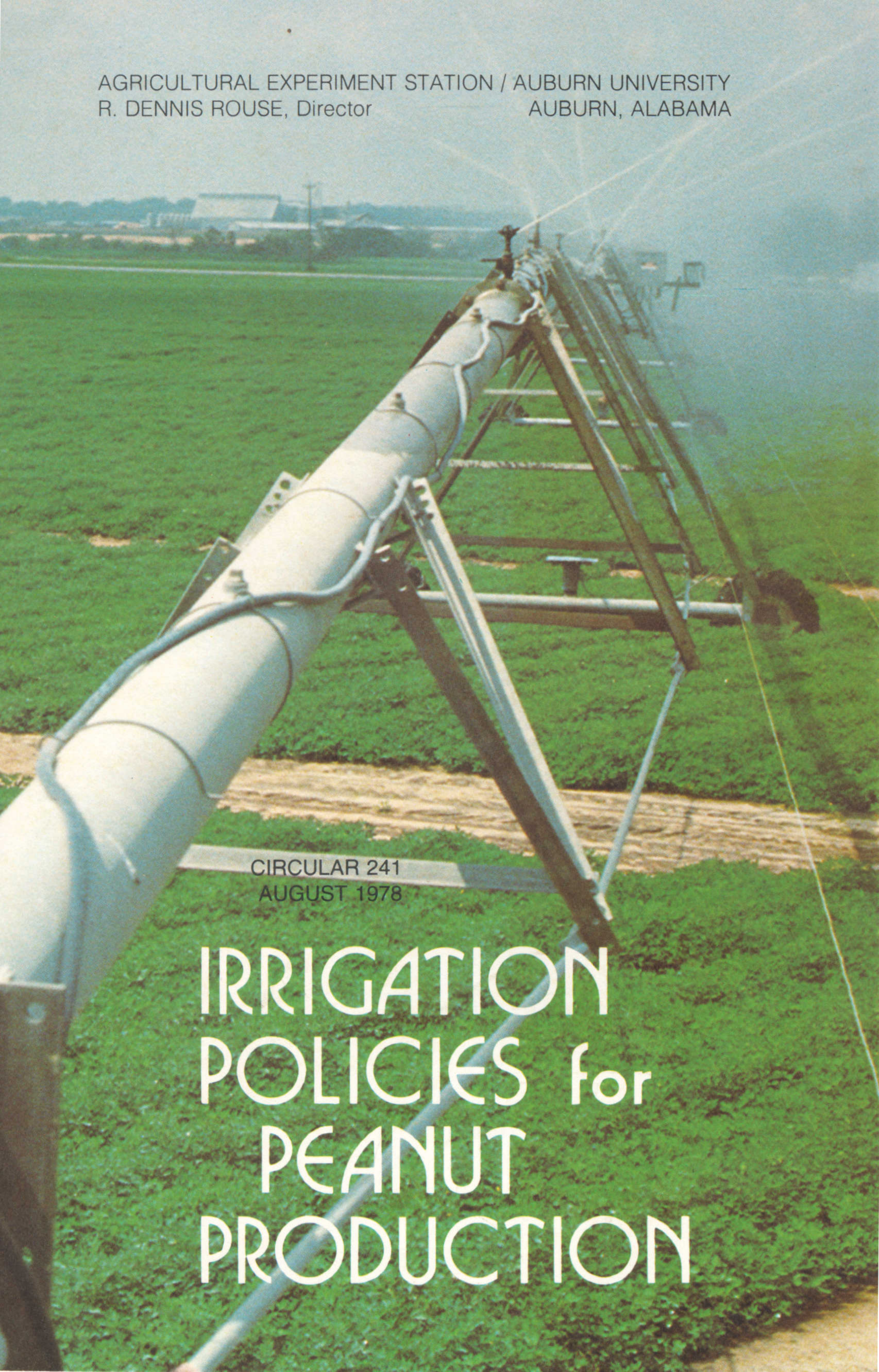
AGRICULTURAL EXPERIMENT STATION / AUBURN UNIVERSITY
R. DENNIS ROUSE, Director AUBURN, ALABAMA



CIRCULAR 241
AUGUST 1978

IRRIGATION POLICIES for PEANUT PRODUCTION

CONTENTS

FIRST PRINTING 3M, AUGUST 1978

Irrigation Policies for Peanut Production

E. W. ROCHESTER, P. A. BACKMAN, S. C. YOUNG, and J. M. HAMMOND*

INTRODUCTION

PEANUT IRRIGATION in the Southeast is rapidly becoming a common practice as growers seek to boost yields. Equipment with low labor requirements, such as the center pivot and cable tow traveler, as well as recent droughts, have accelerated interest in irrigation in Alabama where peanuts are traditionally a big money crop. Farmers in Alabama sold 583 million pounds of peanuts for $122 million in 1977. Production increases, due in part to irrigation and improved management practices, are predicted to increase sales to 750 million pounds by 1980 *(1)*.

