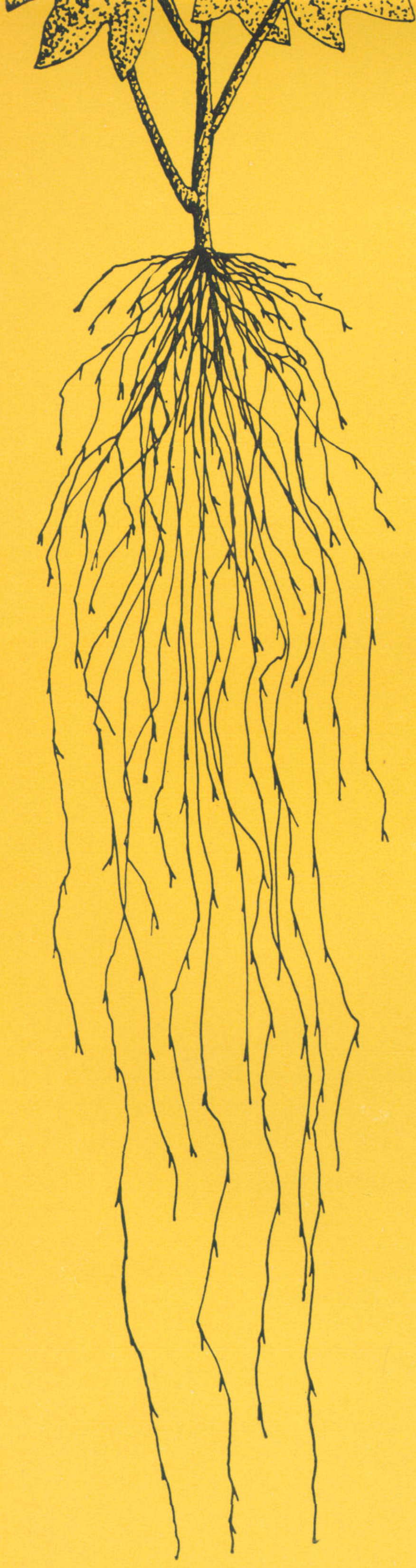

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Water Relations of Cotton: A Rhizotron Study

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INTERPRETIVE SUMMARY

Long-term drought probability data collected for Alabama and other southeastern states have shown that despite the high annual rainfall, cotton plants will suffer at least 20 days of seasonal drought in 9 out of 10 years. While the number of drought days can be reduced by encouraging deeper root penetration, these practices are generally expensive. The experiments reported in this bulletin are designed to permit quantitative estimates of the economic return from practices which increase the effective soil water storage capacity.

The response of cotton plants to water stress was carefully monitored, and the precise time and amount of water stress was estimated by specially developed instrumentation in the Auburn rhizotron. Beyond the general conclusion that deeper roots are as effective as shallow roots in supplying the needs of cotton plants, a number of specific hypotheses relating to the mechanisms by which plants remove water from the soil was tested. These conclusions are reported elsewhere in technical journals. This bulletin includes extensive summaries of the data obtained for those wishing to test their own hypotheses against the data obtained in this set of experiments.

LIST OF TABLES AND FIGURES

WATER RELATIONS of COTTON: A RHIZOTRON STUDY[1]

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INTRODUCTION

SINCE PLANT GROWTH requires a steady supply of water, the ability of a root system to continue supplying water during a drought can mean the difference between success and failure of a crop. Alabama receives about 125 to 150 cm (50 to 60 inches) of moisture annually, often as widely-spaced afternoon thundershowers during the growing season. Consequently, droughts occur periodically, and those plants with deep, well-proliferated root systems survive better than those with shallow, sparse roots.

Previous experiments, Pearson *(11)* showed that soil layers restrict roots whenever soil pH is below about 4.5 to 4.8, soil bulk density of a loamy fine sand is above 1.80g/cm^3, and that of silt loam is above 1.65 g/cm^3. Many soil management practices encourage root extension deeper into the soil. For example, a compacted soil can be loosened by various mechanical treatments; an acid soil can be limed. However, these are expensive operations, and more information is needed to determine the relative effectiveness of roots at different depths in the soil and to evaluate the effectiveness of root systems in supplying sufficient water and

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minerals for top growth under unfavorable subsoil conditions. Adams et al. *(2)* found that when surface soil was limed and fertilized, cotton height increased faster during June and July when the subsoil pH was moderately acid than when subsoil pH was below 5.0. The Auburn rhizotron, Taylor *(14)* was built during 1968 and 1969 to study factors under conditions similar to those expected in the field.

This report describes an experiment in the summer of 1972 conducted in the rhizotron to study (1) the influence of rooting depth and density upon growth and water uptake patterns of cotton plants, (2) the influence of plant water supply on growth rate and yield, (3) the utility of various plant water supply parameters in predicting reduced growth rate due to water stress, and to document (4) the simultaneous reactions of cotton tops and root systems, Brouwer and deWit *(4)* to plant water stress.

MATERIALS AND METHODS

Construction Details of the Rhizotron

The Auburn rhizotron, Figure 1, is an underground root observation laboratory with 10 ccmpartments on each side of a cen-

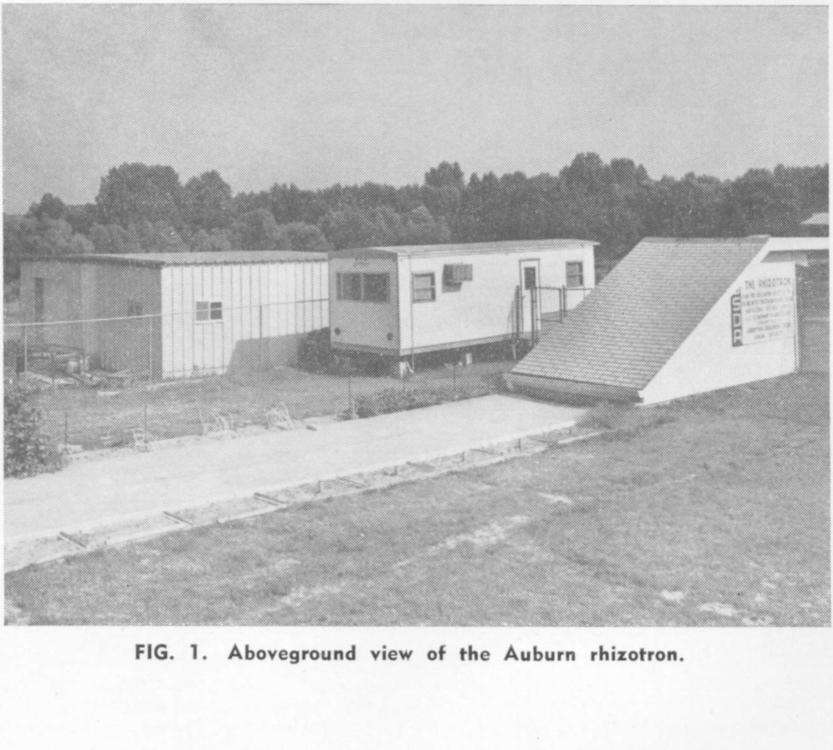

FIG. 1. Aboveground view of the Auburn rhizotron.

tral walkway, Figure 2. The central underground walkway is air-conditioned to provide a temperature near the mean of the soil temperature profile in adjacent field soil. Each compartment has a glass side facing the walkway, side panels of steel or aluminum plate between two stainless steel sheets, a rear wall which is the outer retainer concrete wall, and a bottom consisting of 10-cm (4-inch) thick concrete slab. Concrete surfaces have been treated with epoxy paint to reduce soil contamination by the concrete material. All joints and cracks have been sealed with silicone caulking sealant.

Each compartment is about 188 cm (74 inches) high, 120 cm (48 inches) wide, and 60 cm (24 inches) from front to rear, with a total volume of 1.3 m^3 (47.8 $ft.^3$). Four rectangular porous plates, 15 x 15 x 1.3 cm (6 x 6 x ½ inch) with drainage tubes

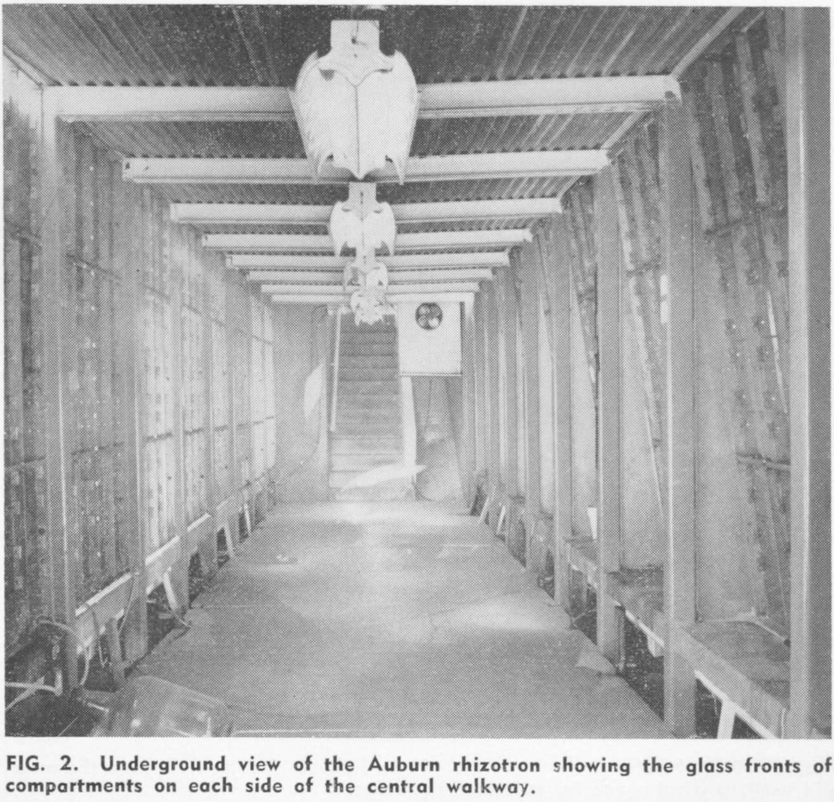

FIG. 2. Underground view of the Auburn rhizotron showing the glass fronts of compartments on each side of the central walkway.

were placed in the bottom of each compartment and covered with a 5-cm (2-inch) layer of diatomaceous earth.

The vertical glass front of each compartment consists of 32 glass panes about 25 cm (10 inches) square and 0.6 cm (¼ inch) thick, with 1.25-cm (½ inch) square grid wire mesh embedded in the glass, Figure 3. This wire provides a stable reference grid for root measurements and also reduces shattering if the glass breaks. Vertical stainless steel bars, 1.3 x 5.0 cm (½ x 2 inches) support the glass panes that are attached by stainless steel clips and sealed with silicone caulking sealant.

By use of the rhizotron, then, repetitive measurements of a growing root system over the entire life of a cotton (*Gossypium hirsutum*) plant can be made. A comparison of successive measurements will show growth or rotting of a population of roots at a given depth for each treatment in an experiment. Facilities for microscopic observations of roots growing in a particular soil environment are available, and time-lapse cinematography provides a permanent record of certain selected experiments.

FIG. 3. Glass face of a compartment of the Auburn rhizotron showing the wire grid used as a reference for root measurements.

Soil Preparation and Measurement

Six of the 20 rhizotron compartments (bins) were used in this study. Three were filled with loamy fine sand, the A_p horizon of Cahaba soil from Tallassee, Alabama. They were designated as (1) control, well-watered (Bin 8); (2) control, allowed to dry (Bin 7); and (3) compaction treatment (Bin 2). The compaction treatment consisted of trampling the soil by foot after the compartment had been filled to within 15 cm (6 inches) of the top, and then filling in the top 15 cm with loose Cahaba soil.

A layer of acid subsoil (pH 4.6) from the 15- to 22-cm layer of a Dothan (formerly Norfolk) loamy fine sand was placed in the bottom of each of the other three compartments. Then they were filled with Cahaba loamy fine sand to obtain the following treatments: (1) 15-cm treatment (173 cm of acid soil overlaid by 15 cm of Cahaba loamy fine sand, Bin 4); (2) 55-cm treatment (133 cm of acid soil overlain by 55 cm of Cahaba material, Bin 5); and (3) 155-cm treatment (33 cm of acid soil overlain by a 155-cm layer of Cahaba material, Bin 6). The Cahaba material in Bins 4, 5, 6, 7, and 8 had a bulk density of about 1.3 g/cm^3; the compacted layer in Bin 2 was about 1.5 g/cm^3 from about 15 to 25 cm deep.

The soils for the experiment were prepared during the early spring of 1972. They were fumigated with methyl bromide and sieved through a 0.6-cm mesh screen to remove old root material. After bins were uniformly filled with soil to the desired density, they were fertilized on April 28 with nitrogen (NH_4NO_3) at the rate of 30 g N/m^2 and potassium (KCl) at the rate of 20 g K/m^2 per bin – the equivalent of 200 lb./acre of KNO_3 (16 g KNO_3 per bin). An additional 15 g N/m^2 was applied to each bin on June 23.

At a 4.6 pH, the Dothan soil material in Bins 4, 5, and 6 had an aluminum activity of 35 μM in the soil solution, Pearson et al. *(12)*. The relationship between water content and hydraulic conductivity was determined for Cahaba soil by the one-step method of Doering *(5)*. The relationship between water content and total water potential was determined in situ in a bin of Cahaba soil, using water content measured by a neutron absorption meter and total water potential measured by thermocouple psychrometer calibrated as described by Fiscus and Huck *(6)*.

A neutron meter access tube was installed in the center of each compartment and sealed at the bottom and top with a rubber stopper which prevented water from seeping into the tube. The neutron probe was calibrated for Cahaba soil in a rhizotron compartment at the end of the growing season, with the access tube in the same position during calibration and measurement.

Measurements of Root Parameters

The quantity of root material at a particular depth on the glass face was assumed representative of the roots at that depth throughout the compartment. A previous experiment, Taylor et al. *(15)* and an unpublished one by F. M. Melhuish, B. Klepper and M. G. Huck, have shown little or no concentration of roots at the glass surface.

Rooting density was defined as *cm of root length in a cm³ of soil volume.* Rooting intensity was defined as *cm of root length visible per cm² of viewing surface.* In this Cahaba soil it was estimated that one could see 0.2 mm into the soil and assumed that all roots in the 0.2-mm layer adjacent to the glass were visible and all roots further than 0.2 mm from the glass were not visible. Depth of vision into the soil was confirmed periodically by microscopy. On the basis of these inferences, rooting density was calculated from root intensity measurements simply by multiplying by 5.

At 2-day intervals root intensity at 15-cm depth increments along the glass was estimated by the line-transect method, Taylor et al. *(15)*, from the number of roots crossing a 105-cm transect. The relationship between root intensity and number of roots crossing the transect was obtained in early August when a range of values was available for measurement. The root count-root intensity relationship was established by the following technique: An operator counted the number of roots intersecting a 25-cm horizontal transect and obtained 56 data sets, and measured the length of roots appearing in an area within and 1.3 cm on either side of that transect line with a ruler. Statistical analysis was employed to obtain the regression formula between root length and number of root intersections:

$$I = -0.00003316\ N^2 + 0.00485 \qquad (1)$$

where I is root intensity and N is the number of roots intersecting a given transect line across the face of a bin. The correlation coefficient was 0.98. This equation differed slightly from that previously developed for corn and tomato root systems, Taylor et al. *(15)*, possibly because of a difference in the anisotropy term, Lang and Melhuish *(10)*, between cotton and the other species.

Plant Shoot Measurements

Plant water potential was determined three times weekly on detached leaves with a pressure chamber, Klepper and Ceccato *(8)*, when measurements were made twice daily (0700 and 1400 hr.). Sampling on one of the two plants in each treatment was started on the hour followed by a second series of samples on the other plant in each treatment. Additional replication was impossible because of the limited number of plants in the study. The leaves on the plants in the 15-cm treatment (Bin 4) were insufficient for sampling more than a few times. Thus, generally 10 samples were taken at each sampling time. Since 3 to 5 min. were required to process each sample, the time of sampling was different for all treatments. This is important since clouds over a short period of time can have a marked effect on plant water potential, Stansell et al. *(13)*. Therefore, the sampling order for the second series of treatments was reversed to make the average water potentials for the two plants as comparable as possible from one treatment to another.

The early morning leaf samples were taken in the shade – usually on the west side of the plant to estimate the maximum plant water potential reached during the night. The afternoon leaves were also generally taken from the west side of the plant and were specifically chosen since they were exposed to the sun. Thus, they were chosen to reflect the minimum water potential values reached during the time of greatest stress.

Two top growth measurements were made: plant height daily with a meter stick, and stem diameter (approximately 40 cm above ground level) continuously with a linear variable differential transformer (LVDT), as previously described, Klepper et al. *(9)*. Each LVDT was incorporated into a holder which permitted recentering the LVDT core daily (Figure 4 showing LVDT arrangement) by turning the micrometer head, which provided an internal calibration standard in absolute units. Actual stem diameter was measured at installation with a micrometer caliper. Daily growth increments in millimeters were measured and recorded for later use in converting millivolt output from the LVDT's into diameter (millimeter) units. Since stem diameter decreases after dawn each morning, increases during late afternoon in response to reductions in evaporative demand, and generally continues to increase nightly, selecting a standard time to compare daily stem diameters for determination of daily growth

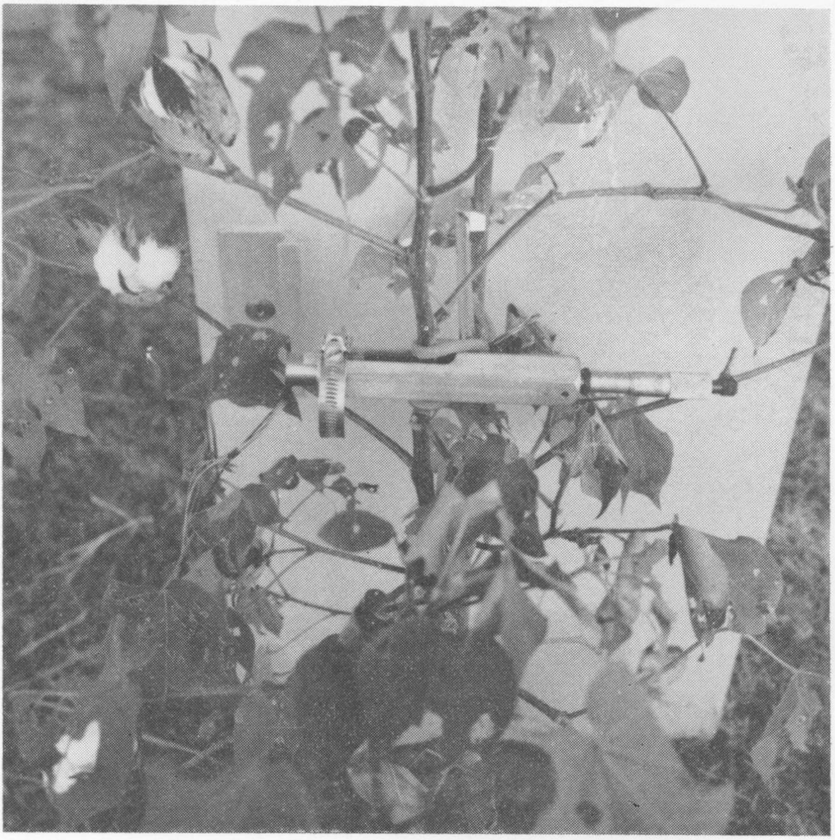

FIG. 4. LVDT apparatus used for continuous monitoring of stem diameter.

increment was arbitrary. The authors chose to compare the maximum values immediately before sunup, since evidently these values were less affected by daily differences in aerial environment.

The output signal voltages from the LVDT's were recorded continuously on strip chart recorders, and pen voltages of the recorders monitored at 2-minute intervals by a digital data acquisition system. With data on the initial voltage and the initial stem diameter, the appropriate calibration factors for each channel, and the instantaneous output signal value, a computer-drawn plot (from magnetic tape records) of stem diameter in millimeters for each plant was prepared throughout the entire experimental period.

