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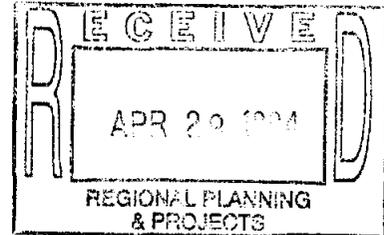
ABSTRACT

Florunner and Spanish peanuts were grown in lysimeters and in the field under automated, high frequency irrigation regimes. In the field, treatments included a non-irrigated check, and irrigation when available soil water depletion reached 15%, 30%, 50% and 70%. Treatments in the lysimeters were the same except that there was no non-irrigated check. All irrigation applications were made automatically using switching tensiometers and electrical solenoids. Water applied to each replicate was metered. Meter readings were recorded daily to compute water use.

In 1992, runner peanuts receiving water at 15% depletion used it at a rate of 1.25 to 1.5 times pan evaporation for the area covered by their canopy. Runners receiving water when soil moisture was depleted to 30% and 50% used water at a rate of 1 and .95 times pan evaporation respectively. Runner peanuts receiving water when soil moisture reached 70% depletion used water at a rate of 1 times pan evaporation for the area covered.

Spanish peanuts receiving water at 15%, 30%, 50% and 70% used water at a rate of 1.0, .85, .85 and 1 times pan evaporation for the area covered.

Automation using tensiometers was only passingly successful due to the variability in performance in native soils. Using the crop coefficients listed above, water use could be predicted quite accurately by a computer program.

In 1993, irrigations were scheduled by computer to deliver water at a rate of 0, 0.5, 0.75, 1.0, and 1.25 times pan evaporation for the area covered by the canopy. In the field, and in lysimeters, 1 times pan was the most effective rate of for well-watered plants. This program is based on a water balance formula where the water available at any time is equal to water in storage (plus rain or irrigation) minus water used.

Photosynthesis was highly correlated with the crop water stress index. On days of high evaporative demand, the rate of CO_2 fixation was reduced by relatively mild soil moisture stress. On days of low evaporative demand, photosynthesis proceeded at a rate normal for the day of measurement and was little affected by soil moisture tension.

INTRODUCTION

Recent innovations in irrigation techniques have allowed much more detailed studies of the water requirements of peanuts. Recent successes with high frequency irrigation seem to justify a new look at traditional irrigation recommendations. Our purpose in this study is not

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to find fault with old recommendations, but to explore new technologies to see if we can now do it better. In this endeavor, it seems appropriate to contrast "traditional" irrigation systems with concepts and techniques which may prove to be the technology of the future.

"Traditional" irrigation practices are described in some detail in the latest volume of the "Irrigation Journal". Briefly, this article suggests that little or no irrigation water be applied to peanuts for the first 50 days to encourage deep rooting and reduce canopy size. Our results indicate that this system may not be the best answer for peanuts. First, there is no real indication that proper irrigation during this 50 day period discourages deep rooting, and there is reason to believe that a large canopy can produce more peanuts than a small one. Secondly, our data indicate that most water used by peanuts is removed from the upper two feet of soil, and we surmise that maintaining a healthy, active root system in this zone is important to the health and productivity of the plants. A third point of departure from the traditional in our concept also deals with the location of the active root system. Even in sandy soils, 2.5 to 3.5 inches of water (net) are required to refill a dry soil profile to a depth of 2 feet; this equates to an application of 3.5 to 5 inches of gross rain or irrigation water. Without belaboring the point, when rain falls or irrigation water is applied, it is important to have the active roots in an area where the water can be utilized. In most cases, this means the active root system needs to be in the upper 2 feet of soil. Our irrigation systems and scheduling techniques are designed to promote an adequate canopy for increased production and to promote a healthy root system in the soil volume where rain and irrigation water can reasonably be expected to penetrate.

Preliminary studies on peanut irrigation conducted in 1991, indicated that, when grown under a high frequency irrigation regime, and in the absence of water stress, yields could be increased from 3500 lbs per acre to 10,000 lbs per acre. This increase in yield was obtained by increasing the frequency of irrigation but not necessarily the amount of water applied. The purposes of this study were to explore this concept, develop guidelines for efficient peanut irrigation, and to promote the high frequency concept with an eye to converting the peanut industry from conventional sprinkler irrigation systems to more efficient center pivot, LEPA, or microirrigation systems.

A project proposal to fund this research was submitted to the Texas Water Development Board in cooperation with the Texas Peanut Producer's Board and the Texas Agricultural Experiment Station. This project was approved and work commenced with the 1992 growing season and was completed Dec. 31, 1993.

Most projects dealing with water usage are based on field applications of water and the plant's response in growth, productivity etc. These type studies are indeed useful, however, there are limitations because it is almost impossible to know where the roots are growing. This means that one can not predict how much total water is available to plants, and quantifying water usage is difficult to impossible. Greater precision in water use measurements can be made in lysimeters where the exact volume of soil exploited by roots is known.

In an effort to improve the precision of our work, we have developed a system for fabricating relatively low cost lysimeters for research. These consist of six foot horse troughs 2 feet deep. The bottom of these cans was covered with a 4 inch layer of gravel to facilitate drainage. The cans were then filled with soil into which the crop to be monitored was planted. Water was applied through trickle irrigations lines at a rate measurable with residential type water meters. Switching tensiometers were used to automatically schedule irrigations when soil

moisture reached specified depletion levels. Water meter readings were recorded daily. These units have proved to be quite accurate for measuring water use over days or weeks, but would not work for minute to minute or even hour to hour water use. One possible limitation with these lysimeters is the influence of soil temperature on plants' water use. In order to verify that the information obtained from our lysimeters is applicable to field conditions, we have accompanied all lysimeter studies with comparable field tests.

MATERIALS AND METHODS

1992

The work reported here represents a joint contract between the Peanut Producer's Board, the Texas Agricultural Experiment Station, and The Texas Water Development Board.

Studies in our research blocks have all been designed to allow the peanut plants to have all the water they can use. We monitor how much they use and translate this to an irrigation requirement.

Two studies based on our 1991 results were initiated in 1992. The objectives of these studies were: a) to determine the amount of water peanuts would like to have under varying soil moisture regimes. b) to determine the measurable stress of growing peanuts under various levels of soil moisture. In 1992, planting was delayed due to rainy weather. Runner and Spanish peanuts were plalted in the field on June 8. Due to delays in receiving allocated funds, the lysimeter planting of Spanish peanuts was delayed until June 18.

While determining the above information, we were attempting to fully automate peanut irrigation by using switching tensiometers, and to determine whether or not irrigation requirements of peanuts could be predicted using a computer program.

Runner, and Tamspan-90 peanuts were grown in non-weighing lysimeters. Soil moisture levels were maintained at 10%, 30%, 50%, and 70% depletion using switching tensiometers which controlled solenoids. Plants were automatically irrigated using microirrigation techniques when soil moisture was depleted to the prescribed level. The amount of water applied at each irrigation was monitored with residential type water meters. Because of the rapid depletion of soil moisture in lysimeters it was not possible to have a non-irrigated check. In this study, the electrical and water systems were allowed to operate on demand for one hour out of eight with three cycles daily. Thus, dry plots could irrigate for one hour. That cycle would be interrupted for 7 hours to allow moisture percolation into the soil and tensiometer response before another irrigation opportunity was allowed.

A similar study was conducted in the field. Owing to the system precision, microirrigation techniques were also used in this study. Due to problems with the switching tensiometers, the high rate of water applied was changed from 10% depletion to 15%. In the field, we did have a non-irrigated check. Tensiometers for this study were set at 12" (30 cm) depth. In this study, irrigation "on" times were extended so that moisture could penetrate the soil to the 12 inch depth. Plots allowed to dry to 70% available moisture required longer to recharge than plots allowed to dry only to 15%. An irrigation event for the .15% depletion would amount to a net delivery of .23 inches whereas the refill at 70% depletion amounted to

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1 inch net. On the other hand, irrigation for the .15% depletion plots frequently occurred daily whereas the 70% depletion plots irrigated once or twice a week under peak demand. This was accommodated with daily irrigation opportunities of 5 hours "on" followed by 6 hours "off". Under these conditions, there were two irrigation opportunities per day.

Plant stress was monitored on select days using an Everest model 510B ag meter. This unit computes a crop water stress index based on crop, canopy temperature and the vapor pressure deficit. The unit is not accurate on humid days and is erratic partly cloudy days. Thus measurements were only made on days when meaningful results could be expected.

Because of the high frequency of irrigation and presumed increase in humidity, there is some fear that disease incidence will be greater in our plots. Disease incidence was monitored on a recurring basis. Additionally, surveys were made any time growth indicated some problem.

Peanuts were harvested and graded at the end of the season, and yields as well as dollar per acre values were calculated.

In 1992, thirty-two non-weighing lysimeters were fabricated and planted to both runner and Spanish type peanuts. Automated irrigations were scheduled by the use of tensiometers. Treatments were replicated, and included irrigation when soil moisture depletion reached 15, 25, 50, and 70 centibars. There were three irrigation opportunities for each lysimeter each day. Therefore, plants were never stressed beyond the specified soil moisture depletion level for more than 7 hours. Soil in these lysimeters was an alluvial sandy loam. Water use over time was compared to weather data as integrated and measured as evaporation from an open, US Weather Bureau Class A pan.

Also, in 1992, runner and Spanish type peanuts were planted to the field in replicated plots. Water was supplied to the plants through a microirrigation twin walled tubing with a rated delivery of .13 acre inches per hour. Irrigation for these plots was automated using switching tensiometers with the same treatments included as for the lysimeter plots. As with the lysimeter plots, there were 3 irrigation opportunities for all treatment and reps each day. The field studies also included non-irrigated check plots.

1993

Results from the 1992 studies showed that single tensiometers in non-uniform soils such as we have in the field at the Experiment Station, and probably over most of the state of Texas, are not a reliable instrument for automatically scheduling irrigation. Irrigation rates varied unacceptably over replications with some plots obviously over-watered, and some under-watered. This problem did not exist, however, where homogenous soils were used such as in our lysimeters.

