Peanut Responses to Soil Water Variables in the Southeast[1]

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ABSTRACT

Three peanut (**Arachis hypogaea**) varieties were maintained at soil water levels ranging from moderately wet to very dry. Pod yield and quality were significantly reduced in treatments receiving less than about 30 cm of water during the growing season. Although not statistically different, yield and quality tended to increase as irrigation amounts increased from 40 to about 60 cm.

Average harvestable yields for 4 years were 4464, 5080 and 4543 kg/ha for Florigiant, Florunner and Tifspan, respectively, when irrigated to a profile depth of 60 cm when the soil moisture tension in the surface 30 cm reached 0.2 bar. This compares with yields of 2631, 3341 and 3125 kg/ha for Florigiant, Florunner and Tifspan, respectively, when the soil water tension in the surface 30 cm profile was allowed to reach 15.0 bars.

Water extraction to a depth of 106 cm was recorded for all three varieties. Apparent plant use of water from profile depths greater than 60 cm was observed at about 75 days after planting.

Evapotranspiration vs age relationships were developed from daily soil water measurements to a 1.2 m soil depth.

Peanut irrigation in the Southeast is increasing rapidly, largely as a result of favorable producer experience and the availability of push button irrigation equipment, such as center pivot systems, which can irrigate large acreages with minimal labor. In Georgia alone, an estimated 33,500 ha (83,000 ac) were irrigated in 1974 (more than 15% of allotted acreage). With top yields now approaching 7000 kg/ha (6000 lb/ac) under favorable rainfall and management practices, irrigation has become a profitable cultural practice.

Very little research has been reported for peanut irrigation in the normally humid southeast, due in part to the difficulty of maintaining irrigation treatment variables for comparison under natural rainfall patterns. Demonstration plots (3) during rainfall-deficient years have been used to develop irrigation guidelines for Georgia growers.

Hiler and Clark (1) reported that irrigation increased yield and quality of peanuts in Texas. Matlock *et al.* (4) also reported yield and quality increases in Texas. Su and Lu (6) found that irrigating to maintain 60% available soil water gave better yields than irrigating when only 40% available water remained in the rooting zone. Mantell *et al.* reported yield and quality were better for peanuts (in Israel) irrigated to a depth of 90 cm at 7- and 10-day intervals, than peanuts irrigated at 14-day intervals.

The objective of our research was to determine, under closely controlled soil water conditions, the yield and quality responses of peanuts to soil water regimes ranging from wet to very dry.

Materials and Methods

During 1970 through 1973, Florigiant, Florunner and Tifspan peanuts were grown in 1.52 x 1.83 m (5 x 6 ft) plots which were sheltered from rainfall by automatic covering equipment (Fig. 1) (5). The plots were isolated from groundwater movement and from each other by

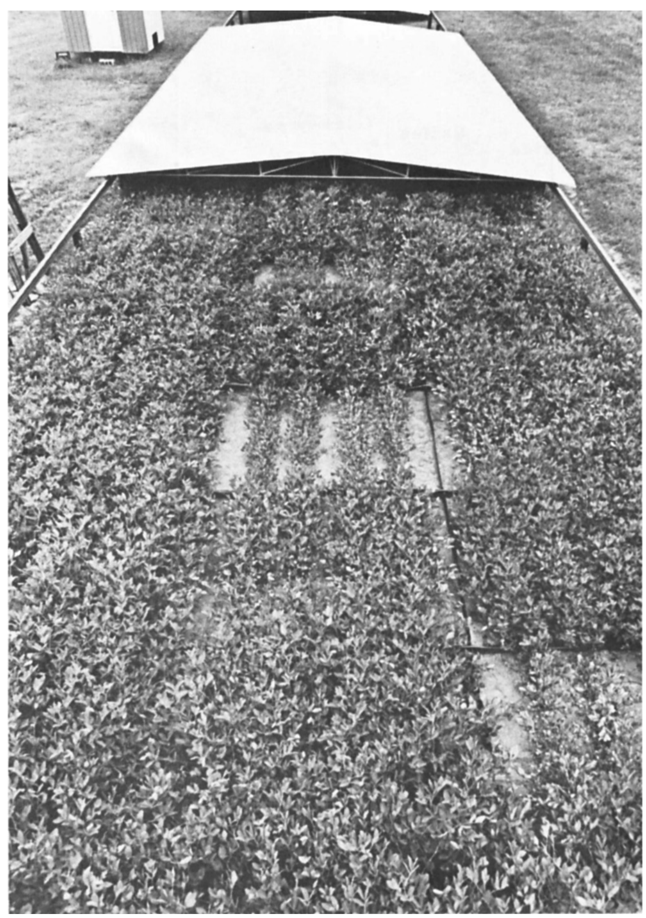

Fig. 1. View of irrigation plots with rainfall controlled shelter.