Efficient use of irrigation for increased peanut yield and quality in the normally humid Southeast requires proper irrigation timing as well as effective soil moisture policies. In related research, Stansell *et al.* *(7)* noted that irrigation increased the quality and yield of peanuts in Georgia. They presented data, figure 1, relating water use of Florunner peanuts to plant age when grown under optimum soil water conditions. Optimum soil water conditions were defined as wetting the top 24 inches of the soil profile to field capacity when the average water tension in the top 12 inches of the profile reached 20 centibars. Figure 1 shows that the water demand starts low, increases to a maximum value at about midseason, and then decreases gradually. Stansell *et al.* also found that plants were able to extract water from depths

*Associate Professor, Department of Agricultural Engineering; Associate Professor, Department of Botany and Microbiology; Research Associate, Department of Agricultural Engineering; and Research Associate, Department of Botany and Microbiology.

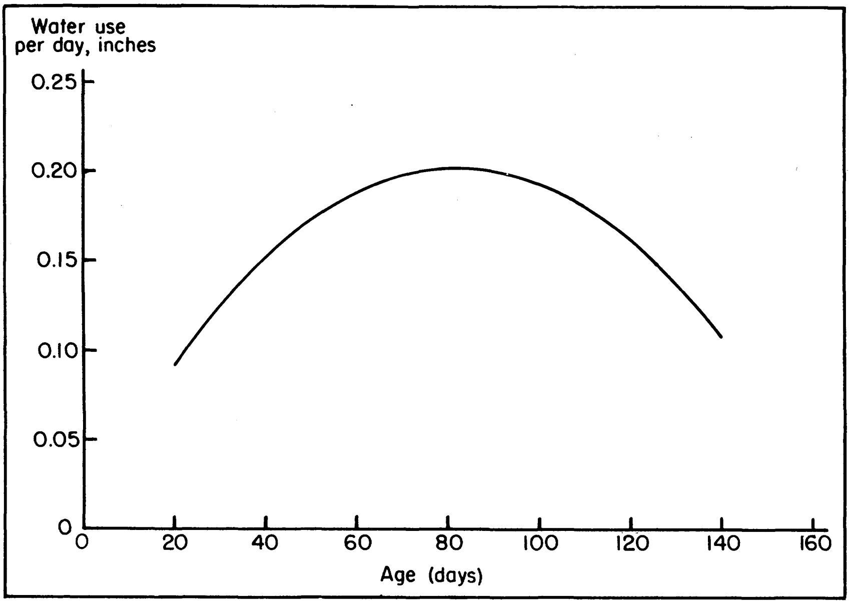


FIG. 1. Estimated daily water use by Florunner peanuts (from Stansell, J.R. et al.) (7).

greater than 24 inches after about 75 days of age. They concluded that the ability of peanuts to utilize water at such depths explains, to some extent, their ability to withstand extended drought stress. Water extraction to a depth of 42 inches was recorded for Florigiant, Florunner, and Tifspan peanuts; however, the authors state that restrictive zones, either mechanical or chemical, may prevent deep profile water extraction.

In addition to determining water needs of the peanut plant, there have been efforts to identify periods in the plant's development which are more susceptible to stress. This follows the widely accepted principle that most nonforage crops are more sensitive to water deficits at certain growth stages than at others *(3,5,6)*. Hiler and Clark *(4)* developed a "stress day index method" to account for these differences in a quantitative manner. This method uses a stress day factor and a crop susceptibility factor to arrive at a plant's stress index. Six stages of growth for the peanut plant were identified and susceptibility factors were assigned to each stage. This dimensionless factor indicates the susceptibility of the plant to given magnitudes of stress. The larger the crop susceptibility factor, the more susceptible the plant is to drought stress. The stages of growth and their crop susceptibility factors as identified by Hiler and Clark are:

Stage	*Crop susceptibility factor*
Anthesis (first flower)	3.5
Peak flowering and early pegging	3.7
Peak pegging	1.7
Early nut development	2.8
Intermediate nut development	2.2
Late nut development	0.7

These findings identify anthesis and peak flowering and early pegging as the two most critical periods in the plant's development. This does not say that the plant needs more water during these stages, but it does say that lack of water will be more detrimental to the plant during this period.

