3.19	—	8.10	—	4.32	—	15.61
Observed wilt	—	3.47	—	8.10	—	4.32	—	15.89
30 percent AWC	2.24	2.86	6.99	8.10	6.48	8.64	15.71	19.60
60 percent AWC	2.46	3.74	6.99	8.10	5.76	11.16	15.21	23.00

[1]Available Water Capacity

TABLE 3

Yield of Seed Cotton and Amount of Soil Moisture Used in Studies at Watkinsville, Georgia, 1955-1956.

Year	Moisture Level at Irrigation	Water Used inches	Yield pounds per acre	Yield pounds per acre per 1" of water	Yield with irrigation pounds per acre	Increase pounds per acre per 1" of irrigation
1955	None	11.33	2383	210	—	—
1955	30 percent AWC[1]	15.71	3104	198	821	127
1955	60 percent AWC	15.21	2880	189	497	86
1956	None	11.15	1952	175	—	—
1956	0 percent AWC	16.32	3621	222	1670	290
1956	Observed wilt plus 5 days	15.61	3306	212	1354	313
1956	Observed wilt	15.89	2911	183	958	222
1956	30 percent AWC	19.60	3463	177	1510	175
1956	60 percent AWC	23.00	3257	142	1305	117

[1]Available Water Capacity

Conclusions

1 Cotton should have an ample but not excessive supply of moisture throughout the growing season.

2 Yields of cotton are proportional to available moisture up to about 6 inches per month during June, July and August.

Cotton on soil with lower-moisture treatments showed a more efficient use of available moisture than did cotton on soil receiving moisture treatments. As soil moisture increased, the efficiency of water use for cotton production decreased.

Cotton needs a good supply of moisture during the boll setting period and until three-fourths of the bolls are mature. Normally two good irrigations are sufficient to insure good yields. Moderate drought in the early growing period does little harm if cotton gets moisture for the development of bolls already set. Water applied at the time of wilting will increase the yield of cotton 86 percent over yields obtained without irrigation. At 1956 prices this yield increase was worth $217.10 per acre.

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