[1]Contribution from the Coastal Plain Experiment Station, University of Georgia College of Agriculture, Tifton, Georgia 31794 and Southern Region, Agricultural Research Service, USDA. This research was supported in part by the Georgia Agricultural Commodity Commission for Peanuts.

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impermeable barriers. The plots were seeded in a modified 4-row pattern in 1.52 m rows. Plants within the drill were spaced to give 172,000, 287,000 and 344,000 plants/ha for the Florigiant, Florunner and Tifspan, respectively. Each variety was grown in a separate block of plots and imposed treatments were in a randomized complete block design replicated 4 times. The surface 30 cm of soil in all plots was replaced each year with similar soil from an area not planted to peanuts within the previous 2 years. Fertilizer was applied in accord with soil test recommendations (3), and nematode populations in the soil were determined at planting, midseason and after harvest.

Soil water was monitored in each plot with electrical resistance blocks installed at depths of 10, 23, 38, 53, 81 and 106 cm. During 1970 and 1971, soil water measurements were recorded manually three times weekly. After automatic data collection equipment was installed at the end of 1971, daily records were maintained. With computer processing, daily soil water status and irrigation requirements were available within a short ($\approx$1 hr) time after measurements were made. For approximately 20 days after planting, the plots were watered to keep the surface 5 to 10 cm moist to promote germination and plant rooting into the soil-water measurement zone. Table 1 and Figure 2 give parameters used to evaluate soil water status.

Irrigation treatments were:

1. Wet topsoil (30 cm) to field capacity when the average water tension of topsoil reached 0.2 bar.
2. Wet 60-cm depth to field capacity when the average water tension of 30 cm zone reached 0.2 bar.
3. Wet 60-cm depth to field capacity when the average water tension of 30 cm zone reached 0.6 bar.
4. Same as treatment No. 2 until 30 days after first bloom (60 days); then, irrigate 60-cm depth when the average water tension in 30 cm zone reached 2.0 bars until harvest.
5. Wet 60-cm depth to field capacity when plants wilted and did not recover overnight.
6. Wet 60-cm depth to field capacity when average water tension of 30 cm zone reached 15.0 bars.

Water was applied when needed by metering the appropriate number of gallons on the plots as surface irrigation.

Table 1. Soil-water parameters for Tifton loamy sand.

Horizon	Depth (cm)	Volumetric Water Content (cm^3/cm^3) at: Field Capacity[1]	Wilting Point[2]	Available Water at Field Capacity (cm^3/cm^3)
A_p	0 - 30	0.120	0.029	.091
B_1	30 - 46	0.163	0.107	.056
B_{21}	46 - 76	0.280	0.161	.119
B_{22}	76 - 99	0.297	0.186	.111
B_{23}	99 -122	0.295	0.204	.091

[1] Corresponds to .07 to .08 bar soil water tension.

[2] Measured by 15-bar pressure.

Plots were harvested by loosening the soil with pitchforks and lifting the plants by hand. The vines with attached pods were placed in burlap bags and dried at 38°C to a kernel moisture of approximately 8% wet basis. Pods remaining in the soil were recovered by screening. After drying, pods were removed from the vines by hand and graded using standard procedures and equipment.

