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Title: Effects of Irrigation Frequency on Yields of Winter Wheat

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Marshall J. English

Deliberately underirrigating a crop may yield economic benefits. The optimal use of water by an irrigator should be achieved under a deficit irrigation regime. It is important to know how water deficits affect yields and the interaction of the deficits with the scheduling of irrigations.

A field experiment was conducted during the 1981 irrigation season to investigate the effects of high and low frequency deficit irrigation on yields of winter wheat. Yield and water use data were used to construct three production functions. The relationship between the level of water use and the resulting yield were determined for three irrigation frequency regimes. Field plots under daily (high frequency), weekly (normal frequency), and stress (reduced frequency) regimes were included in the field experiment as well as two dryland production plots.

The relationships derived from this project were characterized by a large degree of scatter in the results. Highly favorable weather conditions offset the effects of irrigation deficits on plant yields throughout the irrigation season. At this time, a second year of data is in the process of compilation.

The results of a regression analysis showed no statistically significant difference in the water use-yield relationships of the three irrigation frequency regimes. The effect of frequency did not lead to any readily apparent differences in the three production functions.

The efficiency of water use of the different irrigation frequencies increases with decreasing amount of applied water for the 1981 crop year. The most efficient treatment, i.e., least water use per unit of yield, was the pre-plant irrigated, dryfarmed plots. The density of the wheat, a measure of crop quality also increased with decreased water use in this experiment. The optimal irrigation treatment (measured by production and quality) was the two-week frequency set.

EFFECTS OF IRRIGATION FREQUENCY
ON YIELDS OF WINTER WHEAT

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I. INTRODUCTION

Deficit irrigation has shown promise as a practical management technique for increasing efficiency of water use in crop production. In some cases it may be economically beneficial to deliberately underirrigate a crop. The extent of the benefits obtained may be dependent upon the frequency of irrigation applications. To date, the relationship between crop yields and irrigation frequency under deficit irrigation has not been established. With further information concerning this relationship, the merits of deficit irrigation can be examined more accurately.

Operation of conventional irrigation systems follows a cycle of short, intense applications of water separated by long periods of soil moisture extraction by the crop. The goal is to apply the maximum amount of water to the soil that it can store at one time, thus minimizing irrigation frequency. Recent reports have investigated the mertis of irrigating at frequencies much shorter (daily) or longer than conventional practices.

Economic benefits of high frequency irrigation have been described by Rawlins and Raats (1975). These savings are based on two assumptions: (1) that pipe costs are a major expense of the system, and (2) operating costs will not increase with more frequent irrigations. Alternatively, it may be possible to gain benefits from low frequency, deficit irrigations. English and Nuss (1982) presented a case study in which it was shown that low frequency, deficit irrigation could be used to reduce both energy and water use without adversely affecting farm income. Furthermore, if the water saved by deficit irrigation was used to irrigate additional land, farm income could be increased.

The effect of irrigation frequency on crop yields has not been thoroughly examined at both ends of the frequency spectrum. There have been conflicting reports on how water deficits affect yields at different frequencies. The variation in results and approaches to quantifying this relationship prompted this investigation.

A field experiment was designed to develop crop production functions; comparing yield to water use at different irrigation frequencies. Four groups of plots were used: dryland plots, plots irrigated daily, weekly, and at longer intervals. Applied water, precipitation, and soil moisture depletion were measured in each plot, then water use over the irrigation season was compared to yield from each plot.

Unusually abundant spring rains contributed to a high level of yields in all the experimental plots. The large amount of rain also resulted in a compression in the range of water use in the fixed interval plots (daily and weekly intervals). Statistical tests of significance showed that there was a large degree of uncertainty concerning comparisons of the three regression lines derived from the daily, weekly, and variable, fully irrigated plots.

II. LITERATURE REVIEW

Stress and Yield

Crop yields may suffer when plants are stressed. Stress can develop during periods of excessive water loss or inadequate absorption. These two processes are linked by the plant water transport mechanisms, but are influenced by external factors that are usually independent. Temporary stressful situations generally do not adversely affect yields, though prolonged exposure to stress can drastically reduce yields (Hsiao and Acevedo, 1974).

The influence of crop water stress on yield may vary with the type of crop, and the timing and magnitude of water deficit. During certain stages of plant growth, cereal crops are particularly sensitive to water deficits. On the other hand, sugarbeets respond favorably to stress imposed during various plant growth periods (Jensen and Erie, 1971). The relationship between yield and stress is also dependent on the history of stress in previous growth stages (Mogensen, 1980; Fischer, 1973; Stewart and Hagen, 1969). Where water shortages are anticipated the nature of the crop and the availability of water during any part of the irrigation season need to be considered due to the influence of stress.

Plant water deficits are affected by a combination of soil, plant, and atmospheric conditions. The soil's water retention characteristics control the transfer of water to the root surfaces (Salim et al., 1966). As soil moisture declines, the amount of water available to the plant decreases. Water is not always available over the range of field capacity to permanent wilting point. Even when soil moisture levels are high, the water available to the plant can be insufficient when transpiration rates exceed absorption rates (Kramer, 1962).

When absorption of water through the roots lags behind the rate of water lost to the atmosphere, it is due to plant resistance to water movement (Kramer, 1962). The majority of resistance occurs at the roots, where water must pass through the compact layers of cells in the root epidermis, cortex, and endodermis (Kramer, 1962).

Atmospheric conditions regulate the potential transpiration rate. Water losses may be high during high temperatures and/or low relative humidity. Under severe stress, plants restrict stomatal opening to reduce water loss to the atmosphere. However, on hot, dry days, the rate of water loss will still exceed the rate of absorption through the roots creating a temporary stressful condition (Kramer, 1962). If the plant does not return to normal plant conditions, the resulting stressful situation may affect yields.

Physiological effects of water stress on plants depend on the level of water deficit. Higher plants respond immediately to changes in internal water potential (Hsiao, and Acevedo, 1974). Physical growth is the first function affected by deficits. Growth cannot continue without sufficient internal pressure to promote cell enlargement and separation. Changes in water potential in the root medium instantly affect the leaf potential, decreasing the leaf turgor pressure (Hsiao and Acevedo, 1974). Under smaller deficits, the plant reacts quickly to the addition of sufficient water. With larger deficits, the plant may not fully recover, plant size could be stunted, and potential yeild reduced.

To conserve water present in the plant, when water stress occurs, the plant stomates begin to close. Besides saving water, the rate of carbon dioxide assimilation will also be reduced. It is the reduced CO_2 assimilation which ultimately reduces yields. The reduction in carbon dioxide exchange begins to occur at different threshold levels of water deficit in different plants. If this threshold is passed, the plant will take longer to recover than in the case of small water shortages. At this point, there may be significant reductions in crop yield.

The physiological effects of water deficits on wheat (Triticum avestium, et al.) have been investigated by many scientists, engineers, and other researchers. Wheat is a crop with specific critical periods of growth that are especially sensitive to stress (Fischer, 1973). Timing of stress is very important in terms of yields. Both grain yields and total dry matter production depend on whether stress occurs in the tillering, jointing, flowering, or other growth stages.

Wheat plants stressed early in the growing season will limit shoot growth before root growth (Salim et al., 1966). When water is limited the plants will extend roots to locate water rather than expanding the plant's photosynthetic area above the surface. Due to this response, wheat plants can be "conditioned" by the onset of stress in early growth stages (Fischer, 1973; Day and Intalap, 1970; Ehlig and LeMert, 1976). The effects of water deficits later in the season are lessened with the expanded root network.

Stress in the jointing stage can induce the most severe reductions in yields. It has been reported that stress in this stage accelerates stem senescence and reduces spikelets per head (Musick and Dusek, 1980). Day and Intalap (1970) reported plants stressed in this period had fewer heads per unit area and fewer seeds per head. These effects severely limit the potential for yield. It is recommended, under optimum soil water management practices, to maximize wheat yields; even slight water stress should be avoided during this period (Ehlig and LeMert, 1976).

Other reports have stated that the flowering period is the most sensitive to water deficits (Doorenboos and Kassam, 1979; Singh, 1981). Plants stressed in this period mature earlier and have lighter seeds (Day and Intalap, 1970). As wheat plants mature, the susceptibility to stress is reduced. Water held back in the grain filling stage does not have as severe an affect on yields as in the jointing or flowering stages.