The previously cited research provides important data to consider. However, the work by Stansell *et al.* was conducted with disturbed soil profiles and with controlled moisture conditions eliminating rainfall. Utilization of these results in field conditions was not reported. The addition of rainfall and sprinkler irrigation provides additional uncertainties and increases the possibility of disease stress. The results by Hiler and Clark, which were obtained in Texas for Spanish peanuts, have not been verified for other cultivars at other locations. Therefore, since much information is still needed to provide an adequate guide to irrigation of peanuts in Alabama, an experiment was initiated in 1975 at the Wiregrass Substation, Headland, Alabama.

The objective of this research was to determine yield and quality responses of peanuts to soil moisture levels so that the most effective soil moisture policy can be determined.

EXPERIMENTAL PROCEDURE

During the 1976 and 1977 growing seasons, Florunner peanuts were grown in field plots at the Wiregrass Substation. The plots were irrigated using solid-set irrigation with impact sprinklers spaced to give uniform application in the plot area. The measured application rate at the center of the plots was 0.4 inch per hour. The effective intake rate of the Dothan sandy loam soil dropped below 0.4 inch per hour after about

TABLE 1. SOIL CHARACTERISTICS OF DOTHAN SANDY LOAM

Horizon	Depth	Soil composition			Texture
		Sand	Silt	Clay	
	In.	*Pct.*	*Pct.*	*Pct.*	
Ap	0-10	80.0	10.1	9.9	Sandy loam
B1	10-14	64.3	12.5	23.2	Light sandy clay loam
B21t	14-36	57.4	9.2	33.4	Sandy clay loam
B22t	36-50	56.1	7.5	36.4	Sandy clay loam

1¾ hours of irrigation. Table 1 data on the soil characteristics of Dothan sandy loam indicate a gradual decrease in sand and an increase in clay content with depth. Samples taken over the entire plot area indicated no significant variation in profile characteristics with respect to location.

Tensiometers were installed at depths of 6, 12, and 18 inches in the center of each plot to monitor soil moisture, figure 2. The 6-inch tensiometer was located approximately in the middle of the surface horizon, the 12-inch tensiometer in the middle of the thin transitional B1 layer, and the 18-inch tensiometer in the upper part of the B21t horizon. Tensiometer readings were taken at approximately 8 a.m. on Monday, Wednesday, and Friday. The 18-inch soil moisture tension was monitored but not used in irrigation decisions.

Irrigation treatments were assigned to randomized plots with each treatment having four replications. The irrigation treatments were:

(1) **No irrigation[1]**—No irrigation water was applied.

(2) **60-centibar—**Approximately 0.7 inch of irrigation water was applied when the soil tension at either the 6- or 12-inch depth was 60 centibars or greater.

(3) **40-centibar—**Approximately 0.7 inch of irrigation water was applied when the soil tension at either the 6- or 12-inch depth was 40 centibars or greater.

(4) **20-centibar—**Approximately 0.7 inch of irrigation water was applied when the soil tension at either the 6- or 12-inch depth was 20 centibars or greater.

Treatment 4 was not included in 1976 but was added to the 1977 study. Rainfall was measured daily using a non-recording weather bureau rain gauge located approximately 1,000 feet from the plot area. No attempt was made to measure runoff from rainfall.

[1]All treatments were initially irrigated 1 inch in 1977 to obtain a good crop stand.