Diameter of the central stem was monitored for both plants of all treatments except one plant in the 55-cm treatment which was not monitored because it could not be determined that a central stem existed. Because of occasional equipment failures, values are missing for some days on each treatment.

When available, the continuous trace of stem diameter was analyzed to establish relationships among top growth and patterns of daily dehydration. Computer-drawn plots had the shape and appearance of the curve shown in Figure 5. For each plant of each treatment on each day, values were determined for (1) the time DA^1, i.e., the length of time nightly when the diameter appeared to increase linearly with time, (2) the time *AC*, i.e., the time length necessary for the stem to return to its early morning maximum diameter, or the duration of the shrinkage, (3) the distance below the line *AC* of point *B*, or the maximum amount of

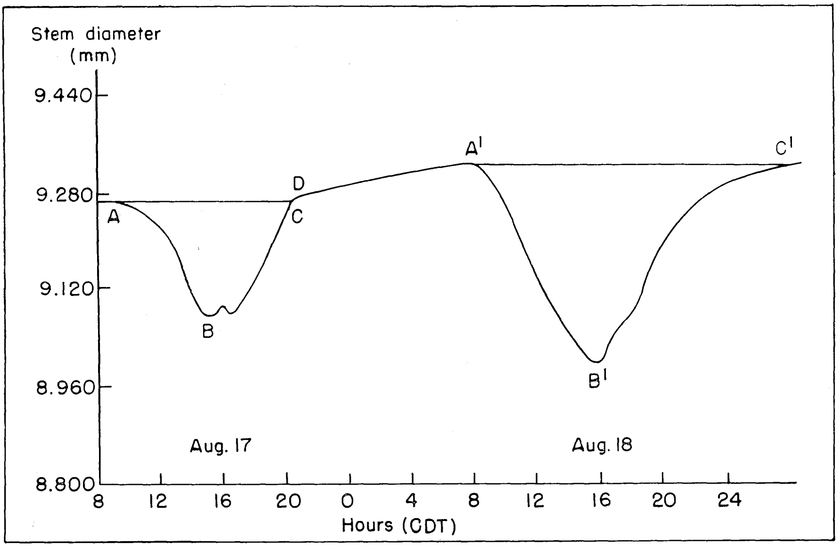

FIG. 5. Diagram showing how data were obtained on stem shrinkage and swelling for reporting in tables. Letter "A" designates the maximum stem diameter attained during the night: "B" the minimum diameter obtained during the day; "C" the point on the curve when the stem diameter returned to its early morning maximum value; "D" the point where the night curve begins to appear linear; and "A^1" the maximum stem diameter attained during the following night. In the tabulated data, the third column is the time, "D"; the fourth column is the diameter at "A^1" minus the diameter at "A"; the fifth column is the length of time represented by the length of line "AC"; the sixth column is the distance in mm at which point "B" is below line "AC"; and the seventh column is area "ABCA."

shrinkage from early morning until the minimum diameter during the day, and (4) the area *ACBA*, or the integrated value of shrinkage in millimeters and duration of shrinkage in hours. The area *ACBA* was determined with a planimeter on the computer-drawn plots. A description of the data acquisition system and magnetic tape files developed can be found in Appendix I.

Time Course of the Experiment

Cotton seed were planted on May 2 in two hills equidistant from the front and rear walls, and approximately 30 cm from a side wall. Plants were thinned to one per hill (two per bin) a few weeks later. Plants were sprayed regularly for insects, especially early in the growing season. Bins were watered every few days to prevent drought from affecting root distribution or top growth before July 4.

On July 5 and 6, all six bins were fitted with metal covers around the plants 5 cm above the soil surface and sloped to shed rainwater. The hole in the metal cover for each plant was lined with soft cloth to prevent injury to the bark and to keep excessive rainwater from running down the stem during storms.

On July 8 routine measurements were begun. Net radiation, Fritschen *(7)*, was monitored over a clipped grass sod about 3 m (10 feet) from the bins at 2-min. intervals. Ambient wet and dry bulb temperatures were recorded at 20-min. intervals. Plant height was measured daily. Plant water potential, soil water content, and rooting density were determined three times weekly. Measurements of Class A pan evaporation, daily total wind speed and direction, and 6-hr. temperature and relative humidity were obtained from the U.S. Weather Bureau station less than 1.5 km (1 mile) from the rhizotron site.

The well-watered control (Bin 8) was irrigated whenever the soil water potential in any layer reached –1 bar. The soil in the 55-cm treatment (Bin 6) was irrigated twice and received 20 liters on August 4 and 80 liters on August 25. The other treatments received no water after July 6.

Each LVDT was moved about 10 cm higher on the central stem and recalibrated on July 31 or August 1. Except for Bin 4, which was terminated on August 11 because their plants became chlorotic, the experiment was terminated on September 5.

RESULTS AND DISCUSSION

Compaction Treatment, Bin 2

Bin 2, which contained Cahaba loamy sand soil with a compacted layer (bulk density 1.5 g/cm^3) from about 15 to 25 cm deep, was not irrigated during the experimental period. Plant height increased almost 1.7 cm/day from July 7 to August 12, then increased 2 cm during the next 6 days. After that, height remained stable. Stem diameter increases followed the same pattern.

Whenever water content of a particular layer decreased below about 0.07 cm^3/cm^3, uptake rate from that layer decreased. In general, rooting density also decreased as water content of a particular layer decreased below 0.07 cm^3/cm^3. Total root length and length of roots in soil wetter than –1 bar are presented in Table 1.

When the experiment was terminated on September 5, the two plants had a total of 401 leaves and 132 bolls (Table 2).

15-cm Treatment, Bin 4

Bin 4 contained 173 cm of Dothan sandy clay loam soil (pH 4.6) as a subsoil material covered with 15 cm of Cahaba loamy fine sand surface soil. This treatment simulated a prevailing field situation with a plow layer limed sufficiently to raise pH to 6.0, but with the subsoil sufficiently acid for the aluminum ions to be highly toxic to cotton roots, Adams and Pearson *(2)*.

Soon after emergence, plants in this compartment became stunted as compared with those of all other treatments. Thereafter, these plants were shorter and yellower than all other plants. Some factor other than water stress apparently caused the reduced growth because plant water potential and stem shrinkage values were about the same as for well-watered plants. However, the plants stopped growing August 1.

In all other bins, cotton growth ceased only when the plant root systems did not extract sufficient water to maintain low plant water stress (high plant water potential). Some roots penetrated at least 15 cm into the acid subsoil. No soil water contents were measured in this compartment because the acid soil layer was so close to the soil surface. The maximum total root length (Table 1) was less than half that of any other treatment.

TABLE 1. TOTAL ROOT LENGTH AND ROOT LENGTH IN SOIL WETTER THAN —1 BAR FOR ALL BINS CONTAINING COTTON AT THE AUBURN RHIZOTRON, 1972

	Bin No. 2		Bin No. 4	Bin No. 5		Bin No. 6		Bin No. 7		Bin No. 8
	Total root length	Root length in soil >—1 bar	Total root length[a]	Total root length	Root length in soil >—1 bar	Total root length	Root length in soil >—1 bar	Total root length	Root length in soil >—1 bar	Total root length[b]
					cm × 10^{-5}					
June 26	1.54	1.54	1.75	0.93	0.93	3.06	3.06	0.0	0.0	0.73
30	1.64	1.64	2.76	1.38	1.38	3.23	3.23	0.0	0.0	0.84
July 3	2.66	2.66	3.46	1.75	1.75	3.39	3.39	0.0	0.0	1.12
7	3.70	3.70	4.33	2.70	2.70	3.73	3.73	0.50	0.50	1.56
10	5.30	5.30	4.82	3.18	3.18	3.65	3.65	0.93	0.93	1.94
14	8.32	8.32	5.07	4.34	4.34	5.01	5.01	1.23	1.23	2.98
17	9.34	9.34	4.73	5.31	5.31	6.45	6.45	3.52	3.52	3.51
21	10.67	10.67	5.16	6.35	6.35	7.61	7.61	4.51	4.51	4.95
26	14.86	14.86	5.55	10.04	10.04	9.96	9.96	8.19	8.19	7.05
31	17.10	17.10	5.02	15.21	15.21	11.46	11.46	10.28	10.28	10.56
Aug. 4	20.13	20.13	5.62	16.26	16.26	10.75	1.75	13.59	13.59	12.00
7	22.30	22.30	4.82	19.55	19.55	12.87	12.87	17.63	17.63	15.66
11	22.85	22.85	3.04	24.84	24.84	13.65	13.65	21.19	21.19	18.75
14	23.76	19.85	------	22.64	22.64	11.03	11.03	21.86	21.86	17.09
18	23.16	14.15	------	23.24	23.24	9.32	9.32	23.65	23.65	19.07
21	19.73	0.0	------	22.57	11.79	5.33	1.35	23.09	23.09	19.35
25	15.74	0.0	------	14.88	4.60	2.45	0.80	17.32	17.32	17.82
27	12.01	0.0	------	18.51	2.51	4.65	4.65	20.28	20.28	22.27
30	9.28	0.0	------	11.69	2.27	3.82	3.82	15.10	11.58	19.20
Sept. 1	7.91	0.0	------	8.68	2.11	3.00	3.00	10.98	8.68	16.93
5	4.49	0.0	------	5.44	2.27	3.16	3.16	7.69	5.40	13.35

[a] No water contents were measured, so no determination possible on roots in soil wetter than —1 bar.
[b] Water content at all depths always greater than at —1 bar.

155-cm Treatment, Bin 5

Bin 5, which contained 33 cm of Dothan sandy clay loam soil (pH 4.6), covered with 155 cm of Cahaba loamy fine sand, was not irrigated. Plant height (Table 3) increased almost linearly with time until August 15, and then increased 1 or 2 cm over the next 5 days. Volumetric water contents and rooting densities are presented as functions of depth and time in tables 4 and 5, respectively. Substantial rooting and water extraction occurred at least 10 cm into the acid subsoil material.

The total root length equaled the root length in soil wetter than −1 bar (Table 1) through August 21, then total root length started to decline and the plant height growth rate decreased. This occurred just as boll formation was starting. When the experiment was terminated on September 5, the two plants had a total of 568 leaves and 95 bolls (Table 2).

55-cm Treatment, Bin 6

Bin 6 contained 133 cm of Dothan sandy clay loam (pH 4.6) covered with 55 cm of Cahaba loamy fine sand. Plants grown in Bin 6 were first to develop water stress. At that time (July 27), about 80 to 90% of the available water was extracted to a depth of 70 cm, even though the well-limed and loosened soil stopped at the 55-cm depth. This 70-cm depth of soil held about 14% available water – equivalent to a 10-cm (4-inch) depth of water. The soil was irrigated twice. Plant height (Table 6) increased almost linearly with time until July 27, then increased again for a few days after the soil was irrigated on August 4. Volumetric water contents and rooting densities are presented as functions of depth and time in tables 7 and 8, respectively. Substantial rooting and water extraction occurred at least 20 cm into the acid subsoil material. The total root length equaled the root length in soil wetter

TABLE 2. LEAVES AND BOLLS PRESENT ON SEPTEMBER 5 FOR THE VARIOUS COTTON PLANTS IN THE EXPERIMENT

Bin	Left plant			Right plant		
	Leaves	Open bolls	Closed bolls	Leaves	Open bolls	Closed bolls
2	237	3	60	164	8	61
4	------	--	----	------	--	----
5	336	0	57	232	0	38
6	155	6	52	254	3	49
7	258	5	67	234	2	53
8	492	2	186	653	3	259

TABLE 3. SUMMARY OF PLANT TOP MEASUREMENTS MADE DURING THE 1972 GROWING SEASON FOR COTTON PLANTS OF BIN 5 AUBURN RHIZOTRON

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm* × 10^2	*mm-hr.* × 10	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Left plant					
7	28.4						--------	--------	--------	--------
8	29.3						--------	--------	--------	--------
9	30.5						--------	--------	--------	--------
10	31.0						3.3 W	0700	11.3 W*	1440
11	31.5						--------	--------	--------	--------
12	32.6						2.0 W	0705	11.0 E**	1425
13	33.6						--------	--------	--------	--------
14	36.0						2.3 W	0700	9.3 E	1434
15	37.5						--------	--------	--------	--------
16	37.8						--------	--------	--------	--------
17	38.2						2.3 W	0711	--------	--------
							8.3 E	1000	11.3 E	1401
18	39.5						--------	--------	--------	--------
19	40.2	----------------LVDT not installed----------------					3.0 W	0703	8.7 W	1415
20	42.5						--------	--------	--------	--------
21	45.4						2.0 W	0714	11.0 W	1405
22	47.0						--------	--------	--------	--------
23	48.5						--------	--------	--------	--------
24	49.0						2.0 W	0709	13.3 W	1425
25	49.5						--------	--------	--------	--------
26	53.5						2.0 W	0710	11.0 W	1414
27	55.5						--------	--------	--------	--------
28	57.1						1.3 W	0708	11.7 W	1419
29	58.6						--------	--------	--------	--------
30	61.4						--------	--------	--------	--------
31	61.6						1.0 W	0711	9.3 W	1406

Aug.	cm	Hr.	mm	Hr.	mm × 10²	mm-hr. × 10	—Bars	Hr.	—Bars	Hr.
1	62.7						--------	--------	--------	--------
2	64.5						1.7 W	0714	10.0 W	1422
3	66.0						--------	--------	--------	--------
4	67.8						2.0 W	0711	10.0 W	1410
5	68.6						--------	--------	--------	--------
6	71.0						--------	--------	--------	--------
7	72.5						2.3 W	0711	12.3 W	1427
8	73.4						--------	--------	--------	--------
9	75.0						2.3 W	0714	12.3 W	1406
10	76.4						--------	--------	--------	--------
11	76.5						2.3 W	0710	15.3 W	1409
12	78.0						--------	--------	--------	--------
13	79.5						--------	--------	--------	--------
14	79.0						4.7 W	0712	13.3 W	1404
15	79.0						--------	--------	--------	--------
16	80.6						4.0 W	0706	19.0 W	1414
17	80.0						--------	--------	--------	--------
18	80.3						5.3 W	0710	19.0 W	1404
19	80.1	----------------	----------------	LVDT not installed	----------------	----------------	--------	--------	--------	--------
20	80.0						--------	--------	--------	--------
21	81.2						10.0 E	0710	24.7 W	1414
22	80.6						--------	--------	--------	--------
23	80.7						8.3 E	0714	26.7 W	1409
24	80.2						--------	--------	--------	--------
25	81.0						17.3 W	0842	28.0 W	1414
26	81.0						--------	--------	--------	--------
27	80.1						11.7 E	0705	--------	--------
28	80.5						--------	--------	--------	--------
29	80.9						--------	--------	--------	--------
30	81.3						14.0 W	0703	31.3 W	1413
31	81.6						--------	--------	--------	--------
Sept.	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	80.2						14.7 E	0710	32.7 W	1408
2	80.6						--------	--------	--------	--------
3	80.8						--------	--------	--------	--------
4	80.5						--------	--------	--------	--------
5	80.5						19.3 E	0713	32.7 W	1406

(Continued)

TABLE 3 (*Con't.*). SUMMARY OF PLANT TOP MEASUREMENTS MADE DURING THE 1972 GROWING SEASON FOR COTTON PLANTS OF BIN 5 AUBURN RHIZOTRON

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Right plant					
7	29.1	------	------	------	------	------	------	------	------	------
8	29.5	------	------	17.9	10.4	9.8	------	------	------	------
9	30.0	0.0	.023	10.4	6.8	4.0	------	------	------	------
10	30.5	9.8	.081	8.0	2.8	1.6	2.7 W	0718	------	------
11	32.3	9.8	.177	6.3	1.2	0.5	------	------	------	------
12	33.9	9.6	.246	7.1	3.2	1.2	------	------	11.3 E	1453
13	34.7	10.4	.255	11.9	10.8	7.5	------	------	------	------
14	36.5	9.8	.180	------	------	------	2.0 W	0716	------	------
15	39.5	------	------	------	------	------	------	------	------	------
16	39.9	8.0	------	11.0	6.4	3.3	------	------	------	------
17	41.7	11.0	.133	11.2	10.8	7.4	2.7 W	0734	10.3 E	1425
									6.0 W	1842
18	43.4	10.4	.170	8.0	2.0	0.7	------	------	------	------
19	45.3	10.1	.250	9.3	4.4	2.8	3.0 W	0728	11.3 W	1438
20	47.7	11.7	.151	12.2	10.0	6.5	------	------	------	------
21	50.0	11.0	.152	11.5	6.8	5.3	4.7 W	0742	12.0 W	1435
22	52.4	10.1	.143	11.5	7.2	5.2	------	------	------	------
23	55.0	------	------	------	------	------	------	------	------	------
24	57.5	13.7	------	------	------	------	1.7 W	0734	12.3 W	1448
25	59.8	10.7	------	3.3	3.6	0.9	------	------	------	------
26	62.5	14.5	.358	8.3	7.2	3.7	1.7 W	0732	10.3 W	1438
27	64.9	10.6	.446	4.6	2.8	0.4	------	------	------	------
28	68.0	14.5	.366	9.0	10.8	5.8	1.0 W	0735	9.3 W	1447
29	70.3	12.9	.285	1.4	1.6	0.2	------	------	------	------
30	72.4	17.4	.349	5.3	8.0	2.4	------	------	------	------
31	73.6	------	------	------	------	------	0.7 W	0738	------	------

Aug.	*cm*	*Hr.*	*mm*	*Hr.*	*mm* × *10*²	*mm-hr.* × *10*	*—Bars*	*Hr.*	*—Bars*	
1	75.8	------	------	------	------	------	--------	--------	--------	--------
2	77.0	11.4	------	11.3	6.4	4.4	3.3 W	0747	11.7 W	1446
3	78.1	12.3	.322	4.7	2.0	0.4	--------	--------	--------	--------
4	80.3	11.4	.509	2.4	1.6	0.4	1.7 W	0739	10.3 W	1436
5	82.4	11.4	.517	7.2	3.6	1.9	--------	--------	--------	--------
6	84.6	10.1	.518	6.0	3.2	0.9	--------	--------	--------	--------
7	86.6	9.8	.509	10.8	12.0	7.4	2.7 W	0733	13.3 W	1445
8	88.8	10.3	.375	10.1	11.6	6.2	--------	--------	--------	--------
9	90.8	11.7	.348	9.6	16.0	9.6	2.7 W	0734	12.7 W	1433
10	92.3	------	.223	------	------	------	--------	--------	--------	--------
11	94.0	------	------	------	------	------	3.3 W	0737	12.3 W	1434
12	95.0	12.8	------	9.3	8.8	5.2	--------	--------	--------	--------
13	97.0	7.9	.267	11.6	13.2	9.7	--------	--------	--------	--------
14	97.0	7.9	.224	12.4	16.4	12.7	3.3 W	0746	11.7 W	1440
15	99.0	7.4	.205	7.2	19.2	17.6	--------	--------	--------	--------
16	99.6	6.3	.143	17.4	32.8	25.9	4.7 W	0741	16.7 W	1426
17	99.0	0.0	.103	14.2	22.0	11.9	--------	--------	--------	--------
18	100.3	7.6	—.063	24.0	40.4	45.6	5.3 W	0732	20.7 W	1423
19	100.8	5.0	—.036	24.0	44.8	49.3	--------	--------	--------	--------
20	101.0	7.9	—.071	23.7	44.8	39.9	--------	--------	--------	--------
21	100.9	8.0	—.027	23.8	39.2	38.2	11.7 E	0731	22.0 W	1434
22	101.4	5.8	—.018	23.8	51.2	52.4	--------	--------	--------	--------
23	101.2	5.8	—.045	24.0	44.0	41.4	11.7 E	0730	28.3 W	1428
24	101.0	5.0	+.027	24.0	53.6	56.8	--------	--------	--------	--------
25	101.0	5.4	—.027	24.0	60.8	64.8	20.7 W	0818	28.3 W	1432
26	101.0	3.9	—.035	19.6	59.2	48.6	--------	--------	--------	--------
27	100.8	3.2	—.044	24.0	62.0	69.2	10.0 E	0724	--------	--------
28	101.0	5.5	—.071	------	------	------	--------	--------	--------	--------
29	101.2	------	------	------	------	------	--------	--------	--------	--------
30	101.4	5.5	------	------	57.2	------	8.7 W	0726	32.7 W	1432
31	101.2	5.5	------	24.0	60.4	59.6	--------	--------	--------	--------
Sept.	*cm*	*Hr.*	*mm*	*Hr.*	*mm* × *10*²	*mm-hr.* × *10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	100.9	------	------	------	------	------	20.0 W	0731	33.3 W	1429
2	101.4	------	------	------	------	------	--------	--------	--------	--------
3	101.4	0.0	------	------	------	------	--------	--------	--------	--------
4	101.4	0.0	------	------	------	------	--------	--------	--------	--------
5	101.0	0.4	------	------	------	------	20.0 E	0735	32.0 W	1424

* West ** East

TABLE 4. VOLUMETRIC WATER CONTENT AS FUNCTION OF DEPTH AND TIME IN BIN 5, AUBURN RHIZOTRON, 1972

	Depth						Total water use
	30	60	90	120	150	180	
			cm³/cm³				*cm/day*
July 8	.223	.235	.265	.245	.253	.322	
10	.213	.220	.259	.238	.251	.345	.27
12	.202	.210	.254	.233	.248	.355	.38
14	.190	.204	.248	.228	.245	.357	.47
17	.174	.196	.240	.221	.241	.358	.44
19	.162	.190	.230	.216	.238	.357	.57
21	.151	.184	.220	.211	.234	.351	.66
26	.124	.170	.202	.201	.222	.347	.54
28	------	.163	.196	.197	.217	.337	----
31	.264	------	.190	.189	.209	.342	----
Aug. 2	.217	.169	.185	.182	.202	.328	----
4	.174	.167	.178	.175	.196	.345	.75
7	.114	.134	.156	.160	.180	.322	1.76
9	.090	.115	.142	.146	.160	.325	1.38
11	.081	.099	.127	.126	.139	.310	1.50
14	.072	.080	.108	.101	.103	.297	1.27
16	.068	.072	.095	.084	.083	.287	1.13
18	.063	.065	.084	.070	.063	.284	.94
21	.056	.056	.070	.052	.045	.277	.76
23	.051	.051	.062	.045	.040	.280	.42
25	.048	.048	.057	.041	.038	.267	.47
27	.045	.045	.053	.037	.036	.262	.33
30	.041	.041	.048	.033	.034	.242	.41
Sept. 1	.039	.040	.046	.031	.033	.242	.13
5	.036	.037	.041	.030	.032	.240	.12

than –1 bar (Table 1) through August 18, although the total root length started to decline after August 11. Plant height reached its maximum August 18, although maximum root length occurred 7 days earlier.

