CONSUMPTIVE USE OF WATER BY PEANUTS AND GRAIN SORGHUM IN OKLAHOMA, 1955

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PREFACE

The experimental work of this thesis research project was performed under the Agricultural Engineering Department, Oklahoma A. and M. College, as a part of the irrigation research of the Oklahoma Agricultural Experiment Station. The soil moisture study method was used to determine the consumptive use of peanuts and grain sorghum throughout the growing season for El Reno, Oklahoma. The grain sorghum experiments were a continuation of the irrigation research conducted on an adjacent area in 1954 using a different plot-layout design.

The results presented herein will permit more efficient irrigation system design and will be beneficial in improving irrigation management practices for obtaining optimum yields of the crops studied. The consumptive use data presented may be used directly in irrigation system design by the application of an irrigation efficiency factor.

This experimental work was conducted on the Oklahoma Livestock Experiment Station, Fort Reno. The plots were located 200 feet due south of irrigation well #2 in the Canadian loam area.

The author wishes to express appreciation to Dwight F. Stephens, Superintendent of Station, for his personal assistance and for making available the experimental area

and the facilities and equipment of the station. Appreciation is extended to James E. Garton, Associate Professor, Irrigation and Ralph S. Matlock, Associate Professor, Agronomy for their valuable suggestions in planning and conducting the experiment, analyzing the data and writing the report.

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CHAPTER I

INTRODUCTION

The availability of water during the crop growing season is of primary importance for obtaining the maximum economic yields in agricultural production. The lack of available water during the growing season has been found to be one of the most limiting factors in maximum crop production in Oklahoma and many other areas of similiar annual rainfall. Water that is not supplied by rainfall should be supplied by some method of irrigation if optimum yields are to be obtained. Due to the vast variability in rainfall amounts and intensities, the water extraction pattern for a specific crop must be known and an adequate irrigation water supply should be obtained to provide most or all of the water. Where irrigation water is supplied from ground water, receding water tables are causing alarm and increasing irrigation costs. In our increasing use of irrigation to meet the growing demand for food and fibers, good utilization of our limited water supply is increasing in importance.

In the normal process of growth, plants transpire water into the atmosphere and utilize it in development of plant tissue. Some water evaporates directly from the soil into the atmosphere. The total utilized in transpiration, in building plant tissue, and that evaporated from the adjacent soil or from rainfall intercepted by plant foliage is called consumptive use.

Significant reduction in crop yields may result if the moisture level is held too high or too low. The knowledge of the effect of the moisture level upon crop yield provides a sound basis for scheduling irrigations to obtain the maximum net return from the investment.

Considerable work is being done in many states to determine the consumptive use by the use of climatic factors in an empirical relationship. Since soil moisture studies conducted in field plots, as used in this experiment, are the most accurate method of determining consumptive use, they are valuable for developing and improving the accuracy of the empirical method.

Previous studies have indicated that the moisture is not extracted uniformly throughout the root zone. Also, the fact that the moisture depletion varies throughout the growing season has been established. Soil moisture extraction patterns are desirable, therefore, for the purpose of determining the consumptive use for optimum yields where the water supply is limited.

CHAPTER II

OBJECTIVES

The objectives of this study were as follows:

1. Determine the consumptive use of water by peanuts and grain sorghum for optimum yields at El Reno, Oklahoma, 1955, by the field plot and soil moisture depletion method.
    a. Determine the seasonal transpiration pattern.
    b. Determine the peak average daily transpiration between irrigations.
    c. Determine the peak monthly transpiration.
    d. Determine the seasonal transpiration.
2. Determine the effect of varying the amount of fertilizer application on the yield of each crop.
3. Determine the soil moisture extraction pattern for each crop with relation to the depth of root zone.
4. Correlate the consumptive use data on grain sorghum obtained the summer of 1955 in this project with the data obtained by Jack Musick (13) in 1954; using a similar type of soil in an adjacent area with the same crop variety.
5. Note if an aquaprobe can be used as a quick method

of determining the soil moisture content.

6. Note if nylon blocks can be used for the determination of soil moisture.

CHAPTER III

REVIEW OF LITERATURE

Definition of Terms

The following terms used in this report were defined by Young (18) as follows:

Irrigation Requirement: The quantity of water, exclusive of precipitation, that is required for crop production. It includes surface evaporation and other economically unavoidable wastes. Usually expressed in depth for any given time (volume per unit area for a given time).

Water Requirement: The quantity of water, regardless of its source, required by a crop in a given period of time, for its normal growth under field conditions. It includes surface evaporation and other economically unavoidable wastes. Usually expressed as depth (volume per unit area for a given time).

Consumptive Use (evapo-transpiration): The sum of the volumes of water used by the vegetative growth of a given area in transpiration and building of plant tissue and that evaporated from adjacent soil or intercepted precipitation on the area in any specified time, divided by the given area. The consumptive use may be expressed in acre-inches per acre or depth in inches, or acre-feet per acre or depth in feet.

Transpiration: The quantity of water absorbed by the crop that is transpired and used directly in the building of plant tissue in a specified time. It does not include soil evaporation. It is expressed as acre-feet or acre-inches per acre or as depth in feet or inches.

Field Capacity: The moisture percentage, on a dry weight basis, of a soil after rapid drainage has taken place following an application of water. This moisture percentage is reached approximately two days after irrigation.

Permanent Wilting Point: The moisture content of the soil at which the plants wilt and do not recover unless water is added. It is expressed as percentage of moisture based on the oven-dry weight of the soil.

Available Moisture: The quantity of water in the soil that is available for plant use, as limited by the field capacity and the permanent wilting percentage. It is expressed as percentage of the dry weight of the soil or as depth of water in inches per foot depth of soil.

Moisture Percentage: The percentage of moisture in the soil based on the dry weight of the oven-dry material.

Apparent Specific Gravity (volume weight): The ratio of the weight of a unit volume of oven-dry soil of undisturbed structure to that of an equal volume of water.

Real Specific Gravity: The ratio of the weight of a single soil particle to the weight of a volume of water equal in volume to the particle of soil.

Soil Moisture: The water in unsaturated soil. It is expressed as a percentage on a dry weight basis, or in inches per foot depth of soil.

Additional definitions used in this report are:

Temporary Wilting Point: The moisture content of the soil at which the lower plant leaves begin to show signs of wilting. The plant will fully recover during the night when the transpiration rate is less than the rate of moisture absorption by the plant roots.

Shelling Percentage: The percentage of sound mature kernels in a sample expressed as percentage of the total sample weight.

Sound Mature Kernels: Peanuts which are not described as (1) small shriveled (15/64 inch by 3/4 inch perforations were replaced by 14/64 inch by 3/4 inch perforations), (2) small pieces of peanuts, (3) foreign material, (4) split peanuts, or (5) damaged peanuts listed in the following report issued by the United States Department of Agriculture, Agricultural Marketing Service (19):

1. "Small shriveled" peanuts in U. S. No. 1 means

peanuts which are shriveled and which will pass through a screen of the type customarily in use, having 15/64 inch by 3/4 inch perforations; and in U. S. No. 2 peanuts which are shriveled and which will pass through a screen of the type customarily in use, having 16/64 inch round perforations.

2. "Small pieces of peanuts" means portions of peanuts which will pass through a screen of the type customarily in use, having 16/64 inch round perforations.

3. "Foreign material" means sticks, stones, dirt, shells, portions of vines or any material other than peanut kernels.

4. "Split peanuts" means the separated halves of the peanut kernel.

5. "Damaged peanuts" means:
   (a) Peanuts which are rancid or decayed to an extent visible externally.
   (b) Moldy peanuts.
   (c) Peanuts showing sprouts over 1/8 inch long. However, all sprouted peanuts, the separated halves of which show decay, shall be classed as damaged.
   (d) Dirty peanuts where the surface is distinctly dirty and the dirt ground in. This condition usually results when peanuts are rubbed in the machinery in the process of handling.
   (e) Wormy or worn injured peanuts-peanuts which show only slight and superficial worn injury with no frass around the injury shall not be considered as damaged.
   (f) Peanuts shall not be considered as damaged which show a light yellow color or a slight yellow pitting of the flesh.

6. "Noticeably discolored skins." Peanuts which show dark brown discoloration, usually netted and irregular, affecting more than 25 percent of the skin, shall be classed as noticeably discolored. Peanuts which are paler or darker in color than is usually characteristic of the variety, but which are not actually discolored, shall not be classed as noticeably discolored.

7. "Badly discolored skins." Peanuts which show bluish or black discoloration, affecting an area in excess of 1/2 of the surface in the aggregate, shall be classed as badly discolored.

Conditions Affecting Consumptive Use

Many factors operate singly or in combination to influence the amount of water consumed by plants. These factors are not necessarily constant but may fluctuate from year to year as well as from place to place. The rate of consumptive use of water primarily depends upon the climate, soil moisture supply, vegetation, and irrigation practices. A summary of these conditions affecting consumptive use, reported by Israelsen (11) is as follows:

The major factors included in climate that affect consumptive use are precipitation, temperature, humidity, wind movement, and length of growing season. Differences in temperature from year to year usually cause differences in consumptive use; abnormally low temperatures may retard plant development, and unusually high temperatures produce dormancy. Increasing wind movement normally increases evaporation; increased humidity and cloudiness reduce it. Hail may damage crops and therefore reduce their rates of transpiration.

The rate of transpiration depends upon the available moisture supply. During the growing period of a crop, there is a continuous movement of water from the soil into the roots, up the stems, and out the leaves of the plant. If the rate of evaporation at the leaves is for a brief period greater than the rate of absorption by roots, wilting occurs and the growth of the plant is impeded. On the other hand, if the conditions are such as to stimulate excessive transpiration, without also conveying substantial amounts of plant food substances into the plant and favoring rapid manufacture of food in the plant leaves, the available water is not used efficiently. Evaporation from the soil surface may be high if the surface is wet or if capillary water is moving to the surface from a high ground water table. Depths evaporated between successive irrigations during a particular growing season decrease as the crop plants develop and the shade increases in proportion to the soil surface.

The vegetative factors affecting consumptive use include the type of vegetation, the stage of development of the plant, its foliage, and the nature of its leaf. As the leaf area of the plants enlarges, the consumptive use increases and reaches a maximum as the plants approach maturity. The consumptive use drops rapidly as maturity proceeds and the function of the plant is transferred from vegetative growth to processes of ripening and reproductive development.

Irrigation factors that influence consumptive use are the size of the farm field irrigation layout, preparation of the field for application, method of conveyance of the water, and the method of water application. Plant diseases and pests may reduce consumptive use by inhibiting plant growth. Noxious weeds may affect consumptive use by increasing the foliage density or by reducing the area irrigated if crops cannot be grown on infested areas.

Methods of Determining Consumptive Use

The principal methods of determining the consumptive use of water by agricultural crops and natural vegetation listed by Israelsen (11) are as follows: Tanks and lysimeter experiments, field experimental plots, soil moisture studies, analysis of climatological data, integration method, and inflow-outflow for large areas.

A common method used to determine the consumptive use of water is to grow the plants in lysimeters or tanks and measure the quantity of water necessary to maintain desired growth. Weighing is the precise means of determining the consumptive use from tanks. The reliability of consumptive use determinations by means of tanks or lysimeters is dependent on nearness of reproduction of natural conditions. Artifical conditions are caused by the limitations of soil, size of tank, regulation of water supply and sometimes environment.

Measurements by soil moisture studies in field plots are usually more dependable than measurements with tanks or lysimeters. The procedure used is to measure the volume of water applied to the plot at each irrigation and to measure any appreciable runoff that may occur. Frequently the field plots are bordered to prevent appreciable runoff and the water is applied to shallow depths to prevent excessive movement of water through the plant root zone.

Where the soil is fairly uniform and the depth to ground water is such that it will not influence the soil moisture fluctuations within the root zone, the consumptive use of water by various crops may be determined by intensive soil moisture studies. This method consist of taking representative soil samples by means of a standard soil tube sampler before and after each irrigation with additional samples between irrigations. If the area receives no additional moisture between water content determinations and the water movement in a vertical direction within the soil is insignificant, the transpiration for each foot zone of soil may be estimated. The water evaporation rates for a given period may be obtained by subtracting the transpiration rate from the total water usage for the desired time interval. The separation of transpiration and evaporation allows the determination of a more accurate estimate of minimum consumptive use for each crop grown for maximum net return.

A method of determining consumptive use by the analysis of climatological data is an empirical relationship adapted to irrigation by Blaney and Criddle (2). It is expressed as $U = KF$ where U is the consumptive use of the crop in inches for a given time period, K is an empirical coefficient, and F is the sum of the monthly consumptive use factors for the period, (sum of the products of mean monthly temperature and monthly percent of annual daytime hours). Measured consumptive use studies permit a more accurate estimate of the empirical coefficient K. The coefficient (K) for each crop is based on the assumption that the crop receives a full water supply throughout the growing season or frost free period.