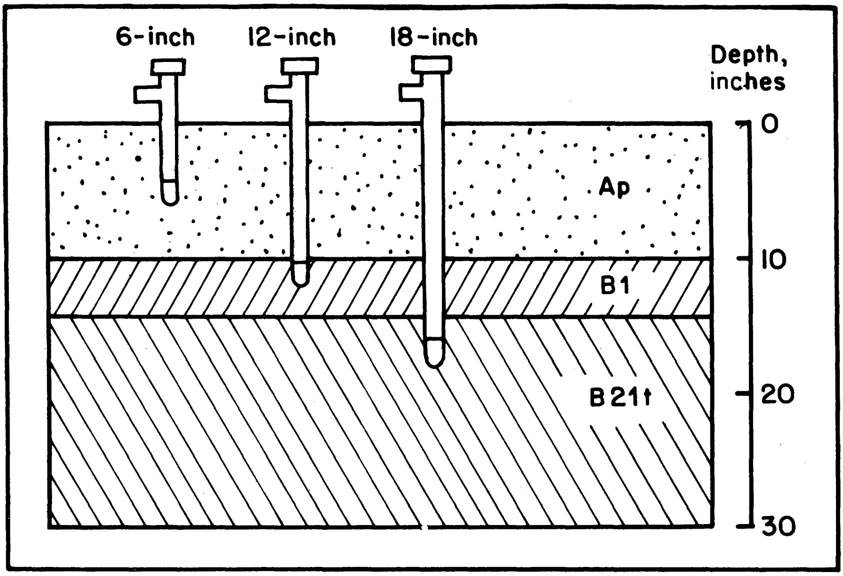


FIG. 2. Tensiometer-soil profile relationship.

Other than irrigation treatments, conventional management practices were followed. This included a full season leafspot control program consisting of applications of Bravo 6F at the rate of 1½ pints per acre on 14-day intervals. The peanuts were planted in 36-inch rows at the rate of 100 pounds per acre. The plot area used was planted in an annual corn-peanut rotation to suppress weeds and diseases. Digging dates for the individual treatments were determined by the arginine maturity index (AMI) *(2)* and the peanuts were dug by machine on or near the date predicted for optimum maturity.

RESULTS

Rainfall in southeastern Alabama during the 1976 and 1977 growing seasons provided contrasting drought conditions. In 1976, August rainfall was more than 3 inches below normal (38 percent of normal), table 2. Conversely, an early season drought occurred during the 1977 growing season when rainfall was nearly 6 inches below normal for the 3-month period of April, May, and June. The conditions afforded by these 2 years will be used to compare the effects of early and late season drought on peanuts.

TABLE 2. RAINFALL AMOUNTS FOR 1976 AND 1977 AT 10-DAY INTERVALS, WIREGRASS SUBSTATION

Month and interval	Rainfall		
	1976	Average expected	1977
	In.	*In.*	*In.*
April			
0-10	0.05	1.50	1.34
11-20	0.05	1.75	0.00
21-30	3.96	1.35	0.75▼▲○
May			
0-10	0.59	1.10	0.02
11-20	4.25	1.05	0.00
21-31	2.25	1.30	1.99
June			
0-10	2.03	1.25	0.30
11-20	1.23	1.40	1.01▼▲○
21-30	1.37	1.60	0.82▼▲▲○○
July			
0-10	1.94	2.00	0.59▼▲▲○○○
11-20	0.81	2.05	1.20▼▲○
21-31	3.24▲	1.95	1.76▼▲▲○○
August			
0-10	0.06▼▲	1.95	3.61
11-20	0.41▼▼▲▲	1.65	1.63▼▲○○
21-31	1.39▼▲▲	1.25	0.53○
September			
0-10	4.93▼▲	1.50	1.21
11-20	0.05	1.20	5.10
21-30	0.75	1.95	1.31
October[1]			
0-10	3.71	0.75	0.46
11-20	0.00	0.55	0.01
21-31		0.60	

[1]Rainfall for the month of October is the amount received before the peanuts were dug. In 1976 the peanuts were planted on May 11 and dug on October 13. In 1977 all treatments were planted on April 25; however, there were three digging dates dictated by kernal maturity. The digging dates were September 19, September 27, and October 12.

The symbols beside the rainfall values indicate that irrigations were made during this period:

▼60-centibar treatment
▲40-centibar treatment
○20-centibar treatment

Soil Moisture

Amounts of water required for the irrigation treatments in 1976 and 1977 are recorded in table 3. In 1976 a total of 26.5 inches of rainfall was received and thus the total water applied to the nonirrigated peanuts was 26.5 inches. Three inches of supplemental water was needed to maintain the 60-centibar treatment, whereas 4.3 inches was needed to maintain the wetter 40-centibar treatment. As already indicated in table 2, the rainfall for August 1976 was more than 3 inches below normal. During this month, 2.4 inches of the total 3 inches of