LYSIMETER STUDIES

In 1993, twenty additional non-weighing lysimeters were fabricated. This was done in part to be certain that our data were not tainted by problems associated with growing peanuts on the same soil for successive years. Soil selected for this study was a fine sand which more nearly represents the major soil type in which peanuts are grown. This soil had a lower water holding capacity than the 1992 soils. In theory at least, these soils would require more frequent

irrigation and improve the precision of our water use data from the lysimeters. As in 1992, there were three irrigation opportunities for each lysimeter each day. Because yields were lower than expected in 1992, treatments were changed to include some fundamental differences in fertility to measure this effect in non-stressed peanuts. With the addition of fertilizer as a factor, we planted only runner type peanuts, and irrigation treatments were reduced to include irrigation at -10 centibars and -50 centibars only.

FIELD RESEARCH

In the field, we returned to scheduling irrigation by computer using inputs of rainfall, evaporation, and canopy size to predict needs. The program used was developed from research at this center. It is a water balance program which predicts water use on the basis of pan evaporation, and on this basis predicts when to irrigate based on soil moisture depletion. This change was made necessary because irrometers were not reliable in our field installations. In the original plan we intended to measure water use as called for based on tensiometer readings and adapt the computer program. Since irrometers were not satisfactory, we chose to reverse the procedure and schedule irrigation by computer - then confirm the validity of the program with more reliable stress index readings from neutron probe and/or crop water stress index readings.

Irrigation water was applied once daily as required, using battery powered timers which were adjusted to deliver water at rates of 0, .5, .75, 1.0, and 1.25 times pan evaporation for the area covered by the plants' canopy. Water was supplied to these plots through twin walled microirrigation lines delivering .13 acre inches of water per hour. Plant growth, and soil moisture were measured and recorded weekly. Crop yields and grade were recorded after drying and processing.

TECHNOLOGY TRANSFER OF HIGH FREQUENCY IRRIGATION CONCEPTS

The basic premise of the irrigation scheduling technique we have found to be most effective is that of a water budget. If the rate of water use by plants can be accurately predicted, we automatically know the amount of water which is being extracted from the soil. In the demonstration/research plot described below we knew that the soil would hold 3.2 inches of available water, and that we did not want to let more than 25% (0.8 inches) of that amount be extracted before we irrigated again. We hoped for rain, but if that did not occur we irrigated to refill the soil profile. In a summer such as 1993, where plants were using as much as 0.4 inches of water per day, a water budget such as ours would dictate irrigation at least every second day. With microirrigation techniques it would be just as easy to irrigate with half as much water daily, and that would be the normal schedule. However, with center pivot systems, it may take more than one day for the system to make the complete circle. Every second day irrigation would still meet the high-frequency criteria of this study.

Using the water budget concept, we intensified our program of technology transfer to the peanut industry in 1993. A research/demonstration test of our irrigation scheduling system was initiated on the Rodney Stephens farm in Comanche Co. using his center pivot irrigation system. Mr. Stephens is a very progressive farmer, and was willing to try high frequency irrigation using

our scheduling technique. Through our work with computer programs to schedule irrigation, we discovered that we could integrate the same inputs as required in the computer program by setting a specially marked wash tub in the field, and measuring net evaporation from that tub. If this tub was positioned under the irrigation sprinklers it would not only account for evaporation, but irrigation water applied and rainfall. This procedure is facilitated in peanuts because we found that well-watered plants use 1 times pan evaporation for the area covered by their canopy. Basically, the operation is quite simple. The initial water level in the tub was set to 1 inch below the rim. From the soils survey for Comanche Co. we found that the water holding capacity of the soil in our test field was 3.2 inches. Since we wanted to irrigate when soil moisture was depleted by 25 percent, we marked a second line 1.8 inches below the rim of the tub. As explained above, this second line represented the 0.8 inch tolerance we thought would be an acceptable figure for soil moisture depletion. We filled the tub to the top of the line at the start of the study, and irrigated as required to keep the water level between the lines. When plants are small, some interpolation is required to achieve proper irrigation rates, however, after the canopies between rows touched, it was possible for Mr. Stephens to gage irrigation requirements by monitoring the water level in the tub. When evaporation brought the water level to the lower line, Mr. Stephens was asked to irrigate long enough to bring the water level in the tub back to the top line (1 in. below the rim). This was the first test of high frequency irrigation where irrigation water was applied to the foliage, and we had some concern that we might induce diseases. These plots were monitored 3 times a week. Soil moisture was measured with a neutron probe at 2 times a week.

RESULTS AND DISCUSSION

1992 RESULTS

Water use:
    1. (Acre Inches total) Water used as expressed in acre inches is shown in Table 1. The water amounts shown are for rainfall plus irrigation over the growing season. It is interesting to note that when plants are given all the water they desire, there is little difference in the total amount applied over a season. When the soil is allowed to dry excessively between irrigations, growth and productivity are impaired.

Table 1. Water used by peanuts in 1992

	15% Depletion	30% Depletion	50% Depletion	70% Depletion	Check
Field Runner	31.95	27.15	25.57	25.61	9.73
Field Spanish	35.54	32.40	27.35	26.96	9.73
Lysimeter Runner	31.38	27.94	24.37	27.04	None
Lysimeter Spanish	27.43	21.87	23.86	28.57	None

2. Daily water use and relation to computer program: The cumulative, actual and computer predicted water use of runner peanuts is shown in figures 1-1 and 1-2. One way to estimate water use by plants is to measure evaporation from an open pan and then, by applying the proper multiplier, the plants' water use can be estimated. When maintained at field capacity (fig. 1-1), runner peanuts used water at a rate of 1.5 times pan evaporation for the area covered by the canopy. When water was limited, the plants cut back to .95 times pan evaporation (fig 1-2). The 1.5 times pan value was higher than we obtained in 1991, and we suspect that these values are somewhat high as a result of the non-uniformity in soils.

**Figure 1.1   Water use by non-stressed peanuts (-0.1 cb between irrigations) crop coefficient = 1.5**
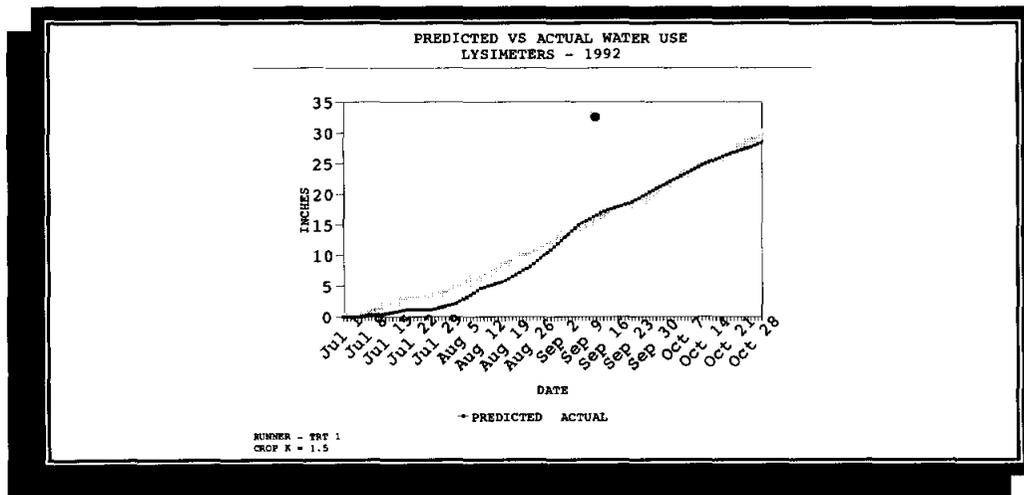
Figure 1.2   Water use by partially stressed peanuts (-0.5 cb between irrigations) crop coefficient = 0.95

PREDICTED VS ACTUAL WATER USE
LYSIMETERS - 1992
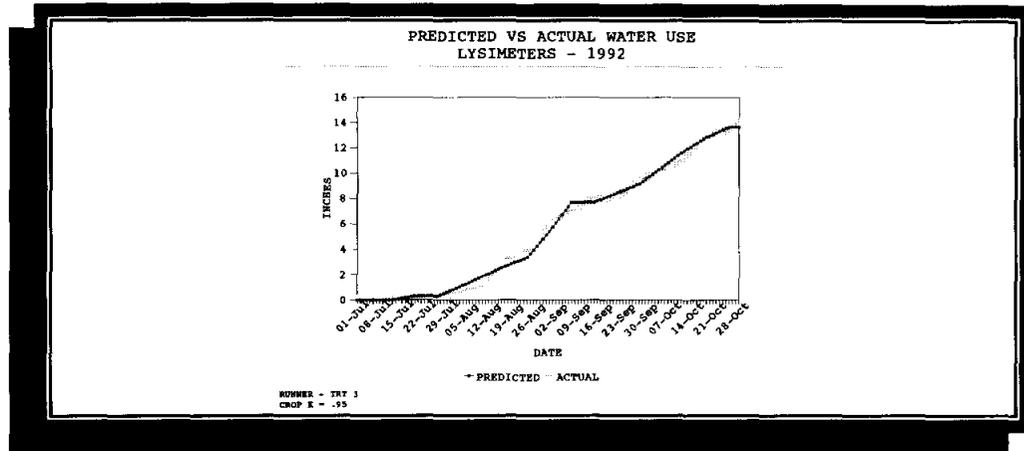
        In 1991, we found that unstressed peanuts used water at a rate of 1.00 times pan. We believe that because of the better growth rates found in 1991 that data is correct. No degree of moisture stress was included in 1991, so that comparison cannot be made.

Stress index: When conditions are right, an infrared thermometer can be a useful tool in measuring the stress of plants. Figure 3.1 through 3.3 show the water stress index for selected days during the season. When using the crop water stress index, a value of zero (0) indicates no stress while a value of one (1) would be the equivalent of a dead plant. A value of .3 is considered to be the point at which plants should be irrigated. In these figures treatments 1 through 5 represent treatments .15% to the non-irrigated check in order of stress.