When the experiment was terminated on September 5, the two plants had a total of 409 leaves and 110 bolls (Table 2).

Drying Control, Bin 7

Bin 7 contained 188 cm of Cahaba loamy fine sand which was not irrigated during the experiment. Plant height increased almost linearly with time until August 15. By August 25, water content was less than 0.08 cm^3/cm^3 at all depths, and rooting density was greater than 1.0 cm^3/cm^3 at all depths. Total root length and root length in soil wetter than –1 bar are presented in Table 1. When the experiment was terminated at September 5, the two plants had a total of 492 leaves and 127 bolls (Table 2).

TABLE 5. ROOTING DENSITY AS A FUNCTION OF DEPTH AND TIME IN BIN 5, AUBURN RHIZOTRON, 1972

	Depth (cm)						
	30	60	90	120	150	165	180
				cm root/cm³ soil			
June 26	.31	.06	.06	0	0	0	0
28	.34	.10	.10	.03	0	0	0
30	.34	.10	.13	.07	0	0	0
July 3	.40	.15	.19	.07	0	0	0
5	.48	.18	.21	.13	.09	0	0
7	.56	.26	.24	.10	.09	0	0
10	.64	.40	.21	.13	.09	0	0
12	.84	.55	.21	.13	.14	0	0
14	.95	.58	.21	.13	.14	0	0
17	1.20	.63	.27	.18	.18	0	0
19	1.38	.73	.27	.27	.22	0	0
21	1.40	.76	.27	.29	.22	0	0
24	1.72	.92	.40	.45	.30	.11	0
26	1.97	.94	.56	.61	.46	.11	0
28	2.09	1.02	.72	.74	.58	.11	0
31	2.12	1.07	.85	1.00	.90	.11	0
Aug. 2	2.14	1.15	.87	1.05	.94	.11	0
4	2.50	1.22	.97	1.33	1.40	.11	0
7	2.48	1.32	1.30	1.88	1.88	.19	0
9	2.57	1.42	1.53	2.27	2.31	.27	0
11	2.50	1.50	1.58	2.48	2.70	.74	0
14	1.93	1.48	1.50	2.42	2.49	.66	0
16	2.52	1.58	1.56	2.33	2.06	.74	0
18	2.12	1.43	1.55	2.70	2.96	.74	0
21	1.73	1.41	1.58	2.47	2.52	.74	0
23	1.60	1.10	1.45	2.23	1.81	.74	0
25	.92	.79	1.15	1.43	1.62	.98	0
27	1.35	.98	1.20	1.90	1.98	1.05	.11
30	.79	.66	1.08	.97	.86	1.05	0
Sept. 1	.32	.45	.79	.82	.66	.98	0
5	.32	.15	.37	.40	.23	1.05	0

Well-water Control, Bin 8

Bin 8 contained 188 cm of Cahaba loamy fine sand, which was watered sufficiently to prevent any layer drying to –1 bar soil water potential. Plant height increased almost linearly with time until August 16. After that date, height continued to increase, but more slowly than before. Volumetric water contents, water additions, and drainage were measured and used to calculate the daily water use. Total root length is listed in Table 1. When the experiment was terminated on September 5, the two plants in this compartment had a total of 1,145 leaves and 450 bolls (Table 2). In all other treatments the available water supply was greatly reduced or exhausted prior to August 15. Yields of the well-watered treatment (in number of bolls) was twice that of any other treatment.

TABLE 6. SUMMARY OF PLANT TOP MEASUREMENTS MADE DURING THE 1972 GROWING SEASON FOR COTTON PLANTS IN BIN 6, AUBURN RHIZOTRON

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm* × 10^2	*mm-hr.* × 10	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Left plant					
7	36.8	------	------	------	------	------	------	------	------	------
8	37.5	8.4	------	11.0	7.2	4.5	------	------	------	------
9	38.0	9.2	.059	6.3	2.8	1.3	------	------	------	------
10	38.5	8.4	.131	9.6	5.2	3.1	3.7 W	0703	13.0 W*	1445
11	39.5	9.9	.146	10.7	7.6	4.8	------	------	------	------
12	43.0	12.2	.193	------	------	------	4.3 W	0710	10.7 W	1432
13	44.6	------	------	------	------	------	------	------	------	------
14	46.0	------	------	------	------	------	3.0 W	0702	8.7 W	1436
15	48.3	------	------	------	------	------	------	------	------	------
16	50.0	------	------	12.1	19.6	13.0	------	------	------	------
17	52.2	14.2	.321	13.7	22.0	17.6	2.3 W	0715	12.7 W	1403
							7.7 E**	1003	7.7 W	1845
18	54.5	11.4	.215	------	------	------	------	------	------	------
19	55.1	10.1	------	------	------	------	2.0 W	0707	12.7 W	1418
20	58.2	------	------	------	------	------	------	------	------	------
21	60.8	------	------	------	------	------	1.7 W	0718	13.3 W	1412
22	62.5	------	------	11.9	8.4	5.5	------	------	------	------
23	64.5	7.9	.054	10.8	8.0	4.0	------	------	------	------
24	66.0	11.4	.080	11.3	13.6	7.4	1.3 W	0712	12.7 W	1222
							8.7 W	0950	14.7 W	1432
									8.0 W	1726
									6.3 W	1822
25	68.3	------	------	------	------	------	------	------	------	------
26	68.3	8.7	------	14.8	25.2	17.2	3.0 W	0715	13.0 W	1420
							7.0 W	0922	11.0 W	1708
							7.3 W	1008	10.7 W	1712
							9.3 W	1045	6.0 W	1852
27	69.1	9.2	.098	6.3	13.2	5.2	6.3 W	0844	9.3 W	1334
28	71.0	9.5	.187	23.9	32.4	38.0	2.7 W	0714	17.3 W	1424
29	71.1	9.8	—.017	5.3	6.8	2.0	------	------	------	------
30	72.8	15.9	.223	11.6	25.2	13.4	------	------	------	------
31	72.5	------	.053	------	------	------	2.0 W	0716	16.0 W	1409

Aug.	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	73.4	------	------	------	------	------	------	------	------	------
2	73.2	7.6	------	18.0	19.6	18.0	4.0 W	0721	15.3 W	1425
3	73.2	9.2	.072	14.0	21.6	16.1	------	------	------	------
4	73.5	10.1	.143	10.2	15.2	7.2	1.3 W	0715	16.3 W	1414
							6.0 W	0750		
5	74.3	5.4	.232	11.6	10.8	7.7	------	------	------	------
6	74.2	9.3	.125	12.7	11.2	7.2	------	------	------	------
7	75.1	9.9	.116	11.2	11.6	8.1	2.3 W	0715	15.0 W	1426
8	75.8	8.8	.161	12.6	15.2	10.4	------	------	------	------
9	76.5	7.9	.178	15.4	16.8	12.3	2.7 W	0717	10.7 E	1411
10	76.9	5.4	.134	------	------	------	------	------	------	------
11	77.8	------	------	------	------	------	1.7 W	0714	11.7 W	1414
12	78.5	11.4	------	10.2	10.0	6.2	------	------	------	------
13	78.5	7.1	.125	14.8	14.8	9.8	------	------	------	------
14	77.7	6.0	.125	21.2	21.6	20.3	3.0 W	0720	11.0 E	1409
15	79.3	4.4	.018	17.4	19.6	16.6	------	------	------	------
16	79.2	7.7	.053	24.0	33.2	32.7	3.7 W	0711	16.7	1417
17	78.0	0.0	—.088	18.9	30.0	16.7	------	------	------	------
18	79.2	7.1	+.045	24.0	56.8	65.7	5.3 E	0715	19.7 W	1406
19	78.6	0.0	—.098	24.0	58.4	71.7	------	------	------	------
20	77.5	0.0	—.124	24.0	46.8	47.1	------	------	------	------
21	79.3	6.6	—.018	24.0	42.0	52.6	13.7 E	0713	28.0 W	1417
22	78.2	5.5	—.080	24.0	40.8	47.3	------	------	------	------
23	78.4	4.4	—.051	24.0	35.6	36.5	17.3 E	0717	33.3 E	1413
24	78.1	0.0	+.027	22.9	46.0	57.5	------	------	------	------
25	78.0	0.0	—.054	24.0	46.0	29.5	24.7 W	0850	34.7 W	1418
26	78.1	0.0	.161	15.1	33.2	25.0	------	------	------	------
27	77.5	0.0	.054	18.3	35.2	41.1	8.0 E	0707	------	------
28	78.2	8.5	—.116	24.0	------	------	------	------	------	------
29	77.7	------	------	------	------	------	------	------	------	------
30	------	------	------	------	------	------	7.3 W	0706	18.3 W	1416
31	77.7	------	------	------	------	------	------	------	------	------
Sept.	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	77.7	9.8	------	------	22.8	------	8.3 W	0713	22.7 W	1411
2	78.0	------	------	------	------	------	------	------	------	------
3	78.2	------	------	------	------	------	------	------	------	------
4	78.0	------	------	------	------	------	------	------	------	------
5	78.0	------	------	------	------	------	10.0 E	0716	12.3 W	1409

Add 4 cm for true height.

(Continued)

TABLE 6 (*Con't.*). SUMMARY OF PLANT TOP MEASUREMENTS MADE DURING THE 1972 GROWING SEASON FOR COTTON PLANTS IN BIN 6, AUBURN RHIZOTRON

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	$mm \times 10^2$	$mm\text{-}hr. \times 10$	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Right plant					
7	28.6	------	------	------	------	------	------	------	------	------
8	29.3	8.2		11.0	7.6	5.6	------	------	------	------
9	30.3	6.6	.173	7.4	2.4	1.0	------	------	------	------
10	31.0	11.2	.164	9.6	5.6	3.0	1.7 W	0720	------	------
11	32.0	11.5	.132	10.5	4.8	2.8	------	------	------	------
12	33.9	11.0	.166	10.7	5.2	3.5	3.0 W	0725	11.3 W	1455
13	36.0	8.7	.162	12.4	12.4	8.2	------	------	------	------
14	36.5	10.6	.114	------	------	------	2.7 E	0718	------	------
15	39.6	------	------	------	------	------	------	------	------	------
16	42.0	9.2	------	13.5	12.8	9.0	------	------	------	------
17	43.4	8.8	.107	11.8	8.4	3.8	2.3 W	0732	10.0 E	1423
18	44.0	11.4	.250	5.0	1.2	0.5	------	------	------	------
19	46.4	10.4	.401	9.1	7.2	3.8	3.0 W	0724	12.3 W	1434
20	47.2	11.4	.313	9.3	10.8	5.9	------	------	------	------
21	49.8	8.4	.259	12.2	12.8	8.0	3.3 W	0737	12.3 W	1431
22	51.5	9.2	.205	12.6	17.2	11.2	------	------	------	------
23	52.5	9.0	.179	9.0	16.4	9.4	------	------	------	------
24	54.9	10.6	.214	------	------	------	2.0 W	0730	15.7 W	1445
25	55.6	------	------	------	------	------	------	------	------	------
26	56.8	10.4	------	12.1	24.4	14.2	3.7 W	0727	14.3 W	1435
27	57.8	9.8	.214	6.4	11.6	4.0	------	------	------	------
28	54.5	12.6	.259	11.0	21.6	13.3	2.3 W	0733	16.0 W	1442
29	60.0	10.1	.161	------	------	------	------	------	------	------
30	61.0	------	------	10.4	26.8	12.4	------	------	------	------
31	61.5	------	------	------	------	------	1.8 W	0734	------	------

Aug.	cm	Hr.	mm	Hr.	mm × 10²	mm-hr. × 10	—Bars	Hr.	—Bars	Hr.
1	62.3	------	------	------	------	------	------	------	------	------
2	63.5	9.5	------	16.6	18.8	16.8	2.7 W	0743	17.7 W	1443
3	64.0	9.5	.098	13.3	18.0	13.3	------	------	------	------
4	64.5	9.5	.187	10.0	15.2	5.3	4.0 W	0734	13.3 W	1433
5	65.0	9.9	.304	10.2	6.4	4.8	------	------	------	------
6	65.9	9.9	.232	11.8	7.2	4.5	------	------	------	------
7	67.5	9.2	.205	12.9	9.6	8.2	3.3 W	0729	14.0 W	1442
8	69.0	9.5	.134	10.7	10.8	4.7	------	------	------	------
9	69.5	10.4	.134	10.4	12.8	8.8	2.0 W	0730	12.3 W	1428
10	70.3	------	.186	------	------	------	------	------	------	------
11	71.5	------	------	------	------	------	2.0 W	0734	8.3 W	1430
12	72.8	10.9	------	10.7	10.4	5.8	------	------	------	------
13	72.0	8.7	.151	16.3	16.8	12.6	------	------	------	------
14	72.0	5.8	.125	20.9	21.6	21.5	3.3 W	0744	15.3 W	1435
15	72.2	6.6	.000	22.8	23.2	25.1	------	------	------	------
16	72.4	5.7	.009	24.0	44.0	56.0	2.3 W	0734	18.0 W	1433
17	73.2	0.0	—.126	23.2	35.2	25.3	------	------	------	------
18	73.1	5.2	+.045	24.0	58.4	73.4	5.3 W	0728	22.0 W	1420
19	73.3	0.0	—.134	23.5	54.4	67.8	------	------	------	------
20	73.3	0.0	—.098	24.0	41.6	43.4	------	------	------	------
21	72.5	9.3	+.018	24.0	42.8	55.6	14.0 E	0728	28.0 W	1431
22	72.8	7.9	—.062	24.0	40.4	51.5	------	------	------	------
23	73.0	6.8	—.054	24.0	39.2	50.9	15.0 E	0735	32.7 W	1425
24	72.6	7.9	—.018	24.0	39.2	48.5	------	------	------	------
25	72.5	7.7	—.045	17.4	40.4	29.6	24.7 W	0915	34.0 W	1433
26	73.0	5.0	+.098	24.0	27.6	33.7	------	------	------	------
27	72.4	8.4	—.040	------	32.4	------	7.3 W	0720	------	------
28	------	------	------	------	------	------	------	------	------	------
29	------	------	------	------	------	------	------	------	------	------
30	73.7	------	------	------	------	------	6.7 W	0722	17.7 W	1429
31	------	------	------	9.5	16.4	------	------	------	------	------
Sept.	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	72.8	------	------	------	------	------	9.3 W	0728	22.7 W	1426
2	73.6	------	------	------	------	------	------	------	------	------
3	73.5	------	------	------	------	------	------	------	------	------
4	73.6	------	------	------	------	------	------	------	------	------
5	73.6	------	------	------	------	------	8.7 E	0732	12.0 W	1420

* West ** East

TABLE 7. VOLUMETRIC WATER CONTENT AS FUNCTION OF DEPTH AND TIME AND TOTAL WATER USE AS A FUNCTION OF TIME FOR BIN 6, AUBURN RHIZOTRON, 1972

	Depth							Total water use
	30	45	60	75	90	120	180	
				cm³/cm³				*cm/day*
July 8	.228	.264	.279	.285	.322	.337	.337	
10	.216	.247	.267	.278	.322	.334	.403	.24
12	.204	.228	.249	.270	.318	.333	.401	.52
14	.191	.211	.234	.265	.305	.331	.399	.47
17	.168	.184	.204	.250	.303	.329	.407	.59
19	.153	.165	.180	.241	.317	.327	.420	.62
21	.111	.137	.150	.234	.321	.326	.419	1.12
24	.087	.086	.105	.221	.300	.324	.380	.78
26	.072	.072	.093	.213	.293	.323	.397	.48
28	.062	.062	.084	.205	.290	.322	.383	.35
31	.054	.054	.075	.193	.297	.320	.390	.23
Aug. 2	.051	.051	.071	.185	.298	.319	.391	.16
4	.047	.047	.069	.177	.299	.318	.380	.17
Irrigated								
7	.240	.257	.257	.269	.298	.317	.375	
9	.185	.200	.200	.247	.290	.316	.382	1.84
11	.147	.157	.162	.220	.289	.315	.372	1.38
14	.097	.097	.108	.189	.288	.313	.385	1.22
16	.075	.075	.085	.174	.287	.312	.382	.78
18	.054	.054	.072	.172	.287	.312	.390	.59
21	.040	.040	.061	.153	.280	.311	.375	.36
23	.037	.037	.060	.150	.277	.310	.384	.10
25	.036	.036	.053	.148	.278	.309	.375	.09
Irrigated								
27	.317	.274	.225	.206	.274	.309	.380	
30	.190	.212	.216	.227	.275	.308	.387	1.52
Sept. 1	.160	.182	.195	.213	.275	.307	.390	.94
5	.105	.120	.132	.199	.278	.307	.381	.93

Large quantities of water are absorbed by plant roots from the soil reservoir. The quantity of water usually considered available to plants from a particular profile depends upon the amount of water retained after drainage for 2 or 3 days (field capacity), the amount retained by soil when the plants can no longer recover overnight (wilting point), and the depth of rooting. Significantly changing the available water capacity (field capacity minus wilting point) of a soil is quite difficult, but rooting depth can often be increased by correcting adverse soil conditions (Pearson *(11)*; Taylor et al. *(16)*. Our results indicated that cotton top growth was reduced to zero whenever the leaf water potential at sunrise was less than –7.6 bars, or whenever the leaf water potential at 2 P.M. was less than –21.1 bars. With the same accuracy, plant water stress at the time growth became zero could be determined in terms of the maximum stem shrinkage, the duration of shrink-

TABLE 8. ROOTING DENSITY OF COTTON AS A FUNCTION OF DEPTH AND TIME IN BIN 6, AUBURN RHIZOTRON, 1972

	Depth (cm)					
	15	30	45	60	75	90
	cm root/cm³ soil					
June 26	1.66	.43	.74	0	0	0
28	1.88	.43	.83	0	0	0
30	1.66	.51	.82	0	0	0
July 3	1.73	.51	.90	0	0	0
5	1.73	.59	.98	0	0	0
7	1.73	.59	1.13	0	0	0
10	1.66	.59	1.13	0	0	0
12	2.17	.66	1.58	0	0	0
14	2.24	.59	1.81	.10	0	0
17	2.53	.74	2.60	.10	0	0
19	2.46	.74	3.01	.11	0	0
21	2.60	.90	3.28	.27	0	0
24	2.87	1.05	3.87	.82	0	0
26	2.81	1.43	3.93	1.05	0	0
28	3.01	1.66	4.73	1.21	0	0
31	2.94	1.58	4.73	1.36	0	0
Aug. 2	3.01	1.66	4.67	1.51	.19	0
4	2.46	1.81	4.06	1.43	.19	0
7	3.15	2.03	4.79	1.36	.59	0
9	3.01	2.24	4.67	1.58	1.05	0
11	3.08	2.39	4.61	1.51	1.05	0
14	2.10	2.39	4.00	.98	.74	0
16	2.38	2.10	3.54	1.05	.98	0
18	1.88	2.17	2.94	.98	.66	0
21	.90	1.51	1.28	.59	.66	0
23	.19	.74	.74	.59	.66	0
25	0	.59	.51	.43	.74	0
27	.59	1.81	.66	.66	.59	0
30	.27	1.36	.43	.66	.82	0
Sept. 1	.51	.66	.51	.59	.51	0
5	.98	.82	.43	.51	.19	0

age, or an amount of shrinkage-duration parameter. In addition to these factors relating stem or top growth to plant water status, our results show that plant water status also has very important effects on root systems.