TABLE 3. TOTAL WATER APPLIED FOR PEANUT IRRIGATION IN 1976 AND 1977, WIREGRASS SUBSTATION

Year and irrigation treatment	Rainfall	Irrigation	Total water applied	Time to mature[1]
	In.	*In.*	*In.*	*Days*
1976				
Nonirrigated.......	26.5	0.0	26.5	156
60-centibar........	26.5	3.0	29.5	156
40-centibar........	26.5	4.3	30.3	156
1977				
Nonirrigated.......	21.6	1.0	22.6	167
60-centibar........	20.0	5.8	25.8	156
40-centibar........	20.0	8.5	28.5	156
20-centibar........	19.8	11.6	31.4	148

[1]As determined by the Arginine Maturity Index.

irrigation water for the 60-centibar treatment was applied. Similarly, 3.7 inches of the 4.3-inch total irrigation for the 40-centibar treatment was applied during this month. The total water application ranged from about 26 to 31 inches applied to the crop in 1976.

Rainfall in 1977 ranged from 19.8 inches to 21.6 inches depending on harvest date. All treatments received an initial 1-inch irrigation at planting to assure germination. This is reflected in table 3 where even the nonirrigated treatment shows 1 inch of irrigation. The 60-centibar treatment required 5.8 inches of supplemental water, whereas the wetter 40-centibar treatment required 8.5 inches. The wettest treatment,

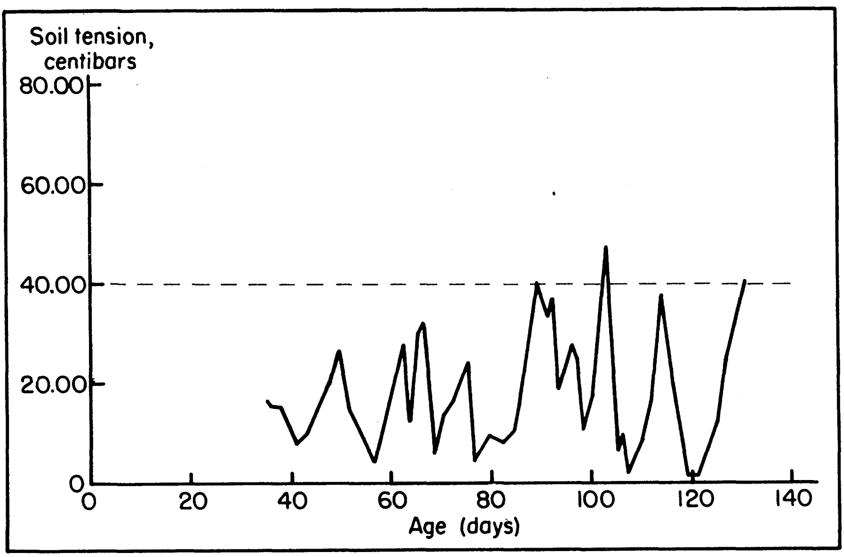


FIG. 3. Average soil tension, 40-centibar treatment, 1976.

the 20-centibar policy, required 11.6 inches of irrigation water. These volumes all include the initial 1-inch application applied before emergence. The total water (irrigation and rain) applied in 1977 ranged from about 23 to 31 inches.

Since a plant must overcome the soil tension to extract water from a soil, the tensiometer data offer an indication of the stress under which the peanuts were growing during the season. Figure 3 is a plot of the average soil tension at the 6-, 12-, and 18-inch depths for the 40-centibar treatment in 1976. The planned soil moisture range is indicated to be between the horizontal axis and the horizontal dashed line. Soil moistures above the dashed line represent unplanned deviations. In only one instance in 1976 was the average soil tension greater than 40 centibars at any time during the growing season. This period of higher stress occurred near the end of the season and corresponds to the August drought.

Figures 4 and 5 are graphs of the average soil tension at the 40- and 20-centibar treatments, respectively, in 1977. The average soil moisture tension was greater than planned in five periods for the 40-centibar treatment and in seven periods for the 20-centibar treatment. Air temperatures of 100°F or higher and evaporation rates as high as 0.4 inch per day contributed to these deviations from the planned moisture range.