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Figure 3.1   Peanut water stress on selected days in July

1992 PEANUT WATER STRESS INDEX
VARIETY = RUNNER

Bar chart: CWSI (y-axis, -0.1 to 0.6) vs DATE (x-axis: 7-13-92, 7-14-92, 7-15-92, 7-23-92, 7-24-92, 7-30-92) with legend TRT 1, TRT 2, TRT 3, TRT 4, TRT 5
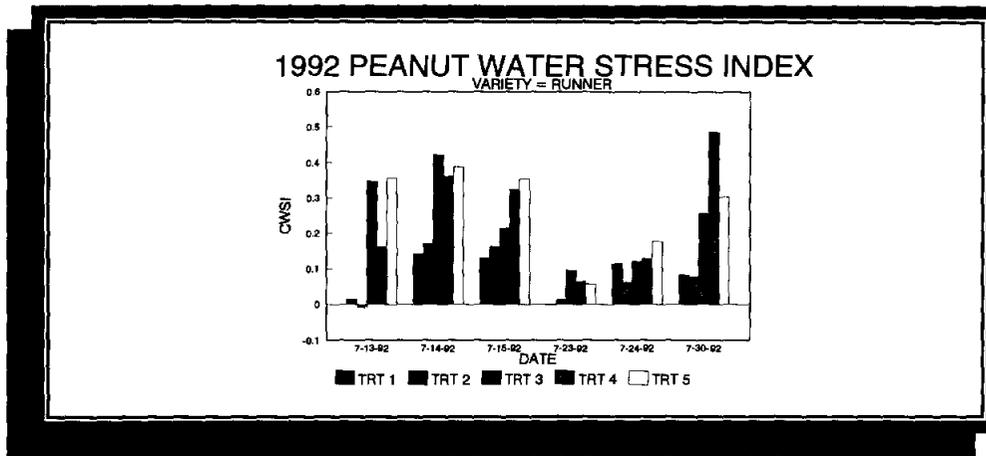
Figure 3.2   Peanut water stress on selected days in August.

1992 PEANUT WATER STRESS INDEX
VARIETY = RUNNER

Bar chart: CWSI (y-axis, -0.1 to 1) vs DATE (x-axis: 8-03-92, 8-04-92, 8-05-92, 8-06-92, 8-07-92, 8-11-92, 8-21-92, 8-31-92) with legend TRT 1, TRT 2, TRT 3, TRT 4, TRT 5
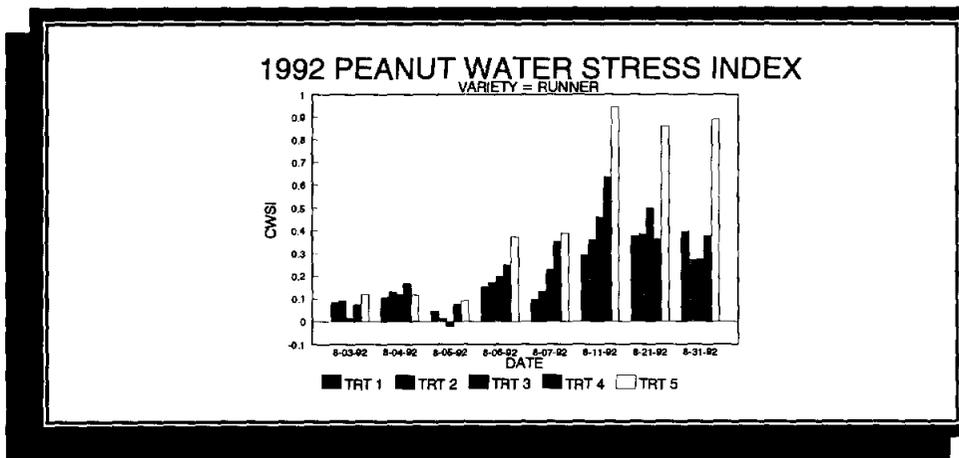
Figure 3.3   **Peanut water stress on selected days in September.**

1992 PEANUT WATER STRESS INDEX
VARIETY = RUNNER
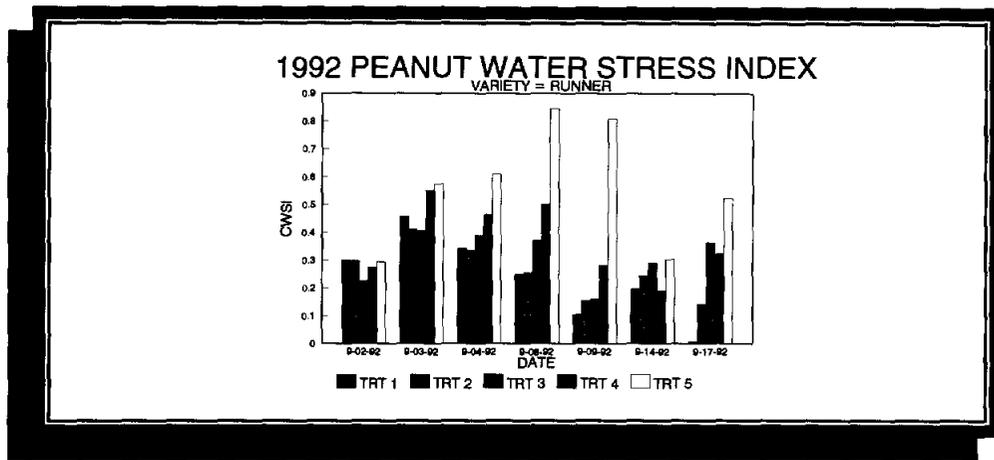
During most of the season, stress increased as irrigation applications decreased. Some irregularities exist because each replicate in the study irrigated automatically on an as required basis. Because of this, it was impossible to establish a set post-irrigation time to make our water stress studies. We expect to be able to correct this in our 1993 studies.

Soil Moisture Tension: Over most of the season, soil moisture remained within the prescribed limits. A typical set of readings are included as figure 4.1; these are the tensiometer readings for August, 1992 in the Tamspan plots.

Figure 4.1 Soil moisture tension over dime at various soil moisture tension levels as controlled by tensiometers

FIELD PEANUT TENSIOMETERS
STEPHENVILLE, TX - AUGUST, 1992

SPANISH   15CB   30CB   50CB   70CB   CHECK
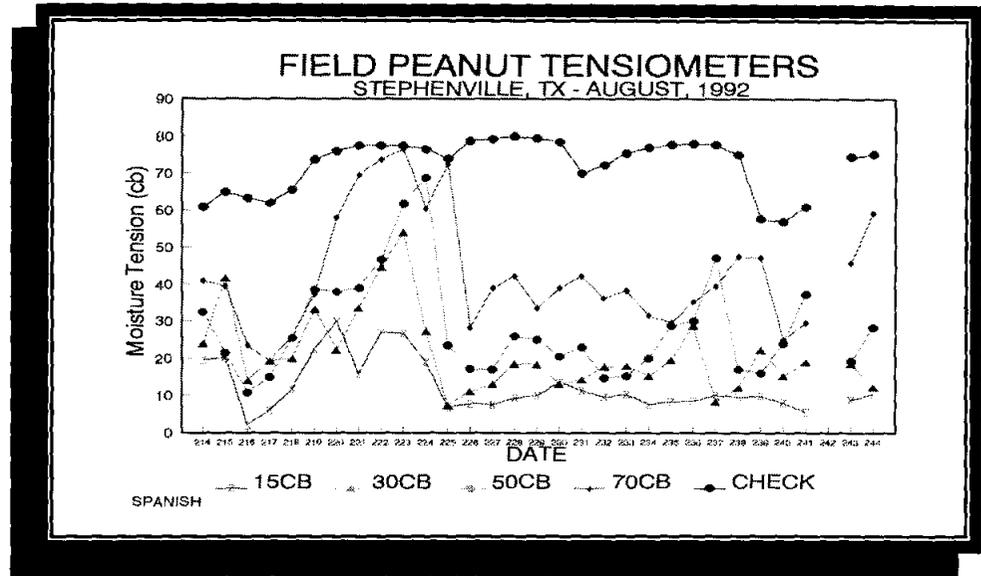
Diseases: Disease incidence was rated visually on July 16, and Aug 17. Southern blight (*S. rolfsii*), pod rot (*P. myriotylum*), limb rot (*R. solani*), and cotton root rot (*P. omnivorum*) were all found in the test block. There were no significant differences in the incidence of any of these diseases due to irrigation treatment.

Yield and Grade: Yields obtained in 1992 are shown in Table 2. Runners consistently out-yielded the Spanish nuts. Yields between treatments were not appreciably different, however, the checks were significantly lower than any irrigation treatment. These results are not too surprising considering that nearly the same amounts of water were applied to all plots.

    The grade of all peanuts grown in lysimeters was above 75, and there were no significant differences among treatments. In the field, the grade of Tamspan ranged from 63 to 69. At 63, the check plots were significantly poorer than any irrigated plots. Grade in the runner peanuts in the field were from 71 to 75, and there was no significant difference among treatments.

    Yields in 1992 were respectable, but somewhat disappointing when compared to those obtained in 1991 lysimeter studies Table 3. The 1992 crop was planted later in the season than the 91 crop, and the summer was probably cooler. Some growth irrigularities were noted in the 1992 planting. The soil for these lysimeters was purchased, and it is possible that plants suffered from some residual herbicide in the soil. The over-riding difference in treatments however, was the historic fertility of

the plots. Prior to the 1991 tests, the lysimeters used had been in a study of water use by pecans and Coastal Bermudagrass, and fertilized at a very high rate. The major thrust of our 1993 work will be to determine the extent to which higher fertility rates in combination with high frequency irrigation can further increase yields and profitability of peanut production.

Table 2. 1992 Yields and Water Use

	15% Depletion		30% Depletion		50% Depletion		70% Depletion		Check	
	Lbs/ Ac	Irr Appl In.	Lbs/ Ac	Irr Appl In.	Lbs/ Ac	Irr Appl In.	Lbs/ Ac	Irr Appl In.	Lbs/ Ac	Rain In.
Field Runner	5660	32	5830	27	5388	26	5467	26	3539	10
Field Spanish	4738	36	4866	32	4673	27	4367	27	2813	10
Lysimeter Runner	5161	31	6085	28	6008	27	5392	27	n/a	n/a
Lysimeter Spanish	3543	27	3504	22	3312	29	3736	29	n/a	n/a

Table 3. 1991 Yield and Quality (Lysimeters)

|	Lbs/Ac	DK%	OK%	G/100	Grade	$/Ton	$/Ac
Spanish	8,435	.76	2.8	45.5	70.4	$649.62	$2739
Runners	10,091	.88	3.8	70.5	70.5	$657.42	$3315

1993 RESULTS

LYSIMETER STUDIES

Water Use: There was no difference in water use based on fertilizer treatments, however, there was a difference based on the degree of soil moisture depletion allowed between irrigations. The irrigation requirement of plants watered when soil moisture

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reached -10 centibars was somewhat higher over the season than for plants irrigated at
-50 centibars. In the lysimeters particularly, there is little or no pore space available to
accommodate rainfall if it occurs. If the nearly 10 inches of seasonal rainfall is added
to the -50 cb treatments, the seasonal water use by both treatments is virtually the same.
Our data suggest that peanuts are very sensitive to water stress, and begin to close their
stomates when soil moisture tension is comparatively low (low stress condition). The
need for high frequency irrigation to eliminate stress is quite apparent.