The loss in yield due to water shortages in the flowering period cannot be recovered by applying more water in the succeeding periods. Additional tillers will be formed if large application of water follows severe stress in the late vegetative stage (Musick and Dusek, 1980), but this does not contribute to grain yields.

The frequency of irrigation will determine if a field can be completely watered within the time span of various "critical" growth stages. This is especially important under a low frequency irrigation regime where the schedule of irrigations may not permit rapid coverage of entire fields.

Identification of critical growth stages and the interdependencies of the stages can provide some guidelines for irrigation water management under limited water supplies. The Feekes scale (Large, 1954) was developed for identifying growth stages of cereals. For this field experiment involving winter wheat the Feekes scale was used to identify growth stages from jointing to harvest. After jointing, spring and winter wheat have comparable schedules for their growth stages (Glenn, personal communication). The order and duration of various growth stages

Table 1. Feekes scale growth stages (1980-81 season) according to growing degree units

Growth Stage	Feeke's Scale	Cumulative Growing Degree Units (°F)	Estimated Date of Occurrence	Observed Date of Occurrence
	1	205	December	
	2	329	January	
Tillering	3	435	February 15	February 28
	4	530	March 13	
	5	620	March 24	March 24
	6	700	April 3	
Stem Extension	7	780	April 15	
(Jointing)	8	855	April 20	April 24
	9	925	April 24	
	10	1,025	April 29	May 5
	10.1	1,040	April 30	
Heading	10.2	1,060	May 1	
	10.3	1,100	May 3	
	10.4	1,155	May 8	
Flowering	10.5	1,220	May 11	May 17
	11.0	1,560	May 29	
	11.1	1,670	June 2	May 29
Ripening	11.2	1,790	June 8	June 12
	11.3	1,960	June 13	
	11.4	2,300	July 3	

are presented in Table 1 for winter wheat during the 1981 growing season. The estimated date of occurrence is based on the cumulative total Growing Degree Units (GDUs), which are based on the minimum and maximum daily temperature (Appendix A). The observed dates are from field checks taken at infrequent intervals over the irrigation season.

Production Functions

Crop production functions are relationships between crop yields and crop water use. Depending on the crop, yield may be expressed as total plant weight, grain or fruit weight, or some other measure of crop value. Many factors affect the relationship between water use and yield. Crop varieties, climate, soil, cultural practices, irrigation practices, and fertilization levels are among the parameters that have sometimes been included in research on crop production functions, individually and in combinations.

Some indices used for crop water use are applied water (including precipitation), soil moisture depletion, transpiration, and evapotranspiration. Production functions are one tool helpful for irrigation planning when water supplies are limited. Irrigation programming can be improved with the knowledge of how crops and families of crops respond to different levels of water use (Hagan and Stewart, 1972).

Yields have been related to the amount of precipitation occurring during the year (Cole, 1938). Cole found a linear relationship between yearly precipitation and wheat yields in a few dryland production areas of the Great Plains. To refine his model, Cole substituted precipitation for the crop growing season as the water use index and found a good correlation for data from 30 locations. The relationship between yield and seasonal precipitation is expressed in Equation (1).

$$Y = (R - 10.19) \times 3.19 \qquad (1)$$

where

Y = yield (bushels/acre)

R = precipitation over the growing season (inches)

Subsequent production function research correlated water use, as represented by soil moisture depletion and rainfall, to yields. A study conducted by Leggett (1958) for dryland wheat production in Eastern Washington is shown in Equation (2).

$$Y = 5.8 \times (SM + R) - 23.8 \qquad (2)$$

where

Y = yield (bushels per acre)

SM = soil moisture in the spring (inches)

R = rainfall during the growing season (inches)

More recently, evapotranspiration (ET) has become commonly used as the water use indice in many crop production research efforts. Evapotranspiration is defined by Burman et al. (1981) as:

> "The combined process by which water is transferred from the earth's surface to the atmosphere. It includes evaporation of liquid water through plant tissues expressed as the latent heat transfer per unit area or its equivalent depth of water per unit area.

Direct measurements of ET from a field are not practical, but indirect determinations can be made by balancing inputs and outputs of water in the soil profile.

Lysimeters can be used to obtain fairly accurate measurements of water use in the field. Lysimeters are large containers placed in the field used to carefully monitor the water used by crops planted within the container. Soil water content, water inputs and outputs are measured to determine evapotranspiration or transpiration. Seasonal totals are related to measurements of crop yield from the lysimeters to produce a production function.

Evapotranspiration research began with observations of actual water use by plants in small containers. Some of the earliest work that related crop yields to transpiration was conducted in the late 1950s (deWit, 1959). Reviewing a wide-ranging survey of the research conducted up to that time, deWit concluded that there was a linear relationship between transpiration and total dry matter production of most crops. With field experiments, deWit reaffirmed the relationship found in the laboratory. Without other limiting factors, transpiration was linearly related to the total dry matter production in the field.

Evapotranspiration based research under field conditions became a common practice within the last decade. Line source experiments (Hanks et al., 1976) are a simple and inexpensive way to provide a range of yield and water use data. This method utilizes a single irrigation line to provide a wide range of water use levels. At each irrigation, sprinklers distribute water in a pattern that decreases linearly with distances from the sprinkler line (Figure 1). Catch cans and soil moisture measurements are made along with precipitation observations, to calculate water use. Yield samples are taken at various distances from the sprinkler line to relate to the various water use levels. Within a small area, a production function can be developed that relates yield response to water levels ranging from full irrigation to unirrigated agriculture production levels.

Each production function derived from field experiments is a singular relationship. The level of maximum yield and/or water use varies for different sites and different years (Stewart, et al., 1977). This could be due to differences in soil hydraulic properties, climate or a variety of other factors. One method used to compare similar production functions (i.e. the same crop, sometimes the same variety) is to use relative valued axes. The ratio of actual yield to maximum attainable yield in each experiment is related to the ratio of actual ET to the maximum