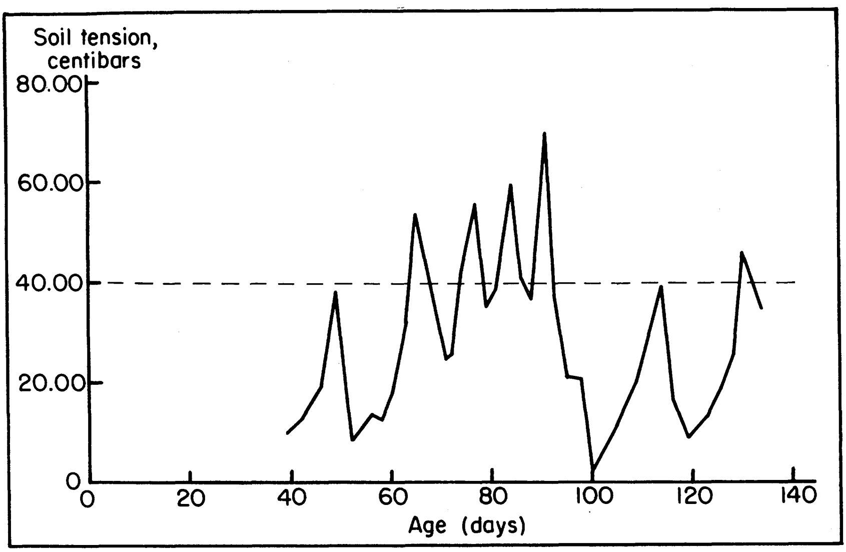


FIG. 4. Average soil tension, 40-centibar treatment, 1977.

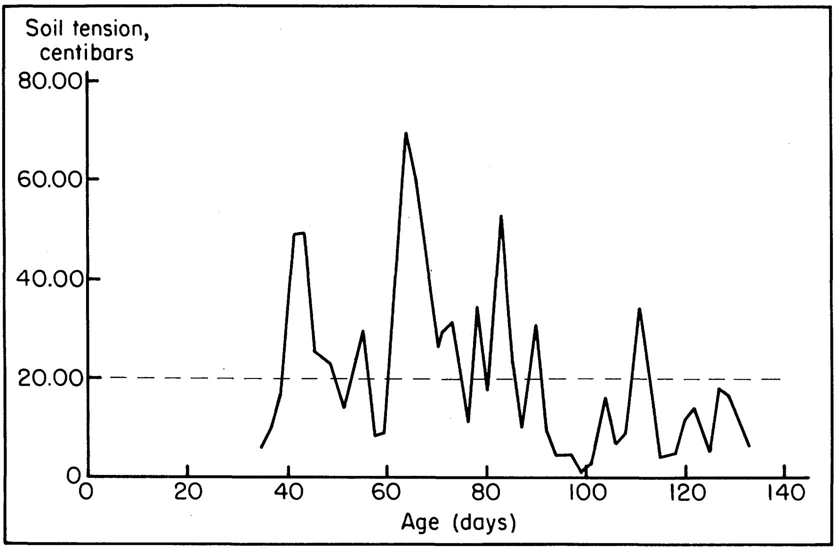


FIG. 5. Average soil tension, 20-centibar treatment, 1977.

The cumulative soil moisture tension for the various treatments beginning on day 41 is presented in table 4. The cumulative tension measured in centibar-days is obtained by adding the daily average tension. During the 41- to 130-day period in 1977, the 60-centibar treatment had the greatest cumulative tension. The 10-day sums indicate a greater cumulative tension during the early period in 1977 and in the later period in 1976.

TABLE 4. CUMULATIVE SOIL-MOISTURE TENSION IN CENTIBAR-DAYS FOR FLORUNNER PEANUTS, 1976 AND 1977, WIREGRASS SUBSTATION

Interval (days after planting)	Soil-moisture tension by treatment					
	20-centibar		40-centibar		60-centibar	
	1976	1977	1976	1977	1976	1977
41-50		345	151	208	136	632
51-60		177	120	140	106	495
61-70		474	203	369	252	548
71-80		261	140	394	315	389
81-90		274	166	460	334	428
91-100		101	264	314	270	144
101-110		86	194	125	405	169
111-120		147	183	239	251	239
121-130		126	127	205	163	190
TOTAL		1,991	1,548	2,454	2,233	3,234

Yield

In 1976, peanut production was increased by decreasing moisture stress with irrigation during the August drought period, table 5. Nonirrigated peanuts produced 3,404 pounds per acre. The peanuts which were maintained at 60 centibars produced 4,660 pounds per acre (a 37 percent increase) with the application of 3.0 inches of supplemental water. The wetter 40-centibar treatment produced even more, 4,873 pounds per acre, with 4.3 inches of supplemental water applied. Irrigation also increased quality, table 5.