Harrold (10) reported that pan evaporation data correlated with consumptive use data determined by lysimeters may be useful in developing soil moisture "bookkeeping" procedures for farm use in scheduling the time and amount of irrigation. Pruitt (15) has developed an "irrigation scheduling guide" by correlating pan-evaporation data with consumptive use data for similar locality. The farm operator would find the guide simple to operate once it was set up for him by irrigation technicians.

Estimates of consumptive use for existing irrigation projects are often made by the integration method. Briefly, this method consists of adding the total quantities of water consumed on different areas in the project and dividing by the total area. To apply this method, data must be available regarding total areas, acreages used in producing different crops, areas of native vegetation, and areas of water and bare land surfaces. Rates of evaporation and evapotranspiration on the different areas also must be known. When the rates of moisture consumption for different surfaces have been determined by tank or field plot measurements, estimates by the integration method are fairly reliable.

The consumptive use for large areas is often determined by the inflow-outflow method. Applying the method, the consumptive use for the area is equal to the quantity of water that flows into the area during a 12-month year, plus the yearly precipitation on the area, plus the water in ground storage at the beginning of the year, minus the water in ground storage at the end of the year and the yearly outflow. All volumes are measured in acre-feet.

Consumptive Use of Water by Peanuts

The only known report on the consumptive use of water by peanuts is reported by Whitt and Van Bavel (20). Excerpts from this report are as follows:

Most favorable climatic conditions for peanuts are moderate rainfall during the growing season and an abundance of sunshine and relatively high temperatures. Largest yields of good quality market peanuts are obtained on well-drained light sandy loam soils.

Ralph S. Matlock in studies at the Oklahoma Agricultural Experiment Station estimates that 25 inches of water are required in the growing season for optimum growth and yield of peanuts. W. J. Vinzant in trials with farmers in Roosevelt County, New Mexico arrived at the same value. Measurements of daily water use have not been made. Workers at all experiment stations prefer to irrigate before the plants show signs of wilting. A good rule is to keep the available moisture above 50 percent in the root zone. . .

Yield increases vary from state to state. In New Mexico and southwestern Oklahoma, irrigation means the difference between a crop and no crop. In Virginia, acre yield increases ranged from 944 pounds to 1365 pounds of nuts. Average production without irrigation was 1529 pounds compared with 2642 pounds per acre with supplemental water.

Depth of rooting estimates vary from two to four feet or more depending on the texture of the soil. Penetration to six feet has been reported of the light sandy soils of Georgia.

A summary of irrigated acreage of peanuts given in the report by Whitt and Van Bavel is presented in Table I.

TABLE I

IRRIGATED ACREAGE OF PEANUTS (ESTIMATED FOR 1954)

State	Acres	Percent of Total
Oklahoma	10,000	7.2
New Mexico	5,600	100.0
Virginia	200	0.2

Consumptive Use of Water by Grain Sorghum

Bechett and Huberty (1) reported the seasonal water requirements for Dwarf Milo for a four year period in the

Sacramento and San Joaquin Valleys of California. A summary of their results is presented in Table II.

TABLE II

WATER REQUIREMENTS FOR DWARF MILO IN THE SACRAMENTO AND SAN JOAQUIN VALLEY OF CALIFORNIA, 1910-1922

Year	Water Requirements for Maximum Yield (Inches)
1910	17.4
1911	28.8
1913	26.7
1922	30.2

Marr (12) reported that the water requirement for Dwarf Milo grain sorghum in the Salt River Valley of Arizona to be 27.3 inches for maximum yield. The average water requirement for 21 fields tested was 25.5 inches.

Fortier (4) reported the water requirements of the arid and semi-arid lands of the Missouri and Arkansas River Basins. The water requirement of kafir corn was 21 inches near Lawton, Oklahoma, in 1919. The water requirement was determined to be 18 inches at Hays, Kansas, 1904. The water requirement for Hays corresponded closely to the 17 inches determined from similar tests near Garden City, Kansas. It was reported that the water requirement for Garden City had increased to 30 inches in 1916.

The seasonal water requirements of the arid and semi-arid lands of the Southwest was reported by Fortier and Young (5). A summary of 16 tests on kafir corn determined a range in the water requirements from 15.8 to 18.5 inches for maximum yield. In summarizing 35 tests with Milo grain sorghum, the water requirements for profitable yields were found to range from 11.5 to 20.0 inches.

The most comprehensive experimentation to determine the water requirements of grain sorghum was performed by McDowell (13) over a five year period in the Witchita Valley of Texas. The water requirement for optimum yields for conditions prevailing in the Wichita Valley was reported to be 38 to 39 inches. The results reported by McDowell is summarized in Table III.

TABLE III

WATER REQUIREMENTS FOR GRAIN SORGHUM IN THE WITCHITA VALLEY OF TEXAS, 1932-36

Year	Water Requirement for Optimum Yield (Inches)
1932	23.6 to 32.6
1933	27.6 to 33.6
1934	30.8
1935	33.3 to 37.3
1936	51.8

Musick (14) reported the seasonal consumptive use by grain sorghum for El Reno, Oklahoma, 1954, to be 21.91 inches. The 1954 growing season in Oklahoma was unusually hot and dry.

Methods of Determining Soil Moisture

One of the most important and difficult problems that faces farmers, engineers, and scientists in irrigation areas is to determine when and how much water to apply to the soils for best crop production. A measure of the amount of available moisture in the soil at a given time is essential in the scheduling of irrigations and determining the amount of water to be applied.

Taylor (17) lists several methods of measuring the soil moisture content. A comparison of those listed shows that none of the presently available field methods are completly satisfactory. The methods reported by Taylor are (1) tensiometer studies, (2) the use of electrical resistance units, (3) neutron method, and (4) gravimetric method.

Electrical resistance blocks have been made of various kinds of plaster, nylon, fiberglass, and plaster blocks with nylon and fiberglass around the electrodes.

Haise (8) discusses the use of nylon blocks in soil moisture studies. A summary of this report is as follows:

Nylon blocks provide greater sensitivity in the higher soil moisture ranges than do the previously used plaster of paris blocks.

One objection to the use of nylon blocks in the field arose from imperfect contact with the soil alternately wet and dry. The outside metal apparently prevents intimate contact between the moisture absorbing fiber and the soil particles. The response of the unit to moisture changes in the soil is often erratic and unreliable under such conditions.

Another method being tested in determining the soil moisture content is the use of an Aquaprobe. Its principle of operation is based on the relation between the soil moisture content and the amount of electrical current the soil will conduct.

CHAPTER IV

METHOD AND PROCEDURE

Location of Experimental Area

The Fort Reno Livestock Research Station, near El Reno, Oklahoma, was selected as the location of the experimental plots. The plots were located on a Canadian loam area.

The following soil description was made 700 feet south and 300 feet west of the actual plot area. (Personal communication with Harry Galloway, USDA, Stillwater, Oklahoma):

0 to 15 inches: Grayish-brown loam which is finely granular, friable, and permeable with a pH of 7.0. The upper portion is slightly lighter in color than that below 6 inches. It grades to the layer below.

15 to 24 inches: Brown loam, which is like the layer above, becomes slightly lighter in color in the lower part and grades to the layer below.

24 to 42 inches: Light brown weakly calcareous loam slightly stratified with fine sandy loam and silt loam.

Below 42 inches: A reddish brown silty clay loam layer which is moderate medium subangular blocky; finer and less permeable than the layers above. It is streaked with thin white seams of calcium carbonate. Lower layer varied in depth and may be absent in places in adjacent field.

Equipment Used

Water was pumped from an irrigation well located 200 feet north of the plot area, piped to the area in a 6 inch main line, and applied to the furrows by the use of gated pipe. An orifice flow meter and recorder were used to measure and record the rate of flow. A gate valve on the pump discharge was used to regulate the flow. The electric motor and pump unit, orifice plate flow meter and recorder, and gate valve are illustrated in Figure 1. An official rain gage located adjacent to the plots was used to measure the rainfall.

Moisture samples were taken by the use of a standard soil sampling tube and a post-hole auger sampler. The samples were dried in an electric oven. Apparent specific gravity samples were taken with a sharpened cylinder soil sampler.

Fertilizer was applied to the plots by the use of a Planet Junior Fertilizer Applicator. A one-row tractor cultivator was used to cultivate the plots.

The peanuts were dug for harvest by a semi-disk digger mounted on a one-row tractor cultivator and threshed by the use of a mechanical peanut picker modified for plot work. Standard peanut grading sieves were employed in determining the size of peanuts. The grain sorghum was threshed by a small grain plot thresher.

Additional equipment used in this study was an Aquaprobe, Bouyoucos bridge, and 54 nylon blocks.

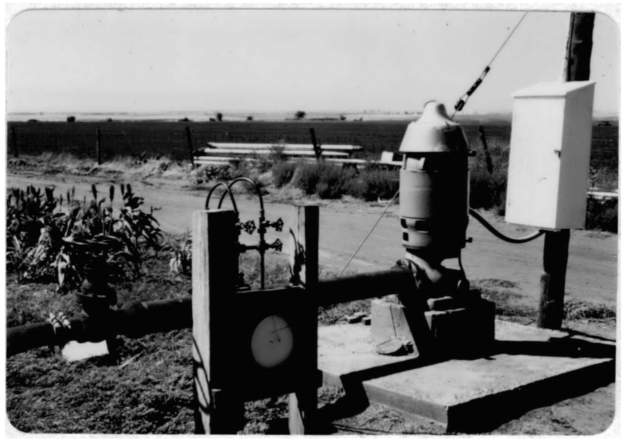

Figure 1. Electric motor and pump unit, orifice flow meter and recorder, and flow regulating gate valve.

Plot Layout and Treatments Used

The peanut plots were laid out in a randomized block, split-plot statistical design to permit statistical analysis of the yield for the selection of optimum water and fertility treatment. The plot layout of peanuts is shown in Figure 2. Eight-row main plots, 50 feet long, and four-row sub-plots, 25 feet in length, were selected for the peanuts. The selection of eight-row plots permitted the harvesting of the six center rows of the main plot without significant border effects due to either water or fertilizer. Three replicates were selected and blocked in the layout. Treatments were randomized within each block.

The grain sorghum plots were laid out in a completely randomized statistical design. The layout of these plots is illustrated in Figure 3. The size of the main plots and sub-plots was the same as used for the peanuts. The four middle rows of the main plot were selected for yield sampling.

Rep I			Rep II			Rep III		
W			W			W		
W_2	F_2	F_1	W_1	F_0	F_3	W_0	F_0	F_1
	F_0	F_3		F_2	F_1		F_2	F_3
W_1	F_3	F_2	W_2	F_1	F_2	W_3	F_2	F_1
	F_1	F_0		F_0	F_3		F_0	F_3
W_0	F_1	F_3	W_3	F_0	F_1	W_1	F_2	F_1
	F_0	F_2		F_2	F_3		F_0	F_3
W_3	F_2	F_0	W_0	F_0	F_3	W_2	F_1	F_2
	F_1	F_3		F_2	F_1		F_0	F_3

W_0 = No irrigation

W_1 = Irrigate after plant has wilted one week

W_2 = Irrigate after plant has wilted 24 hours

W_3 = Maintain soil moisture above 30 percent of available moisture

F_0 = No fertilizer

F_1 = 50 pounds of 6-24-24 per acre

F_2 = 150 pounds of 6-24-24 per acre

F_3 = 300 pounds of 6-24-24 per acre

Figure 2. Layout of peanut plots.

W_3	F_0	F_2	W_0	F_0	F_1	W_0	F_1	F_0
	F_3	F_1		F_2	F_3		F_2	F_3
W_2	F_0	F_1	W_2	F_2	F_0	W_1	F_1	F_3
	F_3	F_2		F_1	F_3		F_2	F_0
W_2	F_0	F_2	W_0	F_3	F_0	W_3	F_0	F_1
	F_1	F_3		F_1	F_2		F_3	F_2
W_1	F_2	F_1	W_1	F_2	F_3	W_3	F_2	F_3
	F_3	F_0		F_1	F_0		F_1	F_0

W_0 = No irrigation

W_1 = Irrigate after plants have wilted for one week

W_2 = Irrigate after plants have wilted for 24 hours

W_3 = Maintain soil moisture above 30 percent of available moisture

F_0 = No fertilizer

F_1 = 100 pounds of 13-13-13 per acre

F_2 = 200 pounds of 13-13-13 per acre

F_3 = 400 pounds of 13-13-13 per acre

Figure 3. Layout of grain sorghum plots.

Crop Management Procedure

The grain sorghum variety, Dwarf kafir 44-14 was planted on June 6. The third planting of an experimental peanut strain, Spanish 13-10, was made on June 27. Two earlier attempts to establish a stand had failed due to weather and mechanical difficulties.