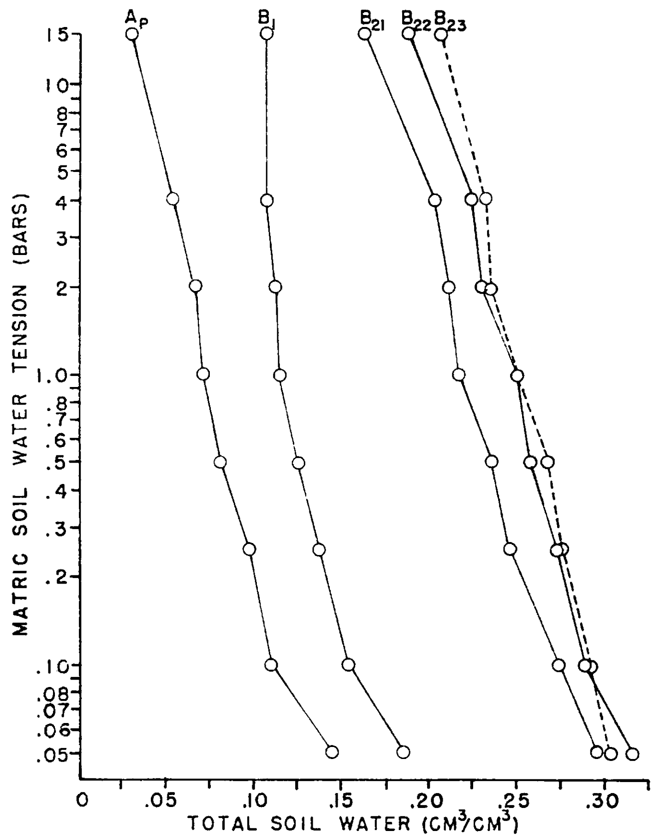

Fig. 2. Water retention curves for Tifton loamy sand.

Results

YIELD AND GRADES:

Yield and grade data for the Florigiant, Florunner and Tifspan peanuts are given in Tables 2, 3 and 4, respectively. Total pods produced under each irrigation treatment includes pods recovered from the soil after harvest. However, harvestable pods are those which were attached to the vines after digging. Grade data are reported for harvestable pods only.

Although the experiment was not designed to statistically compare the performance of the three varieties, yield data showed that both Florigiant and Florunner produced about the same weight of total pods; however, approximately twice as many pods were recovered from the soil for Florigiants as compared with Florunners for irrigation treatment numbers 1 through 4. Relatively few Tifspan pods were recovered.

When considering harvestable pods and sound mature kernels, there were no significant differences attributable to soil water regime for the wetter (1 through 4) treatments; however, severe moisture stress as induced in treatment numbers 5 and 6 was responsible for sharply reduced yields and grades for all varieties.

SOIL WATER EXTRACTION:

Figures 3 through 8 are plots of available water

Table 2. Pod yields and shelling grades for Florigiant peanuts 1970 through 1973, Tifton, Georgia.

Irrigation Treatment	Total Pods Produced (kg/ha)	Harvestable Pods[1] (kg/ha)	Recovered from soil (kg/ha)	Seed Quality [3] % ELK	%SMK	% SS
1	5270b[2]	4096a	1174a	33.56a	67.87a	1.71a
2	5874a	4464a	1410a	33.13a	66.33a	1.61a
3	5404b	4074a	1330a	35.25a	64.00a	1.09a
4	5004b	3910a	1095a	31.94a	60.92a	1.03a
5	1603d	1391c	212b	19.44c	43.03b	.81a
6	3135c	2631b	504b	25.13b	55.06b	1.27a
Coef. of vari.	8.7%	17%	54%			

Table 2. Continued

Irrigation Treatment	Seed Quality % OK	% DK	% Hulls	Vine Weight (gms/plot)	Water added (cm)	Harvestable Pods[1] per cm H_2O (kg/ha)
1	2.81 c	1.62a	27.14 c	1457 c	43	95
2	2.88 c	3.41a	26.97 c	1780a	60	74
3	2.80 c	3.29a	28.66 c	1694ab	53	77
4	4.37bc	3.72a	30.58bc	1701ab	50	78
5	8.90a	2.16a	45.31a	1508 c	18	77
6	5.61b	3.04a	36.05b	1549 bc	30	88

[1] Pods remaining attached to vines after digging.
[2] Column means followed by same letter are not significantly different at .05 level of probability.
[3] Seed quality as determined by Federal-State Inspection service procedures.
% ELK = Kernels riding an 8.53 mm x 25.4 mm screen.
% SMK = Kernels riding a 6.35 mm x 19.05 mm screen includes % SS (Sound Splits).
% OK = Kernels which pass through above screens.
% DK = Damaged kernels.

Table 3. Pod yields and shelling grades for Florunner peanuts 1970 through 1973, Tifton, Georgia.