Ward et al. *(17)*, calculated the probability of plants suffering drought in Alabama during various months of the growing season and at various available water supplies. Data on available water capacity was combined with theirs on drought-day probabilities to estimate the depth of rooting necessary for high yields. Admittedly, these data must be rechecked in experimental trials before farmers undertake large-scale profile modification. The drought probability data for Auburn, Alabama shows that in 9 out of 10 years at least 20 days of seasonal drought should be expected with a soil water storage capacity of 10 cm in the rooting zone. If the depth of limed and loosened soil is decreased to 30 cm (45-cm total depth of rooting), the available water storage capacity is reduced to 6.3 cm and, in 9 out of 10 years, at least 32 days of seasonal drought should be expected. Considerable power is required to lime and loosen the soil to a 60- to 75-cm depth, and in some soils the loosening process is quite temporary. Large quantities of lime would be required to increase soil pH from 4.6 to 6.0, but the available water supply in the 85-cm rooting zone would be 12 cm, and in 2 out of 10 years plants would suffer no drought. In half of the years the plant would suffer less than 35 days drought.

CONCLUSIONS

Data collected during this experiment allow estimates of the available water capacity and rooting depth for these sandy soils. Thus, the minimum depth of rooting necessary for high yields of cotton during most growing seasons can be estimated.

Results (Bin 4) show that an acid (pH 4.6) subsoil at the 15-cm depth reduced growth rate of cotton soon after emergence. These data indicate that some factor other than plant water stress caused a reduction in growth. Therefore, regardless of the frequency of rain or irrigation the depth to an acid soil layer should be greater than 15 cm (6 inches) if maximum cotton yields are desired. Apparently, where root-restricting layers are present, long-term cotton yields would be increased by profile modification to at least 60 cm, and probably to the 75-cm depth. Although long-term yields would be increased by profile modification, the farmer may not be able to justify the additional expense to create soil conditions necessary for additional yields. Therefore, the farmer should carefully consider whether or not the increase in yield is worth the additional cost.

Data from the well-water control (Bin 8) indicate that for best cotton yield the plant must have a continuous water supply during boll formation. Water stress and plant aging reduce the growth of new roots, and thus reduce the ability of the root system to supply water to plant tops. These drought-associated rooting changes apparently cause earlier closure of stomates while light for photosynthesis is optimum. The root-shoot interactions result in a progressive degradation of the water-supplying ability of the root system.

The basic data presented in this bulletin and appendices may be of use to research workers interesting in simulating water uptake by root systems or plant growth as affected by various environmental factors. Because of plant modelers' possible interest in this data, weather data for a station located about 1.5 km from the rhizotron is included in Appendix II. In addition, Appendix III includes a list of summaries of publications for which data were collected wholly or in part at the Auburn rhizotron. These publications will provide further analyses of various plant growth experiments and may be helpful as background material.

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APPENDIX I

Monitoring Environmental Conditions: Data Acquisition, Reduction, and Storage

To facilitate describing root growth and function as influenced by measurable soil properties, the physical environment of the soil in each rhizotron bin was monitored by a network of transducers during the entire experiment. Additional measurements describing the aboveground microclimate were made and recorded on master magnetic tape datasets, which are available for use by other investigators wishing to analyze the accumulated data.

A. Hardware

1. Transducers

a. **Temperature.** The temperature of the soil in each rhizotron compartment was monitored by a network of thermistors buried at 30-cm depth increments in each bin. Commercially-available thermistors from Fenwall Electronics, Inc.[1] were factory-selected for uniformity of temperature response curve. The manufacturer guaranteed absolute accuracy to within 0.2 C over a temperature range of 0 to 80 C, using factory-supplied calibration data applicable to each interchangeable unit.

Statistical regression analysis of the resistance-temperature could be obtained from measured thermistor resistance by substitution into the following equation:

$$T = 236.986744 + (0.00002832 \times r) + (0.4424 \times 1/\sin(r \times 10^{-5})) - (47.869563 \times \log_{10}(r)) \tag{1}$$

where r is measured thermistor resistance in ohms, and T is the indicated temperature in degrees centigrade. The thermistors were embedded in epoxy resin or sealed into heat-shrinkable tubing and buried in the rhizotron compartments at the beginning of the growing season. Additional thermistors embedded in epoxy resin monitored ambient air temperature, wet-bulb temperature, and temperature in the rhizotron walkway.

b. **Net radiation.** A Fritschen *(7)* net radiometer was maintained over clipped grass sod at a distance of approximately 3 m from the rhizotron compartment and 1 m above the sod. The integrating hemisphere was kept under slight positive pressure by a continuous stream of filtered air blown in through an aquarium pump. The factory calibration value of 3.05 mv/ly was used without further experimental verification.

c. **Oxygen concentration.** Oxygen concentration in the air-filled pore spaces of the soil in the compaction treatment (bin 2) was monitored by Chem-tronics Model GP-10 Gas Phase Oxygen Transducers[1] installed in inverted 100-ml glass diffusion chambers. Duplicate transducers were installed just below the compacted layers of bin 2. An additional pair of diffusion

[1] Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

chambers was installed in the center of the compacted zone with one transducer adjacent to the glass window and the other in the center of the bin. Shielded leads in waterproof cable connected each transducer to the Digital Data Acquisition System (DDAS), which recorded the 0- to 10-mv output voltages from each transducer. Calibration was accomplished at periodic intervals by flushing the diffusion chambers with N_2 gas supplied from a cylinder, or with ambient air (21% oxygen) through capillary tubes leading to the surface of the soil.

2. Data Acquisition System Hardware

A Vidar Model 5403-03 Digital Data Acquisition System (DDAS)[1] is installed in an instrument trailer adjacent to the rhizotron. The trailer is air-conditioned to keep ambient temperature and humidity within the DDAS manufacturer's specified tolerance limits. This DDAS is capable of reading analog data from up to 200 input channels (transducers) and converting it to digital form. The input can be either D.C. volts ($\pm$ 10 mv to $\pm$ 100 v full scale) or D.C. resistance (10Ω to 10MΩ full scale) with resolution of $\pm$ 0.01% full scale range. Binary coded decimal (BCD) output from the system is recorded in IBM-compatible EBCDIC characters at a density of 800 bits per inch on a 9-track digital Incremental Magnetic Tape Recorder (ICMR).

Because of frequent thunderstorms during the growing season, lightning protection as well as an auxiliary power source was essential to keep the system in operation on a continuous basis. Lightning protection was accomplished by installing a Joslyn Model 1201-02 lightning and electrical surge protector[1] between the DDAS and the power line. With this device, an impulse voltage of 20,000 volts is held to no more than 50 volts deviation from nominal output over 0.4 microseconds, and output returns to normal operating voltage within less than 0.7 microseconds. All transducer leads utilized multiconductor shielded cable between the various rhizotron compartments and the DDAS. They were buried to minimize interference and signal loss.

With many data acquisition systems a temporary power interruption will cause all data to be lost from the time of the power failure to the time of resetting the digital clock and the ICMR. Power failures tend to occur during periods of heavy rainfall and rapidly changing temperatures, so that data lost for this reason will occur during the most critical times of an experiment. To prevent data loss, the clock for the rhizotron DDAS was ordered with a 100 kHz crystal time base so that it could be operated from a simple power inverter without precision frequency regulation. Both the digital clock and the ICMR were continuously run by a 300-watt Topaz inverter[1] which, in turn, was powered from a 12-volt storage battery. The battery was kept at full charge by a 15-amp battery charger supplemented by an automatic 8-amp battery charger which charged only when needed. The total cost of the inverter and charging components was approximately 10% that of commercially-available off-line power supply units with precision cycle regulation.

In operation, the transducer inputs are grouped into blocks with similar functions clustered on consecutive channels, because each time the system changes range or function, its scan time is increased. While auto-ranging is available for channels with widely fluctuating signal strength, it was not generally used because of the increased scan time required. An online paper tape printer and Nixie tube displays were available for setup or for checking output of a particular channel during an experiment. Two strip chart recorders with a total of 12 channels were used to monitor transducers and to provide feedback information to the experimenters about realtime changes occurring in the plants before computer dumps from the magnetic tapes were available.

Because the rhizotron DDAS is a free-standing system without on-line computer support, the switching mechanism of the scanner requires that when any channel is scanned, all other channels in use must also be scanned. Thus, if one channel has a rapidly changing input which must be scanned frequently to monitor rapid fluctuations (e.g., net radiation, which varies with each cloud), all channels then in use must be scanned at the same frequency even though other channels (for instance, those monitoring soil temperature) change much more slowly. The result is an accumulation of redundant data at the magnetic tape from the slowly-changing input channels.

As a result of recording the status of all channels each time any channel is examined, the tapes were filled sooner than if only essential information was recorded. During the 1972 growing season the DDAS was set to scan all 200 channels at 2-min. intervals. At the recording densities used, tape consumption was still less than two 1,200-ft. reels per week. After primary data reduction by a remote computer in a batch-mode operation, the original tapes could be returned to the rhizotron and reused for storage of additional data until consolidated into the master tape files by computer.

B. Software

1. Primary data reduction

After data collection intervals of 2 to 4 days, tapes from the rhizotron data-acquisition system were processed to remove redundant information and to build data files compatible with further studies. Using a file-oriented language (PL-1 on the Auburn University IBM 360/50 computer) millivolt values representing net radiation and stem diameter were copied at 2-minute intervals. Oxygen concentration, ambient air temperatures, and wet-bulb temperatures were recorded onto the master tape records at 20-minute intervals; soil temperatures were computed and recorded at 60-minute intervals. All other data on the field tapes were ignored.

Information selected for further processing and storage was converted from the electrical units (volts or ohms) into the measurement units appropriate to the device monitored at this time. Stem diameter was computed from the millivolt output of each LVDT according to the calibration factor recorded daily. Net radiation was obtained from the factory calibration value of 3.05 mv/ly. Temperature was obtained from measured resistance by substitution into equation (1).

Following conversion to appropriate units, the data was stored on magnetic tape files as a series of 80-character card-image records, using the format of Brown and Rosenberg *(3)* as illustrated in Appendix Figure 1. As each field tape was processed by the primary data reduction program, the output data file was manually verified to be free from computational errors. Then each scratch tape was copied onto the end of a pair of master tapes. Duplicate or backup master tapes were useful in preventing errors introduced in the updating process.

```
0817023617+0402+0352-0058+0261+0065+0299+0428+0567+0726+0872+1008+1169-0058-0059
0817023817+0412+0359-0058+0262-0011+0299+0428+0566+0726+0872+1008+1169-0056-0058
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0817024415+0000+0000+0000+0000+2266+2241+2044+2014+0149+0000+0369+0151-0054+0168
0817024417+0414+0360-0057+0263+0389+0299+0428+0566+0726+0871+1007+1169-0057-0052
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0817024817+0421+0370-0055+0262+0779+0299+0428+0566+0726+0871+1007+1168-0051-0050
0817025017+0424+0374-0055+0262+0482+0299+0428+0566+0725+0871+1007+1168-0046-0048
0817025217+0428+0382-0054+0262+0623+0299+0428+0566+0725+0871+1007+1168-0023-0044
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0817025817+0427+0387-0054+0261+0130+0299+0428+0566+0725+0871+1006+1168-0058-0042
0817030001+2600+2867+2384+2543+2515+2624+2518+2518+2552+2482+2317+2528+0000+0000
0817030002+2763+2683+2610+2532+2483+2737+2678+2566+2517+2489+2581+2764+3003+0000
0817030003+2681+2655+2674+2564+2627+2702+2761+2651+2718+2673+0000+0000+0000+0000
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0817030007+2771+2665+2658+2572+2514+2737+2664+2608+2590+2540+0000+0000+0000+0000
0817030008+2734+2670+2636+2579+2553+2768+2721+2648+2641+2541+0000+0000+0000+0000
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0817030010+2566+2605+2886+2354+2297+0607+3836+2266+2575+2533+0000+0000+0000+0000
0817030011+2609+2550+0551+2621+9648+2241+2626+2621+2624+2957+0000+0000+0000+0000
0817030012+2962+2706+2604+2714+2599+2843+2515+2879+2648+2716+2607+0000+0000+0000
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0817030014+2344+2772+2631+2826+2782+2705+2675+2577+2671+2671+2783+2687+0000+0000
0817030017+0430+0392-0074+0262+0524+0299+0428+0566+0725+0871+1007+1168-0051-0042
0817030217+0449+0433-0074+0262+0388+0300+0428+0566+0725+0871+1007+1168-0039-0041
0817030415+0000+0000+0000+0000+2261+2241+2037+2013+0122+0000+0237+0151-0044+8675
0817030417+0430+0431-0059+0261+0237+0299+0428+0566+0725+0871+1007+1168-0054-0042
0817030617+0435+0428-0061+0261+0952+0299+0428+0566+0725+0871+1007+1168-0058-0047
0817030817+0429+0423-0061+0261+0727+0299+0428+0566+0725+0871+1007+1168-0056-0052
0817031017+0435+0441-0057+0260+0206+0299+0429+0567+0726+0872+1008+1169-0053-0052
0817031217+0436+0439-0058+0259+0112+0299+0429+0567+0726+0872+1008+1169-0050-0051
0817031417+0445+0456-0056+0258+0684+0300+0429+0567+0726+0872+1007+1169-0051-0051
0817031617+0431+0437-0055+0258+0589+0299+0429+0566+0726+0871+1007+1169-0056-0054
0817031817+0436+0435-0055+0258+0567+0299+0429+0566+0726+0872+1008+1169-0051-0053
0817032017+0434+0435-0056+0258+0757+0299+0429+0567+0726+0872+1008+1169-0055-0053
0817032217+0433+0436-0055+0258+0417+0299+0429+0567+0726+0872+1006+1170-0051-0052
0817032415+0000+0000+0000+0000+2248+2227+2021+1995+0129+0000+0448+0151-0053+5382
0817032417+0437+0435-0053+0258+0448+0299+0429+0567+0726+0872+1008+1169-0049-0052
0817032617+0436+0437-0054+0258+0783+0300+0429+0567+0726+0872+1008+1169-0045-0051
0817032817+0443+0453-0054+0258+0565+0300+0429+0567+0726+0872+1008+1170-0045-0050
0817033017+0443+0431-0052+0255+0524+0300+0429+0567+0726+0872+1008+1170-0052-0050
0817033217+0464+0525-0052+0259+0226+0300+0429+0567+0726+0872+1008+1170-0050-0050
0817033417+0461+0512-0052+0259+0781+0300+0429+0567+0726+0872+1008+1170-0047-0049
0817033617+0453+0450-0052+0258+0203+0300+0429+0567+0726+0872+1008+1170-0055-0049
0817033817+0447+0444-0052+0259-0360+0300+0429+0567+0726+0872+1008+1170-0058-0050
0817034017+0451+0448-0053+0260+0145+0300+0429+0567+0727+0872+1008+1170-0054-0052

Month Day Hour Minute Card   1   2   3   4   5   6   7   8   9   10   11   12   13   14
```

App. Fig. 1. Example of the card-image record format used in compiling master tapes with information from all channels monitored by the data acquisition system. Following the time of observation, a card number is entered to identify the data in the 14 data-columns which follow. In the example shown, corresponding to August 17, 1972, card 17 is entered in the master tape record at 2-minute intervals because it contains net radiation and stem diameter data which fluctuate very rapidly. Card 15, containing ambient air temperature, oxygen concentrations, wet-bulb temperatures, vapor pressure, and relative humidity appears at 20-minute intervals, while cards 1-14 with soil temperature arrays appear only at the beginning of each hour.

2. Secondary data files

Because many different experiments or many different kinds of data are often recorded simultaneously on the rhizotron data acquisition system, short PL-1 routines based on Brown and Rosenberg's *(3)* card-image format were developed for examining a single (or only a few) variables as a function of time. CALCOMP plots of various parameters as a function of time were also prepared for study. Separate auxiliary files containing only microclimatic data or only stem diameter data have been prepared. An auxiliary file with only stem diameter and net radiation at 2-minute intervals (card 51) and at 20-minute intervals (card 52) is shown in Appendix Figure 2.