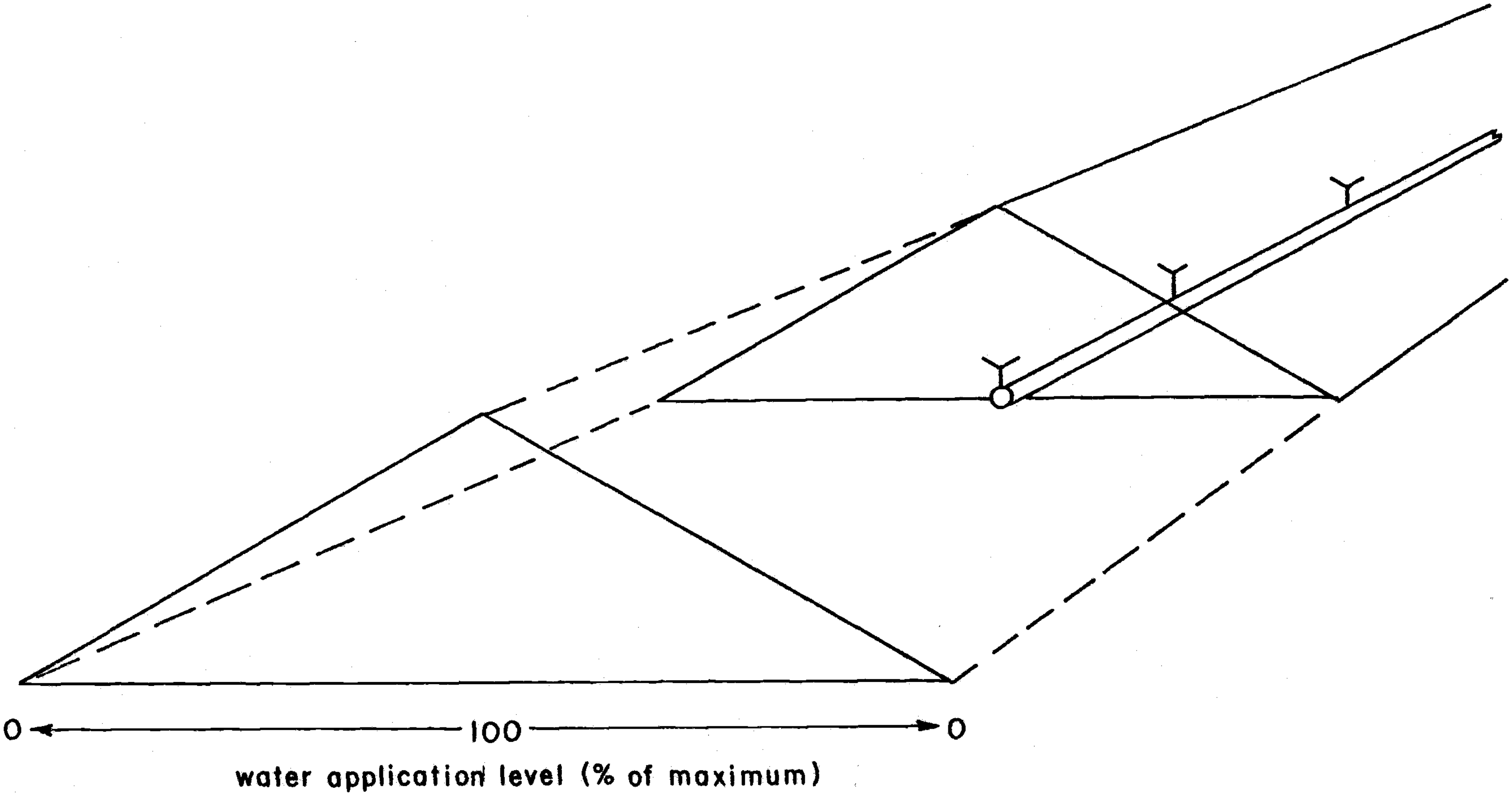

Figure 1. Water application pattern of a line source experiment.

possible crop ET at each site. An example of such a function for wheat is shown in Figure 2. Such relative valued functions can provide better guidelines for optimum water use (Stewart and Hagan, 1973; Doorenbos and Kassam, 1979).

Soil evaporation is one factor limiting the reliability of experimentally determined production functions. Evaporation from the soil surface and from the plant surface varies with changes in local climatic conditions. The absolute yearly amount of solar energy available for evaporative demands remains fairly constant at any latitude. The local microclimate controls the evaporative potential. Humidity, air temperature, wind and the resulting vapor pressure deficit contribute to the evaporative demands of the crop.

Frequency and Yields

The frequency of irrigation will influence the way soil water properties are examined. Under high frequency irrigation, soil water properties such as soil water storage become less important in comparison to the hydraulic conductivity and transmissitivity of water through the soil.

The ability of the soil to supply water to the crop is a function of the physical soil properties. The relationship between soil moisture and soil water potential

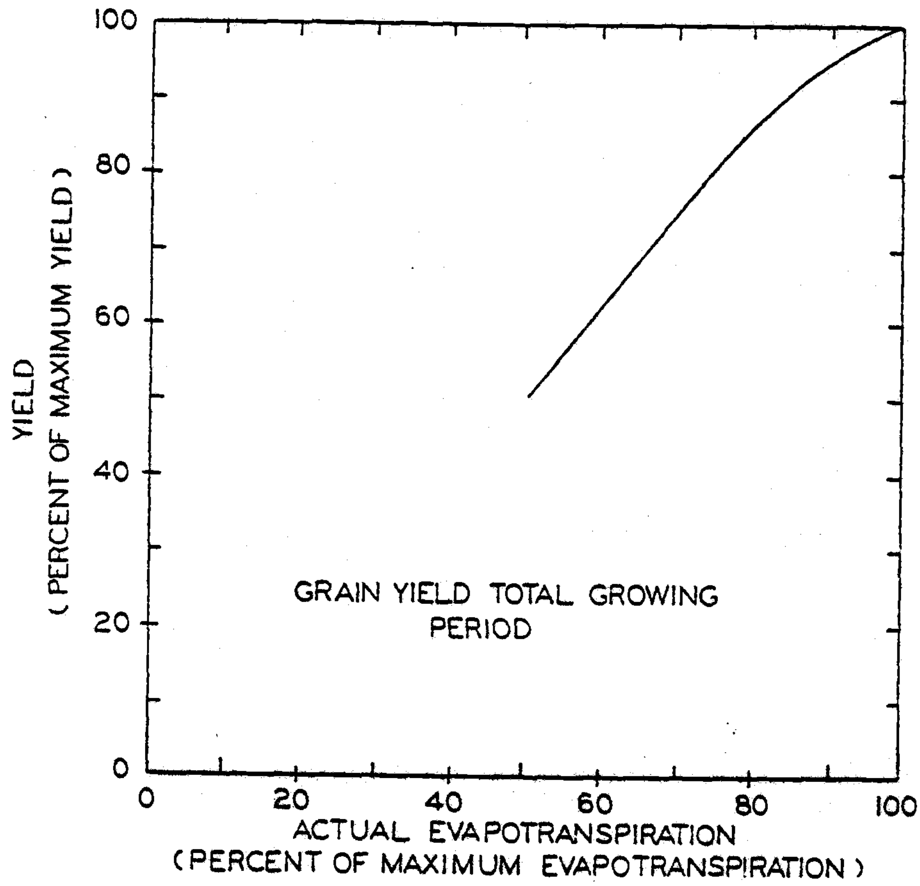

Figure 2. Relationship between season total evapotranspiration and crop yield for winter wheat (adapted from Doorenbos and Kassam, 1979).

partly governs the amount of water available to the crop. A water retention curve graphically illustrates this relationship. Two arbitrary matric levels, the field capacity and the permanent wilting point, delineate the bound of water available to the plants. Figure 3 shows the general relationship for five soil types (Taylor and Ashcroft, 1972).

The field capacity of the soil is not precisely defined and will vary for different soil types. It is commonly assumed to be about one-third bar tension, but it can range from 0.1 to 0.4 bar (Brady, 1974). Permanent wilting point has an even larger range, depending on the definition and interpretation of the point at which the plant can no longer draw water from the soil. The most common range of soil water tension stated for describing permanent wilting point is from ten to 25 bars. These arbitrary levels are used as general guidelines for planning when and how much to irrigate.

Depending on the irrigation interval and the crop, most of the water used by the crop will come from the upper portions of the soil profile (Rawlins, 1973). Minimizing the frequency (i.e., maximizing the interval between irrigations) forces the crop to use water deep in the profile. The depth of extraction will depend on the depth of root penetration. Under high frequency irrigation, the water is supplied to the plant as it is needed; there is

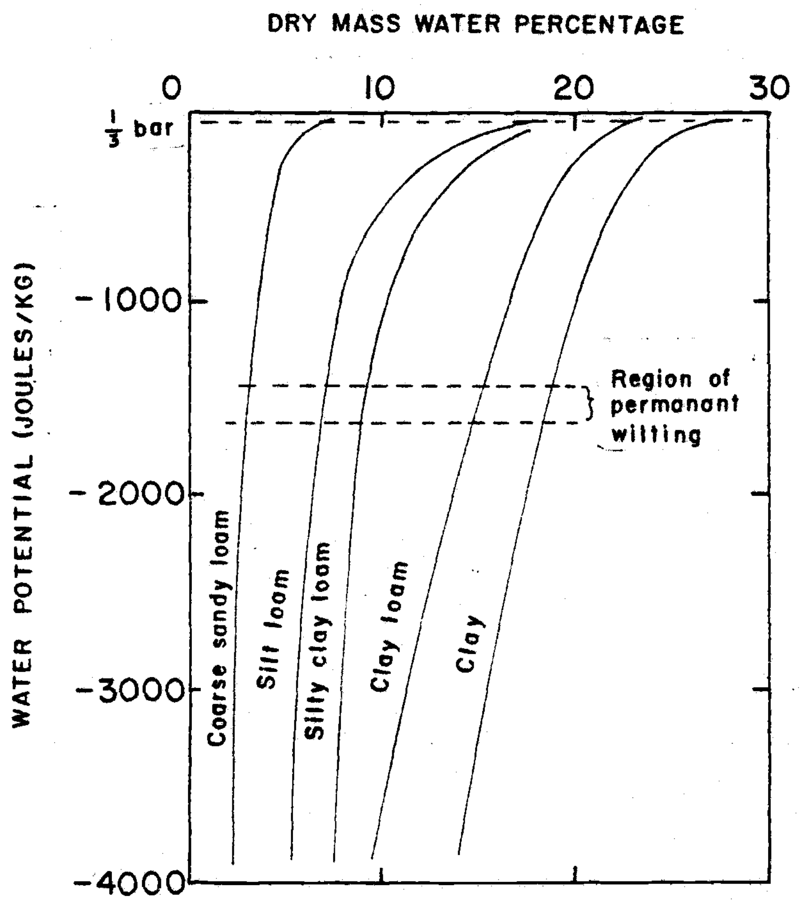

Figure 3. Typical water characteristic curve showing approximate range for field capacity (about one-third bar) and permanent wilting point (depends upon plant needs and flow requirements; in the vicinity of 15 bar).

little need to store water deep in the soil profile (Rawlins, 1973), though if water becomes limited, the crop may suffer reduction in yields due to the limited extent of the root system.