Figure 5.1   **Water use by non-stressed peanuts (-0.10 cb between
irrigations), crop coefficient = 1.00**
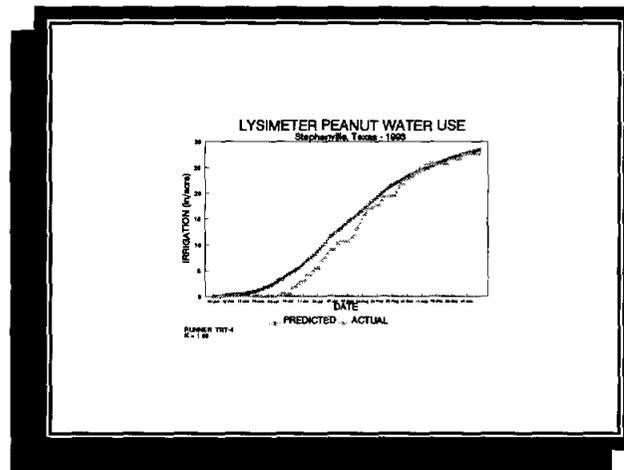
Figure 5.2   **Water use by peanuts allowed a partial stress (-0.5 cb) between
irrigations, crop coefficient = 0.55**
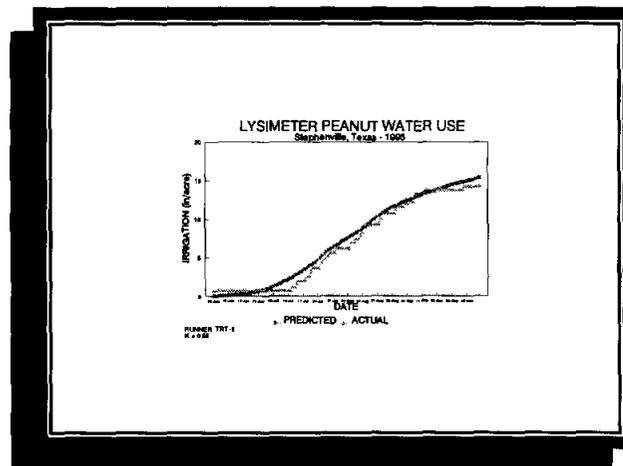
Table 4 Water use by peanuts as influenced by soil moisture levels and fertilizer.

TREATMENT	TOTAL GALLONS USED	TOTAL ACRE INCHES USED
1 (10 CB + 30 lb N)	489.25 a	27.76 a
2 (10 CB + 200 lb N)	525.63 a	29.82 a
3 (50 CB + 200 lb N)	251.00 b	14.26 b
4 (10 CB + INJ N)	488.40 a	27.71 a
5 (50 CB + INJ N)	279.68 b	15.87 b

Plant Growth: Limiting water is not necessarily a conservation practice. The trade off is found in response of the crop as measured by plant growth and productivity. It takes large plants to produce large crops. When the soil was allowed to dry to -50 centibars, plants grew more slowly and remained smaller than plants grown at or near field capacity. The consequence of this fact is shown in differences in plant yield.

Diseases: No unusual incidence of disease was noted in any of the irrigation treatments. This tends to verify our belief that non-stressed plants have more disease resistance than stressed plants. Thus, while plants which are irrigated on an irregular basis may develop diseases during wet periods, we did not find this to be the case under high frequency irrigation.

Photosynthesis vs CWSI: Results from 1991 and 1992 indicated that some good means of quantifying plant stress was needed. The key to most physiological processes is photosynthesis or measuring the rate of carbon dioxide fixation. Because water transpiration (water use) and CO_2 uptake (photosynthesis) both take place through the stomata of leaves, the two processes are very closely linked. Thus, we postulated that photosynthesis would be one of the most reliable parameters for measuring water stress on peanuts. In order to obtain a portable photosynthesis meter, we had planned to use Texas Peanut Producer's funds. However, in 1993 we obtained a Licor instrument from Experiment Station funding, and preserve the Board funds for other needed work.

In other work it has been found that as transpiration slows down due to stress, leaf temperatures rise. This effect is due to the rate of evaporation of moisture from leaf surfaces. Using infrared thermometers, the temperature of a plant's canopy can be easily measured. When leaf temperature is compared to air temperature, the cooling effect of transpiration can be measured. This set of values is of some benefit to users, but as these readings are affected by temperature and humidity, some better system would be desirable. A value known as the crop water stress index (CWSI) can be derived empirically for any given crop if a series of leaf vs air temperatures are taken. The compilation of these readings for peanuts would say in effect that when the plants are

well-watered, maximum cooling for that temperature and humidity is obtained and the CWSI = zero. If similar readings were made on a dead plant, no cooling would take place due to transpiration, there would be no difference in air and leaf temperature, and the CWSI would be 10, or 100% stress. Values derived between 1 and 10 indicate the degree of stress for that crop, and the CWSI becomes a very useful tool to irrigators. By and large, crop stresses greater than 30% are undesirable.

In order to gain a greater insight into the debilitating effects of water stress, photosynthesis was measured on selected days and compared to soil matrix potential, and to CWSI. On days with a high evaporative demand, peanuts growing under even modest stress were not able take in enough water to maintain their turgor. Leaf stomates closed, and photosynthesis was greatly reduced during mid afternoon hours even though soil moisture content was still quite high (-14 to -17 centibars). On these days, the correlation between CWSI and rate of photosynthesis was highly significant. This information will become increasingly valuable to researchers and producers as we learn to better apply a knowledge that plants exhibiting a certain degree of water stress will only be able to fix a known proportion of the photosynthates essential for high production of quality nuts.

Figure 6.1   Correlation of photosynthesis to crop water stress index of peanut

PEANUT PHOTOSYNTHESIS VS CROP WATER STRESS
REGRESSION (Rsq = .798)
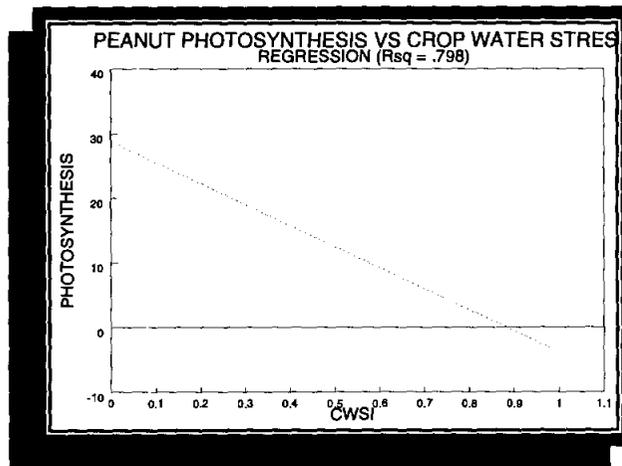
Figure 6.2   **Photosynthesis by peanut plants at varying soil moisture tension values during high evaporative demand.**
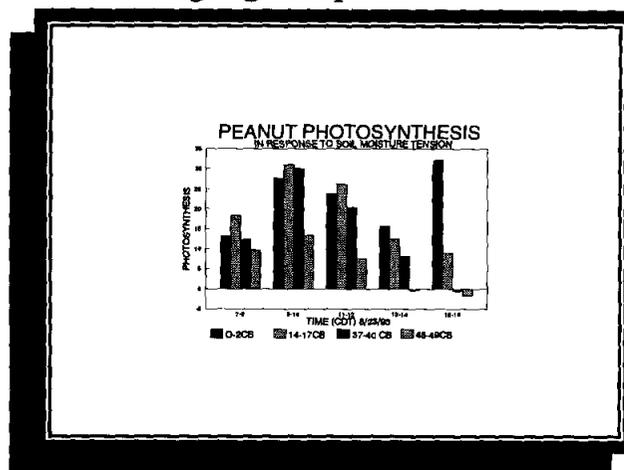
On days with low evaporative demand, peanut plants maintained their turgor with soil moisture as low as -50 centibars. On these days, there was no difference in CWSI as a function of soil moisture tension. Likewise, on low water demand days, there was no difference in the rate of photosynthesis as a function of soil moisture tension. This data emphasizes the fact that soil moisture tension is not always a good indicator for scheduling irrigation.

The reduced rate of photosynthesis by modest soil moisture stress is undoubtedly the reason for reduced plant growth and productivity. These stresses can be expected to occur under any irrigation scheduling system which does not emphasize the value of high frequency application.

Insects damage, Leaf area, Water use and Photosynthesis: The Agricultural Extension Service guideline for peanut production points out that plants can tolerate a given level of leaf loss without adversely affecting yield. In view of the interactive effects of soil moisture and evaporative demand on photosynthesis, this is an area which probably should be re-researched. Under the best management practices of the 1960 - 1990 time frame, moderate to severe water stresses were considered normal. Under this less than optimum water management practice it seems likely that if leaf feeders reduced leaf area, there would be a substantial reduction in transpiring leaf surface, and a corresponding decrease in demand for water. This should have the same whole-plant effect as cloudy or otherwise low evaporative demand days. If so, remaining leaves on a plant would remain better hydrated, thus allowing higher photosynthic rates. The effects of leaf removal would offset potential stress and, under such a scenario, a new, steady-state of lower water use and greater photosynthesis might equal the total photosynthesis/water use of a plant whose root system could not support a full leaf load. Effects on plants where yield expectations are in the range of 3000 pounds per acre

probably would not show the affects of leaf loss. On the other hand, leaf removal on plants where plant/soil moisture conditions capable of sustaining the needs of a full canopy would adversely affect photosynthesis only. Unstressed plants might be severely affected by the loss of a similar number or percentage of leaves.