The stand of peanuts was approximately 27,000 plants per acre. The average plant spacing was 5.8 inches. The grain sorghum was planted to a stand of 30,000 plants per acre with an average plant spacing of 4.3 inches.

Fertilizer was applied in the same manner to both crops. It was applied on the south side of each row, 2 to 4 inches from the seed, and 1 to 2 inches below the ground surface. All of the rows within the plots were fertilized. The peanut plots were fertilized at various rates of 6-24-24 on June 14, soon after the date of the first planting. The grain sorghum plots were side dressed on July 13 with various rates of 13-13-13.

Irrigation Procedure

Irrigation water was applied to the plots through gated pipe. Furrow irrigation was used with borders built around each plot. The method of water application is illustrated in Figure 4. All water was held on the plots, except for negligible losses that occasionally occurred as a result of breakovers. Since the plots were located near the irrigation well, only minor losses occurred due to leakage in the main line. Three inches of water per application were applied to each crop at the rate of 3 inches per hour.

Figure 4. Furrow irrigation with gated pipe.

A high rate of application was selected to minimize differences in water penetration along the rows. The infiltration rate varied from 0.25 inch per hour early in the growing season to 0.10 inch per hour in the latter part of the season. The slope of the plots was negligible.

The time to irrigate the W_3 plots was determined by comparing the soil moisture percentage of the top foot of soil depth with the permanent wilting point. The permanent wilting percentage, determined by soil moisture sampling when the grain sorghum plants in the check plots were in the permanent wilting stage, was found to range from

6.5 to 7.5%. The soil water content in the peanut plots was never sufficiently low to permit the determination of the permanent wilting point for the peanuts.

Water was applied to the W_2 plots 24 hours after noticable temporary wilting occurred. Difficulty in maintaining plant wilt for a period of one week in the W_1 plots arose due to the occurrance of rainfall during the week when the plants were wilting. If the rainfall during the week of wilt was appreciable, the quantity of water, equal to three inches minus the amount of rainfall, was applied one week after the wilting period began.

Soil Sampling Procedure

Soil samples were taken before and after each irrigation. When the soil had approximately reached field capacity, usually two to four days after the water had been applied, soil samples were taken to determine the amount of water in the soil at each depth sampled. Additional samples were taken between the date when field capacity was reached and prior to the next irrigation as time permitted.

The two middle rows in each water treatment of the east replicate were used as representative of the plot area for soil moisture sampling. Soil samples taken within each water treatment were offset approximately 5 feet from the center of the water treatment. Rotation of the side of row and direction from the center of the water treatment to be used as the soil sampling site, was employed to minimize the effect of the hole made in the soil adjacent to plants by the soil tube sampler. Profile samples were taken with either a soil tube sampler or a post-hole auger at the center of 1 foot intervals to a depth of 3 feet at each site. Gray (6) lists the feeder root depth for grain sorghum as 2.5 feet. The same feeder root depth was estimated for the peanuts. Soil samples were taken 1 to 2 inches to the side of the row as the plant spacing within the row did not always lend itself easily to sampling in the row.

Samples used in water content determinations were placed in airtight containers and weighed shortly after collection. Each sample was dried in an electric oven at 105 to 110°C for a minimum of eight hours and the dry weights determined. The water content of each sample was expressed as percentage of oven-dry weight of soil.

The undisturbed core samples for the apparent specific gravity determinations were taken with a sharpened cylinder sampler. Three samples were collected at approximately the center of each foot depth of soil at each crop location. The real specific gravity was determined by the use of a 150 ml. pycnometer bottle. The core samples used in the apparent specific gravity determinations were also used for the real specific gravity determinations. The real specific gravity did not vary appreciably. A summary of the apparent specific gravity values, real specific gravity, and the calculated and estimated values of field capacity and temporary wilting point is presented in Table XVI of Appendix B.

Study of Nylon Blocks

Nylon blocks were located in the row at the center of each one foot interval to a depth of 3 feet. Each block was located within one foot of a soil sampling location. A small quantity of water was added to the soil at each block location previous to the block placement. Water was added to provide close contact between the blocks and the soil.

A time interval of three weeks between the placement of the blocks and the bridge readings was allowed to permit soil moisture equilibrium in the surrounding area.

The electrical resistance in each block was determined by the use of a Bouyoucos bridge. Bridge readings were observed soon after the soil moisture sample had been obtained for each block location.

Aquaprobe Study

Aquaprobe readings were obtained at the soil moisture sampling locations. Since the orientation of the instrument affects the dial readings, it was oriented in the same direction for each reading.

Crop Yield Sampling Procedure

Fifteen feet of each of three rows nearest the center of the water treatment were taken from each peanut sub-plot on December 1. The disc cut the peanut vines at a point on the plant between the location of the peanuts and the lower plant root development. After the peanut vines were cut, most of the soil was removed from the peanuts by shaking the vines. The vines from each 15 feet of row were tied into a bundle and labeled.

The peanuts were threshed when adequate drying of the vines had occurred. The vines in each bundle were counted at the time of threshing. All sticks and other foreign material were removed before weighing. The cleaned quantity of peanuts was then placed in a paper bag, weighed, and 20 double-seeded peanut pods were taken at random from each bag. These samples were used in determining the shelling percentage of each 15 feet of row sampled. After the peanuts of a sample were hulled, they were passed through slotted peanut hand sieves. The number and weight of the peanuts collected on each sieve were recorded. Also, the number and weight of any peanuts which were discolored were recorded. The shelling percentage of each sample was expressed as the percentage of sound mature kernels, based on the total weight of sample extracted (peanut hulls included). Yield of peanuts was expressed as the weight in pounds per acre of sound mature kernels.

The grain sorghum heads were harvested from 15 feet of each of three rows nearest the center of the water treatment in each sub-plot on October 12. The samples were air-dried for approximately two weeks, threshed by the use of a college plot thresher, and weighed to the nearest 1/10 gram. Yields were expressed as bushels per acre.

Procedure for Calculations

The average daily consumptive use of water between irrigations for the three foot root zone was determined for both the peanuts and grain sorghum. Consumptive use for each foot of soil could be determined only for the peanuts due to difficulties encountered in properly determining the time interval between soil samplings in the grain sorghum plots. The basic formula, normally used in transpiration calculations, was used in determining the moisture depletion by peanuts from each foot of soil for the 3 foot root zone depths. The formula used is as follows:

$$d = \frac{P \, A_s \, D}{100}$$

where d = depth of soil moisture depletion in inches,

P = difference in percent of soil moisture between two determinations,

A_s = apparent specific gravity of the soil, and

D = depth of soil sampled in inches.

This formula may be used in the determination of the transpiration between two soil samplings only when no water has been added between samplings to the depth of soil sampled. The addition of water to this depth may occur as gravity or capillary water. Since rainfall between soil samplings in each crop nullified the transpiration data in several instances, values for the consumptive use between samplings were used. The spacing of the soil samplings in the peanut plots was adequate to permit the estimation of the percent moisture used from each foot of soil during the growing season. The consumptive use between samplings was determined by adding the moisture depletion from the 3 feet of soil sampled to the amount of rainfall that occurred for the time interval. Values of consumptive use by peanuts for each foot sampled were calculated using the percent of seasonal moisture depleted from each foot of soil sampled.

The yields were analyzed statistically for each crop according to standard analysis procedure. The new multiple range test for significant difference between water treatment means of grain sorghum yields was run at the 1% level.

CHAPTER V

RESULTS

Yield and Consumptive Use for Peanuts

The peanut yields in pounds per acre for the water and fertility treatments are summarized in Table IV. Also included in this table, is the yield increase per acre-inch of irrigation water applied. A statistical analysis of the yield to determine if significant differences existed between water treatments, fertility treatments, and their interactions is presented in Table V. The only significant difference that was obtained was the water and replication interaction. This interaction was highly significant at the 0.1% level.

Standard error for means, standard error for difference between the means, and coefficient of variation values are listed in Table VI.

The relation between water treatment and crop yield for each fertility treatment is illustrated in Figure 5. Figure 6 illustrates the relation between fertility treatment and crop yield for each water treatment. Although no significant difference between the water treatments was obtained, it should be noted that there was an increasing crop response to fertilizer at the higher water level (Figure 5). Since the results obtained in this experiment did not define the

TABLE IV

PEANUT YIELDS IN POUNDS PER ACRE

Fertility Treatments	Water Treatments				
	W_0	W_1	W_2	W_3	Means
F_0	932	963	835	811	885
F_1	895	867	686	1010	864
F_2	1106	852	780	1170	977
F_3	946	708	696	1068	854
Means	970	847	749	1015	895
Irrigation Water Applied Inches	0	8.50	11.50	17.50	
Yield Increase Per Acre-Inch of Irrigation Water Applied	---	-14.5	-19.2	2.6	

TABLE V

ANALYSIS OF VARIANCE OF PEANUT YIELDS

Source	d.f.	M. S.	F	P
Replications	2	18,787	---	---
Water	3	425,697	---	---
Fertilizer	3	91,766	1.93	---
Water x Rep. interaction	6	684,616	14.4	.001
Water x Fert. interaction	9	86,024	1.80	---
Fert. x Rep. interaction	6	59,332	1.24	---
Error (Water x Fert. x Rep) interaction	18	47,702		

TABLE VI

STANDARD ERROR FOR MEANS, STANDARD ERROR FOR DIFFERENCE BETWEEN MEANS, AND COEFFICIENT OF VARIATION FOR WATER TREATMENTS

Statistic	
Standard Error Mean	63.05
Standard Error Difference	89.16
Coefficient of Variation	15.6%

the peak crop response to water, higher levels of water application are necessary to obtain the consumptive use of water by peanuts for optimum crop yield.

The size of vine development during the latter portion of the growing season is illustrated in Figure 7. The difference in color between the plots shown is due to the difference in exposure of the film and not due to differences in the effect of the water and fertility treatments upon the plants. No apparent difference in vine growth between treatments was noted at any time during the growing season. The plants receiving the higher water level treatment were not as green in appearance near maturity as were those in the check plots.

The shelling percentage of the peanut yields based on percent by weight of sound mature kernels is given in Table VII.

Freezing temperatures in late October and early November stopped the physiological growth of the plants. At this time, many of the nuts had not fully matured. Late

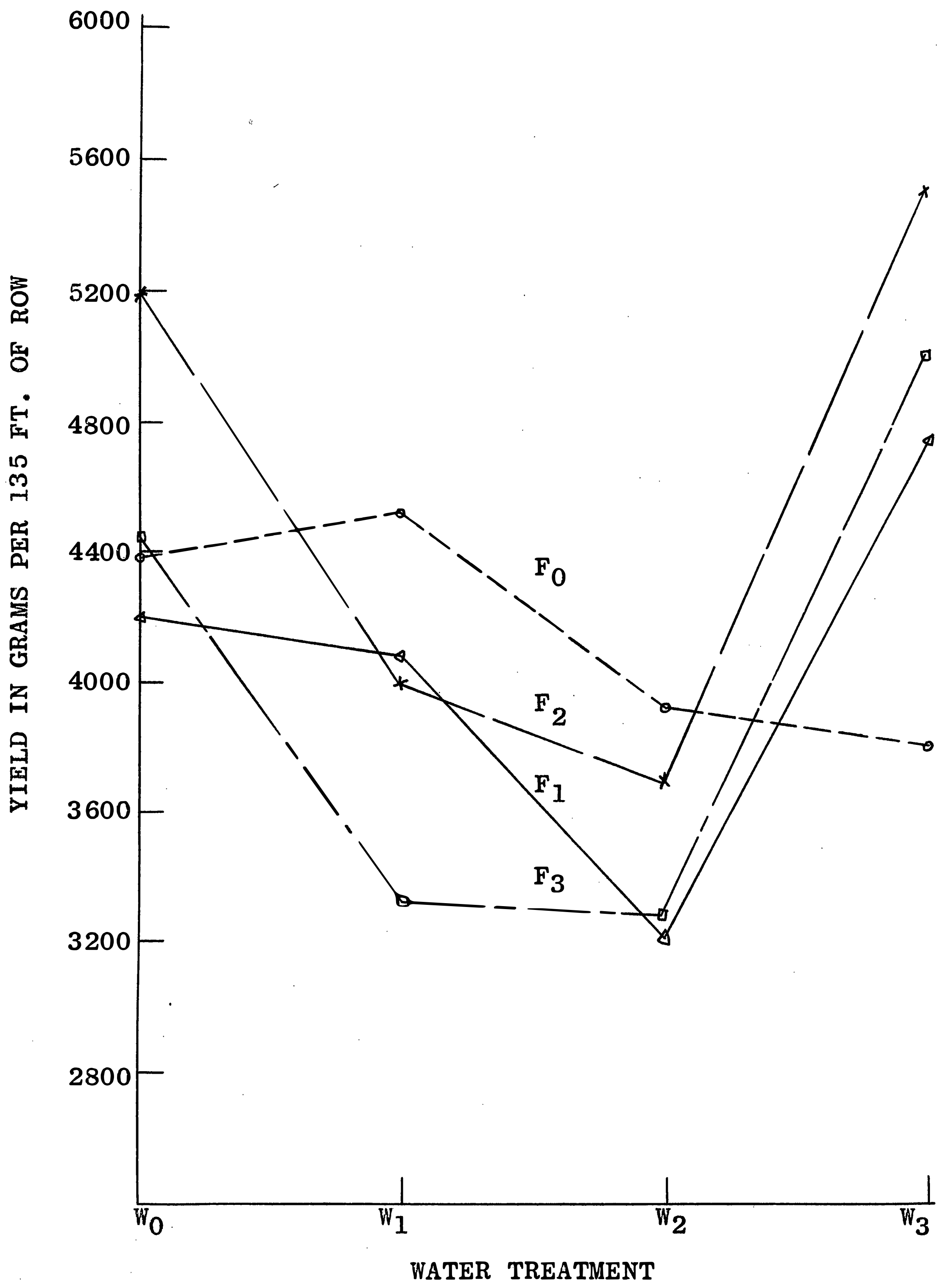

Figure 5. Relation between water treatment and crop yield of peanuts for each fertility treatment.