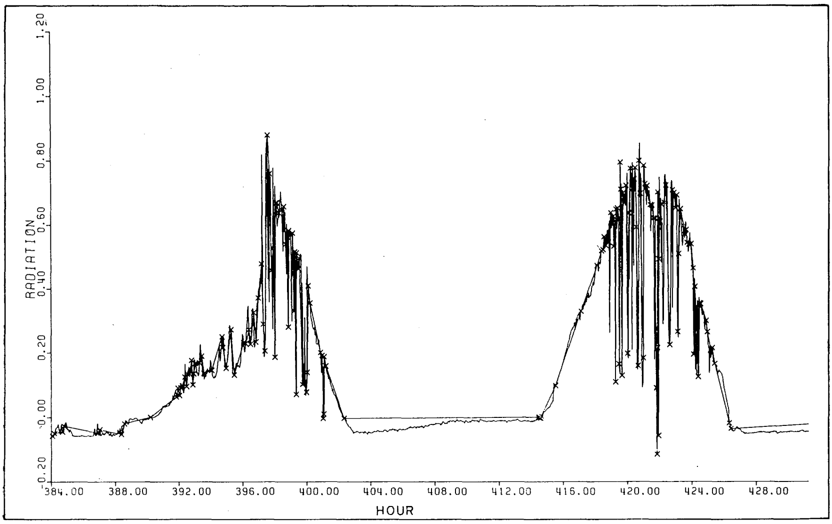
817	2365110231	9275	-57	260	6412243	7981	8211	9303	9241	780815728	-57	-58
817	2385110232	9276	-57	261	-1012243	7981	8203	9303	9241	780815728	-55	-57
817	2405110232	9276	-57	261	-3712243	7981	8203	9303	9241	779915728	-44	-55
817	2425110232	9276	-58	261	28512243	7981	8211	9303	9241	779915728	-34	-52
817	2445110232	9276	-56	262	38812243	7981	8203	9303	9232	779915728	-56	-51
817	2465110233	9276	-55	262	-5512243	7981	8203	9303	9232	779915719	-49	-50
817	2465210233	9276	-55	262	-5512243	7981	8203	9303	9232	779915719	-1071	0
817	2485110233	9277	-54	261	77812243	7981	8203	9303	9232	779915719	-50	-49
817	2505110234	9277	-54	261	48112243	7981	8203	9294	9232	779915719	-45	-47
817	2525110234	9278	-53	261	62212243	7981	8203	9294	9232	779915719	-22	-43
817	2545110234	9278	-54	261	16512243	7981	8203	9294	9232	779915719	-18	-39
817	2565110234	9278	-53	260	-1712243	7981	8203	9294	9232	779915710	-49	-41
817	2585110234	9279	-53	260	12912243	7981	8203	9294	9232	779015719	-57	-41
817	3005110234	9279	-73	261	52312243	7981	8203	9294	9232	779915719	-50	-41
817	3025110236	9284	-73	261	38712252	7981	8203	9294	9232	779915719	-38	-40
817	3045110234	9284	-58	260	23612243	7981	8203	9294	9232	779915719	-53	-41
817	3065110235	9283	-60	260	95112243	7981	8203	9294	9232	779915719	-57	-46
817	3065210235	9283	-60	260	95112243	7981	8203	9294	9232	779915719	-897	0
817	3085110234	9283	-60	260	72612243	7981	8203	9294	9232	779915719	-55	-51
817	3105110235	9285	-56	259	20512243	7990	8211	9303	9241	780815728	-52	-51
817	3125110235	9285	-57	258	11112243	7990	8211	9303	9241	780815728	-49	-50
817	3145110236	9286	-55	257	68312252	7990	8211	9303	9241	779915728	-50	-50
817	3165110234	9284	-54	257	58812243	7990	8203	9303	9232	779915728	-55	-53
817	3185110235	9284	-54	257	56612243	7990	8203	9303	9241	780815728	-50	-52
817	3205110235	9284	-55	257	75612243	7990	8211	9303	9241	780815728	-54	-52
817	3225110235	9284	-54	257	41612243	7990	8211	9303	9241	780815737	-50	-51
817	3245110235	9285	-52	257	44712243	7990	8211	9303	9241	780815728	-48	-51
817	3265110235	9284	-53	257	78212252	7990	8211	9303	9241	780815728	-44	-50
817	3265210235	9284	-53	257	78212252	7990	8211	9303	9241	780815728	-1033	0
817	3285110236	9286	-53	257	56412252	7990	8211	9303	9241	780815737	-44	-49
817	3305110236	9284	-51	257	52312252	7990	8211	9303	9241	780815737	-51	-49
817	3325110238	9294	-51	258	22512252	7990	8211	9303	9241	780815737	-49	-49
817	3345110238	9293	-51	258	78012252	7990	8211	9303	9241	780815737	-46	-48
817	3365110237	9286	-51	257	20212252	7990	8211	9303	9241	780815737	-54	-48
817	3385110236	9285	-51	258	-35912252	7990	8211	9303	9241	780815737	-57	-49
817	3405110236	9286	-52	259	14412252	7990	8211	9312	9241	780815737	-53	-51
Month Day	Hour Minute Card 1	2	3	4	5 6	7	8	9	10	11 12	13	14

App. Fig. 2. Example of a specialized subset of data selected from the master tape described in Figure 1. Millivolt output from the LVDT's stored on card 17 in the master tapes has been converted to stem diameter in millimeters by use of the calibration values recorded each morning. In the data presented here (August 17), card 51 represents the diameter of stems on channels 1, 2, and 5 to 12. Instantaneous net radiation (ly/min) is shown in column 13, while column 14 contains a 15-minute moving average of the radiation given in column 13. Columns 3 and 4 are not used because the corresponding plants (in bin 4) had already been harvested on August 16. Card 52 contains the same information as card 51 except that it is entered into the data stream at 20-minute intervals and contains a 20-minute summary of net radiation in column 13 and a daily total in column 14.

For many studies, such as those of Huck and Klepper (in preparation) relating stem diameter to plant water potential, it is useful to store data in a format compatible with the Continuous Systems Modeling Program (CSMP) supplied by IBM[1]. The values for xylem water potential as a continuous function of time, for example, were computed by a CSMP program described elsewhere (Huck and Klepper, in preparation).

Because it views input data as a continuous function, CSMP requires a set of discrete points entered as x-y pairs, with a variable spacing of the x-values permitted. Thus, it is possible to greatly reduce the volume of data without significant reduction of information content, as illustrated in Appendix Figure 3. The linear-interpolation function of CSMP then simply connects each x-y point with a straight line, and a continuous function (of time) which very closely approximates the original data is regenerated in the simulation. The computer-cost of the linear interpolation is generally less than the search time for an input-output operation if the data file had been stored on a peripheral device.

To obtain a set of x-y pairs from the dataset shown in Appendix Figure 2, the second derivative (with respect to time) of these rapidly-fluctuating measured variables was computed from a five-point moving average. Each time the second derivative of a time-dependent variable changed, a set of x-y paired values was recorded on a temporary disk dataset, giving both the



App. Fig. 3. Instantaneous net radiation plotted as a function of time from August 17 to 19. Values labeled "hour" are cumulative hours from the beginning of August 1972. "X" symbols along the curve represent those points at which the data compression program considered that an entry was necessary because of a significant change in the second time derivative. Negative values of net radiation (night) were ignored. The goodness of fit achieved by straight-line segments connecting the "X" symbols compared with the data line connecting the 720 measurement points per day (2-minute measurement interval) can be seen from visual inspection of the plots.

time and the value of the variable at that time. The accumulation of data pairs at strategic points was copied to cards for later use in simulation studies, Appendix Figure 4.

All net radiation values and stem diameter values for all channels have been processed by a computer program which examines the second derivative of the measured value with respect to time. Card datasets of the compressed data in CSMP-compatible format are also available to interested investigators upon written request to the authors.

```
HOUR     Y        HOUR     Y        HOUR     Y        HOUR     Y
379.43,10.147, 383.43,10.210, 384.10,10.216, 385.77,10.228,      ...AUGCHN01
386.43,10.231, 387.10,10.235, 388.10,10.239, 389.43,10.244,      ...AUGCHN01
390.43,10.247, 391.10,10.248, 391.43,10.251, 391.77,10.250,      ...AUGCHN01
392.10,10.245, 392.43,10.177, 392.77,10.176, 393.10,10.175,      ...AUGCHN01
393.43,10.171, 393.77,10.170, 394.77,10.163, 395.77,10.153,      ...AUGCHN01
396.43,10.141, 399.10,10.024, 399.77,10.022, 400.10,10.039,      ...AUGCHN01
400.77,10.023, 401.43,10.045, 403.77,10.155, 406.77,10.195,      ...AUGCHN01
407.10,10.196, 407.77,10.202, 408.43,10.204, 409.10,10.209,      ...AUGCHN01
409.77,10.210, 410.43,10.215, 411.10,10.216, 411.77,10.220,      ...AUGCHN01
412.77,10.222, 413.43,10.226, 414.10,10.226, 415.10,10.226,      ...AUGCHN01
415.43,10.224, 415.77,10.219, 416.43,10.066, 416.77, 9.844,      ...AUGCHN01
417.10, 9.836, 417.43, 9.815, 417.77, 9.795, 418.10, 9.777,      ...AUGCHN01
418.43, 9.760, 418.77, 9.747, 420.43, 9.677, 420.77, 9.672,      ...AUGCHN01
421.77, 9.631, 422.43, 9.614, 422.77, 9.617, 423.77, 9.592,      ...AUGCHN01
424.10, 9.593, 427.77, 9.753, 428.10, 9.764, 431.17, 9.807,      ...AUGCHN01
431.83, 9.812, 433.90, 9.823, 434.57, 9.825, 436.30, 9.830,      ...AUGCHN01
```

App. Fig. 4. Listing of the X-Y coordinate values of the "X" symbols plotted in Appendix Figure 3. Note that by the information compression technique used here, some 1,440 measurement points have been summarized by approximately 60 points without significant loss of information content. The card image records listed here are in CSMP-compatible format with a . . . symbol at the end of each record for convenience in grouping into a function statement used in continuous simulation studies.

APPENDIX II

Data Not Cited in Text and U.S. Weather Bureau Data

Appendix Table 1. Summary of plant top measurements made during the 1972 growing season for the cotton plants of bin 2, Auburn rhizotron.

Appendix Table 2. Volumetric water content as function of depth and time in bin 2, Auburn rhizotron, 1972.

Appendix Table 3. Rooting density as a function of depth and time in bin 2, Auburn rhizotron, 1972.

Appendix Table 4. Summary of plant top measurements made during the 1972 growing season for the cotton plants of bin 4, Auburn rhizotron.

Appendix Table 5. Rooting density as a function of depth and time in bin 4, Auburn rhizotron, 1972.

Appendix Table 6. Summary of plant top measurements made during the 1972 growing season for the cotton plants of bin 7, Auburn rhizotron.

Appendix Table 7. Volumetric water content as function of depth and time in bin 7, Auburn rhizotron, 1972.

Appendix Table 8. Rooting density as a function of depth and time in bin 7, Auburn rhizotron, 1972.

Appendix Table 9. Summary of plant top measurements made during the 1972 growing season for the cotton plants of bin 8, Auburn rhizotron.

Appendix Table 10. Water balance. Volumetric water content as function of depth and time, water added to surface, and water removed from bottom by suction or by plant use, in bin 8, Auburn rhizotron, 1972.

Appendix Table 11. Rooting density as a function of time and depth in bin 8, Auburn rhizotron, 1972.

Appendix Table 12. Data of temperature, relative humidity, radiation, and windspeed for the experimental period. Data were obtained from the U.S. Weather Bureau station about 1.5 km from the Auburn rhizotron.

APPENDIX TABLE 1. SUMMARY OF PLANT TOP MEASUREMENTS MADE DURING THE 1972 GROWING SEASON FOR THE COTTON PLANTS OF BIN 2, AUBURN RHIZOTRON

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm* × 10^2	*mm-hr.* × *10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Left plant					
7	36.5	------	------	------	------	------	------	------	------	------
8	37.8	9.1	------	11.0	7.6	5.9	------	------	------	------
9	38.5	9.8	.113	8.6	3.2	1.3	------	------	------	------
10	39.8	11.4	.177	6.0	2.8	1.3	2.7 W	0650	13.0 W*	1430
11	40.6	9.8	.239	9.7	2.8	1.8	------	------	------	------
12	42.5	9.8	.263	9.3	3.6	1.1	3.0 W	0700	11.0 E**	1415
13	45.0	9.3	.251	11.1	6.4	4.3	------	------	------	------
14	46.5	12.2	.232	6.0	5.2	1.4	2.7 W	0655	9.0 W	1425
15	48.2	------	------	------	------	------	------	------	------	------
16	50.6	8.4	------	4.4	1.2	0.6	------	------	------	------
17	51.9	11.2	.246	11.3	8.0	5.7	2.0 W	0704	12.7 W	1354
							9.3 E	0957	6.7 W	1835
18	53.9	8.0	.232	12.1	8.4	5.8	------	------	------	------
19	55.3	10.1	.192	12.1	8.8	6.2	3.7 W	0657	11.7 W	1409
20	56.8	------	.114	9.4	13.6	7.7	------	------	------	------
21	59.8	8.2	.162	11.9	10.4	6.0	3.0 W	0705	12.0 W	1358
22	61.5	9.9	.179	11.9	12.4	8.1	------	------	------	------
23	63.5	10.3	.218	10.8	14.0	7.6	------	------	------	------
24	64.5	11.7	.115	10.8	19.2	11.9	2.3 W	0702	16.3 W	1416
25	67.7	10.7	.190	4.4	3.2	0.5	------	------	------	------
26	69.4	10.6	.275	8.6	7.6	3.7	1.7 W	0704	11.7 W	1409
27	70.8	12.8	.298	5.2	6.8	1.4	------	------	------	------
28	71.8	15.9	.290	9.7	16.8	9.0	1.7 W	0703	12.3 W	1411
29	74.8	10.4	.140	------	------	------	------	------	------	------
30	75.6	16.4	------	7.9	10.4	4.7	------	------	------	------
31	76.8	------	------	------	------	------	0.8 W	0706	12.0 W	1402

Aug.	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	78.3	------	------	------	------	------	------	------	------	------
2	79.3	10.1	------	14.1	19.2	15.7	2.0 W	0705	13.7 W	1412
3	81.0	8.7	.102	11.2	13.2	7.8	------	------	------	------
4	82.0	9.8	.198	11.0	10.4	5.3	2.3 W	0704	11.7 W	1403
5	83.4	7.9	.239	11.9	15.6	10.2	------	------	------	------
6	84.7	9.5	.235	11.3	15.6	8.6	------	------	------	------
7	86.6	9.0	.207	12.2	21.2	15.2	2.7 W	0703	17.7 W	1414
8	86.8	8.5	.175	12.9	22.4	15.8	------	------	------	------
9	88.0	8.4	.121	10.4	15.2	10.2	2.7 W	0706	15.3 W	1404
10	89.4	------	------	------	------	------	------	------	------	------
11	90.0	------	------	------	------	------	3.3 W	0703	16.3 W	1404
12	90.5	10.7	------	9.4	8.8	4.9	------	------	------	------
13	91.4	10.6	.179	------	------	------	------	------	------	------
14	91.5	7.6	.138	12.6	14.8	9.8	4.0 W	0707	16.7 W	1402
15	91.0	6.6	.118	13.2	16.0	11.6	------	------	------	------
16	91.4	5.0	.084	12.6	20.4	14.3	6.3 W	0702	19.0 W	1410
17	91.8	2.8	.168	11.7	15.6	8.2	------	------	------	------
18	92.2	6.8	.051	24.0	28.8	27.8	5.0 W	0707	19.0 W	1400
19	92.5	6.9	—.040	24.0	34.4	36.8	------	------	------	------
20	93.0	8.5	—.060	24.0	41.6	41.8	------	------	------	------
21	91.8	6.6	—.057	24.0	27.2	29.6	10.7 E	0705	25.3 W	1410
22	92.2	6.6	—.029	24.0	32.0	32.7	------	------	------	------
23	92.2	6.8	—.019	24.0	24.0	24.3	13.3 E	0710	28.7 W	1406
24	92.4	6.0	—.002	24.0	28.4	33.9	------	------	------	------
25	92.5	0.0	—.001	24.0	32.8	35.0	20.7 W	0848	31.3 W	1410
26	92.5	0.0	—.027	24.0	34.0	39.8	------	------	------	------
27	92.8	0.0	—.051	24.0	37.2	------	14.0 E	0702	------	------
28	92.7	------	------	------	------	------	------	------	------	------
29	92.6	------	------	------	------	------	------	------	------	------
30	92.7	------	------	------	------	------	------	------	------	------
31	92.7	0.0	------	------	------	------	22.0 W	0700	37.0 W	1410
Sept.	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	92.6	0.0	------	------	31.6	------	26.0 E	0707	36.7 W	1405
2	92.4	------	------	------	------	------	------	------	------	------
3	92.2	------	------	------	------	------	------	------	------	------
4	92.0	------	------	------	------	------	------	------	------	------
5	91.5	------	------	------	------	------	32.7 E	0710	36.0 W	1402

(Continued)

APPENDIX TABLE 1 *(Con't.)* SUMMARY OF PLANT TOP MEASUREMENTS MADE DURING THE 1972 GROWING SEASON FOR THE COTTON PLANTS OF BIN 2, AUBURN RHIZOTRON

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Right plant					
7	35.5	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	35.8	9.9	-----	12.6	9.6	4.5	-----	-----	-----	-----
9	36.0	9.2	.108	9.3	6.0	3.0	-----	-----	-----	-----
10	37.0	9.6	.167	8.6	2.4	0.9	2.3 W	0715	-----	-----
11	38.3	9.9	.212	9.0	2.8	1.4	-----	-----	-----	-----
12	40.5	9.3	.243	7.7	2.0	0.6	3.0 W	0722	11.0 E	1447
13	41.5	10.1	.250	12.2	7.2	5.7	-----	-----	-----	-----
14	43.0	-----	-----	-----	-----	-----	2.3 W	0714	-----	-----
15	44.6	-----	-----	-----	-----	-----	-----	-----	-----	-----
16	46.8	9.0	-----	7.9	4.0	1.6	-----	-----	-----	-----
17	47.8	9.0	.393	9.4	7.2	3.8	3.0 W	0737	12.0 E	1430
18	49.9	9.0	.314	11.3	7.2	4.4	-----	-----	-----	-----
19	51.6	9.9	.323	-----	-----	-----	3.3 W	0732	11.7 W	1445
20	54.2	-----	-----	-----	-----	-----	-----	-----	-----	-----
21	56.5	-----	-----	10.8	10.0	6.9	4.3 W	0744	14.0 W	1438
22	57.0	10.1	-----	11.0	16.8	8.6	-----	-----	-----	-----
23	59.7	11.0	.198	12.6	27.8	22.1	-----	-----	-----	-----
24	61.7	8.4	.169	13.0	26.0	18.2	2.7 W	0740	14.7 W	1452
25	64.7	9.0	.317	5.3	8.8	1.8	-----	-----	-----	-----
26	65.4	11.4	.426	10.4	16.0	7.9	2.3 W	0735	12.3 W	1443
27	68.0	-----	-----	-----	-----	-----	-----	-----	-----	-----
28	70.5	-----	-----	-----	-----	-----	1.3 W	0738	12.7 W	1451
									9.0	1708
29	71.8	-----	-----	-----	-----	-----	5.3 W	0916	-----	-----
30	73.2	-----	-----	-----	-----	-----	-----	-----	-----	-----
31	74.3	-----	-----	-----	-----	-----	1.7 E	0742	12.0 W	1402

Aug.	cm	Hr.	mm	Hr.	mm × 10^2	mm-hr. × 10	—Bars	Hr.	—Bars	Hr.
1	75.6	------	------	------	------	------	3.3 E	0816	7.7 E	1752
									5.0 E	1830
2	77.4	9.8	------	17.3	21.2	21.2	4.0 E	0755	13.3 W	1450
3	78.5	7.3	.006	11.0	9.6	5.2	------	------	------	------
4	80.5	8.7	.211	11.5	10.8	6.9	3.3 E	0743	12.3 W	1439
5	83.5	8.5	.180	12.4	15.6	11.4	------	------	------	------
6	83.7	8.7	.162	11.6	15.6	9.1	------	------	------	------
7	86.0	9.0	.157	14.1	25.2	18.2	3.3 W	0737	16.0 W	1448
8	87.5	9.3	.083	13.5	23.6	15.3	------	------	------	------
9	89.5	7.0	.060	13.0	21.6	15.5	3.0 W	0737	17.3 W	1435
10	90.2	------	------	------	------	------	------	------	------	------
11	91.0	------	------	------	------	------	4.3 W	0742	15.0 W	1427
12	91.7	10.3	------	10.5	12.0	6.4	------	------	------	------
13	92.9	8.2	.188	11.6	11.6	8.4	------	------	------	------
14	92.5	7.3	.174	11.8	16.8	9.6	5.7 W	0750	13.3 W	1444
15	93.6	7.7	.151	12.2	18.0	11.8	------	------	------	------
16	94.2	8.7	.111	16.1	29.6	21.6	4.7 E	0745	20.3 W	1438
17	94.3	3.8	.076	15.5	21.2	11.0	------	------	------	------
18	94.4	6.6	.046	19.9	31.2	24.0	5.0 W	0735	21.7 W	1428
19	94.6	4.9	.015	24.0	41.2	39.9	------	------	------	------
20	95.0	6.5	—.037	24.0	56.0	55.0	------	------	------	------
21	94.2	8.7	—.080	24.0	38.8	41.2	12.7 E	0735	25.3 W	1437
22	94.5	6.6	—.048	24.0	44.0	46.2	------	------	------	------
23	94.2	6.2	—.017	24.0	36.0	37.7	11.7 E	0740	29.3 W	1431
24	94.6	5.4	—.001	24.0	42.4	47.2	------	------	------	------
25	95.0	0.0	—.045	24.0	41.2	43.0	25.3 E	0920	31.0 W	1435
26	95.3	0.0	—.014	24.0	44.4	45.6	------	------	------	------
27	95.1	0.0	+.005	23.7	46.4	50.9	11.7 E	0730	------	------
28	95.1	0.0	—.060	24.0	44.8	------	------	------	------	------
29	------	------	------	------	------	------	------	------	------	------
30	95.2	------	------	------	------	------	22.7 W	0729	37.0 W	1435
31	94.9	------	------	------	35.2	------	------	------	------	------
Sept.	cm	Hr.	mm	Hr.	mm × 10^2	mm-hr. × 10	—Bars	Hr.	—Bars	Hr.
1	94.6	------	------	------	------	------	28.0 W	0734	36.0 W	1432
2	94.5	------	------	------	------	------	------	------	------	------
3	94.5	------	------	------	------	------	------	------	------	------
4	94.5	------	------	------	------	------	------	------	------	------
5	94.5	------	------	------	------	------	32.0 E	0735	36.7 W	1428