The hydraulic conductivity of the soil is of greater importance than the range of available water under high frequency irrigation (Rawlins, 1973; Hobbs and Krogman, 1980). Hydraulic conductivity is a characteristic of the soil, but is also a function of soil matric potential (Figure 4).

Under limited circumstances, soil water conditions are controlled by infiltration rather than extraction from storage. When soil moisture levels remain high, as under high frequency irrigation, the soil matric potential is limited to a small range (Rawlins, 1973). The hydraulic conductivity will also be restricted to a narrow range. In this situation, the application rate will determine the amount of water transmitted to the plant, as long as water is not applied in excess amounts. Soil water will be used at the application rate when irrigation provides sufficient water to the crop.

Optimal yields can be achieved under high frequency irrigation when full ET requirements are met (Hobbs and Krogman, 1980; Miller, 1977; Faci and Fereres, 1980). However, a recent study showed that crop yields could be maintained even when ET was reduced below the maximum rate, following establishment of full cover (Miller, 1977). A similar experiment was designed to specifically to

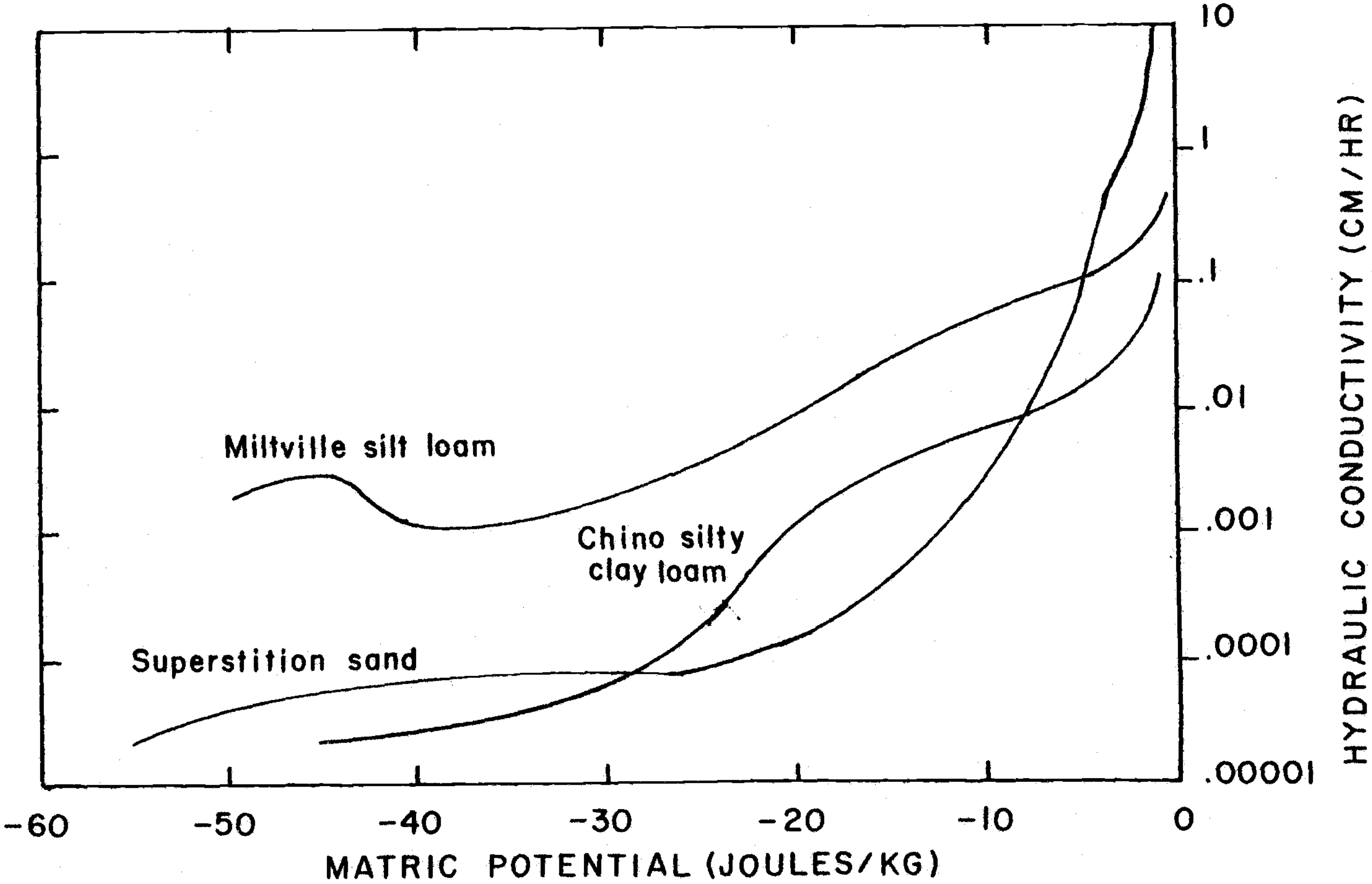

Figure 4. Hydraulic conductivity as a function of the matric potential for three soils.

replicate Miller's work but with a different crop; grain sorghum (Faci and Fereres, 1980). It was found in the latter experiment that yields declined considerably when ET was reduced below the maximum rate.

These conflicting reports may be explained in part by differences in experimental procedure. Miller began differential irrigation treatments with a full soil profile, Faci and Fereres started with a partially depleted profile. Miller measured soil moisture gravimetrically twice a week while Faci and Fereres measured initial and final soil moisture levels with a neutron probe. The soils used in the two experiments had different textures and moisture retention characteristics. One objective of the present experiment was to include portions of both approaches and compare results to those experiments.

The influence of the timing of water deficits have been investigated in previous studies (Dorenboos and Kassam, 1979; Fischer, 1973; Singh, 1981). Figure 5 illustrates relative differences of stressing wheat at various growth stages. It is important, when attempting to optimize water use, to note how deficits may affect crop yields at these different growth stages. A strategy of low frequency, deficit irrigation implies that the relationship between timing and yield will be more critical.