Irrigation Treatment	Total Pods Produced (kg/ha)	Harvestable Pods[1] (kg/ha)	Recovered from soil (kg/ha)	Seed Quality[3] % SMK	% SS	% OK
1	5317ab[2]	4609a	708a	75.05a	5.57a	3.89b
2	5858a	5080a	778a	75.50a	4.34a	3.14b
3	5359ab	4728a	630ab	74.69a	4.84a	3.96b
4	5075 b	4580a	495abc	74.12a	5.36a	3.66b
5	2640d	2375c	265 c	58.35c	3.11a	10.17a
6	3720c	3341b	379 bc	68.54b	4.19a	5.53b
Coef. of vari.	13%	17%	50%			

Table 3. Continued

Irrigation Treatment	Seed Quality % DK	% Hulls	Vine Weight (gms/plot)	Water added (cm)	Harvestable Pods[1] per cm H_2O (kg/ha)
1	0.42 bc	19.62c	1376ab	40	115
2	0.54abc	19.81c	1472a	55	92
3	0.12 c	20.63c	1467a	44	107
4	0.54abc	20.71c	1485a	46	100
5	1.38a	29.19a	1219 b	17	140
6	1.18ab	23.40b	1380ab	26	128

[1] Pods remaining attached to vines after digging.
[2] Column means followed by same letter are not significantly different at .05 level of probability.
[3] Seed quality as determined by Federal-State Inspection service procedures.
% SMK = Kernels riding a 6.35 mm x 19.05 mm screen includes % SS (Sound Splits).
% OK = Kernels which pass through above screens.
% DK = Damaged kernels.

in the soil profile for each irrigation treatment for the Florigiant variety in 1972. Extraction of water from profile depths greater than 60 cm is indicated at about 75 days of age. The ability of peanuts to utilize water at such depths explains to some extent, their ability to withstand extended drought stress. At field capacity, 1.2 m of soil (Tifton loamy sand) will store more than 10-cm available water, which is apparently usable by peanuts.

Table 4. Pod yields and shelling grades for Tifspan peanuts 1970 through 1973, Tifton, Georgia.

Irrigation Treatment	Total Pods Produced (kg/ha)	Harvestable Pods[1] (kg/ha)	Recovered from soil (kg/ha)	Seed Quality[3] % SMK	% SS	% OK
1	3995 b[2]	3783ab	211ab	71.26a	5.71a	5.06ab
2	4787a	4543a	245a	71.78a	6.13a	4.51ab
3	4535ab	4407a	128 bc	69.81a	5.36a	5.76ab
4	4441ab	4309a	132 bc	72.58a	5.68a	3.97 b
5	2561 c	2491 c	70 c	66.44b	3.03 b	5.69ab
6	3227 c	3125 bc	103 c	66.47b	4.39ab	6.12a
Coef. of vari.	16%	18%	50%			

Table 4. Continued

Irrigation Treatment	Seed Quality % DK	% Hulls	Vine Weight (gms/plot)	Water Added (cm)	Harvestable Pods[1] per cm H_2O (kg/ha)
1	0.44 b	22.47 c	1138ab	40	95
2	0.44 b	22.42 c	1290a	50	91
3	0.24 b	23.35 bc	1209ab	40	110
4	0.52 b	22.22 c	1198ab	43	100
5	1.79a	25.01ab	958 c	17	147
6	0.58 b	26.10a	1101 bc	28	112

[1] Pods remaining attached to vines after digging.
[2] Column means followed by same letter are not significantly different at .05 level of probability.
[3] Seed quality as determined by Federal-State Inspection service procedures.
% SMK = Kernels riding a 6.35 mm x 19.05 mm screen includes % SS (Sound Splits).
% OK = Kernels which pass through above screens.
% DK = Damaged kernels.

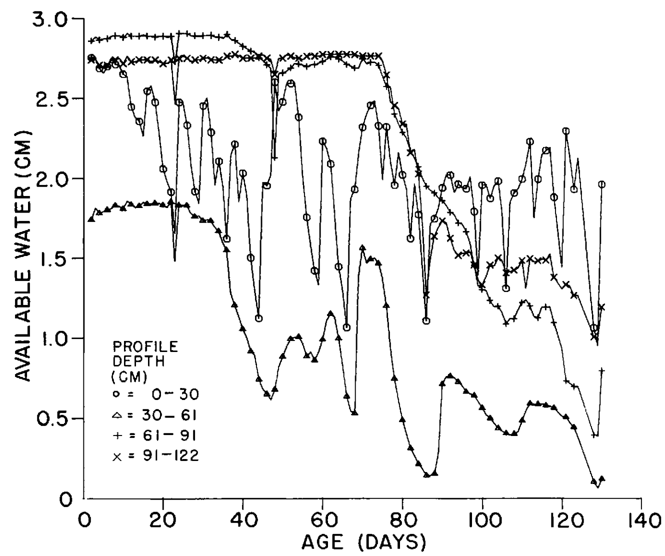

Fig. 3. Available water in soil profile: Treatment No. 1.