* West ** East

APPENDIX TABLE 2. VOLUMETRIC WATER CONTENT AS FUNCTION OF DEPTH AND TIME IN BIN 2, AUBURN RHIZOTRON, 1972

	Depth						Total water use
	30	60	90	120	150	180	
			cm^3/cm^3				*cm/day*
July 8	.216	.198	.187	.215	.212	.251	
10	.200	.180	.177	.201	.208	.262	.81
12	.177	.166	.167	.195	.208	.266	.78
14	.158	.155	.158	.190	.208	.266	.37
17	.138	.141	.147	.183	.210	.303	.36
19	.126	.132	.140	.178	.212	.308	.42
21	.118	.123	.132	.172	.215	.326	.16
24	.107	.110	.120	.164	.212	.337	.38
26	.100	.102	.113	.157	.207	.295	1.21
28	.094	.095	.105	.148	.199	.295	.62
31	.084	.085	.094	.138	.187	.297	.54
Aug. 2	.078	.079	.086	.130	.180	.260	1.15
4	.074	.074	.078	.123	.172	.251	.65
7	.067	.067	.067	.107	.140	.213	1.18
9	.063	.063	.062	.095	.120	.177	1.29
11	.059	.059	.056	.084	.104	.162	.84
14	.055	.055	.052	.073	.081	.128	.85
16	.053	.053	.049	.067	.071	.106	.72
18	.051	.051	.046	.061	.062	.083	.72
21	.048	.048	.042	.053	.052	.045	.70
23	.046	.046	.040	.048	.046	.038	.38
25	.044	.044	.038	.043	.042	.035	.29
27	.042	.042	.036	.040	.038	.033	.24
30	.040	.040	.034	.036	.034	.032	.16
Sept. 1	.039	.039	.033	.035	.033	.032	.08
5	.037	.037	.032	.034	.032	.032	.06

APPENDIX TABLE 3. ROOTING DENSITY AS A FUNCTION OF DEPTH AND TIME IN BIN 2, AUBURN RHIZOTRON, 1972

	Depth					
	30	60	90	120	150	180
	cm root/cm³ soil					
June 26	.63	.10	0	0	0	0
28	.69	.10	0	0	0	0
30	.63	.09	.04	0	0	0
July 3	.96	.23	.04	0	0	0
5	.89	.24	.16	.07	0	0
7	.97	.27	.24	.16	.07	0
10	1.07	.45	.45	.24	.13	.10
12	1.20	.56	.69	.34	.19	.10
14	1.40	.64	.85	.45	.24	.27
17	1.47	.77	1.00	.53	.29	.27
19	1.60	.89	1.13	.61	.37	.43
21	1.40	.87	1.31	.66	.35	.35
24	1.77	1.05	1.53	.81	.51	.43
26	1.77	1.32	1.68	.89	.56	.66
28	1.77	1.30	1.70	.94	.72	.98
31	1.77	1.25	1.83	1.09	.85	1.13
Aug. 2	1.82	1.32	1.78	1.09	.87	1.21
4	1.77	1.42	2.04	1.31	1.20	1.58
7	1.72	1.35	2.02	1.55	1.80	1.88
9	1.60	1.15	1.88	1.53	2.05	2.38
11	1.38	1.05	1.81	1.53	2.00	2.81
14	1.58	1.20	1.81	1.48	2.12	2.81
16	1.53	1.15	1.73	1.41	2.02	2.53
18	1.36	1.10	1.71	1.43	2.11	3.01
21	1.13	1.02	1.71	1.33	1.58	2.39
23	.90	.90	1.46	1.23	1.51	2.10
25	.50	.84	1.38	1.25	1.51	1.81
27	.61	.77	1.36	.95	1.13	.74
30	.56	.82	1.08	.87	.97	0
Sept. 1	.31	.61	1.08	.87	.69	.10
5	.28	.50	.85	.36	.09	0

APPENDIX TABLE 4. SUMMARY OF PLANT TOP MEASUREMENTS MADE DURING THE 1972 GROWING SEASON FOR THE COTTON PLANTS OF BIN 4, AUBURN RHIZOTRON

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm* × 10^2	*mm-hr.* × 10	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Left plant					
7	31.9	------	------	------	------	------	------	------	------	------
8	32.5	11.5	------	13.7	6.8	3.8	------	------	------	------
9	32.5	------	------	------	------	------	------	------	------	------
10	33.1	------	------	12.7	4.4	2.7	2.0 W*	0655	10.0 W	1435
11	34.0	6.6	------	14.4	9.6	9.2	------	------	------	------
12	35.5	12.2	.025	11.0	5.2	1.8	2.3 E**	0703	------	------
13	36.5	11.0	.173	14.4	8.0	6.3	------	------	------	------
14	38.0	10.7	.132	5.8	6.8	1.0	2.3 E	0657	11.3 E	1429
15	39.3	------	------	------	------	------	------	------	------	------
16	39.7	9.2	------	13.0	10.8	9.6	------	------	------	------
17	41.0	8.7	.183	9.9	1.6	0.3	1.7 W	0706	11.7 W	1358
									6.0 W	1840
18	41.8	7.9	.292	9.4	4.0	2.8	------	------	------	------
19	43.0	9.9	.308	10.5	4.8	3.6	2.0 W	0700	8.7 W	1410
20	43.4	10.6	.296	12.9	15.2	12.4	------	------	------	------
21	44.5	9.3	.160	12.1	9.2	7.4	2.0 W	0709	11.3 W	1402
22	45.3	9.3	.165	12.6	12.4	7.0	------	------	------	------
23	46.0	10.7	.160	14.4	18.0	12.1	------	------	------	------
24	46.3	12.6	.097	23.6	33.6	33.7	1.7 W	0704	15.3 W	1421
25	47.1	10.4	—.018	12.1	7.6	2.4	------	------	------	------
26	47.5	11.0	.096	20.2	19.6	16.8	2.3 W	0706	14.7 W	1411
27	47.7	8.0	.037	8.6	20.4	7.0	------	------	------	------
28	48.6	10.4	.102	------	------	------	1.7 W	0706	14.0 W	1416
29	48.6	------	------	6.6	7.2	1.3	------	------	------	------
30	48.7	15.5	.183	12.6	15.6	10.1	------	------	------	------
31	48.8	------	------	------	------	------	1.3 W	0709	------	------

Aug.	cm	Hr.	mm	Hr.	mm × 10²	mm-hr. × 10	—Bars	Hr.	—Bars	Hr.
1	49.3	------	------	------	------	------	--------	--------	--------	--------
2	49.1	8.7	------	18.2	15.6	12.0	2.0 W	0710	13.3 W	1418
3	49.3	9.9	.061	13.2	14.0	9.6	--------	--------	--------	--------
4	49.5	8.0	.097	13.7	14.4	9.0	2.7 W	0707	9.7 E	1407
5	50.0	8.4	.080	20.9	21.6	20.7	--------	--------	--------	--------
6	49.8	8.0	.028	17.7	22.8	17.1	--------	--------	--------	--------
7	50.3	8.0	.049	22.6	34.4	35.2	2.7 W	0706	17.7 E	1417
8	49.8	5.0	−.036	23.1	30.4	25.1	--------	--------	--------	--------
9	49.9	8.2	+.010	21.2	33.2	29.2	5.3 W	0711	--------	--------
10	49.9	6.8	.029	------	------	------	--------	--------	--------	--------
11	49.9	------	------	------	------	------	5.3 W	0708	--------	--------
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Right plant					
7	24.5	------	------	------	------	------	--------	--------	--------	--------
8	25.1	------	------	------	------	------	--------	--------	--------	--------
9	25.5	------	------	------	------	------	--------	--------	--------	--------
10	26.5	------	------	------	------	------	--------	--------	--------	--------
11	28.7	------	------	------	------	------	--------	--------	--------	--------
12	31.4	------	------	------	------	------	--------	--------	12.0 E	1424
13	31.0	------	------	------	------	------	--------	--------	--------	--------
14	31.5	------	------	------	------	------	--------	--------	--------	--------
15	33.3	------	------	------	------	------	--------	--------	--------	--------
16	34.0	9.0	------	9.9	0.8	0.7	--------	--------	--------	--------
17	34.6	12.9	.155	6.6	2.0	1.3	--------	--------	--------	--------
18	35.3	11.0	.217	4.9	2.8	1.0	--------	--------	--------	--------
19	36.8	10.1	.226	10.2	3.2	1.8	--------	--------	--------	--------
20	38.3	10.9	.216	12.4	8.8	5.4	--------	--------	--------	--------
21	40.0	11.0	.129	9.4	4.4	2.2	--------	--------	--------	--------

(Continued)

APPENDIX TABLE 4 (*Con't.*). SUMMARY OF PLANT TOP MEASUREMENTS MADE DURING THE 1972 GROWING SEASON FOR THE COTTON PLANTS OF BIN 4, AUBURN RHIZOTRON

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm* × 10^2	*mm-hr.* × 10	*—Bars*	*Hr.*	*—Bars*	*Hr.*
22	40.5	9.8	.102	11.0	4.8	2.1	------	------	------	------
23	41.1	9.9	.097	10.7	8.4	4.5	------	------	------	------
24	41.0	12.3	.082	13.8	10.4	6.6	------	------	------	------
25	41.9	9.0	.091	9.9	4.8	1.6	------	------	------	------
26	43.6	11.0	.069	14.6	18.8	12.8				
27	43.7	8.7	.119	6.3	9.2	1.9	------	------	------	------
28	44.5	10.6	.244	22.8	28.4	27.9	------	------	------	------
29	45.3	8.4	------	2.7	3.2	0.5	------	------	------	------
30	45.8	12.9	------	7.5	21.6	8.3	------	------	------	------
31	46.0	------	------	------	------	------	------	------	------	------
Aug.	*cm*	*Hr.*	*mm*	*Hr.*	*mm* × 10^2	*mm-hr.* × 10	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	46.8	------	------	------	------	------	------	------	------	------
2	48.5	------	------	------	------	------	------	------	------	------
3	49.1	------	------	------	------	------	------	------	------	------
4	50.0	------	------	------	------	------	------	------	------	------
5	51.0	------	------	------	------	------	------	------	------	------
6	49.7	------	------	------	------	------	------	------	------	------
7	51.9	------	------	------	------	------	------	------	------	------
8	51.1	------	------	------	------	------	------	------	------	------
9	51.3	------	------	------	------	------	------	------	------	------
10	51.9	------	------	------	------	------	------	------	------	------
11	51.3	------	------	------	------	------	------	------	------	------

* West ** East

APPENDIX TABLE 5. ROOTING DENSITY AS A FUNCTION OF DEPTH AND TIME IN BIN 4, AUBURN RHIZOTRON, 1972

	Depth		
	15	30	45
	cm	*cm*	*cm*
June 26	1.51	.11	0
28	1.81	.11	0
30	2.46	.11	0
July 3	3.01	.19	0
5	3.54	.27	0
7	3.74	.27	0
10	3.87	.59	0
12	3.87	.59	0
14	4.18	.51	0
17	3.87	.51	0
19	3.93	.59	0
21	4.12	.66	0
24	3.93	.59	0
26	4.55	.59	0
28	4.37	.59	0
31	4.06	.59	0
Aug. 2	3.93	.59	0
4	4.61	.59	0
7	3.87	.59	0
9	3.80	.59	0
11	2.31	.51	0

Appendix Table 6. Summary of Plant Top Measurements Made During the 1972 Growing Season for the Cotton Plants in Bin 7, Auburn Rhizotron

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm* $\times$ *10*[2]	*mm-hr.* $\times$ *10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Left plant					
7	29.1	------	------	------	------	------	--------	--------	--------	--------
8	29.5	8.5	------	11.5	10.8	7.4	--------	--------	--------	--------
9	29.5	10.1	.133	6.1	9.6	7.4	--------	--------	--------	--------
10	31.0	10.3	.404	11.1	10.4	6.5	3.3 W	0705	12.0 E	1447
11	32.0	9.0	.148	10.7	9.2	6.0	--------	--------	--------	--------
12	32.5	10.9	.188	12.2	10.8	8.2	3.7 W	0712	9.3 E**	1435
13	34.0	9.0	.107	------	------	------	--------	--------	--------	--------
14	35.5	------	------	------	------	------	3.0 W	0705	9.0 W*	1440
15	36.7	------	------	------	------	------	--------	--------	--------	--------
16	37.5	------	------	14.3	12.8	9.8	--------	--------	--------	--------
17	39.5	9.9	.125	11.2	12.8	7.4	3.3 W	0718	6.7 E	1846
							9.7 E	1006	11.3 W	1406
18	40.5	10.6	.143	9.1	3.2	1.5	--------	--------	--------	--------
19	43.0	10.9	.188	9.3	6.4	4.2	2.7 W	0712	12.0 W	1426
20	45.3	11.5	.125	11.2	8.0	5.2	--------	--------	--------	--------
21	46.9	8.8	.170	12.2	13.6	9.2	2.7 W	0722	12.0 W	1417
22	48.7	------	------	15.4	10.4	7.5	--------	--------	--------	--------
23	50.5	9.3	.043	10.5	4.4	3.5	--------	--------	--------	--------
24	52.0	------	------	------	------	------	2.0 W	0715	13.7 W	1435
25	54.9	------	------	------	------	------	--------	--------	--------	--------
26	55.6	11.0	------	11.3	13.6	8.4	2.3 W	0715	11.7 W	1422
27	56.7	12.2	.348	5.0	12.4	4.4	--------	--------	--------	--------
28	59.1	11.7	.152	15.4	29.6	16.2	1.3 W	0717	13.7 W	1428
29	59.0	10.1	.143	10.7	12.8	7.6	--------	--------	--------	--------
30	61.7	16.1	.143	8.5	15.6	5.8	--------	--------	--------	--------
31	61.7	------	.161	------	------	------	1.0 W	0719	9.7 W	1412

Aug.	*cm*	*Hr.*	*mm*	*Hr.*	*mm* × *10*²	*mm-hr.* × *10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	63.9	------	------	------	------	------	------	------	------	------
2	65.2	11.0	------	11.0	3.6	2.5	1.3 W	0729	12.0 W	1428
3	66.3	9.8	.107	10.4	9.2	6.0	------	------	------	------
4	67.5	------	------	9.7	8.8	4.2	2.0 W	0716	11.3 W	1419
5	69.0	11.0	.375	9.6	10.8	6.6	------	------	------	------
6	70.5	11.2	.375	11.2	19.6	12.4	------	------	------	------
7	72.5	9.0	.152	11.5	15.2	10.6	2.0 W	0716	16.0 W	1427
8	73.2	9.0	.294	9.9	13.6	6.9	------	------	------	------
9	75.0	11.0	.366	10.2	16.4	10.6	2.7 W	0720	14.7 W	1414
10	75.9	------	.197	------	------	------	------	------	------	------
11	76.1	------	------	------	------	------	2.7 W	0717	14.3 W	1417
12	76.8	12.3	------	9.3	9.2	4.5	------	------	------	------
13	78.0	9.8	.241	9.3	7.2	4.0	------	------	------	------
14	78.7	10.6	.233	12.5	16.8	9.6	3.0 W	0720	9.7 W	1414
15	78.5	10.4	.151	12.9	19.2	12.8	------	------	------	------
16	78.3	10.6	.107	15.9	30.4	21.4	4.7 E	0715	19.0 W	1420
17	78.9	6.6	.072	11.8	18.8	9.6	------	------	------	------
18	79.2	9.8	.063	21.6	32.8	26.1	4.0 E	0717	19.7 W	1410
19	79.6	8.7	.018	24.0	33.6	31.0	------	------	------	------
20	79.5	9.3	—.027	24.0	31.6	27.8	------	------	------	------
21	80.7	10.1	—.002	24.0	22.8	22.8	9.7 E	0716	21.3 W	1421
22	81.2	11.4	—.027	------	------	------	------	------	------	------
23	80.7	------	------	24.0	22.8	24.2	11.0 E	0720	20.7 W	1415
24	81.2	13.3	—.009	24.0	31.2	32.4	------	------	------	------
25	79.8	10.4	—.027	24.0	36.0	37.8	12.3 W	0800	25.0 W	1421
26	80.5	9.2	—.053	24.0	36.0	28.8	------	------	------	------
27	79.8	6.0	+.009	23.7	36.8	------	12.3 E	0710	------	------
28	------	------	------	------	------	------	------	------	------	------
29	------	------	------	------	------	------	------	------	------	------
30	79.8	------	------	------	------	------	16.7 W	0710	29.3 W	1419
31	------	------	------	------	------	------	------	------	------	------
Sept.	*cm*	*Hr.*	*mm*	*Hr.*	*mm* × *10*²	*mm-hr.* × *10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	80.5	------	------	------	------	------	20.0 E	0716	30.7 W	1414
2	80.2	------	------	------	------	------	------	------	------	------
3	80.3	------	------	------	------	------	------	------	------	------
4	80.5	------	------	------	------	------	------	------	------	------
5	80.3	------	------	------	------	------	20.0 E	0719	30.7 W	1409

(Continued)

APPENDIX TABLE 6 *(Con't.)*. SUMMARY OF PLANT TOP MEASUREMENTS MADE DURING THE 1972 GROWING SEASON FOR THE COTTON PLANTS IN BIN 7, AUBURN RHIZOTRON

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm* × 10^2	*mm-hr.* × *10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Right plant					
7	31.2	------	------	------	------	------	------	------	------	------
8	31.4	8.8	------	16.5	11.6	9.9	------	------	------	------
9	31.5	9.3	.067	13.8	8.8	6.2	------	------	------	------
10	31.0	------	.103	10.7	7.6	4.6	3.0 W	0723	------	------
11	32.0	11.7	.062	11.6	7.2	5.7	------	------	------	------
12	32.4	10.9	.116	11.6	7.2	5.4	------	------	12.7 E	1500
13	34.0	10.1	.113	------	------	------	------	------	------	------
14	35.8	------	------	------	------	------	2.7 W	0718	------	------
15	36.3	------	------	------	------	------	------	------	------	------
16	38.5	------	------	------	------	------	------	------	------	------
17	39.5	9.6	------	12.2	10.0	6.9	3.0 W	0728	13.3 E	1418
18	40.5	10.4	.170	5.2	1.6	0.8	------	------	------	------
19	42.4	10.9	.304	7.8	7.2	3.5	3.3 W	0721	15.0 W	1432
20	44.3	12.3	.134	9.6	10.0	6.2	------	------	------	------
21	47.1	9.8	.196	12.2	13.6	9.2	2.7 W	0732	13.3 W	1427
22	48.6	9.2	.170	12.2	16.8	10.4	------	------	------	------
23	50.0	9.0	.167	9.3	15.2	8.2	------	------	------	------
24	51.8	10.9	.134	8.2	12.8	4.9	2.7 W	0727	15.7 W	1443
25	53.8	10.4	.285	------	------	------	------	------	------	------
26	54.8	15.6	.134	11.3	13.6	8.0	2.3 W	0724	13.3 W	1432
27	57.1	12.3	.277	4.9	7.2	1.5	------	------	------	------
28	59.1	12.5	.277	11.2	18.8	12.9	1.5 W	0729	13.7 W	1440
29	60.9	11.0	.196	3.6	3.6	0.4	------	------	------	------
30	62.1	18.9	.197	7.1	10.0	3.5	------	------	------	------
31	63.0	------	------	------	------	------	1.0 W	0732	------	------