Side-by-side examination of deficit high frequency (daily irrigations), deficit normal frequency (weekly irrigations), and deficit low frequency (extended intervals

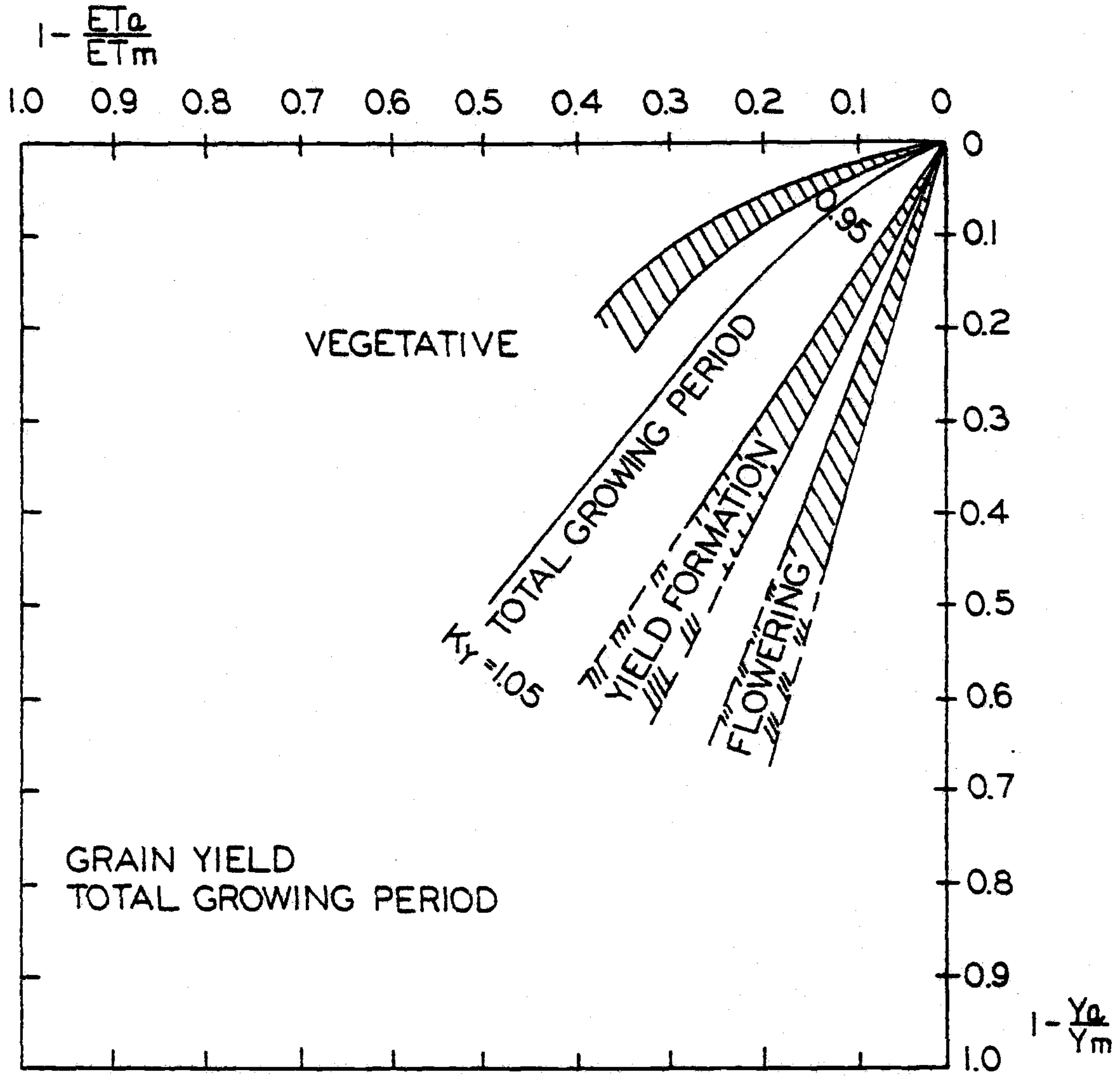

Figure 5. Relationship between season total evapotranspiration and crop yield for winter wheat with the effects of incurring deficits at various growth stages (adapted from Doorenbos and Kassam, 1979).

between irrigations) was done in an attempt to quantify some of the effects of different irrigation frequencies on yields. An important part of this experiment was to study the effects of deficits imposed through the extended interval treatments. A rotating schedule of irrigations was planned for the longer interval treatments to closely parallel actual practices that would be used in the field as suggested by English and Nuss (1982).

III. EXPERIMENTAL METHODS

There are many crop production functions developed from experiments using a single irrigation frequency (Stewart and Hagan, 1969). The purpose of this experiment was to investigate the effects of different irrigation frequencies on wheat production functions. The procedure used to impose water deficits in this experiment was intended to make comparisons of wheat production at different frequencies, as well as to check the results of previous studies.

The experiment has been carried out for one season at the time of this writing. One year's field data will probably not be enough to justify a definitive conclusion regarding the effects of irrigation frequencies on crop yield. This thesis develops background information and presents the results of the first year of field work. A second year of field trials is being completed at this writing.

The experimental plots are located on a farm near Hermiston, Oregon. The field was provided by a cooperating farmer, John Madison, who furnished water, seed, fertilizer, and some of the labor for this experiment. The Madison Farm is located ten miles (16 km) south of Hermiston on Oregon Highway 207. This area is predominately a dryland agricultural region on the Columbia Plateau. Average annual precipitation in the area is 9.4 inches (24 cm) (USWB, 1982). The Madison Farm has water rights to to Butter Creek and two wells located on the farm. Figures 6 and 7 show the location of the farm and the experimental plots, respectively.

The soil at the experimental site was once classified as a Ritzville loamy fine sand (Soil Conservation Service, 1937). A more recent classification labels the soil as a Koehler loamy fine sand. These soil types are very similar, both originating from loess deposits of wind-borne sand and silt particles. The top layer of the Koehler series is light, brown, and non-calcearous. Deeper layers may have high concentrations of lime carbonate (SCS, 1937).

The area where the plots are located is underlain by stream-deposited smooth gravel and stones cemented by the carbonate of lime into a hardpan layer or caliche (SCS, 1937). The depth of the cemented layer was determined while drilling with a hydraulic soil auger to install access tubes for the neutron probe. Occasionally small (½ - 2 inch diameter) smooth stones would be brought up with the power auger. The caliche layer ranges from three to more than ten feet in depth with an average depth of about six feet. Subsequent observations of water movement through the soil profile showed that the cemented layer was porous enough to not restrict percolation.

Laboratory measurements of the soil bulk density ranged from 1.20 gm cm^{-3} to 1.80 gm cm^{-3}. An average of eight measurements was used for this experiment. It was