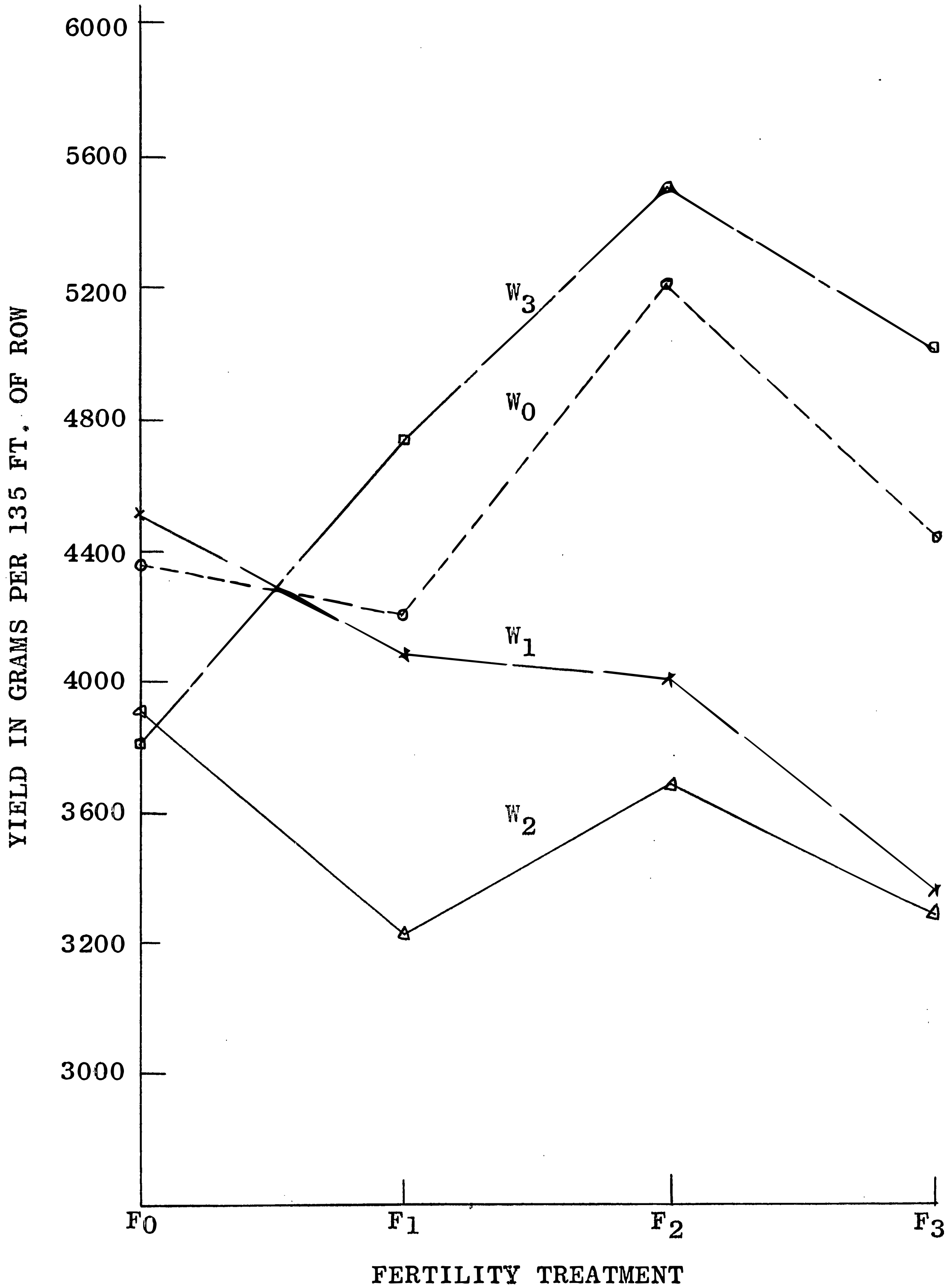

Figure 6. Relation between fertility treatment and crop yield of peanuts for each water treatment.

W_0 plot of Rep II in foreground

W_3 plot of Rep I in background

W_1 plot of Rep II in foreground

W_2 plot of Rep I in background

Figure 7. Peanut plots during the latter portion of the growing season.

TABLE VII

SHELLING PERCENTAGE OF PEANUT YIELDS BASED ON PERCENT BY WEIGHT OF SOUND MATURE KERNELS

Replication	Fertilizer Treatment	Water Treatment W_0	W_1	W_2	W_3	Means
1	F_0	71.6	64.0	61.5	68.7	66.4
	F_1	71.0	61.6	59.3	67.9	64.9
	F_2	73.8	59.1	61.7	71.6	66.5
	F_3	70.2	59.6	63.8	73.9	66.9
Means		71.7	61.1	61.6	70.1	66.1
2	F_0	73.3	61.6	65.0	68.0	67.0
	F_1	70.6	66.3	65.6	68.0	67.6
	F_2	77.2	66.5	61.7	68.4	68.4
	F_3	72.2	63.6	65.4	68.9	67.5
Means		73.4	64.5	64.4	68.3	67.6
3	F_0	66.4	74.0	71.4	64.8	69.2
	F_1	68.5	66.6	73.2	64.1	68.1
	F_2	64.7	70.7	69.5	61.2	66.5
	F_3	66.3	70.4	72.4	63.9	68.2
Means		66.5	70.4	71.6	63.5	68.0
Means		70.5	65.3	65.9	67.3	67.2

maturity was primarily due to the late establishment of an adequate stand of peanuts.

Average daily consumptive use curves are presented in Figure 8. Data on the consumptive use by peanuts and grain sorghum are summarized in Table VIII. The net irrigation requirement for the W_3, W_2, and W_1 plots was 17.50 inches, 11.5 inches, and 8.5 inches respectively.

Yield and Consumptive Use for Grain Sorghum

The grain sorghum yields in bushels per acre for the different water and fertility treatments are summarized in Table IX. The yield increase per acre-inch of irrigation water applied is also included in this table. A statistical analysis of the yield to determine if significant differences existed between water treatments, fertility treatments, and their interactions is presented in Table X. The difference in the mean yield for water treatments was highly significant at the 0.1% level. The new multiple range test for significant difference between water treatment means at the 1% level is presented and explained in Table XI. Differences between fertility treatments and the interaction of the water and fertility treatments were not significant.

Standard error for means, standard error for difference between the means, and coefficient of variation values are given in Table XII.

The relation between water treatment and crop yield for each fertility treatment and the relation between fertility treatment and crop yield for each water treatment is illustrated in Figures 9 and 10 respectively.

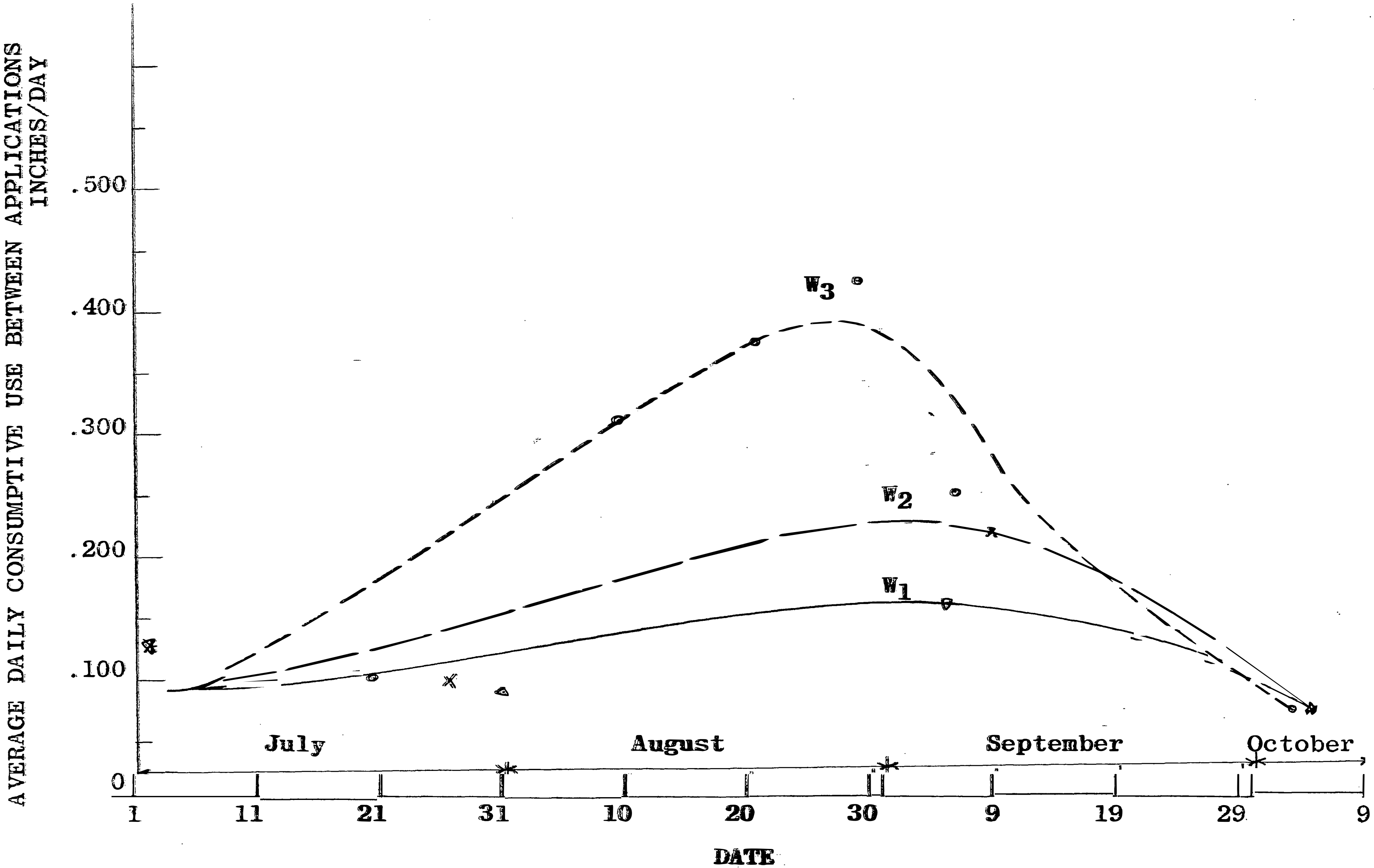

Figure 8. Average daily consumptive use curves for peanuts, Ft. Reno, Oklahoma, 1955.

TABLE VIII

SUMMARY OF CONSUMPTIVE USE OF WATER BY PEANUTS AND GRAIN SORGHUM

Crop and Treatment		Peak Daily Consumptive Use Inches	Date of Peak Consumptive Use	Average Daily Consumptive Use for Irrigation Season (Inches)	Peak Monthly Consumptive Use Inches	Seasonal Consumptive Use Inches
	W_3	0.420	Aug. 25-Sept. 2	0.197	9.94	23.21
Peanuts	W_2	0.215	Aug. 16-Sept. 2	0.146	5.02	17.25
	W_1	0.153	Aug. 25-Sept.16	0.120	2.96	14.17
	W_3	0.367	Aug. 16-Aug. 25	0.191	8.48	24.07
Grain Sorghum	W_2	0.281	Aug. 20-Sept. 2	0.167	7.48	21.07
	W_1	0.121	Aug. 12-Sept. 2	0.112*	3.41	16.95

*The consumptive use value between June 13 to 22 was deleted due to excessive rainfall for that period.