Figures 7 and 8 show that the available water in the entire profile can be essentially removed during extended drought periods. Water extraction patterns were similar for the three varieties.

Treatment number 1 (small, frequent irrigations), in general, received less water during the season than treatment numbers 2, 3 and 4 (larger, less frequent irrigations). Although adequate water was maintained in the surface 30 cm profile, the available water in the 30 to 60 cm zone was reduced to a low level (Figure 3). Water deficiency in the deeper profile resulted in some reduction of vine dry weight at harvest (Tables 2,

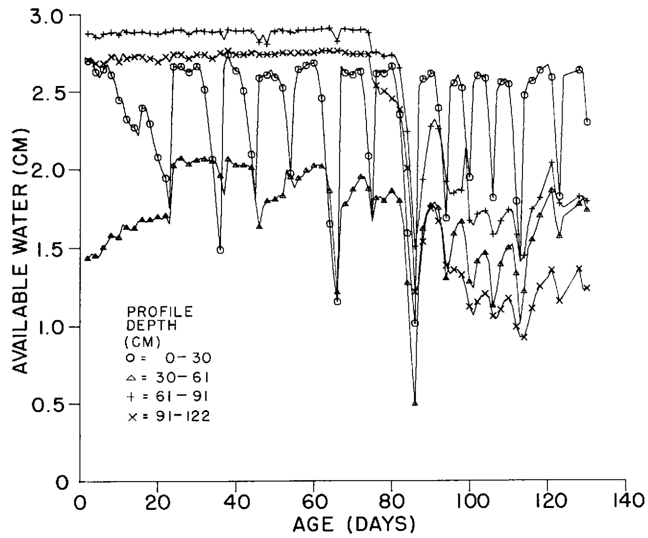

Fig. 4. Available water in soil profile: Treatment No. 2.

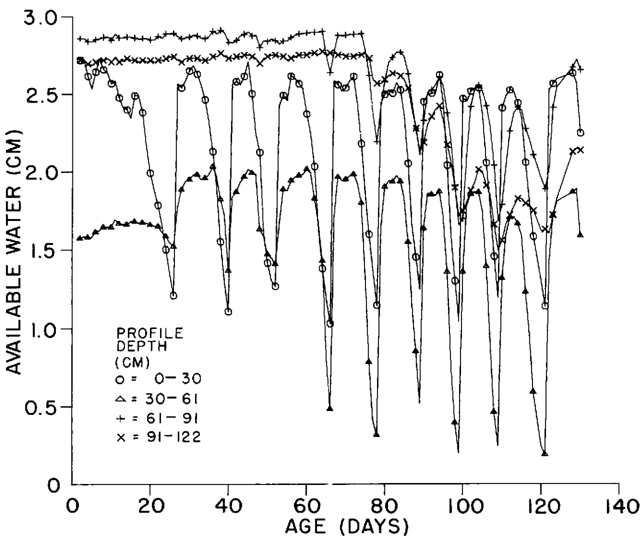

Fig. 5. Available water in soil profile: Treatment No. 3.

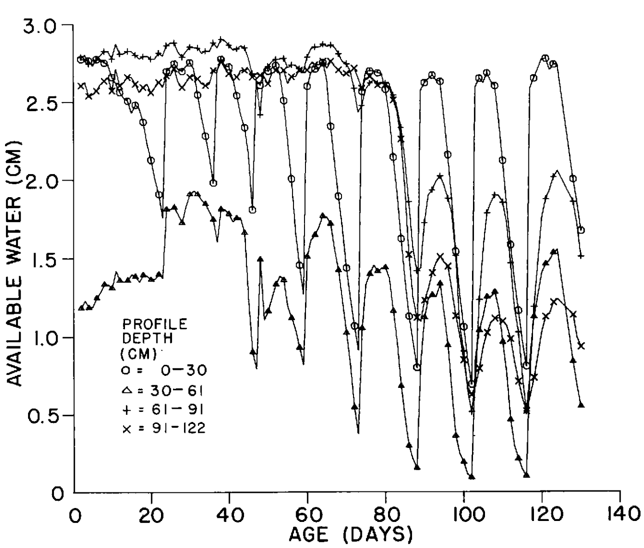

Fig. 6. Available water in soil profile: Treatment No. 4.