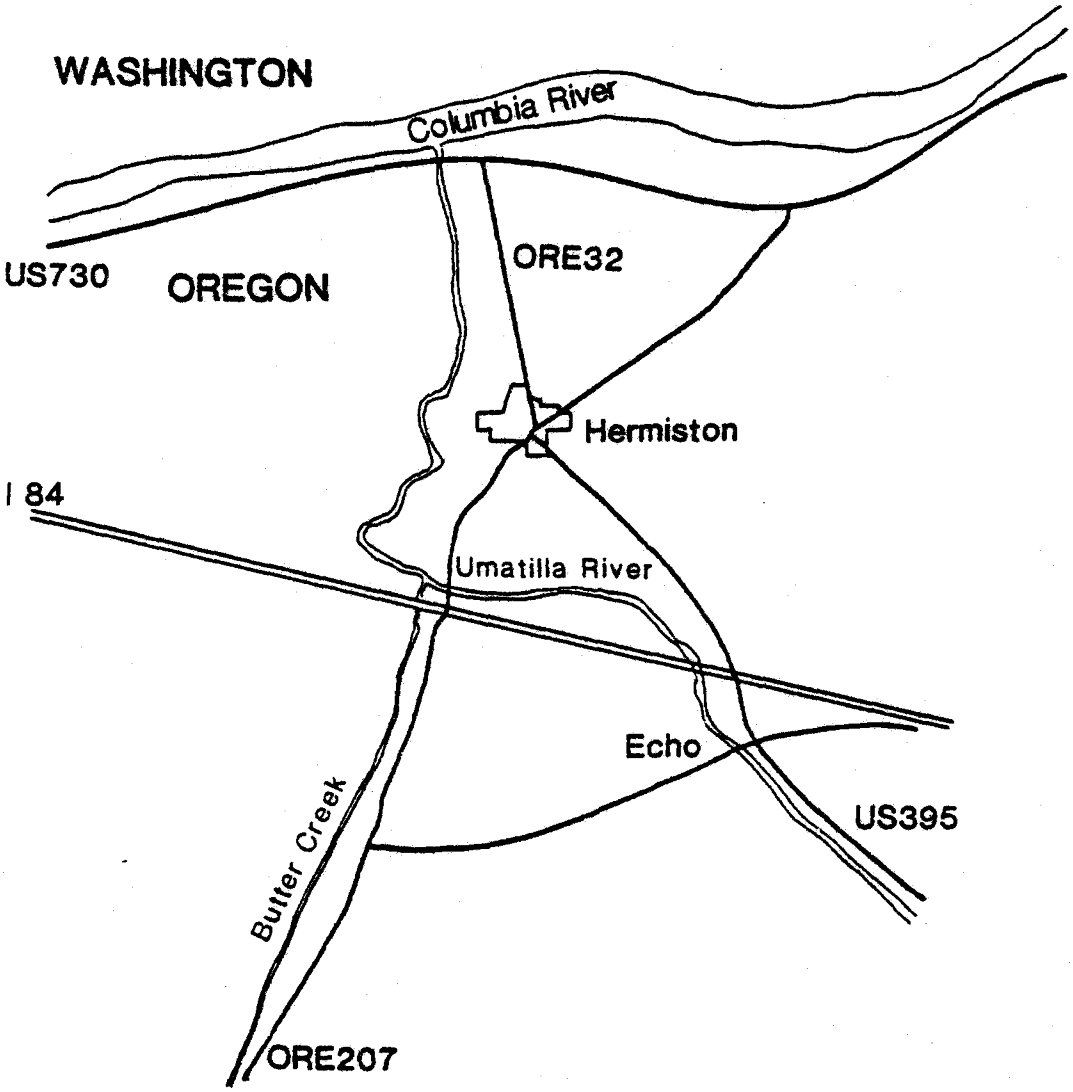

Figure 6. Area near Hermiston, Oregon, site of field experiment.

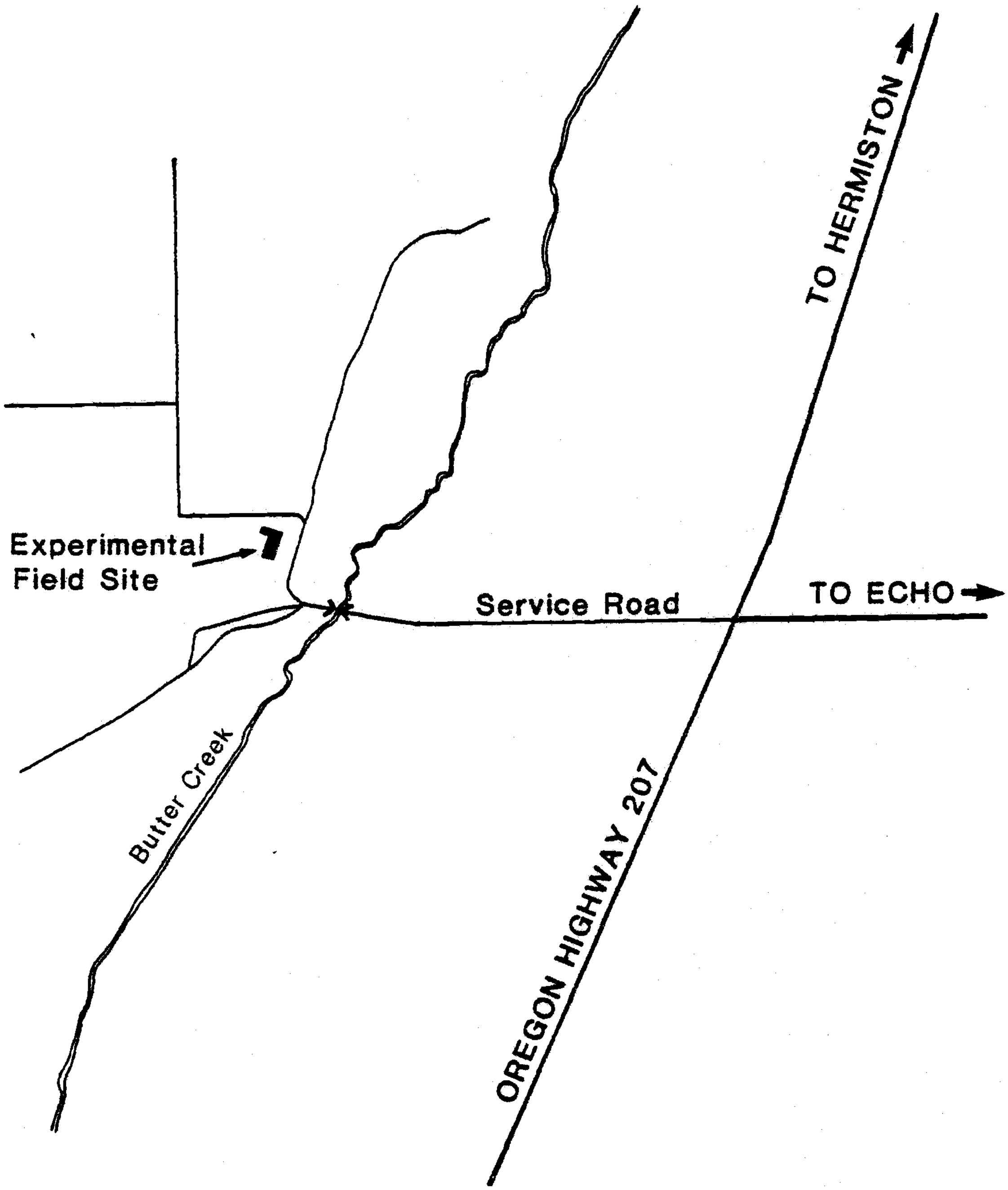

Figure 7. Experimental field site on Madison Farm.

assumed for simplicity that the bulk density across the whole field was 1.45 gm cm^{-3}. The water holding capacity of the soil was determined from observations of water movement through the soil following an initial spring irrigation. A value of 1.5 inches of water per foot (12.5 cm/m) of soil was used, as reported for this soil and crop (SCS, 1973).

Design

The crop selected for this experiment was winter wheat (*Tritium aestevium* var. Stephens). Stephens wheat is the dominant variety of winter wheat grown in Oregon and the Hermiston area. Stephens was released by the Oregon Agricultural Experiment Station in 1977. The variety is adaptable to a diverse cross-section of climates and geographic areas of the Pacific Northwest. Beginning with 0.7 percent of the total winter wheat crop in Oregon in 1978, Stephens rapidly increased to 96 percent of the crop by 1980 (Oregon Wheat Growers League, 1980).

Stephens is a bearded, white-chaffed, semi-dwarf wheat (Oregon Wheat Growers League, 1978). It is resistant to a variety of problems such as stripe rust, leaf rust, some smuts, and lodging. Grain test weight usually is about 55 pounds per bushel. Milling and baking qualities are very good.

Layout

The area of the research plots was approximately three acres (1.2 ha). The irrigated plots were contained in a 200-ft (61 m) by 527.5-ft (161 m) area. Adjacent to the irrigated plots on the west side, were two dryland plots measuring 190 ft (58 m) by 200 ft (61 m). The research plots were staked out in February 1981 and a rough topographic survey of the area was made at that time.

The field was surveyed with a 50-ft (15 m) grid pattern (Figure 8). The highest elevation of the field was near the center of the west edge of the plots. The mainline for the irrigated plots was set along the western edge running north to south. Runoff was not a concern due to the combination of gentle slope and the fact that the grain was drilled approxiately perpendicular to the slope.

The different irrigation treatments were aligned parallel to the prevailing westerly winds to minimize water losses from sprinkler spray drift. This was especially important for the reduced frequency treatments that were to be severely stressed and which therefore received the fewest irrigations.