TABLE IX

GRAIN SORGHUM YIELDS IN BUSHELS PER ACRE

Fertility Treatments	Water Treatments				
	W_0	W_1	W_2	W_3	Means
F_0	33.5	55.3	53.5	46.8	47.3
F_1	30.9	47.3	48.1	48.7	43.8
F_2	27.2	50.7	52.7	45.1	43.9
F_3	38.2	49.9	53.2	45.4	46.6
Means	32.4	50.8	51.9	46.5	45.3
Irrigation Water Applied Inches	0	3.38	7.50	13.50	
Yield increase per acre-inch of irrigation water applied	--	5.44	2.60	1.04	

TABLE X

ANALYSIS OF VARIANCE OF GRAIN SORGHUM YIELDS

Source	d.f.	M. S.	F	P
Water treatments	3	3,271,947	9.01	.001
Fertilizer treatments	3	137,048	---	---
Water x Fertilizer interaction	9	97,010	---	---
Error	32	437,996		

TABLE XI

THE NEW MULTIPLE RANGE TEST FOR SIGNIFICANT DIFFERENCE BETWEEN WATER TREATMENT MEANS OF GRAIN SORGHUM YIELDS AT THE 1% LEVEL.

Water Treatments	W_0	W_1	W_2	W_3
Means	1892	2713	2962	3027

Note: Any two means not underscored by the same line are significantly different at the 1% level.

Any two means underscored by the same line are not significantly different at the 1% level.

TABLE XII

STANDARD ERROR FOR MEANS, STANDARD ERROR FOR DIFFERENCE BETWEEN THE MEANS, AND COEFFICIENT OF VARIATION FOR WATER TREATMENTS

Statistic	Grain Sorghum
Standard Error Mean	191.05
Standard Error Difference	270.17
Coefficient of Variation	25.0%

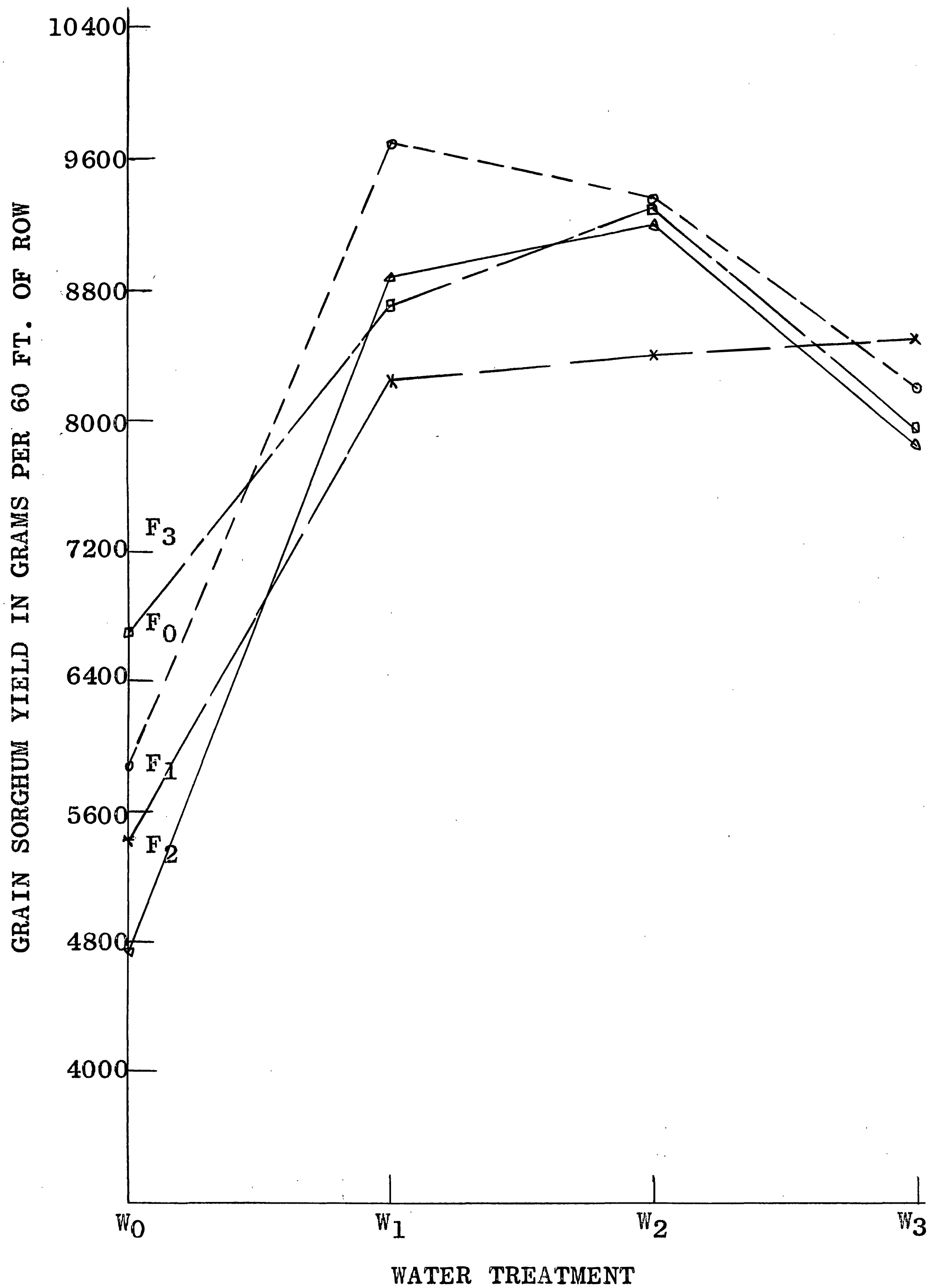

Figure 9. Relation between water treatment and crop yield of grain sorghum for each fertility treatment.

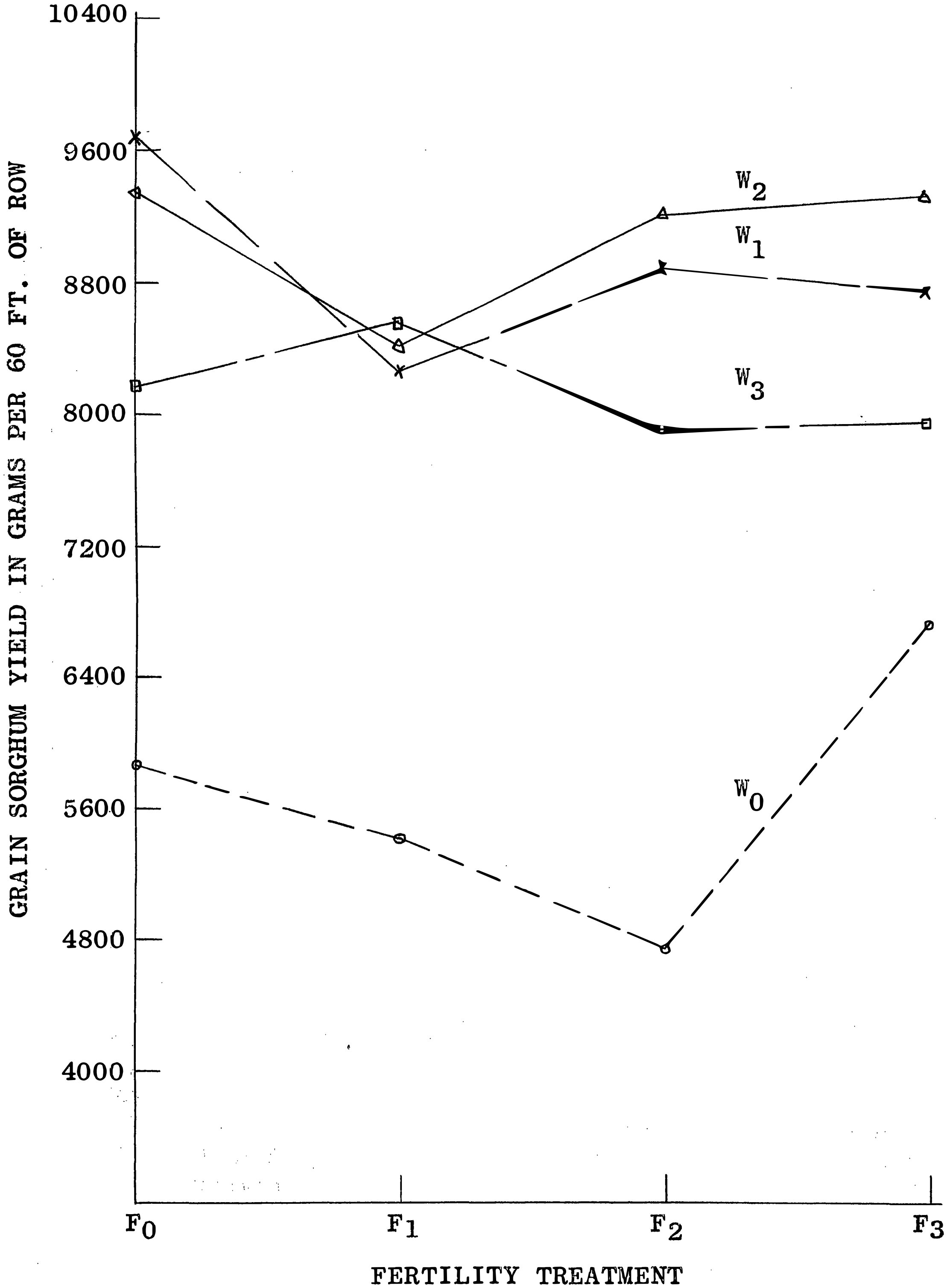

Figure 10. Relation between fertility treatment and crop yield of grain sorghum for each water treatment.

The appearance of the grain sorghum plots near maturity is illustrated in Figure 11. No appreciable difference was noted between the appearance of the W_3, W_2, and W_1 plots as the plants approached maturity. However, considerable difference in plant growth and yield was present between W_0 and the other treatments.

Considering the results presented in the new multiple range test and the appearance of the plots near maturity, the W_1 treatment was selected as the water treatment for optimum yield of grain sorghum where the water supply is limited. Temporary wilting of the plants for periods not exceeding one week did not significantly decrease the yield. The slope of the moisture use-yield curve, Figure 12, between treatments W_1 and W_2 also illustrates this fact.

The average daily consumptive use curves are presented in Figure 13. These curves illustrate the rate of consumptive use for each water treatment throughout the growing season. The peak daily consumptive use occurred during the period of August 16 to 25 for W_3 and between August 20 and September 2 for W_2. The peak daily consumptive use for the W_1 plots was not clearly defined as the rate of consumptive use did not change appreciably throughout the growing season. Data on the consumptive use by grain sorghum is summarized in Table VIII. The peak daily consumptive use, average daily use for irrigation season, monthly use, and the seasonal use was calculated to be 0.121 inch, 0.112 inch, 3.41 inches, and 16.95 inches respectively for optimum yields for a limited water supply. The irrigation water