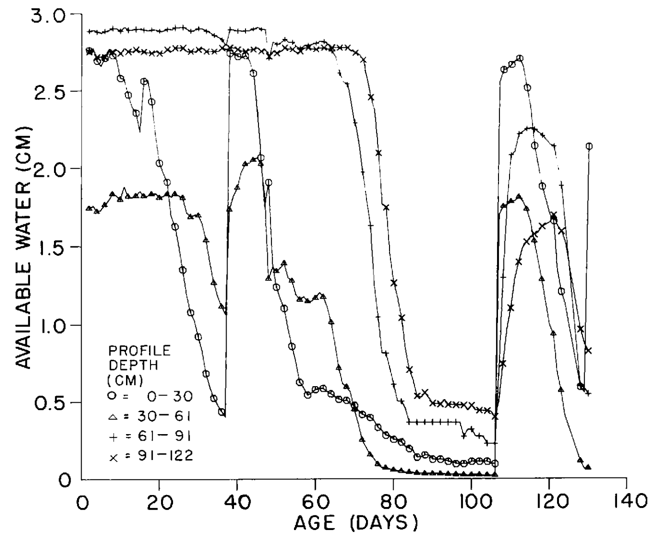

Fig. 7. Available water in soil profile: Treatment No. 5.

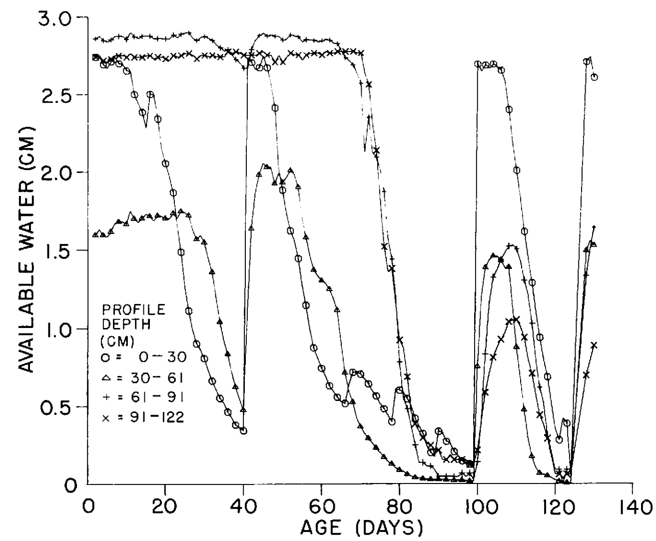

Fig. 8. Available water in soil profile: Treatment No. 6.

3 and 4).

Water use by peanuts as a function of age was determined for treatment 2 for the three varieties. Since rainfall and groundwater movement into and out of the plots was essentially zero, the net change in profile water (to a 1.2 m depth) plus irrigation water applied gave an estimate of plant water use for the period between irrigations. Regression analyses of the 4 years data were used to prepare the curves shown n Figure 9. Water use by the Florigiant variety was significantly greater than that by the Florunner. Tifspan water use rate peaked earlier than the other varieties and reflects its earlier maturity.

Discussion

Total pods produced by the Florigiant variety were significantly higher under treatment number 2 than for other treatments, although all treat-

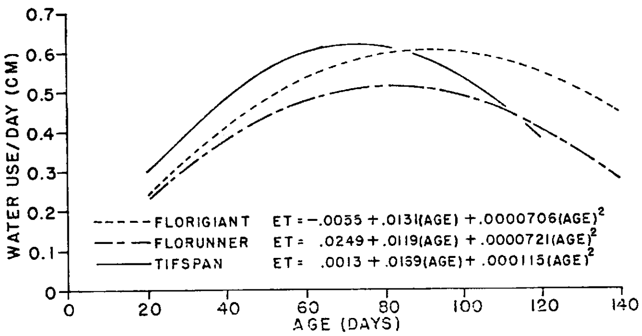

Fig. 9. Water use by peanuts on treatment No. 2 as a function of age when grown under optimum soil water conditions.

ments receiving more than 40 cm of irrigation produced reasonably high yields (Table 2). The weight of Florigiant pods recovered from the soil was excessive and highly variable, with the amount depending on irrigation amount. Harvestable pods among treatment numbers 1 through 4 were not statistically different.