Investigation of this effect was beyond the scope of this project, however, incidental insect damage does suggest a reason for some renewed investigation. Two of our lysimeters became infested with a very resistant strain of red spiders. One happened to be a high frequency replicate and the other, low. The three valid replicates in the high frequency test averaged 9,140 lbs per acre equivalent, and the one infested rep 4,621 lbs (50% reduction). The low frequency average was 6,241 lbs per acre while the infested rep produced 4,005 lbs equivalent (36% reduction).

Yields, Quality, and Crop Value: In our 1993 studies, yields of up to 11,000 lbs of peanuts per acre were obtained. Potential yields of peanuts under high frequency irrigation were in the neighborhood of 9,000 to 10,000 lbs per acre (Table 5). Some limitations to field production do exist. Suggested studies on production practices with an eye to developing a total system which takes advantage of high frequency irrigation will be discussed in the field study section on yield.

Table 5 Yield, grade and value of lysimeter grown runner peanuts 1993.

Treatment	Yield, lbs per acre	Grade	Value per acre
1. 30#N 10 cb	9,090 a	74.25 a	$3,222 a
2. 200#N 10 cb	8,165 a	72.65 a	$2,825 a
3. 200#N 50 cb	6,239 b	68.20 a	$2,029 b
4. Inj N 10 cb	8,729 a	73.17 a	$3,043 a
5. Inj N 50 cb	5,648 b	69.80 a	$1,885 b

FIELD STUDIES

Water Use: In 1993, irrigation scheduling was based on class A pan evaporation, and water was applied as needed to maintain plants at 0, 0.5, 0.75, 1.0, and 1.25 times pan evaporation for the area covered by the plants' canopy. The irrigation treatments in this study were completely replicated. Fertilizer applications were replicated, but designed to bracket possible needs for future studies rather than being applied in all possible combinations of a true factorial design.

Irrigation scheduling by pan evaporation was quite satisfactory. Table 6 shows the relative irrigation water use by plants receiving the various treatments.

Table 6   **Comparative water use based on irrigation rate for peanuts receiving preplant and injected fertilization.**

	Water Use Acre Inches Preplant Fertilizer	Water Use Acre Inches Injected Fertilizer	Increased water use due to improved growth
Irr= 1.25 X Pan	27.48	28.36	0.88
Irr= 1.00 X Pan	18.63	22.90	4.27
Irr= 0.75 X Pan	11.19	14.05	2.86
Irr=0.50 X Pan	6.77	9.55	2.78
Check (Rain)	9.27	N/A	N/A

Because of equipment limitations, replications were not scheduled or measured individually. Differences in water usage between preplant and injected fertilizer probably are due to increased growth rate by plants receiving small increments of fertilizer injected over the season.

On the basis of observation as well as neutron probe values, it was our impression that 1.25 times pan treatments were over-watered. On the same basis, it is probably valid to assume that during rain events, there was little pore space in the soil profile of these treatments in which to store the additional water. This would create unwanted runoff and potential pollution problems. If the rainfall is lost to this treatment, total water for the season was approximately 30 inches.

Plants receiving 1.0 time pan evaporation maintained better plant color than the 1.25 treatments, and there was seldom any water-logged appearance to the soil. If one adds the seasonal rain (9.27 inches) to the irrigation amount, the total water applied in the 1.0 treatment again comes too about 30 total inches of water for the season. Since there was no increase in yield or grade between these two treatments, one must assume that the extra irrigation water applied with the 1.25 rate was not beneficial and could be harmful.

Soil Moisture Depletion: Soil moisture was monitored weekly using a neutron probe. The neutron source in these measurements was lowered to 6, 18, and 30 inches respectively. Because of the spherical measuring pattern, these values represent moisture levels or moisture depletion in the first, second and third foot of soil over the season. Changes in soil moisture over the season can be seen in figures 7.1 through 7.5.

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Figure 7.1   Comparative soil moisture values for peanuts growing at 1.25 times pan evaporation.
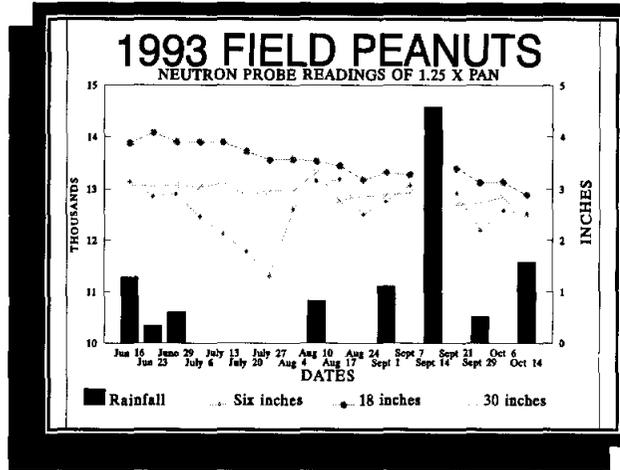

**Figure 7.2   Comparative soil moisture values for peanuts growing at 1.0 times pan evaporation.**
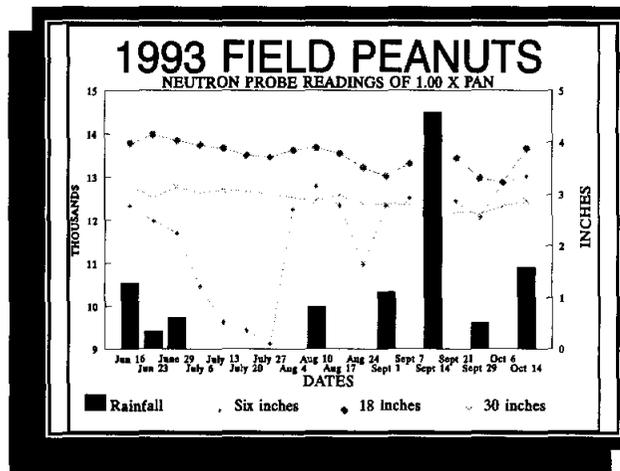
Figure 7.3 Comparative soil moisture values for peanuts growing at 0.75 times pan evaporation.

1993 FIELD PEANUTS
NEUTRON PROBE READINGS OF .75 X PAN

Rainfall   , Six inches   • 18 inches   30 inches
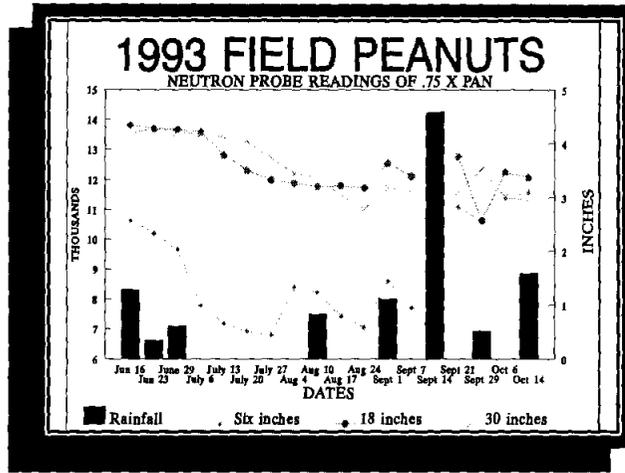
Figure 7.4 Comparative soil moisture values for peanuts growing at 0.5 times pan evaporation.

1993 FIELD PEANUTS
NEUTRON PROBE READINGS OF .50 X PAN

Rainfall   . Six inches   • 18 inches   30 inches

20
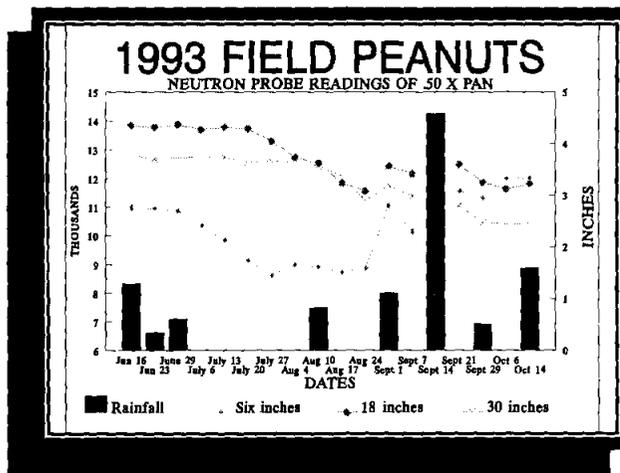
Figure 7.5 Comparative soil moisture for peanuts growing without irrigation in 1993.
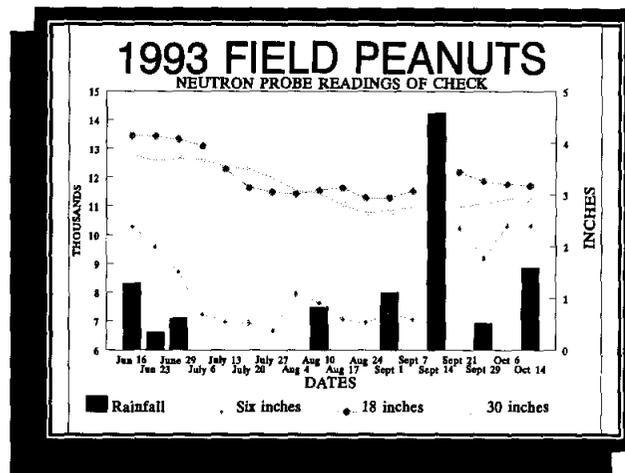
The probe access tubes were placed in the furrow between rows, and because of this, it appears that our irrigation applications were not keeping up with the rate of water use during the early part of the season. Actually, because the irrigation tubing and water applications were made in the planted row, and since early season applications were relatively small, the wetted front did not extend far enough laterally to be detected. As the amount of irrigation water applied increased, one can see the recovery of moisture levels to expected values - at least for the higher irrigation rates. The moisture in this upper profile remained low for most of the season where only 0.75 and 0.5 times pan rates of water were applied. This indicates that plants were de-watering the soil at a rate which exceeded the rate that it could move laterally from deficit irrigation rates.

In the treatments receiving 1 or 1.25 times pan evaporation, there was little moisture removed from the deeper soil profiles. On the other hand, plants irrigated at 0.5 or 0.75 times pan evaporation did have to draw on these lower moisture reserves for their growth and development.