Aug.	cm	Hr.	mm	Hr.	mm × 10²	mm-hr. × 10	—Bars	Hr.	—Bars	Hr.
1	64.1	------	------	------	------	------	------	------	------	------
2	65.3	------	------	11.3	9.2	6.1	2.0 W	0740	13.0 W	1439
3	67.0	10.7	.116	8.3	6.4	3.0	------	------	------	------
4	67.5	11.2	.179	10.8	10.0	6.2	2.3 W	0729	11.3 W	1428
5	68.5	12.8	.142	10.0	9.2	6.2	------	------	------	------
6	69.9	12.0	.179	10.2	12.8	7.0	------	------	------	------
7	70.7	11.2	.125	10.5	8.4	5.6	2.3 W	0725	15.3 W	1437
8	72.7	10.1	.205	10.0	8.4	5.2	------	------	------	------
9	74.0	9.5	.206	9.1	6.4	4.2	3.0 W	0727	14.0 W	1423
10	75.5	11.0	.134	------	------	------	------	------	------	------
11	76.1	------	------	------	------	------	2.7 W	0730	10.0 W	1427
12	77.9	11.8	------	9.6	7.2	4.1	------	------	------	------
13	79.1	9.6	.125	8.3	6.4	3.5	------	------	------	------
14	80.6	10.1	.089	11.3	9.6	5.3	4.7 W	0741	14.7 W	1430
15	80.6	10.1	.089	11.3	9.2	5.5	------	------	------	------
16	81.5	11.8	.089	15.1	16.0	11.4	6.3 W	0732	18.0 W	1430
17	82.4	9.0	.054	12.2	12.0	6.8	------	------	------	------
18	83.4	11.7	.099	13.9	17.2	11.6	5.0 W	0727	16.0 W	1418
19	84.1	------	.116	16.7	24.8	19.8	------	------	------	------
20	84.5	4.6	.026	12.9	29.2	19.3	------	------	------	------
21	85.1	7.4	.108	22.7	20.0	16.4	7.0 E	0724	------	------
22	85.0	7.3	.008	24.0	32.8	36.9	------	------	------	------
23	85.1	7.9	—.026	24.0	36.8	40.3	8.0 E	0730	21.3 W	1423
24	85.7	9.9	—.026	24.0	44.0	50.9	------	------	------	------
25	85.1	10.6	—.054	24.0	51.8	63.8	12.0 W	0810	25.3 W	1431
26	85.3	3.6	—.125	23.5	52.7	41.8	------	------	------	------
27	84.8	5.5	+.027	------	53.6	------	12.0 W	0718	------	------
28	------	------	------	------	------	------	------	------	------	------
29	------	------	------	------	------	------	------	------	------	------
30	84.9	------	------	------	------	------	16.3 W	0719	30.0 W	1429
31	------	------	------	------	42.4	------	------	------	------	------
Sept.	cm	Hr.	mm	Hr.	mm × 10²	mm-hr. × 10	—Bars	Hr.	—Bars	Hr.
1	85.1	------	------	------	------	------	20.3 W	0725	32.0 W	1423
2	84.6	------	------	------	------	------	------	------	------	------
3	84.8	------	------	------	------	------	------	------	------	------
4	84.9	------	------	------	------	------	------	------	------	------
5	85.0	------	------	------	------	------	20.0 E	0729	32.0 W	1417

* West ** East

APPENDIX TABLE 7. VOLUMETRIC WATER CONTENT AS FUNCTION OF DEPTH AND TIME IN BIN 7, AUBURN RHIZOTRON, 1972

	Depth						Total water use
	30	60	90	120	150	180	
			cm³/cm³				*cm/day*
July 8	.200	.190	.235	.229	.245	.327	
12	.178	.178	.218	.222	.255	.370	.04
14	.167	.172	.210	.218	.257	.361	.56
17	.153	.163	.198	.210	.258	.367	.38
19	.144	.157	.190	.205	.258	.372	.36
21	.135	.150	.182	.200	.258	.355	.72
24	.122	.141	.169	.191	.249	.360	.50
26	.114	.135	.161	.185	.242	.345	.78
28	------	------	.154	.180	.235	.335	----
31	.185	------	.167	.172	.226	.338	----
Aug. 2	.156	.133	.158	.165	.218	.342	----
4	.132	.128	.150	.159	.212	.337	.85
7	.105	.116	.138	.147	.201	.320	.95
9	.095	.109	.130	.139	.192	.300	.97
11	.085	.103	.123	.131	.181	.279	.99
14	.082	.096	.112	.119	.162	.240	.95
16	.080	.092	.105	.109	.142	.209	1.17
18	.077	.087	.099	.101	.116	.169	1.37
21	.072	.081	.090	.087	.088	.102	1.35
23	.070	.077	.084	.080	.072	.078	.93
25	.067	.073	.079	.073	.065	.066	.59
27	.065	.070	.075	.067	.058	.057	.49
30	.061	.064	.069	.059	.050	.050	.41
Sept. 1	.059	.060	.065	.055	.047	.047	.31
5	.055	.055	.062	.049	.042	.041	.23

APPENDIX TABLE 8. ROOTING DENSITY AS A FUNCTION OF DEPTH AND TIME IN BIN 7, AUBURN RHIZOTRON, 1972

	Depth					
	30	60	90	120	150	180
			cm root/cm^3 *soil*			
June 26	0	0	0	0	0	0
28	0	0	0	0	0	0
30	0	0	0	0	0	0
July 3	0	0	0	0	0	0
5	.09	0	0	0	0	0
7	.23	0	0	0	0	0
10	.40	.03	0	0	0	0
12	.59	.19	.06	.03	0	0
14	.74	.24	.06	.03	0	0
17	.87	.40	.15	.18	.03	0
19	.92	.48	.27	.21	.06	0
21	.87	.61	.34	.21	.06	0
24	1.20	1.02	.68	.37	.09	0
26	1.30	1.10	.73	.48	.18	0
28	1.35	1.15	.79	.71	.34	0
31	1.38	1.20	.89	.94	.35	0
Aug. 2	1.43	1.25	.91	1.17	.45	0
4	1.58	1.30	1.17	1.60	.53	.11
7	1.92	1.53	1.42	2.13	.89	.27
9	1.90	1.65	1.47	2.38	1.15	.43
11	1.88	1.75	1.49	2.57	1.38	.74
14	1.90	1.80	1.34	2.15	1.35	1.58
16	1.75	1.70	1.62	2.54	1.45	1.58
18	1.85	1.75	1.41	2.61	1.60	1.73
21	1.66	1.73	1.44	2.32	1.73	1.81
23	1.60	1.73	1.32	2.30	1.60	1.58
25	.90	1.28	1.10	1.80	1.28	1.66
27	1.53	1.58	1.27	2.12	1.31	1.58
30	1.33	1.35	1.09	1.51	.89	.74
Sept. 1	.74	1.05	1.02	1.21	.63	.43
5	.82	.97	.71	.69	.26	.11

APPENDIX TABLE 9. SUMMARY OF PLANT TOP MEASUREMENTS MADE DURING THE 1972 GROWING SEASON FOR THE COTTON PLANTS OF BIN 8, AUBURN RHIZOTRON

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm* $\times 10^2$	*mm-hr.* $\times$ *10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Left plant					
7	30.8	------	------	------	------	------	--------	--------	--------	--------
8	31.4	12.3	------	11.8	10.8	9.0	--------	--------	--------	--------
9	30.0	11.7	.068	9.1	6.0	3.3	--------	--------	--------	--------
10	30.3	10.7	.072	9.4	3.6	2.7	2.3 W	0710	11.7 W*	1447
11	32.0	------	.136	10.0	2.4	1.7	--------	--------	--------	--------
12	34.4	10.1	.199	9.4	4.4	2.8	3.0 W	0717	8.0 E**	1440
13	35.0	9.5	.193	12.7	12.0	5.0	--------	--------	--------	--------
14	36.5	8.8	.093	14.1	9.2	6.8	2.7 W	0706	6.7 W	1445
15	37.7	------	------	------	------	------	--------	--------	--------	--------
16	38.8	------	------	------	------	------	--------	--------	--------	--------
17	39.7	------	------	------	------	------	2.3 W	0721	10.7 E	1410
									6.7 W	1850
18	40.2	------	------	------	------	------	--------	--------	--------	--------
19	42.0	11.2	------	10.2	6.4	3.7	3.0 W	0715	10.7 W	1425
20	43.5	13.3	.142	9.6	10.0	4.3	--------	--------	--------	--------
21	43.8	8.8	.197	10.4	4.8	2.4	3.3 W	0727	12.0 W	1420
22	45.5	9.8	.232	12.2	11.2	4.9	--------	--------	--------	--------
23	46.0	8.8	.169	10.0	6.6	2.1	--------	--------	--------	--------
24	47.0	11.2	.170	13.0	18.4	7.0	2.3 W	0718	11.3 W	1437
25	48.5	10.6	.188	9.4	6.4	2.2	--------	--------	--------	--------
26	49.5	11.5	.151	10.4	5.2	2.4	2.0 W	0720	9.0 W	1425
27	50.9	7.7	.268	7.8	6.4	2.9	--------	--------	--------	--------
28	52.0	12.2	.125	11.3	10.8	4.3	0.7 W	0721	11.3 W	1433
29	53.8	11.7	.188	------	------	------	--------	--------	--------	--------
30	55.3	16.1	.214	5.6	3.6	0.6	--------	--------	--------	--------
31	56.2	------	------	------	------	------	0.7 W	0723	--------	--------

Aug.	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	57.2	——	——	——	——	——	——	——	——	——
2	60.1	10.6	——	12.1	8.4	6.1	2.3 W	0733	9.7 W	1432
3	61.4	10.7	.178	10.2	8.0	4.2	——	——	——	——
4	62.5	10.7	.233	11.0	8.4	4.4	2.0 W	0721	7.7 W	1424
5	63.5	11.8	.196	10.2	10.0	6.1	——	——	——	——
6	64.0	12.2	.179	9.4	9.2	3.8	——	——	——	——
7	65.9	10.7	.169	11.9	13.6	10.0	2.7 W	0720	13.0 W	1431
8	67.7	9.2	.152	11.9	14.4	9.4	——	——	——	——
9	69.5	9.6	.098	——	——	——	2.3 W	0723	13.3 W	1418
10	71.0	——	——	——	——	——	——	——	——	——
11	71.5	——	——	——	——	——	2.7 W	0722	10.0 W	1421
12	73.3	12.9	——	9.0	6.4	2.5	——	——	——	——
13	74.5	10.4	.125	8.3	4.4	2.1	——	——	——	——
14	74.7	10.1	.160	13.3	11.6	8.4	4.0 W	0732	9.0 W	1423
15	74.9	10.7	.654	7.2	6.4	2.2	——	——	——	——
16	75.4	——	——	——	——	——	3.0 E	0724	15.7 W	1424
17	76.7	——	——	——	——	——	——	——	——	——
18	77.4	——	——	——	——	——	4.3 E	0720	15.0 W	1412
19	77.6	——	——	——	——	——	——	——	——	——
20	78.3	10.7	——	13.1	15.6	8.8	——	——	——	——
21	79.2	12.2	.072	10.6	6.4	3.4	5.0 E	0720	12.0 W	1423
22	80.2	10.7	.062	14.0	11.6	8.2	——	——	——	——
23	80.6	10.4	.036	12.3	11.6	7.7	8.3 E	0723	13.3 W	1418
24	80.9	12.2	.053	19.4	12.8	9.7	——	——	——	——
25	81.3	11.5	.036	19.3	15.6	10.3	8.7 W	0804	16.7 W	1424
26	81.7	11.8	.018	11.8	14.4	7.3	——	——	——	——
27	81.9	9.9	.071	——	——	——	5.0 E	0712	——	——
28	——	——	——	——	——	——	——	——	——	——
29	——	——	——	——	——	——	——	——	——	——
30	83.0	7.9	——	——	——	——	8.3 W	0713	13.0 W	1422
31	——	——	——	11.2	8.0	4.2	——	——	——	——
Sept.	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	83.3	——	——	——	——	——	11.7 E	0719	16.0 W	1417
2	83.9	——	——	——	——	——	——	——	——	——
3	84.1	——	——	——	——	——	——	——	——	——
4	84.1	——	——	——	——	——	——	——	——	——
5	84.5	——	——	——	——	——	12.0 E	0722	10.7 W	1412

(Continued)

APPENDIX TABLE 9 (*Con't.*). SUMMARY OF PLANT TOP MEASUREMENTS MADE DURING THE 1972 GROWING SEASON FOR THE COTTON PLANTS OF BIN 8, AUBURN RHIZOTRON

Date	Height	Duration of nighttime linear phase	Daily increase in diameter	Duration of shrinkage	Maximum shrinkage	Time-diameter shrinkage	Water potential a.m.	Time (a.m.) potential measured	Water potential p.m.	Time (p.m.) potential measured
July	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
					Right plant					
7	37.1	------	------	------	------	------	------	------	------	------
8	38.2	8.2	------	10.5	8.4	6.9	------	------	------	------
9	38.5	10.7	.128	8.6	8.4	4.6	------	------	------	------
10	39.2	12.8	.115	9.7	5.2	4.1	2.3 W	0725	------	------
11	40.5	13.1	.207	1.7	0.8	0.4	------	------	------	------
12	42.0	10.7	.304	11.0	4.8	3.4	------	------	14.0 E	1506
13	42.8	9.6	.254	12.7	15.2	9.8	------	------	------	------
14	44.3	10.6	.194	------	------	------	3.3 W	0720	------	------
15	45.4	------	------	------	------	------	------	------	------	------
16	47.0	9.8	------	14.1	14.4	11.7	------	------	------	------
17	48.3	8.5	.062	12.2	12.4	9.4	3.3 W 9.3 E	0724 1011	12.0 W	1415
18	49.2	14.5	------	------	------	------	------	------	------	------
19	50.9	11.5	------	15.5	9.6	4.6	4.7 W	0718	11.0 W	1427
20	52.3	13.9	.063	14.6	8.0	4.9	------	------	------	------
21	54.5	10.0	.188	12.2	20.0	13.3	4.3 W	0729	12.0 W	1424
22	55.6	------	------	10.4	16.0	8.5	------	------	------	------
23	57.3	13.6	.305	9.0	13.6	6.2	------	------	------	------
24	58.9	12.9	.358	11.6	24.4	13.0	2.7 W	0723	13.0 W	1440
25	60.9	11.2	.276	------	------	------	------	------	------	------
26	61.5	18.5	.384	9.4	10.0	5.0	2.0 W	0723	9.3 W	1427
27	63.0	13.4	.381	3.9	3.6	0.8	------	------	------	------
28	64.8	14.0	.392	17.7	30.4	23.4	1.0 W	0721	12.3 W	1436
29	66.0	13.3	.099	1.6	2.0	0.2	------	------	------	------
30	68.1	17.0	.455	7.5	12.8	4.1	------	------	------	------
31	68.5	------	.098	------	------	------	0.7 W	0726	------	------

Aug.	cm	Hr.	mm	Hr.	mm × 10²	mm-hr. × 10	—Bars	Hr.	—Bars	Hr.
1	70.0	------	------	------	------	------	------	------	------	------
2	71.6	11.4	------	11.3	7.6	4.1	2.3 W	0740	11.3 W	1435
3	72.3	13.6	.232	7.7	4.8	1.8	------	------	------	------
4	73.3	13.1	.366	6.9	6.8	2.2	2.0 W	0725	9.3 W	1426
5	74.8	9.9	.481	7.7	4.4	3.1	------	------	------	------
6	76.0	13.7	.491	5.5	3.6	1.0	------	------	------	------
7	77.7	9.3	.411	11.0	18.8	12.0	2.7 W	0723	12.3 W	1435
8	79.0	9.5	.277	7.5	5.6	2.6	------	------	------	------
9	80.8	9.0	.402	10.4	18.4	12.1	2.0 W	0726	13.3 W	1420
10	81.8	12.9	.384	------	------	------	------	------	------	------
11	82.9	15.0	------	------	------	------	2.3 W	0726	8.7 W	1423
12	83.8	10.7	------	3.3	2.8	0.4	------	------	------	------
13	84.5	11.7	.402	3.0	2.0	0.4	------	------	------	------
14	85.9	11.2	.384	11.5	13.6	5.9	3.0 W	0737	12.3 W	1428
15	87.3	10.7	.269	8.0	7.2	1.6	------	------	------	------
16	88.1	11.0	.286	13.9	21.2	14.0	3.3 W	0729	14.0 W	1428
17	89.1	10.1	------	9.2	10.4	4.9	------	------	------	------
18	89.9	9.9	.143	12.5	15.6	10.3	3.7 W	0724	13.3 W	1415
19	91.0	11.5	.107	13.9	15.2	10.2	------	------	------	------
20	91.7	11.2	.057	12.5	14.8	7.8	------	------	------	------
21	92.7	12.8	------	16.3	15.6	12.0	6.7 E	0723	11.7 W	1426
22	93.5	12.8	------	22.2	15.6	12.6	------	------	------	------
23	93.6	11.7	.035	9.2	10.4	5.3	8.7 E	0726	14.0 W	1421
24	95.1	------	------	------	------	------	------	------	------	------
25	95.7	------	------	------	------	------	8.3 W	0811	17.3 W	1427
26	95.7	------	------	------	------	------	------	------	------	------
27	96.1	------	------	------	------	------	6.7 E	0715	------	------
28	------	------	------	------	------	------	------	------	------	------
29	------	------	------	------	------	------	------	------	------	------
30	97.0	12.3	------	------	------	------	8.0 W	0716	12.7 W	1425
31	------	------	------	------	------	------	------	------	------	------
Sept.	*cm*	*Hr.*	*mm*	*Hr.*	*mm × 10²*	*mm-hr. × 10*	*—Bars*	*Hr.*	*—Bars*	*Hr.*
1	97.5	------	------	------	------	------	12.0 W	0722	15.7 W	1420
2	98.1	------	------	------	------	------	------	------	------	------
3	98.1	------	------	------	------	------	------	------	------	------
4	98.1	------	------	------	------	------	------	------	------	------
5	98.6	------	------	------	------	------	11.7 E	0726	11.3 W	1415

* West ** East

Appendix Table 10. Water Balance. Volumetric Water Content as Function of Depth and Time, Water Added to Surface, and Water Removed from Bottom by Suction or by Plant Use in Bin 8, Auburn Rhizotron, 1972