Harvestable Florunner pods from treatment numbers 1 through 4 were not statistically different although the mean yield for treatment number 2 was highest (Table 3). Pods recovered from the soil for Florunners were less than from Florigiants, although higher than desirable. The difference in harvestable pods between Florigiant and Florunners is almost wholly attributable to pod shedding.

As was true for the other varieties, harvestable Tifspan yields (Table 4) were not different among treatment numbers 1 through 4; however, shallow frequent irrigations (treatment number 1) significantly reduced total pods produced with respect to treatment numbers 2, 3 and 4. Relatively few Tifspan pods were recovered from the soil.

Pods shed by Florigiant and Florunner peanuts were high. Earlier work by J. R. Stansell (1965) also indicated high pod losses associated with large seeded Virginia-type peanuts (VB G-2 and VB-67) and irrigation amount. Troeger *et al.* (7) determined the ratio of peg detachment force to pod projected area is least for Florigiant, intermediate for Florunner and highest for Spanish. They also noted that attachment strength decreased after pod maturity. Since Florigiant and Florunner peanuts tend to mature over a range of plant age, immature, mature and over-mature pods were present at digging, with the over-mature pods more susceptible to mechanical detachment.

Summary and Conclusions

Average harvestable yield for 4 years was 4464, 5080 and 4543 kg/ha for Florigiant, Florunner and Tifspan peanuts, respectively, when the surface 60 cm of soil was irrigated when the 30 cm profile water reached a tension of 0.2 bar (treatment 2). Harvestable yields of 4096, 4609 and 3783 kg/ha, respectively, were obtained when irrigating to only 30 cm deep (treatment 1).

Harvestable yield and quality (as indicated by SMK) was not statistically reduced by irrigating at 0.6 bar (treatment 3) nor by irrigating at a control tension of 2.0 bars after plants were 60 days of age (treatment 4.). Drier treatments (treatments 5 and 6) did significantly reduce both yield and quality.

Soil moisture sensors did not reflect water needs of seedling peanuts until a reasonably extensive root system was developed (at about 20 days of age). During this early period, plots were watered to keep the surface 5 to 10 cm moist.

During drought periods water extraction from deep profile zones provided available water to the plants. The curves of Figures 3 through 8 indicate root activity in the subsoil to more than 1.2 m. These patterns could be greatly altered in fields where restrictive zones, either mechanical or chemical, exist.

Curves relating water use rates to the peanut age were developed. The curves are based on water extraction from the soil profile to a depth of 1.2 m. These curves should provide a basis for irrigation scheduling.

This study indicated that peanuts can utilize a substantial reserve of deep profile water if root growth is not restricted.

References

1. Hiler, E. A. and R. N. Clark. 1971. Stress day index to characterize effects of water stress on crop yields. Trans. ASAE 14(4): 757-1761.

2. Mantell, A., E. Rosenberg, A. Hortzook, Y. Barr, M. H. Khilfa, M. H. Risheh and Z. T. Najjar. 1972. The effect of irrigation frequency and water quality on peanuts growing in the lower Jordan Valley. Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel. Special Publication No. 10.

3. McGill, J. Frank, R. J. Henning, L. E. Samples, John C. French and Sam S. Thompson. 1973. Growing peanuts in Georgia. Cooperative Extension Service, U. of Ga. College of Agriculture. Bul. 640.

4. Matlock, R. S., J. E. Garton and J. F. Stone. 1961. Peanut irrigation studies in Oklahoma, 1956-1959. Okla. Agr. Exp. Sta. Bul. B. 580.

5. Stansell, J. R. and G. N. Sparrow. 1963. Rainfall controlled shelter for research plots. J. Ag. Eng. 44(6): 318-319.

6. Su, Kuang-Chi and Ping-Chang Lu. 1963. The effect of time of irrigation and amount of water irrigated on peanut yield, J. Agric. Assoc. China (N.S.) 41, 43.

7. Troeger, J. M., E. J. Williams and J. L. Butler. 1975. (Unpublished manuscript in preparation.)