Based on 1976 prices, the nonirrigated peanuts were valued at $358 per ton, significantly less than both irrigated treatments, table 6. The highest quality peanuts, valued at $412 per ton, were obtained with the wettest treatment of 40 centibars. The overall effect of irrigation was an increased value of almost $400 per acre ($610 compared to $1,003).

The 1977 growing season (an early season drought) produced considerably different results than were obtained in 1976. Yields from the nonirrigated, 60-centibar, and 40-centibar treatments were not statistically different. However, all three were significantly less than the 20-centibar treatment, which produced 3,836 pounds per acre, table 5. This was an increase of 389 pounds per acre. Nut quality for 1977 was statistically the same for all treatments. As a result, peanut quality (dollars per ton) was nearly the same for all treatments and differences in peanut value (dollars per acre) rose largely because of differences in yield and irrigation worth for the other treatments.

A striking result was the general lack of response to irriga-

TABLE 5. YIELDS AND GRADES OF PEANUTS IN 1976 AND 1977, WIREGRASS SUBSTATION

Year and irrigation treatment	Yield/ acre	Seed quality[1]	
		SMK+SS	OK
	Lb.	*Pct.*	*Pct.*
1976			
Nonirrigated	3,404[a]	62.6[c]	4.5
60-centibar	4,660[b]	66.5[cd]	2.5
40-centibar	4,873[b]	72.3[d]	2.8
1977			
Nonirrigated	3,447[e]	76.1[g]	2.5
60-centibar	3,366[e]	77.5[g]	2.3
40-centibar	3,283[e]	77.6[g]	1.1
20-centibar	3,836[f]	75.3[g]	2.9

[1]Seed quality as determined by Federal-State inspection procedures.
Values with like superscripts are not significantly different.
No statistical analysis was made between treatments of different years.

TABLE 6. IRRIGATION WORTH IN 1976 AND 1977, WIREGRASS SUBSTATION

Year and irrigation treatment	Yield (lb./in. of total water)	Peanut quality ($/ton)	Peanut[1] value ($/acre)	Irrigation[2] worth ($/acre)
1976				
Nonirrigated	128	358	610	—
60-centibar	158	378	880	270
40-centibar	161	412	1,003	393
1977				
Nonirrigated	153	450	775	—
60-centibar	130	463	779	4
40-centibar	115	461	770	- 5
20-centibar	122	458	878	103

[1]Because peanut quality is extremely important in determining gross return, peanut value is a better indicator of worth than raw yield data for comparisons between treatments of a given year. However, because of fluctuations in the economy, peanut value does not offer a valid comparison between years.

[2]Irrigation worth is the increase in value due to irrigation.
Irrigation worth = value of irrigated peanuts − value of nonirrigated peanuts.

tion in 1977 when there was an early season drought, table 5. The maximum yield of 4,873 pounds per acre achieved in 1976 was not obtained in 1977 despite the application of more than 11 inches of water to the 20-centibar treatment. In fact the yield was more than 1,000 pounds less in 1977. In 1976, 128 to 161 pounds of peanuts were produced for each inch of total water received by the crop, table 6. The highest return was obtained from the wettest irrigated plots. In 1977, from 122 to 153 pounds of nuts were produced for each inch of total water, with the most efficient utilization of water by the nonirrigated treatments.

SUMMARY AND CONCLUSIONS

The 2-year continuing study of peanut irrigation has provided two contrasting drought conditions. In 1976, the late season drought produced somewhat predictable results: yield and quality improved with increases in soil moisture. The 1977 early season drought influenced peanuts in a more unexpected manner and demonstrated the capabilities of the peanut to withstand certain early season droughts. Of particular interest was the lower maximum yields obtained in the irrigated treatments in 1977 as compared to 1976. The cause of these lower yields cannot be ascertained with certainty at this time. Possible causes are a different location, soil moisture stresses during different portions of the season, or perhaps other physiological factors, such as higher than normal soil and air temperatures. However, in addition to the yield increases shown in 1977, additional benefits were obtained even in the nonirrigated plots, which were irrigated to ensure a uniform stand. Although this benefit was not measured quantitatively, it could have had a major impact on production of the nonirrigated plots.

A summary of the results obtained thus far follows:

1. All irrigation treatments increased yield and quality in 1976 when there was a late season drought.

2. The 1977 early season drought delayed maturity of peanuts in nonirrigated treatments.

3. With the 1977 early season drought, irrigation caused yields to be produced in a growing period shorter than the nonirrigated peanuts, but did not necessarily increase yields or quality.