The research field was divided into 18 separate treatment plots; 16 that were irrigated and two that were dryframed. Two of the plot groups were under similar fixed lateral irrigation regimes. The daily and weekly plots were on fixed intervals with a set of five intended levels

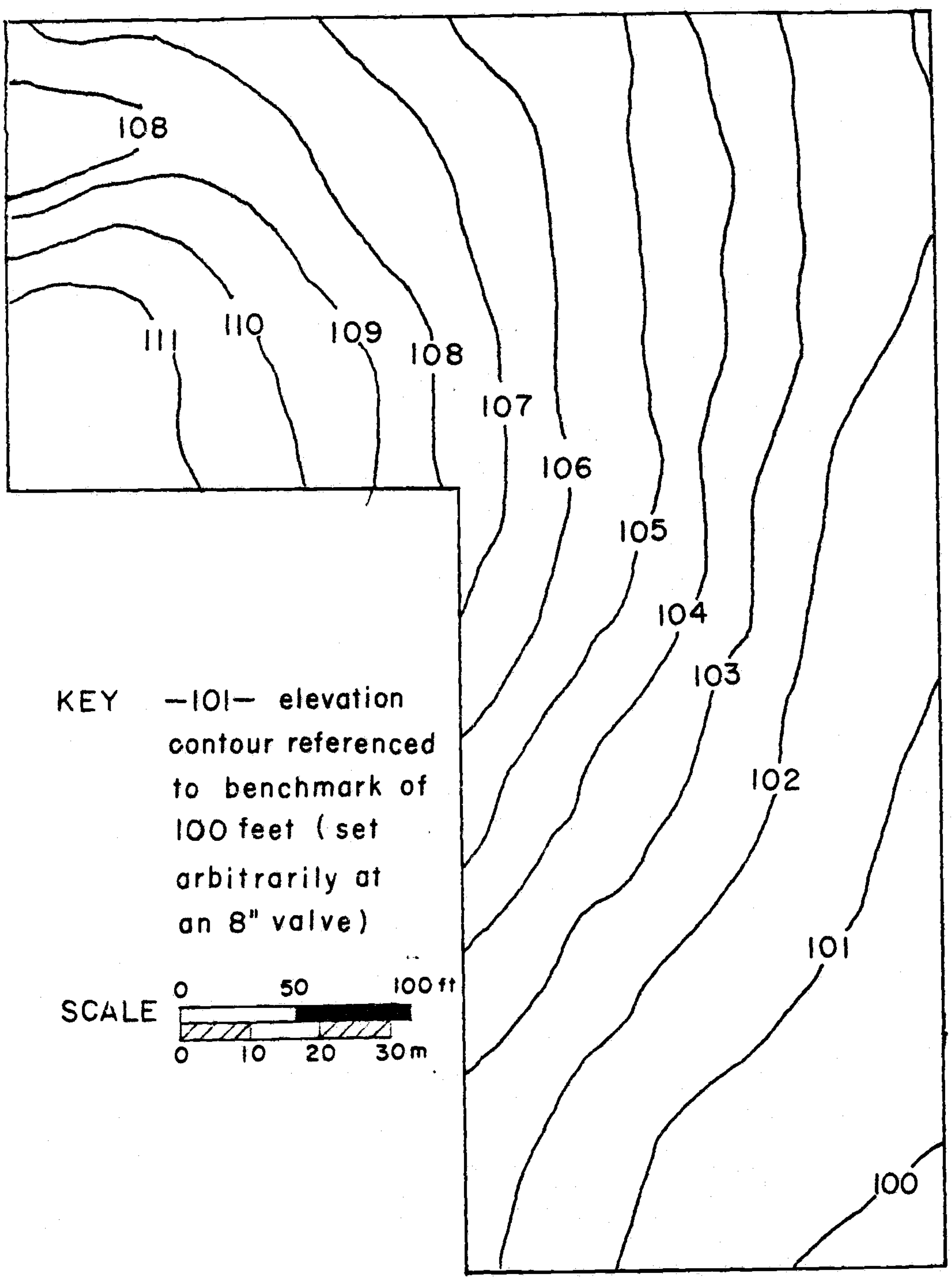

Figure 8. Topographic survey of field experiment site.

of applied water, ranging from 20 percent to 100 percent of the nominal ET requirements.

The third set of plots used to investigate the effect of reducing the irrigation frequency and possibly the level of water use. One plot was irrigated at an interval of about ten days, two more were irrigated at approximately two-week intervals, and the remaining three were irrigated on about a four-week interval. These intervals were chosen to represent levels of mild, moderate, and severe crop stress, respectively. A summary of the plot labels and their respective irrigation regimes are listed in Table 2.

The five daily and five weekly plots were 20 ft (6.1 M) by 140 ft (43 m). The six reduced frequency plots were 45 (13.7 m) by 140 ft (43 m). Included in the 45-foot width were buffer areas of 15 ft (4.6 m) along each side of these plots. A 20-foot (6.1 m) buffer area was included along the north, south, and west sides of the field. A 40-foot (12.2 m) buffer lined the east edge of the field (Figure 9).

Preparations

Preparations for the experiment began in the fall of 1980. Barley (*Hordeum vulgerae*, var. Steptoe) had been grown under dryland conditions the previous year at the experimental site. Stubble from the barley was plowed under in the summer of 1980, then sprayed with Roundup to reduce volunteer barley. The soil moisture was completely

Table 2. Plot designations and irrigation treatments

Plot Designation	Irrigation Treatment
D1	Daily irrigation at 100% of ET demand
D2	Daily irrigation at 80% of ET demand
D3	Daily irrigation at 60% of ET demand
D4	Daily irrigation at 40% of ET demand
D5	Daily irrigation at 20% of ET demand
W1	Weekly irrigation at 100% of ET demand
W2	Weekly irrigation at 80% of ET demand
W3	Weekly irrigation at 60% of ET demand
W4	Weekly irrigation at 40% of ET demand
W5	Weekly irrigation at 20% of ET demand
T1	Approximately two-week interval between irrigations; 100% of depletion applied
T2A, T2B	Approximately three-week interval between irrigations; 100% of depletion applied; staggered
T3A, T3B, T3C	Approximately four-week interval between irrigations; 100% of depletion applied; staggered
SD	Pre-planting irrigation in fall, no further irrigation
ND	Pre-planting irrigation in fall, pre-irrigation in March, no further irrigation

depleted by the barley crop at the end of the 1980 crop year.

The three-acre tract was pre-irrigated on September 20. A four-inch (10.2 cm) irrigation was applied to assist emergence of the crop to be planted that fall. Fertilizer was applied at a rate of 100 pounds of 16-16-16 fertilizer