Plant Growth: The rate of plant growth is important, because large plants are capable of producing more flowers and fruit than small plants. It is important that plants obtain their maximum size as quickly as possible so that blooming can occur in time to allow peanut maturation before frost. Plant growth as indicated by canopy size was measured weekly.

Figure 8.1 **Seasonal growth of peanut plants when grown following high preplant fertilizer applications.**
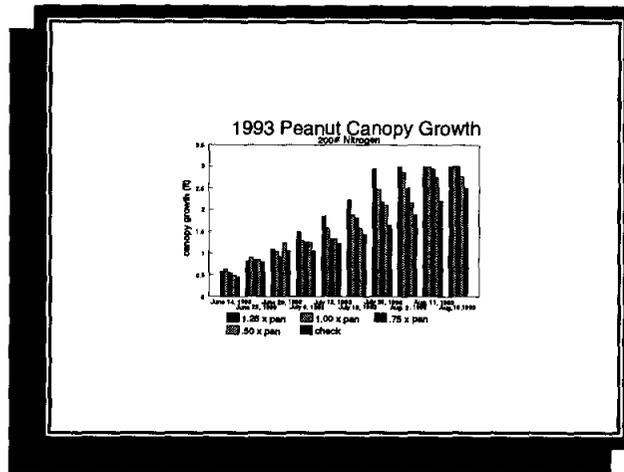

Figure 8.2 **Seasonal growth of peanuts when grown with supplemental fertilizers applied during the season.**
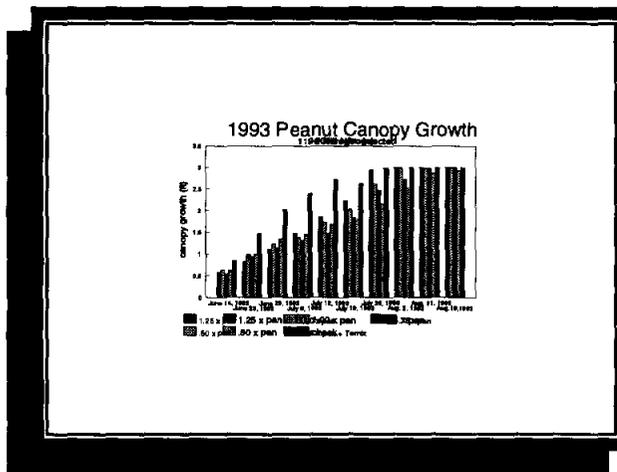
The treatment which emulates most closely the practices of commercial producers included preplant and side-dressed Temik. In commercial practice, this is to done to control nematodes, and perhaps to reduce damage from thrips. Growers must also feel that the practice is profitable. Peanuts grown according to commercial practices and our irrigation schedule were lapping the rows by July 19. Other treatments, even at 1.25 times pan evaporation were not lapping for another 7 days.

Other than the outstanding performance of the Temik treated plants, there were

no surprises in the rate of growth of plants. The more water plants received, the faster they grew.

Diseases: Disease incidence in peanuts is always a concern. Most writers report that disease are more prevalent in plants receiving high amounts of irrigation water. This is attributed to higher humidities. Our experience with other crops indicate that plants which are never stressed exhibit more resistance to disease than plants that are subjected to periodic stress.

Plants in our irrigation treatment were evaluated for diseases as other parameters were measured, and formally at the end of the growing season. No economic disease incidence was found in any plots, and no significant differences were found between treatments.

Nutrient Levels: Because of the reduction in yields obtained in 1992 over 1991, we speculated that there would be a strong response to supplemental fertilizer applications. Heavy preplant applications of fertilizer should be more susceptible to leaching and run-off. Environmentally, it seems more sound to apply fertilizers at a time and rate when they can be utilized by the plant with little or no excess to find its way into surface or subsurface water supplies. In order to develop some base data on the rate of nutrient use by peanuts, we made a separate planting where part of the seed bed was treated with 200 lbs of nitrogen preplant, and the rest of the field only treated with 35 lbs of nitrogen. Whole plant samples were removed weekly. The tissue was dried and ground and sent to the soil testing lab at College Station for analysis. Because nitrogen is quite soluble, this element often traced in plants and soil as an indicator of water pollution potential. Figure 8.1 shows the plant level of nitrogen over the season. It is interesting to note that even with quite high levels of nitrogen in the soil, plant tissues did not reflect a difference. Further, it is interesting to note that even though peanuts fix atmospheric nitrogen in root nodules, tissue nitrogen declines over the season, and the rate of that decline was not affected by high preplant applications of nitrogen when applied preplant.

**Figure 9.1 Seasonal nitrogen levels in well-watered peanuts.**
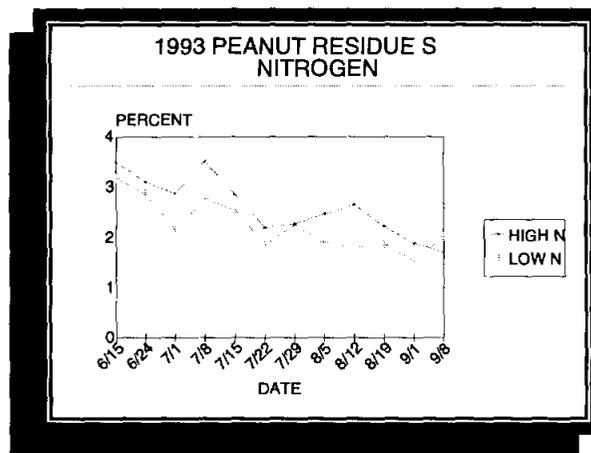
**Figure 9.2 Seasonal phosphorus levels in well-watered peanuts.**

1993 PEANUT RESIDUE S
PHOSPHORUS

PERCENT

HIGH N
LOW N

DATE
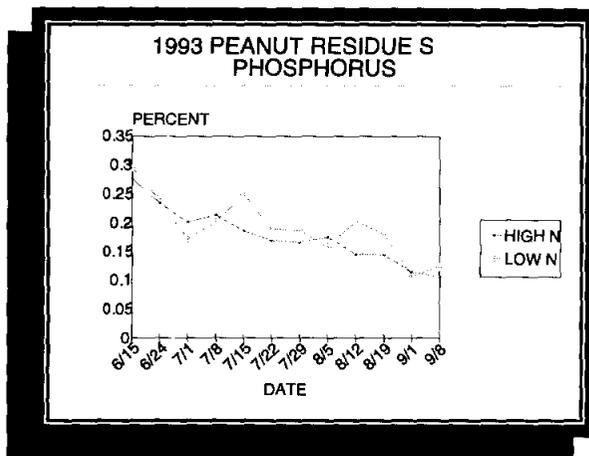
Figure 9.3   Seasonal potassium levels in well-watered peanuts.

1993 PEANUT RESIDUE S
POTASSIUM

PERCENT

HIGH N
LOW N

DATE
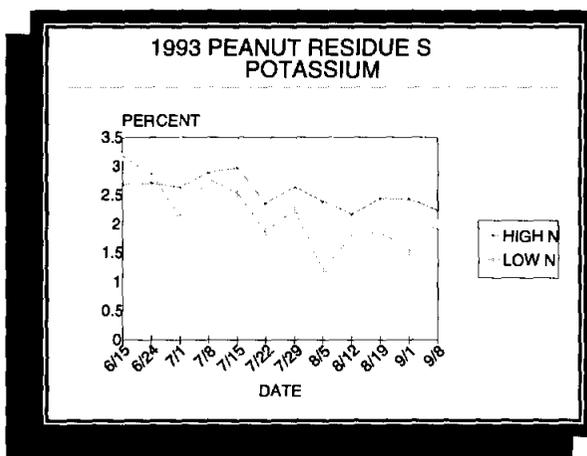
Figure 9.4 Seasonal calcium levels in well-watered peanuts.

1993 PEANUT RESIDUE S
CALCIUM
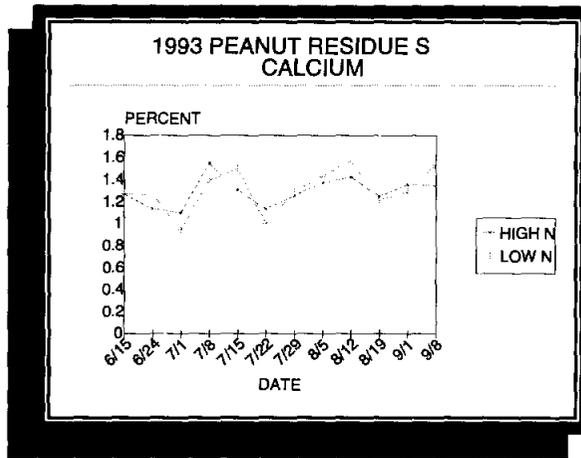
Figure 9.5 Seasonal magnesium levels in well-watered peanuts.

1993 PEANUT RESIDUE S
MAGNESIUM
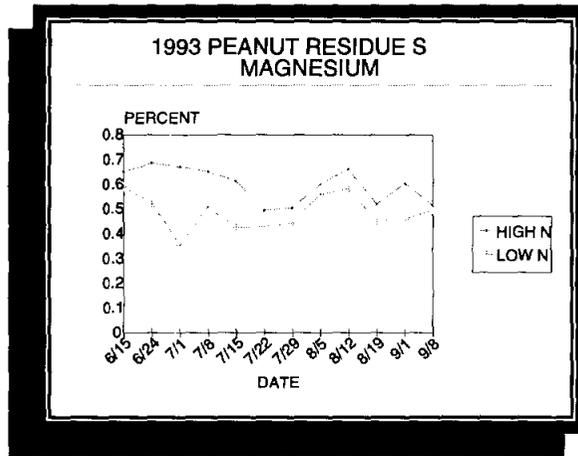
Figure 9.6   **Seasonal iron levels in well-watered peanuts.**

1993 PEANUT RESIDUE S
IRON

PARTS PER MILLION

HIGH N
LOW N

DATE
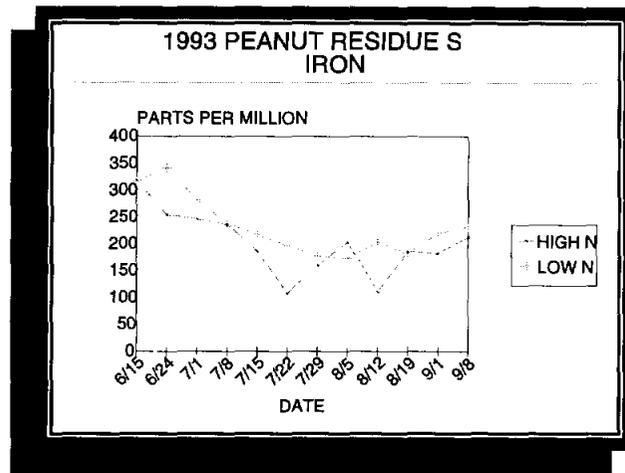
Figure 9.7 Seasonal copper changes in well-watered peanuts.