	Depth (cm)						Water added	Water removed	Water use period	Total water use
	30	60	90	120	150	180				
	cm^3/cm^3						*(Liters)*	*(Liters)*	*Date*	*cm/day*
July 8	.262	.274	.230	.262	.327	.367	----	10	8-10	1.34
10	.226	.260	.235	.257	.319	.337	----	6	10-14	1.37
12	.197	.260	.221	.261	.311	.337	----	4		
14	.175	.237	.213	.235	.295	.315	----	----	14-17	0.57
17	.172	.223	.190	.218	.287	.325	18	----	17-21	0.48
21	.187	.222	.191	.222	.293	.317	20	4	21-26	0.67
26	.247	.234	.176	.200	.265	.292	----	4	26-31	0.60
28	.227	.225	.177	.200	.270	.293	----	----	31	------
31	.201	.196	.167	.196	.256	.288	----	5	Aug. 4	0.17
Aug. 2	.177	.195	.162	.195	.262	.285	40	----	4-9	0.60
4	.325	.270	.161	.174	.255	.272	20	0.5	--------	------
9	.387	.222	.160	.182	.239	.260	20	----	9-14	2.14
11	.275	.250	.174	.190	.237	.274	----	----	--------	------
14	.170	.196	.168	.185	.230	.252	40	----	--------	------
16	.212	.187	.156	.176	.228	.268	- -	----	14-18	1.86
18	.172	.173	.145	.171	.220	.260	20	----	--------	------
21	.126	.138	.128	.154	.195	.245	60	----	18-23	3.01
23	.143	.150	.132	.160	.190	.239	60	----	--------	------
25	.229	.198	.165	.174	.200	.232	40	----	23-27	0.61
27	.227	.214	.181	.198	.251	.306	40	----	Aug. 27 Sept. 1	1.55
30	.185	.198	.178	.210	.277	.337	20	----	--------	------
Sept. 1	.228	.200	.174	.204	.260	.334	60	----	1-5	2.37
5	.255	.218	.166	.192	.250	.281	----	----	--------	------

APPENDIX TABLE 11. ROOTING DENSITY AS A FUNCTION OF TIME AND DEPTH IN COMPARTMENT 8, AUBURN RHIZOTRON, 1972

	Depth					
	30	60	90	120	150	180
			cm root/cm³ soil			
June 26	.34	0	0	0	0	0
28	.34	0	0	0	0	0
30	.39	0	0	0	0	0
July 3	.52	0	0	0	0	0
5	.67	0	0	0	0	0
7	.72	0	0	0	0	0
10	.90	0	0	0	0	0
12	1.13	.04	0	.06	0	0
14	1.25	.04	0	.09	0	0
17	1.39	.15	0	.09	0	0
19	1.51	.18	.06	.20	0	0
21	1.66	.27	.10	.26	0	0
24	2.01	.48	.21	.26	0	0
26	2.08	.53	.32	.34	0	0
28	2.32	.69	.37	.34	0	0
31	2.59	1.13	.74	.39	.04	0
Aug. 2	2.49	1.08	.69	.42	.04	0
4	2.86	1.18	.92	.55	.04	0
7	3.25	1.63	1.53	.80	.04	0
9	3.35	1.88	1.71	.93	.04	0
11	3.42	2.05	2.00	1.14	.07	0
14	3.08	1.83	1.90	1.01	.09	0
16	3.16	1.78	1.61	.83	0	0
18	3.43	1.93	2.02	1.33	.12	0
21	3.21	2.22	2.15	1.31	.07	0
23	3.09	1.92	2.12	1.41	.20	0
25	2.80	1.88	1.95	1.41	.21	0
27	3.45	2.26	2.45	1.70	.40	.05
30	3.05	1.92	1.90	1.59	.34	.09
Sept. 1	2.52	1.73	1.93	1.26	.31	.09
5	2.14	1.43	1.05	1.02	.40	.14

APPENDIX TABLE 12. DATA OF TEMPERATURE, RELATIVE HUMIDITY, RADIATION AND WINDSPEED FOR THE EXPERIMENTAL PERIOD. DATA WERE OBTAINED FROM THE U.S. WEATHER BUREAU STATION ABOUT 1.5 km FROM THE AUBURN RHIZOTRON

Date 1972	Temperature (°F)				Relative humidity (%)				Total radiation	Total windspeed and direction
	0000	0600	1200	1800	0000	0600	1200	1800	*Ly/day*	*Miles/day*
July 7	67	66	80	79	100	100	50	60	585	E 79
8	66	66	82	80	100	100	43	53	516	E 54
9	65	66	82	78	100	90	43	65	474	E 63
10	78	65	----	----	85	99	44	48	582	E 112
11	----	----	----	----	82	100	46	44	616	N 86
12	----	----	----	----	95	98	46	50	560	NE 52
13	----	----	----	----	100	93	42	45	583	S 75
14	----	----	----	----	100	100	52	84	484	S 62
15	----	67	84	79	100	100	64	83	483	S 47
16	69	69	82	80	100	100	72	98	212	S 43
17	70	67	86	88	100	100	58	72	689	E 55
18	75	72	86	84	100	100	62	78	580	E 70
19	72	72	86	71	100	100	52	100	602	E 85
20	69	70	84	82	100	100	58	66	660	E 98
21	71	70	87	86	98	100	48	46	570	E 48
22	73	72	92	86	94	98	44	60	542	N 47
23	76	72	92	72	92	100	42	100	518	NW 50
24	72	72	91	82	100	100	52	74	555	W 65
25	74	69	73	76	100	100	100	100	325	S 78
26	70	69	85	82	100	100	66	80	502	S 81
27	74	73	81	75	100	100	62	100	324	W 84
28	69	72	85	82	100	100	64	56	489	W 99
29	73	73	75	69	100	100	100	100	280	S 91
30	68	67	79	71	100	100	100	100	392	E 54
31	64	66	78	73	100	94	80	100	412	E 70

Aug. 1	69	69	83	81	100	100	68	71	532	S 57
2	70	69	86	80	100	100	68	60	541	SW 59
3	79	68	84	79	100	100	70	99	469	W 50
4	70	71	82	82	100	100	88	99	466	W 47
5	72	71	87	83	100	100	53	70	580	N 87
6	73	69	70	70	100	100	100	100	461	W 44
7	70	68	89	86	100	100	52	61	571	SW 75
8	77	71	88	83	83	99	59	90	509	W 58
9	76	70	88	83	100	100	58	74	499	W 70
10	68	68	84	73	100	100	60	100	416	S 41
11	68	69	85	78	100	100	56	92	528	E 63
12	74	69	83	80	98	100	68	90	414	E 48
13	71	68	84	82	100	100	59	81	407	N 47
14	69	66	85	81	100	100	66	87	463	E 56
15	68	67	88	84	100	100	49	76	421	NE 26
16	70	69	89	70	100	100	100	100	497	E 84
17	71	70	80	81	100	100	76	84	323	E 57
18	68	69	89	84	100	100	50	76	482	N 57
19	71	73	91	88	100	100	47	57	492	N 81
20	75	72	92	81	89	98	42	80	474	N 101
21	73	80	82	79	98	100	66	81	404	E 93
22	71	68	84	77	87	99	48	68	477	E 90
23	68	68	85	76	92	100	50	78	335	E 90
24	69	68	87	79	100	100	52	86	399	E 40
25	70	70	89	81	100	100	48	76	453	W 62
26	70	72	92	74	100	94	39	94	402	N 60
27	69	71	90	82	100	100	46	49	447	N 79
28	71	67	86	81	78	82	43	52	522	N 133
29	70	66	85	80	84	100	56	66	415	N 133
30	71	68	86	81	100	100	43	44	498	E 128
31	72	68	83	78	76	100	51	59	452	E 121
Sept. 1	69	67	84	79	96	100	46	50	476	E 94
2	66	63	86	82	86	100	39	48	460	N 48
3	66	64	89	87	97	100	37	38	423	NW 46
4	69	68	92	82	96	100	40	64	390	SW 91
5	72	71	76	72	100	100	78	100	195	N 56

APPENDIX III

Publications for Which Research Was Conducted Wholly or Partially in the Auburn Rhizotron

1. Fiscus, Edwin L., and M. G. Huck. 1972. Diurnal fluctuations in soil water potential. Plant Soil 37:197-202.

Soil water potentials varied diurnally at all depths in a 188-cm (approximately 6-ft.) profile containing roots of large cotton plants. Thermocouple psychrometer probes were inserted horizontally through holes in the glass wall of a rhizotron compartment, sealed at the glass-soil interface, and monitored at 20-minute intervals. Soil temperature monitored with diodes also varied diurnally.

2. Huck, Morris G. 1975. Root distribution and water uptake patterns. *In* John K. Marshall [ed.] The belowground ecosystem: A synthesis of plant-associated processes. IBP Symposium, Ft. Collins, Colo., September 5-7, 1973 (In Press).

This review-type paper discusses the effects of various soil factors upon root distribution and then the effects of root distribution upon water uptake patterns. The paper discusses some of the results from root observation laboratories (the rhizotrons). It further discusses the manner in which rhizotron data can be combined with data from other types of experiments to simulate root system development as affected by soil environmental conditions.

3. Huck, M. G., Betty Klepper, and H. M. Taylor. 1970. Diurnal variations in root diameter. Plant Physiol. 45:529-530.

Time-lapse microphotography indicated that some roots of a 14-week old cotton plant shrank and swelled diurnally in response to soil water conditions and aboveground evaporative demand. Time-lapse photography was through a microscope focused through the glass wall onto a root located in soil immediately behind the wall. The root diameter at maximum shrinkage was about 60% of the early morning diameter.

4. Klepper, Betty, and V. Douglas Browning. 1971. Drought affects growth of cotton stems. Highlights Agr. Res. 18:16. Auburn Univ. Agr. Exp. Sta., Auburn, Ala.

Cotton stem diameter was monitored using a linear variable differential transformer (LVDT). Output from the LVDT was recorded at 2-minute intervals on a digital data acquisition system. During a drying cycle, the stems shrank diurnally. The daily increase in diameter slowed as the soil became progressively drier. A rhizotron compartment was covered with sheet metal at the soil surface to cause the drought cycle.

5. Klepper, Betty, V. Douglas Browning, and Howard M. Taylor. 1971. Stem diameter in relation to plant water status. Plant Physiol. 48:683-685.

An instrument containing a linear variable differential transformer (LVDT) was constructed to obtain continuous nondestructive measurements of both short-term changes in stem diameter and long-term growth. In cotton plants, stem diameters, leaf water potentials, and leaf relative water content are all closely related to net radiation at the top of a canopy. The

LVDT output was recorded at 2-minute intervals on the digital data acquisition system of the rhizotron.

6. Klepper, Betty, H. M. Taylor, M. G. Huck, and E. L. Fiscus. 1973. Water relations and growth of cotton in drying soils. Agron. J. 54:307-310.

Two 70-day-old cotton plants (*Gossypium hirsutum* L. 'Auburn 7-683') were subjected to a 26-day drying cycle at the Auburn rhizotron to quantitatively study water relations and growth as the soil dried. Measurements were made of rooting density changes; stem diameter and height increase; and soil water content (neutron meter), soil water potential (thermocouple psychrometer), and plant water potential (pressure chamber). The pattern of cotton plant rooting with depth shifted during drying while those grown simultaneously in a similar profile with moisture maintained did not.

7. Molz, Fred J., Betty Klepper, and V. Douglas Browning. 1973. Radial diffusion of free energy in stem phloem: An experimental study.

The rehydration of a water-stressed cotton stem was studied experimentally in a rhizotron compartment and in a growth chamber. The main objective of the experiments was to ascertain if a proposed diffusion theory can describe the dynamics of the rehydration process. Stem shrinkage was induced by allowing the soil root system of cotton plants to dry by evapotranspiration. Tension in the xylem was then released suddenly by severing the stem under distilled degassed water, with the subsequent increase in stem diameter monitored with an LVDT. From the basic data of stem diameter vs time, fractional uptake curves for free energy were computed and compared with predictions derived from theory. The comparisons indicate that the theory is applicable at least to first order. The overall study illustrates the intimate involvement of the xylem and phloem as far as radial water exchange is concerned.

8. Moore, Charles L., Fred J. Molz, and V. Douglas Browning. 1974. Transpirational drying: An aid to the reduction of the sanitary landfill leaching. Proc. 4th Ann. Environ. Eng. Sci. Conf., Louisville, Ky., March 4-5, 1974. *In press.*

Rhizotron bins were used to study root penetration and root growth habit into a ½-scale sanitary landfill profile. The leachate from drains at the bottom of the bins was collected, measured, and analyzed. Volumes and concentrations of leachate from vegetated and nonvegetated profiles were compared.

9. Pearson, Robert W. 1974. Significance of rooting pattern to crop production and some problems of root research. *In* The plant root and its environment. p. 247-270. E. W. Carson, [ed.] The Univ. Press of Virginia.

This review article discusses various types of facilities for investigating plant root development. The rhizotron's glass wall with wire grid allows the continuous measurement of root development on a nondestructive basis during an entire growing season. These observations can determine how plant root development changes with soil conditions and plant maturity.

10. Pearson, Robert W., Joel Childs, and Zane F. Lund. 1973. Uniformity of limestone mixing in acid subsoil as a factor in cotton root penetration. Soil Sci. Soc. Amer. Proc. 37:727-731.

Cotton (*Gossypium hirsutum* L.) root growth response to different degrees of mixing limestone in strongly acid subsoil was determined using both short-term radical elongation experiments in plant growth boxes and full growth cycle root extension experiments in the rhizotron. The roots displayed no chemotropic response to limed pathways in acid subsoil. Roots grew best when the entire subsoil mass was mixed with limestone. However, when applied at an adequate rate, even poorly mixed limestone increased rooting depth at least twofold. Both radical elongation rate and final root pattern were closely related to percentage of total subsoil mass limed in the incompletely-mixed treatments, even when the neutralized soil zones were as much as 7.6 cm apart.

11. Stansell, J. R., Betty Klepper, V. Douglas Browning, and H. M. Taylor. 1973. Plant water status in relation to clouds. Agron. J. 65:677-678.

Stem diameter and net radiation were recorded on the digital data acquisition system for both cloudy and non-cloudy time periods. A pressure chamber was used to determine plant water status. Clouds caused significant changes in plant water status in a short time period, therefore, care should be taken to sample different treatments under comparable radiation.

12. Stansell, J. R., Betty Klepper, V. Douglas Browning, and H. M. Taylor. 1974. Effect of root pruning on the water relations and growth of cotton. Agron. J. 66:591-592.

13. Taylor, H. M. 1969. The rhizotron at Auburn, Alabama — A plant root observation laboratory. Auburn Univ. Agr. Exp. Sta. Cir. 171.

This circular describes the rhizotron and the types of research that scientists can perform using the rhizotron and its associated equipment.

14. Taylor, H. M. 1969. New laboratory gets to the roots. *In* What's new in research. Crops and Soils 72:20.

This article describes the usefulness of the rhizotron in conducting plant root studies. It emphasizes that the glass walls of the rhizotron compartment allow measurements of root penetration on a non-destructive basis.

15. Taylor, H. M., M. G. Huck, Betty Klepper, and Z. F. Lund. 1970. Measurement of soil-grown roots in a rhizotron. Agron. J. 62:807-809.

Measurements were made of both shoot and root growth on a corn (*Zea mays* L.) and a tomato (*Lycopersicon esculentum*) plant in a rhizotron. Root intensity at the transparent panel was estimated by two methods. It increased during the root growing season for both species, but was always greater for corn. Estimates of root density and total root length were three times greater for corn than for tomatoes at the end of the growing season. Sidewalls and glass panels showed no concentration effect on root growth.

16. Taylor, H. M., and Z. F. Lund. 1970. The root system of corn. 25th Ann. Corn and Sorghum Res. Conf. Proc. 25:175-179.

The root system of corn is described for a sandy soil in the rhizotron compartment. During favorable growing seasons, a single corn root produced about 18 miles of roots excluding root hairs. The roots were at the bottom of the 6-ft. compartment 39 days after the corn grains were planted.

17. Taylor, H. M., M. G. Huck, and Betty Klepper. 1971. Root development in relation to soil physical conditions. p. 71-91, *in* D. I. Hillel, [ed.] Optimizing the soil physical environment. Academic Press, New York.

This review-type article presents data collected in the Auburn rhizotron where three different soil conditions were evaluated for their effects on cotton root development. The data showed that a high-strength soil pan excluded root development through the pan for about 20 days, and that a clay loam soil allowed cotton plants to grow taller than those on a loamy sand soil – presumably because of the greater quantity of available water in the clay loam soil during a period of low rainfall. The cotton roots reached the bottom of the compartment (188 cm) about 80 days after planting. No differences were found among the three compartments in the time at which the roots reached the bottom.

18. Taylor, H. M. and Betty Klepper. 1971. Water uptake by cotton roots during an irrigation cycle. Australian J. Biol. Sci. 24:853-859.

Two-month-old cotton plants growing in a rhizotron compartment filled with loamy fine sand were subjected to an irrigation cycle. Rooting density, soil water content, soil water potential, water extraction per unit length of root, plant height, and leaf water potential were estimated throughout the cycle. The soils dried progressively from top to bottom. Water extraction per unit length of root was greater in wetter soils and decreased exponentially as soil water potential decreased. In general, deep roots were as effective as shallow roots in water extraction. Rooting density was greater in the surface soil at first, but became uniform later. After irrigation, water extraction per unit length of root was about the same at all soil depths.

19. Taylor, H. M. and Betty Klepper. 1973. Rooting density and water extraction patterns for corn (*Zea mays* L.). Agron. J. 65:965-968.

An experiment was conducted to compare water-absorbing efficiency of corn (*Zea mays* L.) roots deep in the profile with that of roots near the soil surface. Plants were grown in a rhizotron compartment with rainfall excluded by a metal cover over the soil. Soil water content was determined with a neutron probe; rooting density from measurements of roots on the glass viewing surface of the compartment. Leaf area was calculated by a length-width method and plant height was measured daily. Stomatal aperture was estimated twice daily with a pressure drop promoter.

20. Taylor, H. M. 1972. The rhizotron at Auburn, Alabama: Design and three years' use. Proc. 3rd Intl. Seminar for Hydrology Professors. Purdue Univ., Lafayette, Indiana. June 1971.

This article describes the rhizotron located at Auburn, Alabama, provides the criteria used in its design and discusses opportunities for research and the problems that have been encountered in the first 3 years of rhizotron use.

21. Taylor, Howard M. and Betty Klepper. 1974. Water relations of cotton; I. Root growth and water use as related to top growth in soil water content. Agron. J. 66:584-588.

Many experiments have evaluated the effects of decreasing soil water contents on top growth and yield of plants, but few experiments have simultaneously evaluated root growth. An experiment was conducted to determine the response of cotton (*Gossypium hirsutum* L., 'Auburn 623b') roots and tops to decreasing soil water content. Plants were grown in rhizotron compartments with rainfall excluded by metal covers over the soil. Soil profile and irrigation schedule treatments provided different levels of soil and plant water potentials. Soil water content was determined with the neutron meter, rooting density from measurements of roots on the glass viewing surface of each compartment. Plant water potential was determined with a pressure chamber apparatus, and top growth was evaluated by plant height. At the same time that total root length ceased to increase, plant top growth slowed or ceased, and plant water potential near sunrise decreased. Root length ceased to increase when the soil water content of any layer increased to about 0.06 to 0.07 cm^3/cm^3, which corresponds to a soil water potential slightly wetter than -1 bar, or a hydraulic conductivity of about 2×10^{-4} cm/day. Thus, for conditions of this experiment, cotton root growth correlated with decreases both in plant water potential and in soil water content.

STATE AGRICULTURAL EXPERIMENT STATIONS

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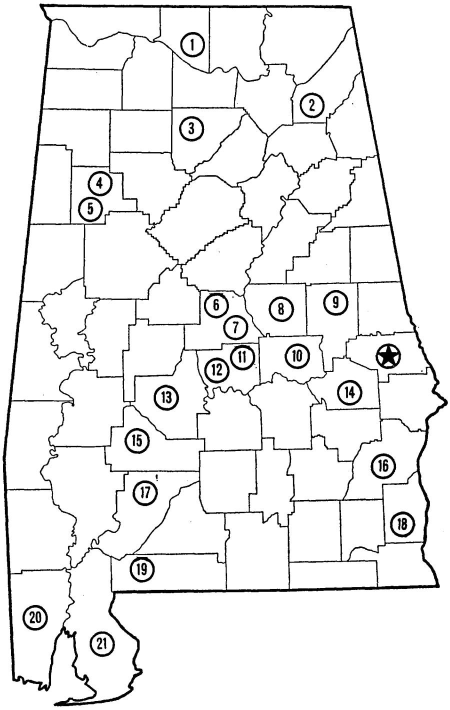

Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.