4. In the 2-year study the greatest yield and quality were obtained from the wettest irrigation treatments.

Results obtained indicate that the period of the growing season during which drought occurs has an effect on the yield potential of peanuts grown in the Southeast. Early season drought proved less damaging to total yield. State yield averages support this conclusion. The 1976 yield (2,400 pounds per acre) was depressed over the previous year's yield (2,605 pounds per acre). In contrast, the 1977 yield of 2,750 pounds per acre was a state record yield even with early season drought. These observations do not agree with Hiler and Clark's crop susceptibility factors which indicate that early season stress is the most damaging for Spanish peanuts. Climate, peanut variety, and soil factors may in part be responsible for these differing conclusions.

The 2 years of field studies certainly leave several unanswered questions regarding peanut irrigation. Of particular interest is the effect of drought periods during different portions of the growing season, and also heat and drought altered physiology of the peanut plant.

ACKNOWLEDGMENT

The authors express their appreciation to the Department of Research Data Analysis for contributions in the selection of the experimental design and in the analysis of data. Appreciation is extended to personnel of the Wiregrass Substation for their help and cooperation in maintaining this experiment. The authors also appreciate the contributions of Larry Ratliff, Soil Conservation Service, USDA, and Ben Hajek, Department of Agronomy and Soils, for their help in the collection and analysis of soils used in this study. Appreciation is expressed to John Weete and Bill Branch, Department of Botany and Microbiology, for their assistance in determining peanut maturity.

LITERATURE CITED

(1) ANONYMOUS. 1977. Impact 80. Ala. Coop. Ext. Serv. Auburn Univ. Auburn, Ala.

(2) CRAWFORD, MARK. 1977. AMI Determines Maturity. The Peanut Farmer 13(7):14-15.

(3) HAGAN, R. M. AND J. I. STEWART. 1972. Water Deficits—Irrigation Design and Programming. Journal of the Irrigation and Drainage Division. Proceedings of the American Society of Civil Engineers. 98(IR2):215-237.

(4) HILER, E. A. AND R. N. CLARK. 1971. Stress Day Index to Characterize Effects of Water Stress on Crop Yields. Trans. ASAE. 14(4):757-761.

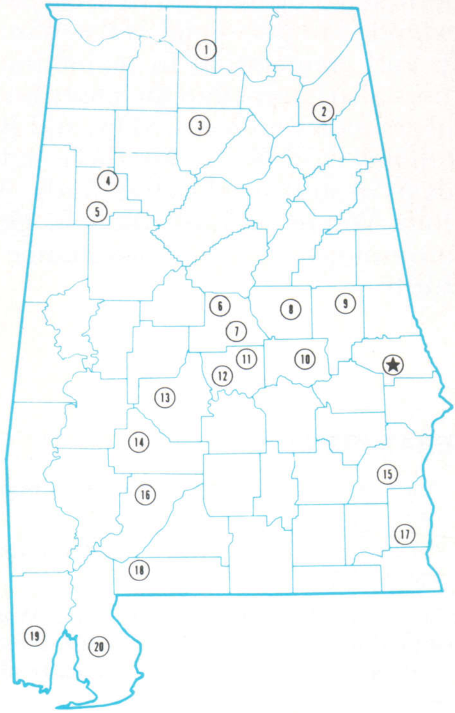
(5) SALTER, P. J. AND J. E. GOODE. 1967. Crop Responses to Water at Different Stages of Growth. Commonwealth Agricultural Bureaux, 246pp.

(6) SHIPLEY, J. AND C. REIGER. 1970. Water Response in the Production of Irrigated Grain Sorghum, High Plains of Texas, 1969. Texas Agr. Exp. Sta. Prog. Rept. No. 2829.

(7) STANSELL, J. R., *et al.* 1976. Peanut Responses to Soil Water Variables in the Southeast. Peanut Science. 3(1):44-48.

Alabama's Agricultural Experiment Station System
AUBURN UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



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. Lower Coastal Plain Substation, Camden.
15. Forestry Unit, Barbour County.
16. Monroeville Experiment Field, Monroeville.
17. Wiregrass Substation, Headland.
18. Brewton Experiment Field, Brewton.
19. Ornamental Horticulture Field Station, Spring Hill.
20. Gulf Coast Substation, Fairhope.