W_0

W_1

W_2

W_3

Figure 11. Grain sorghum plots near maturity

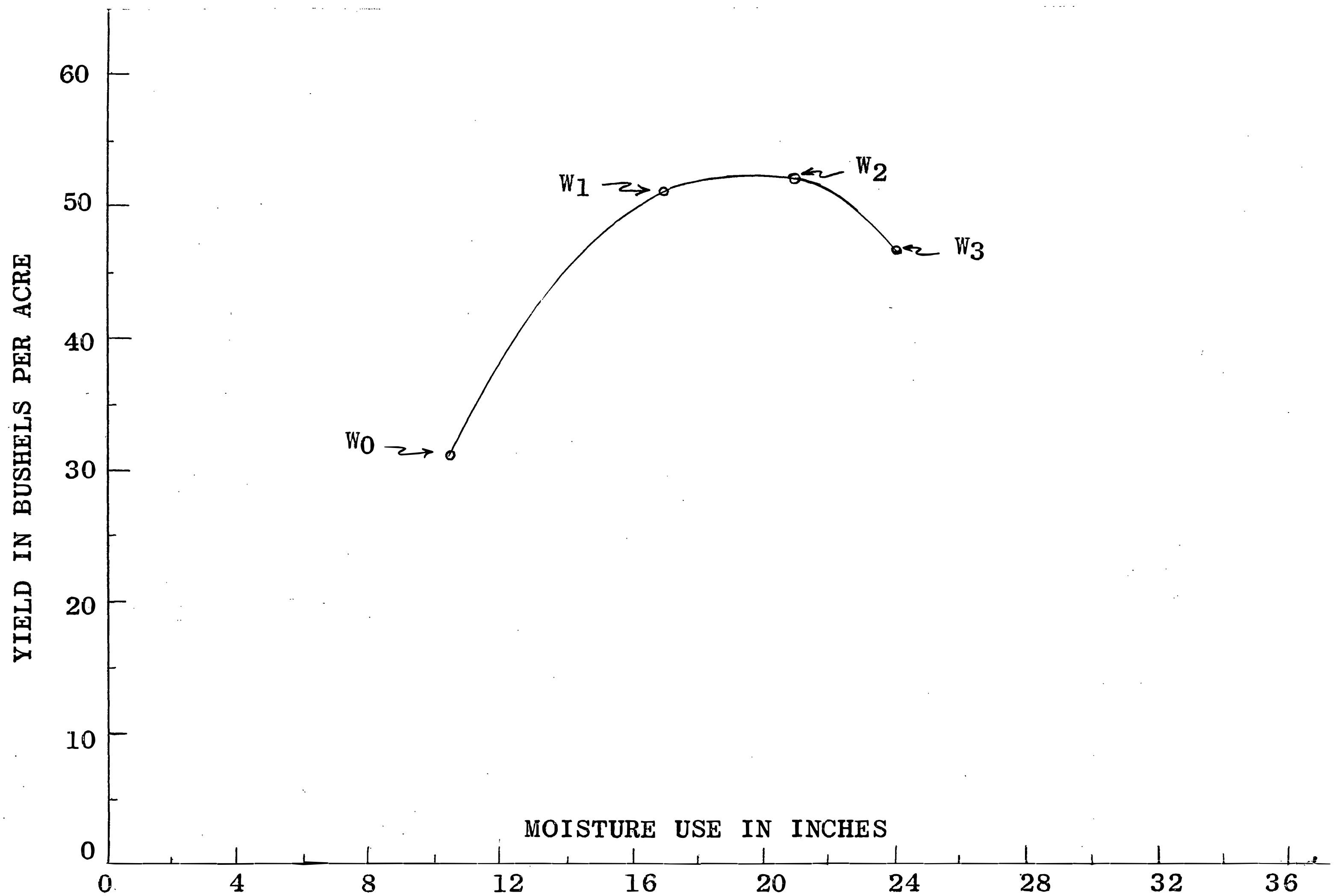

Figure 12. Moisture use-yield curve for grain sorghum, Ft. Reno, Oklahoma, 1955.

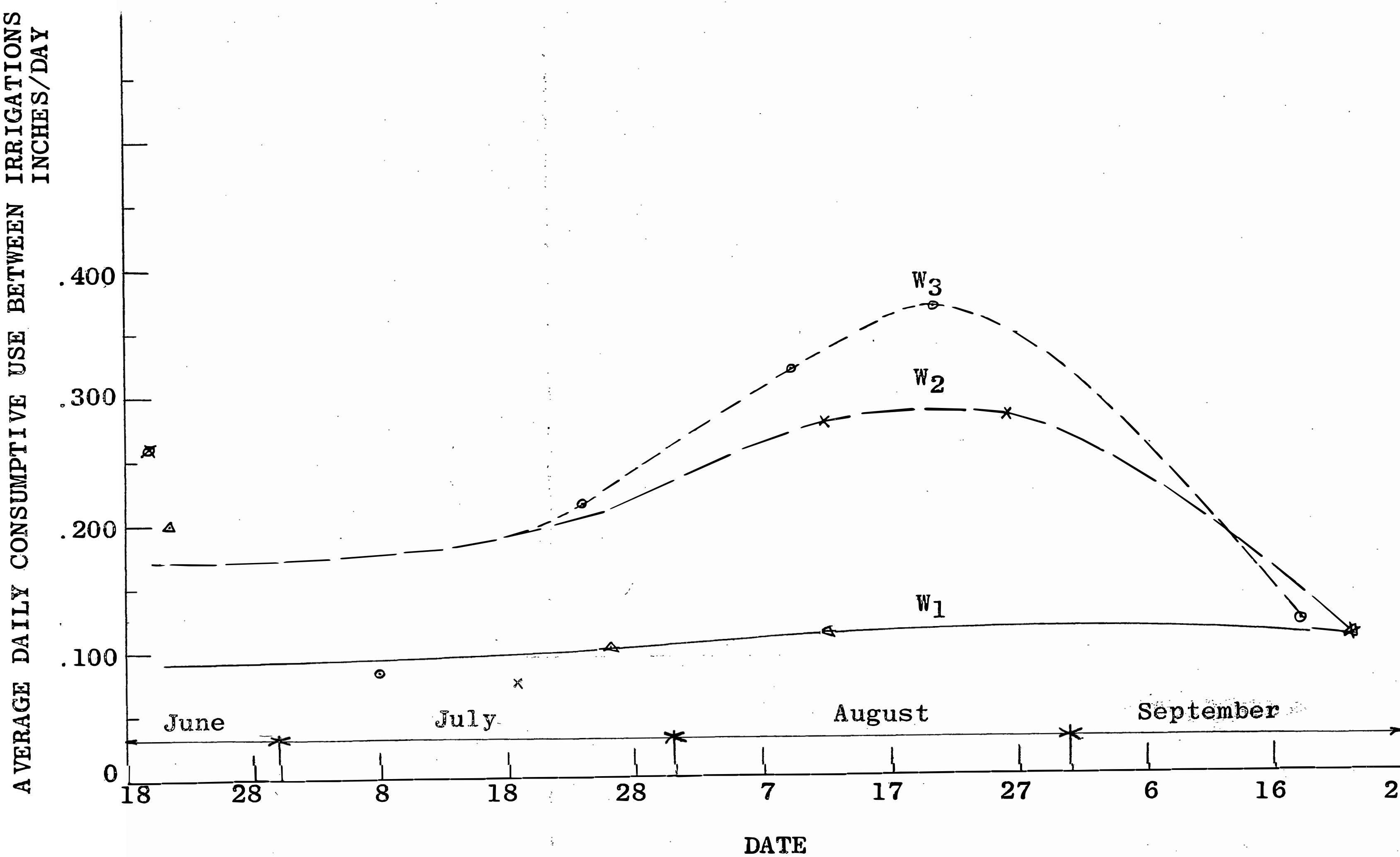

Figure 13. Average daily consumptive use curves for grain sorghum, Ft. Reno, Oklahoma, 1955.

applied for this treatment was 6.38 inches. The water was applied in one 0.50 inch, one 1.00 inch, and two 3 inch applications. The 0.50 inch and 1.00 inch applications were applied early in the growing season.

A comparison of the consumptive use for 1955 and that determined by Musick (13) for 1954 illustrates the effect of climatic conditions on the consumptive use by grain sorghum. Musick reported the consumptive use by grain sorghum for 1954 as 21.91 inches. This value was determined for the wilt 24 hours treatment. Considerable difference occurred in the total days of plant wilting in the W_0, W_1, and the W_2 treatments between 1954 and 1955. This difference was primarily due to vast differences in climatic conditions between the two growing seasons. The consumptive use of water by grain sorghum, calculated by the empirical method from climatological data by Garton and Criddle (6), was 21.12 inches for Fort Reno, Oklahoma, 1955. The net irrigation requirement was 10.55 inches.

Soil Moisture Extraction Pattern

The percent of total soil moisture depletion by peanuts at one foot intervals is presented in Table XIII.

A study of moisture-extraction data was reported by Shockley (16). In the report of this study, Shockley stated the following:

> The study included such irrigated crops as alfalfa, cotton, potatoes, sugar beets, corn, wheat, barley, sorghum, flax, soybeans, guar, grapefruit, oranges, dates, and pears grown in soils varying in texture from loamy fine sands to silty clay loams, and varying in depth from less than 3 feet to around 10 feet.

From an evaluation of all the available moisture-extraction data, the conclusion was reached that practically all irrigated crops had a common moisture-extraction pattern even though the soil varied widely in texture or depth. The pattern which developed indicated that, of the total moisture extracted from the soil by the crops, about 40 percent came from the upper quarter of the root zone, 30 percent from the second quarter, 20 percent from the third quarter, and 10 percent from the bottom quarter (Fig. 1). Individual crop values in general were within 10 percent of the figures.

Using the data reported by Shockley, 50 percent of the total moisture extracted from the soil by the crop came from the upper third of the root zone, 33 percent from the middle third, and 17 percent from the bottom third. The results of the study on peanuts compare favorably with those presented by Shockley.

TABLE XIII

RELATION OF SOIL MOISTURE USAGE BY PEANUTS AT ONE FOOT INTERVALS OF THE ROOT ZONE DEPTH

Treatment	Soil Depth in Feet		
	0 - 1' %	1 - 2' %	2 - 3' %
W_1	63.6	21.6	14.8
W_2	46.4	32.6	21.0
W_3	58.1	31.0	10.9

Variation in the extraction pattern existed between the different water treatments. One cause of this variation was the different depth of water penetration. The depth of penetration depends upon the soil moisture content of the soil when the water is applied. Another cause of variation was probably due to the difference between treatments in the water holding capacity of the soil.

Climatological Data

Climatic factors have considerable effect on the rate of consumptive use of water by crops. These climatic factors can either increase or decrease the rate of consumptive use within hours after a change has occurred in the climatic conditions surrounding the crop. It is estimated that the consumptive use for the 1955 growing season would be a minimum since the temperatures during this season were considerably lower than usual. Climatological data for the 1955 growing season are presented in the following tables in Appendix C.

Table XVII.	Precipitation data for Fort Reno, Oklahoma experimental plots of peanuts and grain sorghum, 1955.
Table XVIII.	Monthly climatological precipitation data for Fort Reno, Oklahoma, 1955.
Table XIX.	Average monthly relative humidity May-November, 1955, Oklahoma City Airport, Oklahoma City, Oklahoma.
Table XX.	Maximum and minimum daily temperatures, El Reno, Oklahoma, May-November, 1955.
Table XXI.	Daily evaporation and wind velocity for Lake Overholser, Oklahoma, May-November, 1955.
Table XXII.	Total daily solar radiation in gram-calories per square centimeter, May-November, 1955, Stillwater, Oklahoma.

Observations Made With Nylon Blocks and Aquaprobe

The data obtained with the nylon blocks and the Aquaprobe gave inconsistent results.

Table XXIII of Appendix D gives the data collected on the nylon blocks. Figure 14 illustrates the relation between the bridge readings and the corresponding soil moisture content determinations.

The Aquaprobe readings and soil moisture data is presented in Table XXIV of Appendix E. The results of the Aquaprobe study are shown in Figure 15.

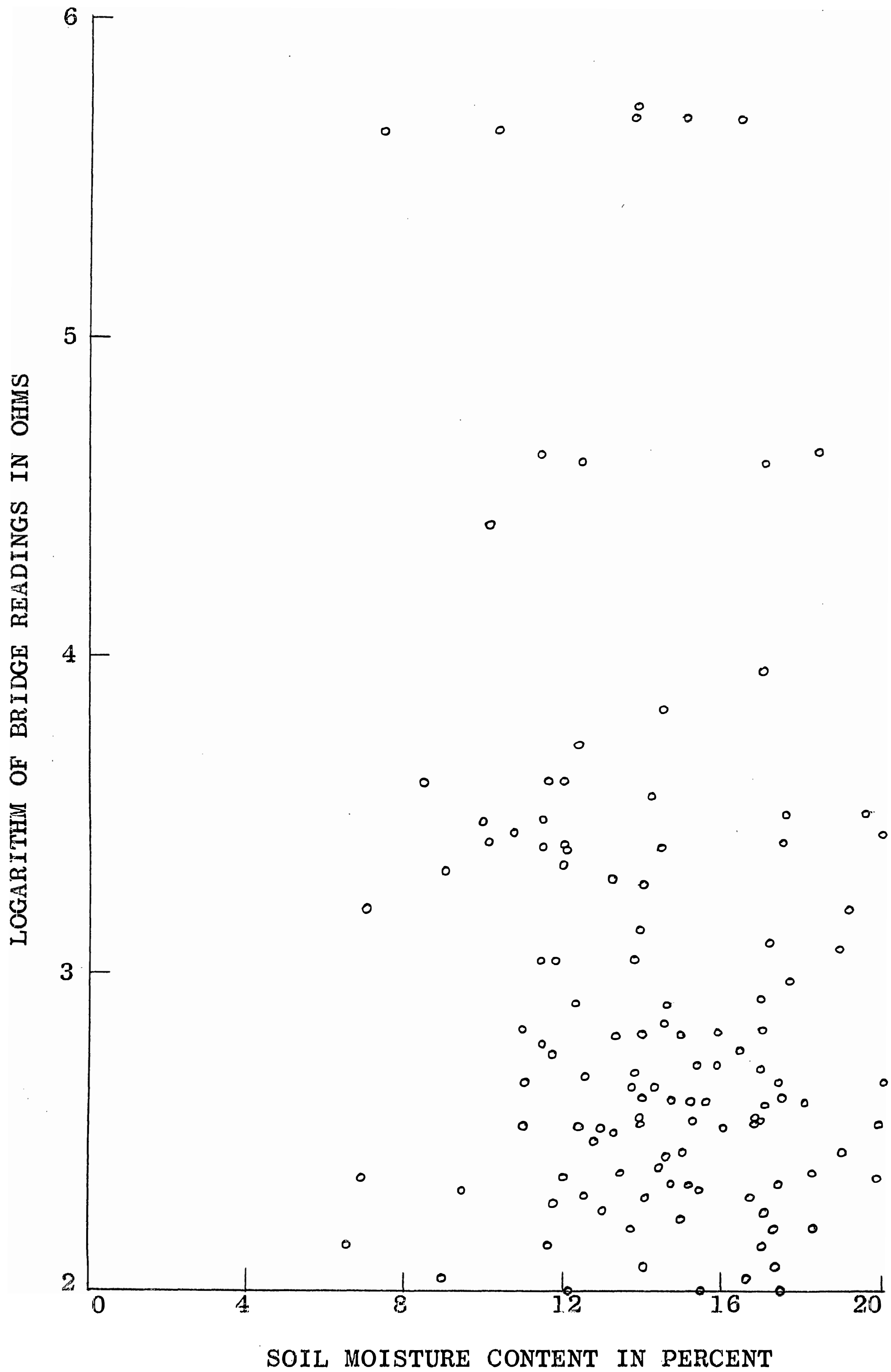

Figure 14. Relation between soil moisture content and bridge readings for nylon blocks.