1993 PEANUT RESIDUE S
COPPER

PARTS PER MILLION

HIGH N
LOW N

DATE
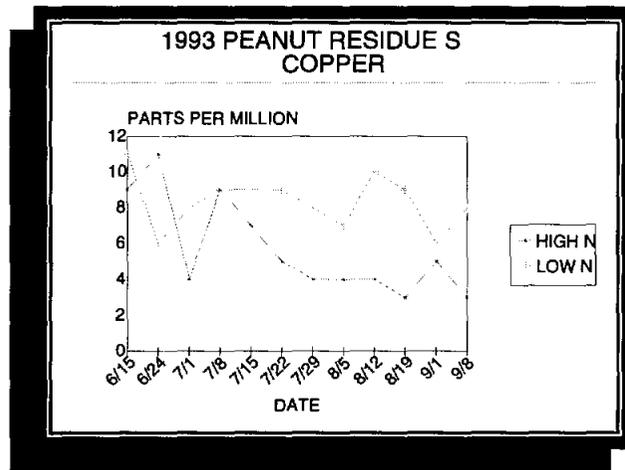
Figure 9.8 Seasonal Manganese levels in well-watered peanuts.

1993 PEANUT RESIDUE S
MANGANESE

PARTS PER MILLION

(HIGH N / LOW N)

DATE
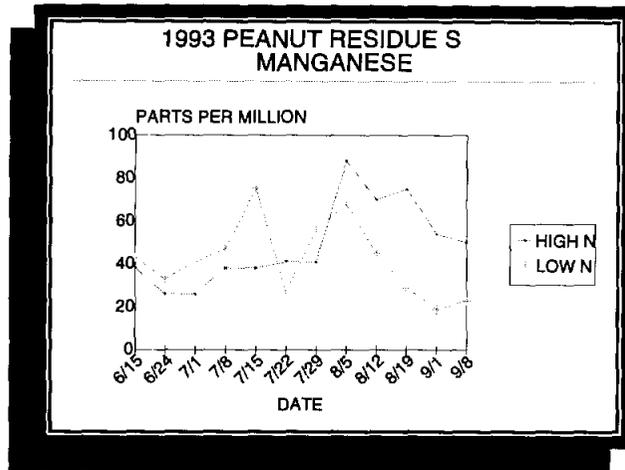
Figure 9.9 Seasonal sodium changes in well-watered peanuts.

1993 PEANUT RESIDUE S
SODIUM

PARTS PER MILLION

(HIGH N / LOW N)

DATE
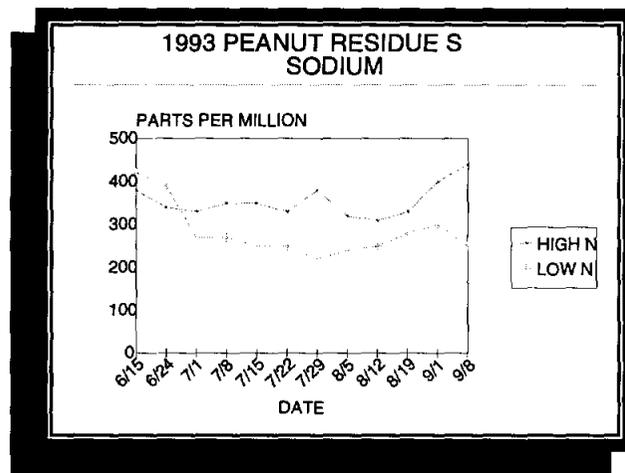
Yields, Nut Quality, and Value: Yields obtained in the field plots were not as good as obtained in lysimeters. This is due at least in part to the harvesting equipment available. The plot digger used was developed for Spanish peanuts, and had a 60 inch spread from outside knife to outside knife. Due to the excellent growth obtained in some of our plots, the production area was very close to full span of 72 inches. By the time this equipment limitation was recognized, the plots were mostly harvested, and no valid, unbiased, way of estimating yield losses could be developed. Simple arithmetic indicates that we only harvested 83.3 percent of the potential production, but this value is probably only valid

for the best treatments. Plots with a slower growth rate were harvested with the 60 inch digger without unnecessary losses. The unfortunate consequence is that our harvest data are biased towards the slower growing plots.

When field yields are compared to lysimeter values, one must remember that commercial digging devices are not as efficient as hand digging and harvesting. We used this latter technique in harvesting lysimeter plots, and the difference in results probably represents the lack of efficiency in present field harvesting equipment.

From a purely scientific standpoint, it is difficult to say that anything but irrigation was worth while. This shows very clearly when one looks at grade alone (38% vs 70%).

In view of the harvesting difficulties experienced, we are probably justified in a less critical view of the data. It is note worthy that 4 of the top 5 treatments by yield come from fertilizer injected treatments. The only injected treatment that is not in this top group was the low irrigation rate, or 0.5 times pan evaporation. Treatment 1 which contained a custom preplant treatment of 35 lbs N per acre and 1.25 times pan evaporation was also among the top yielding treatments.

Table 7 Yields, quality, and dollar value of field grown peanuts Stephenville, TX 1993

| Treatments	Yield, Pounds per Acre	Grade	Value Per Ton	Value Per Acre
1 1.25+35N preplant	5036 ab	70.6 ab	$ 676.95	$1697.30 ab
2 1.00+35N preplant	4328 abc	68.1 abcde	$ 650.26	$1403.10 bc
3 0.75+35N preplant	4356 abc	67.5 abcde	$ 644.74	$1406.60 bc
4 0.50+35N preplant	3890 c	63.8 de	$ 608.33	$1185.70 c
5 Check+35N preplant	1620 d	38.5 f	$ 367.83	$ 299.80 d
6 1.25+200N preplant	3963 bc	62.78 e	$ 599.11	$1191.70 c
7 1.00+200N preplant	4561 abc	66.1 bcde	$ 630.78	$1442.90 bc
8 0.75+200N preplant	4230 abc	66.7 bcde	$ 636.62	$1355.20 bc
9 0.50+200N preplant	4232 abc	65.4 cde	$ 624.28	$1320.30 bc
10 Ck+200N preplant	1509 d	38.4 f	$ 366.30	$ 287.60 d
11 1.25+120N injected	4977 abc	71.4 abc	$ 681.07	$1697.80 ab
12 1.00+120N injected	4620 abc	72.3 ab	$ 690.65	$1597.70 ab
13 0.75+120N injected	4851 abc	70.2 abcd	$ 670.41	$1627.40 ab
14 0.50+120N injected	4368 abc	66.0 bcde	$ 629.25	$1375.00 bc
15 1.25+120N plus Temik injected	5234 a	73.9 a	$ 705.82	$1850.50 a

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Where 200 lbs of Nitrogen was applied just prior to planting, there was a considerable reduction in stand. Seeds germinated to the extent that the seed coat split and the epicotyl made slight growth, but there was not enough growth to allow emergence from the soil. Seeds in this inhibited state did not rot in the field, but remained healthy though they ceased to grow. Where irrigation water was subsequently applied, these sprouted seedlings resumed growth and from all visible attributes made normal plants. Where no irrigation water was applied, even re-planted seeds failed to grow. We speculate that fertilizer salts inhibited seedling development, and that subsequent irrigations, if applied, diluted these salts to the point where normal growth could occur.

COMMERCIAL APPLICATION AND TECHNOLOGY TRANSFER

In order to test our data under commercial conditions, arrangements were made through Mr. Bob Whitney (County Extension Agent, Comanche Co.) to put in a research/demonstration scheduling study on the Farm of Rodney Stephens. Mr. Stephens is a progressive farmer who is quite interested in innovative procedures to make his operations better. He allowed us to set up treatments in two fields just across a field road from each other. We have designated East and West because of their relative position.

The east field had a center pivot system, but as the field was rectangular, the system only made 1/2 circle. The west field had a similar pivot irrigation system but served a larger field requiring the whole circle. Specially marked tubs were set in both fields and filled to the top line on June 16. In the east field we asked Mr. Stephens to irrigate often enough to keep the water level in this tub between the two top lines. In the west field we simply monitored the "normal" irrigation practices of Mr. Stephens.

Figure 10.1   Soil moisture with TAMU scheduling.
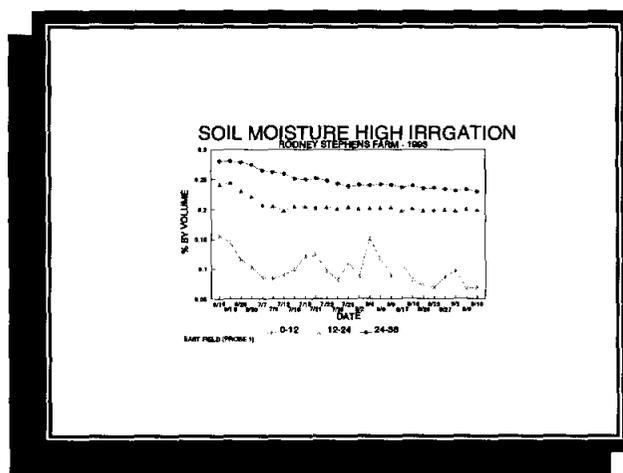
Figure 10.2 Soil moisture with traditional irrigation scheduling
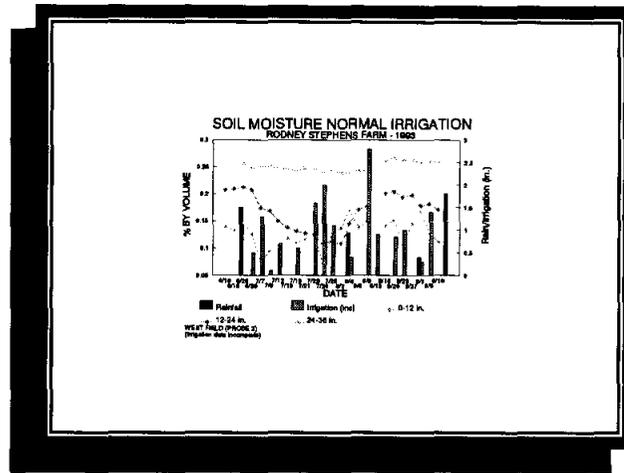
It was our initial plan to monitor irrigation frequency and rate by measuring the difference between evaporation and the changes in the level of water in the evaporation pans. This proved unworkable, and rain gages were set in the field in the vicinity of the evaporation pans to collect irrigation water applied. There was not much rain to confound these readings in 1993, but we corrected the readings to reflect only irrigation by comparing field values to those of a separate rain gage set on a post outside the irrigation system's reach. This system was workable, but we did have a period where it appeared someone else was emptying our gages between farm visits. For this reason, we have indicated in our figures that the irrigation data is incomplete. The fact that Mr. Stephens kept the water level in the evaporation pans from June 30 through Sept 19 indicated he was following our scheduling plan.