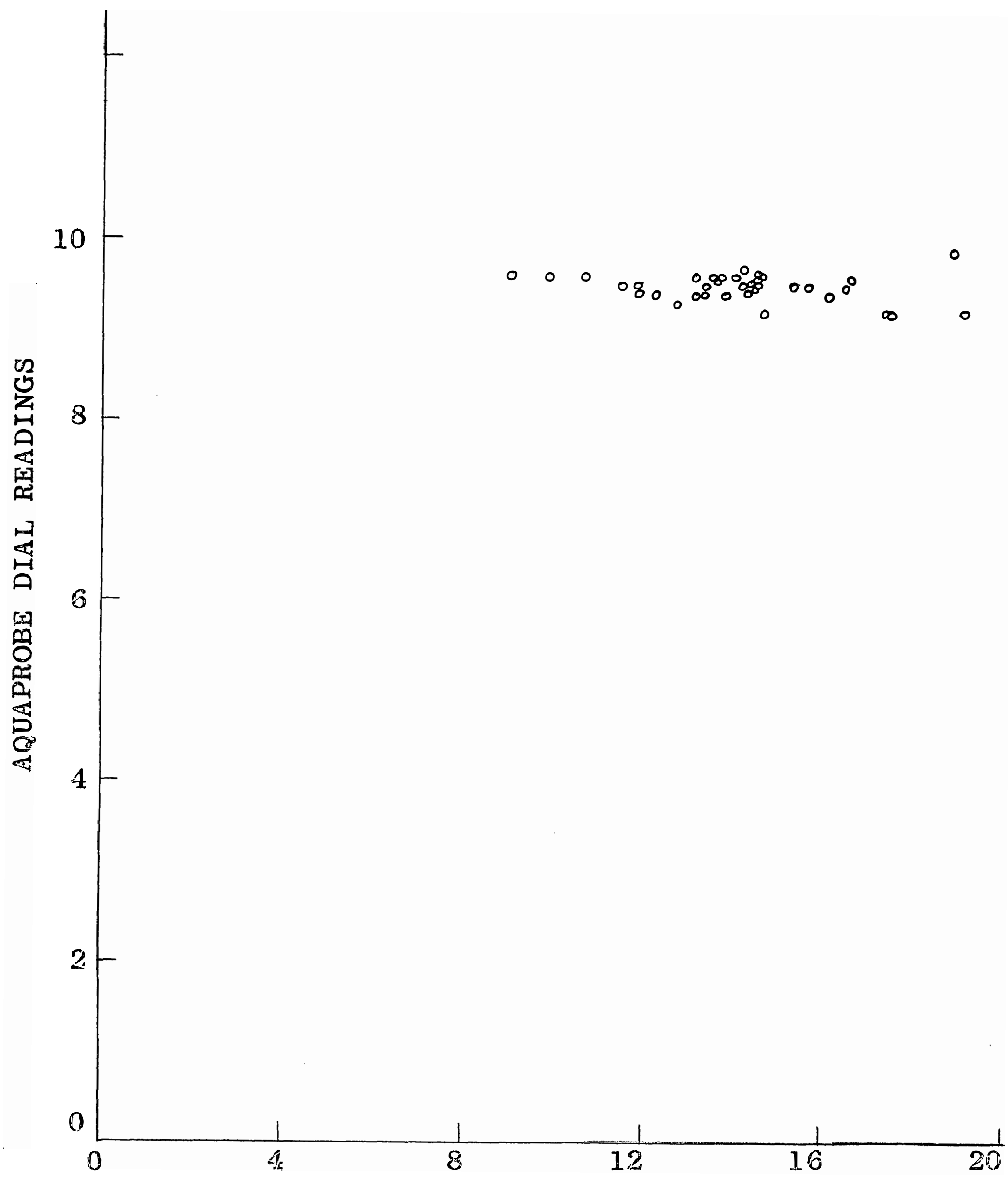

Figure 15. Relation between soil moisture content and Aquaprobe dial readings.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The consumptive use data for optimum yields of peanuts and grain sorghum for a limited water supply was determined for Fort Reno, Oklahoma, 1955, by the field plot and soil moisture depletion method. The effect of varying the amount of fertilizer application upon the yield of each crop and the soil moisture extraction pattern by peanuts with relation to the depth of root zone were obtained.

A close correlation was obtained between the data collected on the consumptive use of water by grain sorghum for 1955 with that obtained in 1954 for the same area.

The following conclusions were made from this study for investigation procedure and conditions previously stated.

1. The peak daily consumptive use of water by peanuts for maximum yield occurred between August 25 and September 2. The peak daily use was 0.420 inches. The average daily consumptive use for the irrigation season was 0.197 inches. Peak monthly use was 9.94 inches. The seasonal use by peanuts was 23.21 inches. The net irrigation requirement was 17.50 inches.
2. Increasing the rate of fertilizer application did not significantly increase the yield of peanuts.

3. An increasing response to fertilizer by peanuts was noted at the higher level.
4. The percent of total soil moisture extracted from each foot of root zone by peanuts was as follows: 58.1 percent from first foot, 31.0 percent from the second foot, and 10.9 percent from the third foot.
5. The peak daily consumptive use of water by grain sorghum for optimum yield and limited water supply occurred between August 12 and September 2. The peak daily use was 0.121 inch. The average daily consumptive use for the irrigation season was 0.112 inch. The peak monthly use was 3.41 inches and the seasonal use was 16.95 inches. The net irrigation requirement was 6.38 inches.
6. Moisture stresses in the peanuts and grain sorghum for periods not exceeding one week did not significantly decrease the yield of each.
7. Increasing the rate of fertilizer application did not significantly increase the yield of grain sorghum.
8. The data obtained with the nylon blocks and the Aquaprobe gave inconsistent results.
9. The consumptive use of water by grain sorghum for optimum yields is affected by variations in climatic conditions.
10. Continuation of the study of the consumptive use of water by peanuts and grain sorghum with variations in

climatic conditions and types of soils is recommended to better define their usage.

The following changes in procedure are recommeded for future study:

(a) Use sandy soil for peanut plots.

(b) Irrigate the wilt one week treatments only when no rainfall has occurred during the week of wilt.

(c) Use a higher soil moisture treatment to obtain maximum yield of peants.

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APPENDIXES

TABLE XIV

IRRIGATION APPLICATIONS AND CONSUMPTIVE USE OF WATER BY PEANUTS

Treatment - W_3

Date	Number of Irriga-tion	Length Usage Period Days	Consum-ptive Use Inches	Daily Consumptive Use Between Irrigations Inches			
				0-3'	0-1'	1-2'	2-3'
			1.90*				
June 28	1	8	1.00	0.125	0.073	0.039	0.014
July 6	2	28	2.83	0.101	0.059	0.031	0.011
Aug. 3	3	13	4.12	0.317	0.184	0.098	0.034
Aug. 16	4	9	3.30	0.367	0.213	0.114	0.040
Aug. 25	5	8	3.36	0.420	0.244	0.130	0.046
Sept. 2	6	11	3.00	0.273	0.159	0.085	0.030
Sept. 13	7	41	4.70	0.115	0.067	0.036	0.012
Totals		118	23.21				

Treatment - W_2

Date	Number of Irriga-tion	Length Usage Period Days	Consum-ptive Use Inches	0-3'	0-1'	1-2'	2-3'
			1.94*				
June 28	1	8	1.00	0.125	0.058	0.041	0.026
July 6	2	41	3.95	0.096	0.044	0.031	0.020
Aug. 16	3	17	3.66	0.215	0.100	0.070	0.045
Sept. 2	4	14	3.00	0.214	0.099	0.070	0.045
Sept. 16	5	38	4.70	0.124	0.058	0.040	0.026
Totals		118	17.25				

Treatment - W_1

Date	Number of Irriga-tion	Length Usage Period Days	Consum-ptive Use Inches	0-3'	0-1'	1-2'	2-3'
			1.86*				
June 28	1	8	1.00	0.125	0.080	0.027	0.018
July 6	2	50	4.25	0.085	0.054	0.018	0.013
Aug. 25	3	22	3.36	0.153	0.097	0.033	0.023
Sept. 16	4	38	4.70	0.124	0.079	0.027	0.018
Totals		118	14.17				

* Differential soil moisture between June 14 and July 7.

TABLE XV

IRRIGATION APPLICATIONS AND CONSUMPTIVE USE OF WATER BY GRAIN SORGHUM

Date	Number of Irrigation	Length Usage Period Days	Consumptive Use Inches	Daily Consumptive Use Between Irrigations Inches
Treatment - W_3				
June 8	1	24	6.26	0.261
July 2	2	12	1.00	0.083
July 14	3	20	4.33	0.216
Aug. 3	4	13	4.12	0.317
Aug. 16	5	9	3.30	0.367
Aug. 25	6	48	5.06	0.105
Totals		126	24.07	
Treatment - W_2				
June 8	1	24	6.26	0.261
July 2	2	34	2.33	0.068
Aug. 5	3	15	4.12	0.275
Aug. 20	4	13	3.66	0.281
Sept. 2	5	40	4.70	0.117
Totals		126	21.07	
Treatment - W_1				
June 8	1	31	6.26	0.202
July 9	2	34	3.45	0.101
Aug. 12	3	21	2.54	0.121
Sept. 2	4	40	4.70	0.117
Totals		126	16.95	

TABLE XVI

SOIL CHARACTERISTICS OF PLOT AREA, CANADIAN LOAM

	Field Capacity Percent	Wilting Point Percent
Calculated*	17.12	6.86
Estimated from sampling Grain Sorghum	18-19	6.5-7.5
Estimated from sampling Peanuts	18-19	---

Apparent Specific Gravity**		
Soil Depth Feet	Peanuts	Grain Sorghum
0-1	1.52	1.50
1-2	1.45	1.44
2-3	1.44	1.48

Real Specific Gravity
2.71

* Field capacity was calculated by use of ceramic plates for 1/3 atmosphere tension. Wilting point was calculated by use of pressure membrane apparatus for 15 atmospheres tension. Calculations were made by Walter Knisel, Graduate Fellow, Oklahoma A. and M. College.

** Apparent specific gravity values are average values for three undisturbed core samples taken by a sharpened sampling cylinder.

TABLE XVII

PRECIPITATION DATA FOR FORT RENO, OKLAHOMA EXPERIMENTAL PLOTS OF PEANUTS AND GRAIN SORGHUM, 1955

Month	Day	Rainfall in Inches
April	6	0.20
	23	1.16
Total		1.36*
May	9	0.50
	10	1.00
	12	2.60
	14	1.60
	17	0.25
	19	3.75
	21	0.25
Total		9.95*
June	13	0.16
	14	0.50
	15	0.10
	16	0.05
	17	3.20
	18	0.50
	22	1.25
Total		5.76*

Continued on next page

TABLE XVII (CONTINUED)

July	16	0.65
	18	0.18
	23	0.50
Total		1.33
August	7	0.40
	8	0.72
	22	0.30
	29	0.06
Total		1.48
September	1	0.30
	24	
	25	1.70**
	26	
Total		2.00
October	5	
	6	9.25***
	7	
Total		9.25
November	0	0

* Data for April, May, and June were taken from precipitation data collected at Fort Reno Experiment Station.

** A total of 1.70 inches of precipitation was collected for the three day period, September 24, 25, and 26.

*** A total of 9.25 inches of precipitation was collected for the three day period October 5, 6, and 7.

TABLE XVIII

MONTHLY CLIMATOLOGICAL PRECIPITATION DATA
FOR FORT RENO, OKLAHOMA, 1955

Month	1955 Rainfall Inches	*Normal Rainfall Inches	Deviation from Normal Inches
April	1.36	3.17	-1.81
May	9.95	4.67	+5.28
June	5.76	4.21	+1.55
July	1.33	2.24	-0.91
August	1.48	2.74	-1.26
September	2.00	2.65	-0.65
October	9.25	2.06	+7.19
November	0	1.99	-1.99
Totals	31.13	23.73	+7.40

* Normal rainfall represents average annual rainfall from 1931 - 1954.

TABLE XIX

AVERAGE MONTHLY RELATIVE HUMIDITY OKLAHOMA CITY AIRPORT,
OKLAHOMA CITY, OKLAHOMA,
MAY - NOVEMBER, 1955

Month	Relative Humidity Percent*
May	69
June	70
July	60
August	72
September	74
October	62
November	48

* Relative humidity observations were made at 6-hour intervals.

TABLE XX

MAXIMUM AND MINIMUM DAILY TEMPERATURES FOR EL RENO, OKLAHOMA
MAY - NOVEMBER, 1955

Day of Month	May		June		July		August		September		October		November	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	89	63	86	69	94	74	97	72	89	53	72	61	75	44
2	89	66	84	69	94	74	97	69	89	57	71	64	61	40
3	89	67	83	67	93	72	92	70	85	67	66	62	56	20
4	93	56	87	64	94	73	94	72	96	63	76	66	69	34
5	90	67	81	58	96	73	96	72	92	60	85	67	76	44
6	89	62	82	55	97	74	100	72	95	58	80	64	69	45
7	98	62	87	57	98	76	99	75	97	59	71	44	51	30
8	86	55	84	62	100	77	97	73	97	62	73	49	50	22
9	80	60	68	55	99	76	97	75	97	66	75	50	65	25
10	75	60	68	48	98	73	90	70	89	64	76	48	70	32
11	71	62	73	48	98	69	90	69	80	62	82	58	75	43
12	75	58	80	49	100	68	91	64	85	57	77	59	77	38
13	87	57	88	61	99	74	91	66	91	62	74	42	74	51
14	83	57	87	64	99	68	90	60	94	65	70	43	67	32
15	80	61	86	63	100	71	92	61	95	69	79	47	78	52
16	77	61	83	65	94	72	93	69	94	71	73	48	52	15
17	80	60	84	64	90	67	97	62	92	71	66	44	47	18
18	75	60	88	60	89	66	91	63	85	71	77	38	57	39
19	67	57	84	61	92	68	91	63	95	70	82	50	68	28
20	65	59	87	62	93	70	90	69	96	69	85	56	72	38
21	76	61	90	59	95	68	98	73	95	72	76	52	74	48
22	84	58	91	64	99	72	97	75	88	68	82	47	76	55
23	83	63	89	62	98	70	95	72	81	69	75	54	71	32
24	82	58	92	68	94	72	100	75	82	63	68	32	57	21
25	81	65	94	72	95	72	99	77	74	62	80	38	55	30
26	80	61	97	70	96	74	96	69	68	55	79	44	66	32
27	88	57	91	72	97	74	96	68	85	66	79	54	62	25
28	81	55	87	69	98	72	93	68	89	67	74	49	36	15
29	79	52	93	73	99	75	100	69	89	72	64	34	37	14
30	83	55	94	74	100	74	91	69	75	62	65	33	37	20
31	85	68			100	74	89	56			78	44		
Means	81.9	60.1	85.6	62.8	96.4	72.0	94.5	68.9	88.3	64.4	75.2	49.7	62.7	32.7

TABLE XXI

DAILY EVAPORATION AND WIND VELOCITY FOR LAKE OVERHOLSER, OKLAHOMA
MAY - NOVEMBER, 1955

Day of Month	May		June		July		August		September		October	
	Evap.	Wind	Evap.	Wind	Evap.	Wind	Evap.	Wind	Evap.	Wind	Evap.	Wind
1	---	---	.40	103	.39	111	.22	11	.19	19	.11	49
2	.38	90	.12	73	.35	87	.26	14	.22	15	.10	18
3	.39	115	.26	70	.36	76	.28	15	.25	40	---	55
4	.26	70	.24	88	.35	61	.15	14	.14	49	---	66
5	.28	32	.27	87	.28	48	.16	29	.19	9	---	97
6	.27	51	.11	42	.22	48	.22	62	.21	13	---	126
7	.31	65	.23	70	.48	84	.36	14	.21	3	.28	193
8	.32	74	.04	60	.45	107	.36	102	.22	1	.14	50
9	.20	74	.16	153	.47	104	.27	39	.32	32	.18	55
10	.17	66	.20	170	.41	78	.36	57	.37	71	.08	50
11	---	35	.22	121	.37	46	.17	30	.09	18	.24	55
12	---	62	.22	39	.31	26	.27	22	.19	23	.07	123
13	.13	52	.17	54	.34	30	.25	16	.18	20	.12	64
14	.25	36	.16	53	.32	45	.26	19	.26	65	.35	37
15	.25	66	---	53	.28	28	.25	19	.25	65	.15	17
16	.19	72	.27	67	.32	35	.29	25	.23	53	.13	20
17	.11	36	.43	81	.30	41	.29	35	.25	71	.10	101
18	.35	35	.39	64	.17	22	.30	21	.27	62	.18	83
19	---	61	.15	38	.07	42	.26	24	.11	40	.20	19
20	---	38	.15	20	.32	44	.29	40	.17	37	.20	65
21	.10	26	.37	16	.27	45	.24	54	.22	83	.30	90
22	.09	2	.31	50	.30	48	.36	87	.39	74	.10	28
23	.28	17	.28	36	.26	28	.24	51	.10	41	.19	93
24	.28	32	.41	129	.21	30	.12	40	.15	54	.23	167
25	*	19	.27	71	.25	36	.28	54	.12	95	.18	50
26	.30	93	.33	68	.41	19	.32	50	.17	46	.08	82
27	.29	93	.20	71	.38	124	.30	58	---	37	.32	74
28	.36	112	.20	71	.29	39	.26	7	---	35	.26	161
29	.35	127	.15	68	.29	33	.16	27	.41	85	.22	170
30	.26	90	.36	103	.30	31	.37	59	.20	76	.15	156
31	.30	81			.23	17	.29	31			.17	97
Means	.25	61	.24	71	.31	52	.26	36	.22	44	.18	81

TABLE

TOTAL DAILY SOLAR RADIATION* IN GRAM-CALORIES PER SQUARE CENTIMETER
MAY - NOVEMBER, STILLWATER, OKLAHOMA, 1955

Day of Month	May	June	July	August	September	October	November
1	485.7	644.3	721.4	592.8	651.3	171.3	376.5
2	485.8	577.2	721.2	---	595.2	43.4	381.3
3	498.3	555.8	743.4	399.0	418.2	87.0	407.3
4	690.9	656.6	---	390.9	573.9	108.5	393.3
5	402.8	434.2	469.5	---	583.8	483.9	386.4
6	642.7	686.7	761.8	650.1	602.4	389.7	123.0
7	604.2	569.1	730.8	451.2	575.0	527.7	191.4
8	444.1	163.8	714.3	529.2	551.1	508.2	401.1
9	217.8	487.8	716.4	368.7	501.7	507.9	283.8
10	305.4	440.7	747.0	501.9	43.2	506.4	370.6
11	204.0	582.0	657.3	647.4	501.3	385.8	360.5
12	314.1	720.0	608.4	663.8	492.3	---	355.5
13	700.8	533.0	679.4	664.5	534.9	468.0	---
14	686.4	516.9	664.3	778.9	331.4	486.9	334.2
15	227.7	572.4	709.8	664.9	494.1	455.7	662.7
16	---	665.4	456.6	568.8	500.7	453.3	386.4
17	---	334.0	401.4	646.4	514.5	462.1	356.4
18	---	686.8	561.9	587.7	366.0	448.2	163.8
19	32.7	526.2	327.6	585.4	255.1	445.5	352.2
20	120.5	747.6	748.8	568.8	515.0	409.6	340.8
21	---	696.3	727.2	600.2	499.8	399.6	325.7
22	658.2	686.6	---	419.4	183.6	400.4	237.3
23	523.1	745.3	---	529.2	369.0	375.6	331.2
24	723.9	669.0	---	496.8	326.3	452.7	276.0

Continued on next page

TABLE CONTINUED

25	195.4	653.1	---	606.0	52.9	455.4	339.3
26	609.6	684.8	720.1	596.7	137.4	429.3	293.7
27	754.9	503.6	680.9	---	333.6	375.6	263.1
28	775.2	565.6	702.3	---	385.5	274.8	183.2
29	779.1	683.7	670.3	601.5	389.7	335.7	320.1
30	708.7	699.9	630.9	548.1	213.0	424.5	87.3
31	503.4		607.9	638.9		400.8	
Totals	13,295.4	17,688.4	16,880.9	15,297.2	12,491.9	11,673.5	9,284.1
Means	492.4	589.6	649.3	566.6	416.4	389.1	320.1

* Solar radiation values were determined with an Eppley Type Phyrheliometer, horizontal surface element, which measures total sky radiation (direct sky radiation plus diffuse sky radiation).

TABLE XXIII

BOUYOUCOS BRIDGE READINGS AND CORRESPONDING SOIL MOISTURE CONTENT

Resistance by Bridge Ohms	Soil Moisture Content Percent	Resistance by Bridge Ohms	Soil Moisture Content Percent	Resistance by Bridge Ohms	Soil Moisture Content Percent
495	14.62	4020	8.50	1200	18.90
400	15.58	1920	14.00	330	16.10
395	18.28	1620	7.11	4,4000	18.41
3600	14.53	210	9.50	650	15.95
330	13.16	330	10.95	10,000	16.68
350	15.34	210	15.42	340	19.83
650	14.01	6800	14.51	2800	20.23
360	16.85	100	17.45	3000	9.93
220	14.75	3200	11.51	400	15.25
1100	11.48	480	12.60	1630	19.15
600	13.47	160	17.30	25,400	11.96
340	16.79	41,300	12.38	2500	14.48
300	12.73	555,000	13.81	390	17.19
170	15.15	3200	17.60	450,000	7.38
160	18.34	2870	10.72	140	13.58
440	13.70	630	13.30	190	13.80
240	13.73	110	16.58	455,000	10.30
240	18.27	320	13.35	330	12.40
800	12.33	650	15.00	400	14.75
270	14.48	*	21.80	11,000	13.76
520	15.42	440	14.30	520	15.90
1100	11.80	180	13.10	280	18.95
200	12.50	180	17.15	410	13.92
200	16.67	26,000	10.50	3200	19.62
500,000	13.66	490	13.88	540	16.50
220	15.15	460	17.42	200	14.10
220	17.45	4000	12.08	2600	10.23
1380	13.95	360	16.78	*	12.15

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APPENDIX D

TABLE XXIII CONTINUED

500,000	14.90	460	20.75	800	14.61
120	17.45	5200	12.43	2600	17.55
2500	11.50	500,000	16.38	*	11.93
2000	12.80	960	17.74	*	15.99
500	17.10	360	13.90	410	17.45
2200	12.00	340	13.83	100	12.15
560	11.70	160	13.76	*	13.80
100	15.45	*	15.49	1260	17.20
140	6.43	280	15.10	*	12.18
4020	11.59	120	14.00	*	13.50
2100	9.25	4000	16.91	840	16.92
110	8.92	670	16.82	43,000	11.42
230	12.09	230	19.85	670	11.05
4600	11.04	240	17.00	*	13.20
230	6.91	11,100	16.40	2460	12.04

* Resistance greater than can be measured by bridge.

TABLE XXIV

AQUAPROBE READINGS AND CORRESPONDING SOIL MOISTURE CONTENT

Dial Readings	Percent Soil Moisture Content
9.4	12.30
9.6	14.46
9.4	11.90
9.9	18.87
9.4	11.95
9.2	19.08
9.6	10.65
9.5	11.89
9.5	15.35
9.7	14.21
9.4	13.15
9.2	17.45
9.6	13.15
9.2	16.70
9.5	11.55
9.6	13.72
9.4	16.10
9.6	9.05
9.5	16.55
9.5	14.35
9.6	9.94
9.5	13.38
9.5	14.45
9.4	14.32
9.5	14.26
9.6	14.00
9.6	16.62
9.4	13.80
9.5	15.68
9.3	13.75
9.4	13.30
9.6	13.56
9.2	14.84
9.5	14.30
9.6	14.60
9.6	14.49

VITA

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Master of Science

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