Soil moisture was monitored with a neutron probe. The access tube for these readings was set in the middle of the planted row near our evaporation pan. Readings were made twice a week for most of the summer. The planting was monitored for disease and other problems 3 times a week for most of the summer.

Soil moisture levels, rainfall, and the best irrigation data available are shown in figures 10.1 and 10.2. While we recorded irrigation, or rainfall on the day we were at the site, this does not indicate that water was applied that day. This reflects the amount of water applied since our last visit.

In the east field, soil moisture at all depths reached pretty much a steady state after 4 weeks of irrigation. Soil moisture at the 0 - 12 inch level changed somewhat from visit to visit, but there was no long term loss or gain in moisture.

In the west field, where Mr. Stephens was irrigating by his good instincts as a farmer, there was a fluctuation in moisture levels at the 0 - 12 inch soil level, and also a sharp decline in moisture at the 12 - 24 inch level. Starting at the end of July, irrigation water applied was great enough to bring the 2 foot profile back to the preplant level.

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Field yields for the east field were 4800 pounds per acre which is probably among top yield for area producers. Yields in the west field were not recorded.

SUMMARY AND CONCLUSIONS

1. High frequency applications of irrigation water can substantially increase the yield of peanuts. When compared to 1991 and 1993 data, lysimeter yields for 1992 were lower than expected. Some growth irregularities were noted in 1992, and it is possible that the soil purchased for these lysimiters contained some residual herbicide. While a specific herbicide could not be identified from symptoms, no other explanation was found.

2. Under the conditions that prevailed in 1993, peanuts effectively used 30 inches of water.

3. Supplementing rainfall with high frequency applications of irrigation water at 1.0 times pan for the area covered by the canopy was the optimum rate for irrigation of peanuts.

4. Irrigation scheduling by computer has the advantage of seasonal prediction of water use for growing crops, but in the field, water applications can be scheduled just as accurately by informed measurements of evaporation from a simplified pan such as a wash tub. The simplicity of this system should lead to more rapid adoption by peanut producers.

5. Microirrigation techniques have been demonstrated to peanut farmers particularly as applied to the corners of their center pivot systems. The concept has been accepted, and commercial sales of systems for small fields is moving forward in counties where we have demonstrated the concept.

6. In peanuts, water stress begins to develop about the same time that soil moisture is any value less than field capacity. The intensity of this stress is more dependent on evaporative demand than soil matrix potential. Severe plant stress can develop in peanuts even if irrigations are scheduled to replace soil moisture when it is 30% depleted.

7. In peanuts, the crop water stress index is highly correlated with the plants ability to fix CO_2 (photosynthesis).

ACKNOWLEDGEMENTS

LYSIMETER FABRICATION
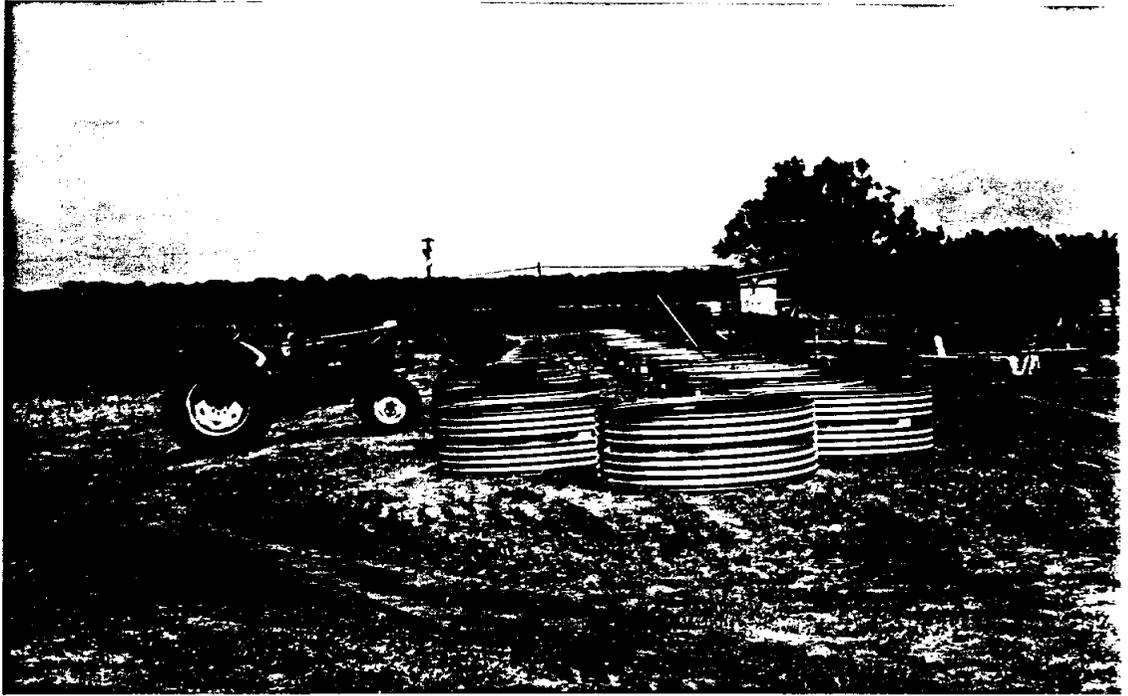
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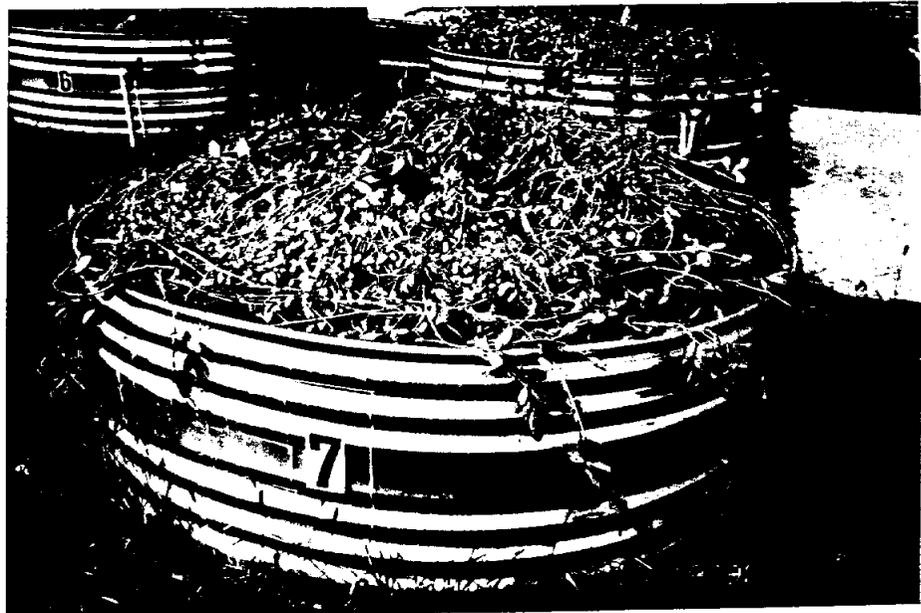
FIELD VERIFICATION

GROWTH AND YIELD RESPONSE

HARVESTING AND GRADING
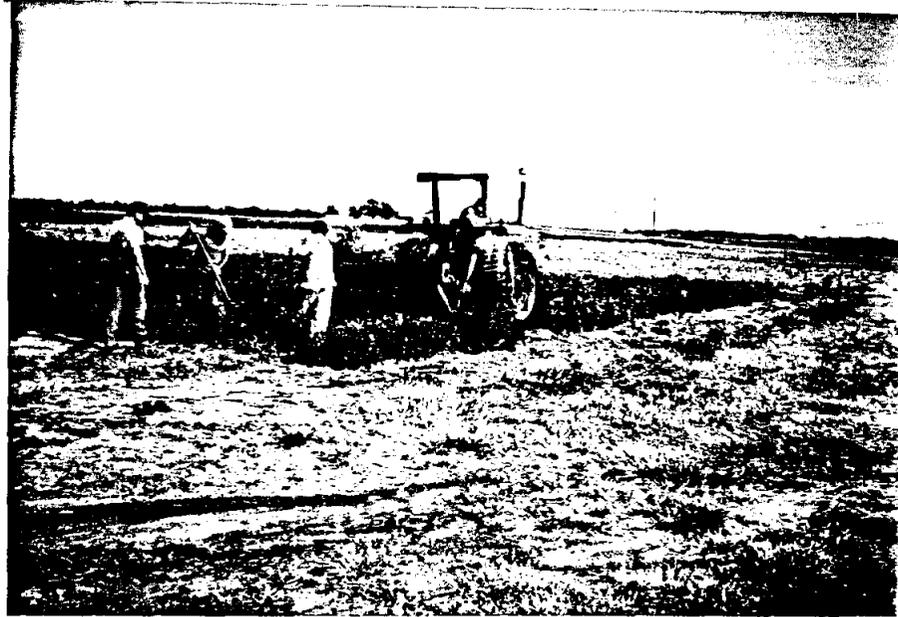
TECHNOLOGY TRANSFER

USER FRIENDL
APPLICATION
TECHNIQUES

MEASURABLE

RESULTS

TECHNOLOGY TRANSFER
FIELD DAYS