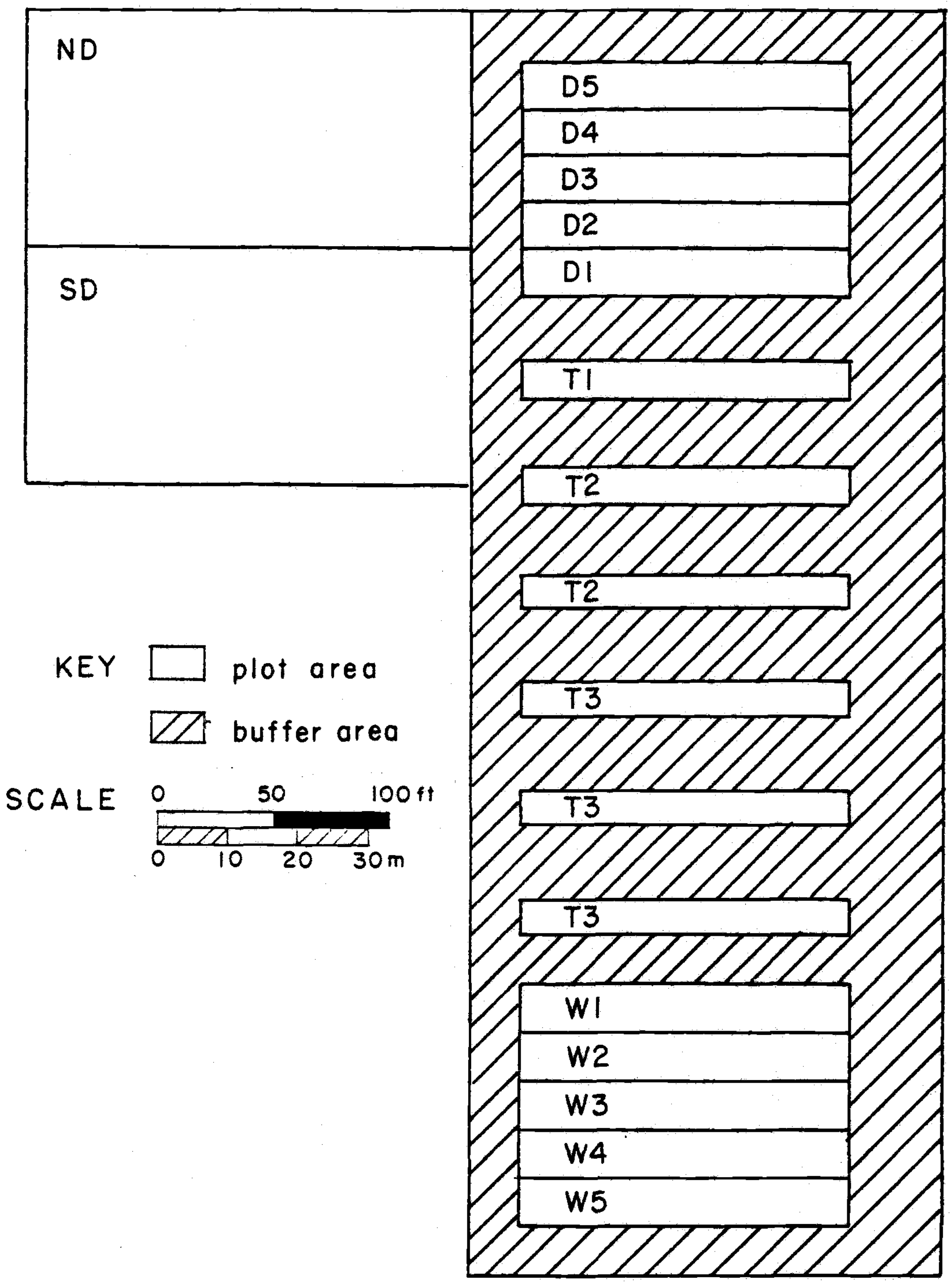

Figure 9. Overall plot layout of field experiment.

and 40 pounds of sulfur per acre. The area was then planted in Stephens wheat on October 7th and 8th at a rate of 18 seeds/foot. Dryland planting spacing of 12 inches (30.5 cm) was used along with a seeding depth of three inches (7.6 cm).

A good stand of wheat was apparent in February. Access tubes for the neutron probe were installed during the last weekend of February. It was noted that some volunteer barley was present at this time. One hundred and two holes were drilled with a Geddings auger and aluminum access tubes inserted with one foot (.3 m) protruding above the soil surface for eacy location and to standardize the initial depth of readings.

The field was sprayed with Roundup to reduce volunteer barley in the field. Fertilizer was applied in the spring (March 29), distributed on the plots in proportion to the yields expected at the various levels of water applications that were planned. The amounts applied as top dressing are listed in Table 3. No further cultural operations were performed until harvest.

To minimize plot area and pipe requirements, a network of six lateral lines was used to irrigate each fixed interval group of five plots (daily and weekly). By regulating the time of operation of each line, a pattern of stepwise increases in applied water could be incurred in each set of plots (Figure 10). The outermost line of each group

Table 3. Top dressing fertilizer (March 1981)

Plot	Nitrogen (lb/ac)
D1, W1	250
D2, W2	250
D3, W3	196
D4, W4	125
D5, W5	71
T1	196
T2A, T2B	125
T3A, T3B, T3C	71
ND	57
SD	0

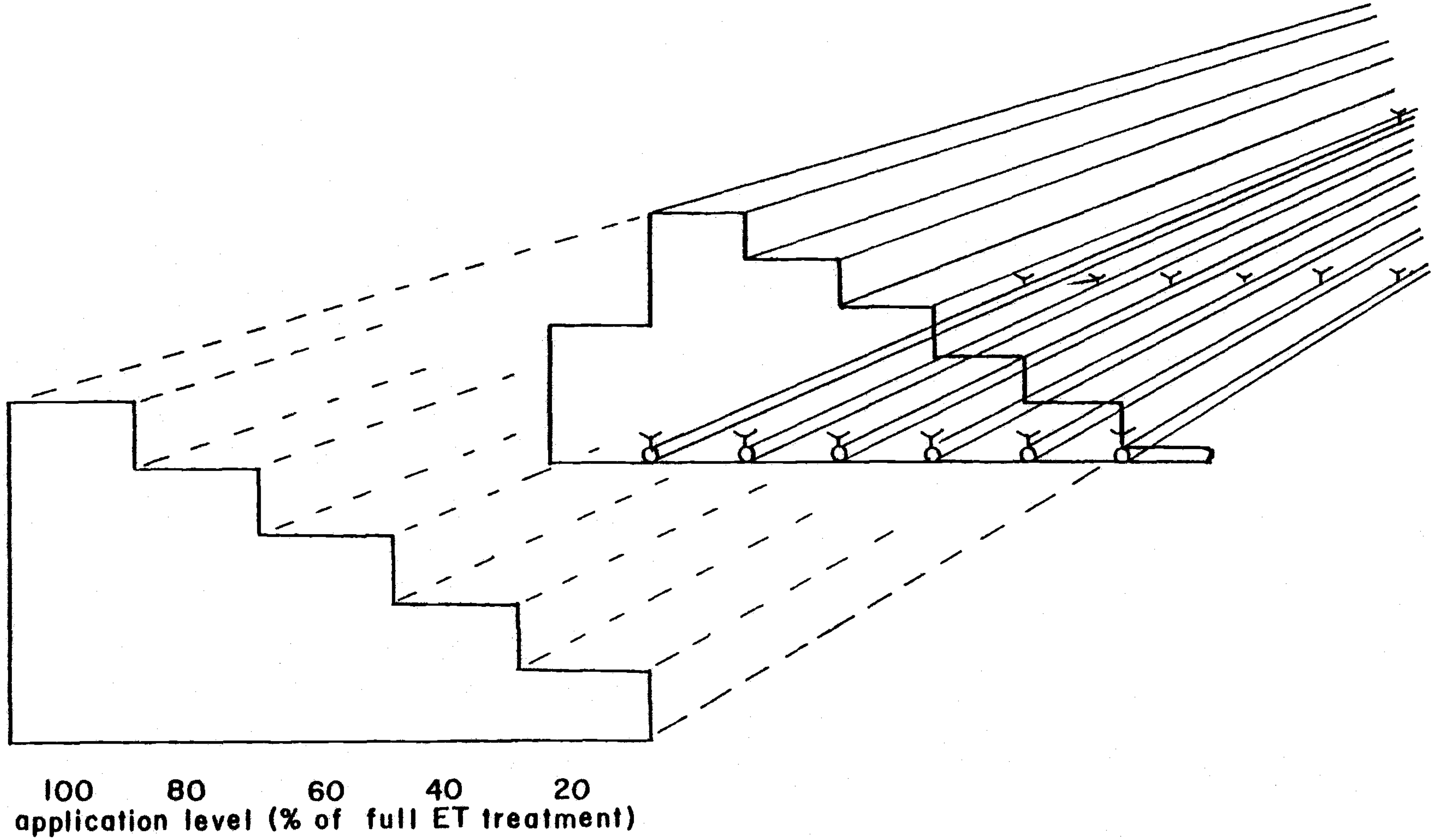

Figure 10. Water application pattern of fixed interval lateral systems (daily and weekly treatments).

would be operated the shortest period, the next one longer, and the next longer, etc.

To produce this step pattern, a sprinkler with a fairly even uniform pattern of application was chosen (Rain Bird Model 14VH). Unlike sprinklers used in line source experiments, these sprinklers have a rather flat pattern of coverage over their full radius of coverage, while the line source type needs a sprinkler with a triangular pattern of application.

The system was assembled in Corvallis for shipment to the experimental site near Hermiston. Most of the aluminum pipe and fittings for the system came from equipment on hand at Oregon State University (OSU). Alteration of existing 40-foot, two-inch aluminum laterals to 20-foot sections was done by a local irrigation equipment firm. Testing and repair of existing valves and hydrants and purchase of any necessary new equipment was also contracted to this firm. The sprinklers were donated to the project by the Rain Bird Corporation of Glendora, California. The majority of the system was packed and shipped by truck to the site in late March 1981.

The mainline was installed first. From the supply hydrant at the far northeastern corner of the field, six-inch pipe was laid down to the northwest corner of the irrigated plots. Two flowmeters were inserted at the corner to monitor water applications. The mainline ran south along the western edge of the irrigated plots.

All laterals were set out east from the mainline. Each lateral consisted of seven sections of two-inch (5 cm) aluminum pipe. The sprinklers on each lateral section were set on 12-inch (30.5 cm) risers at the beginning of the season. The risers were extended later in the season to 30 inches (76.2 cm) to accomodate the elevating canopy height.

There were six neutron probe access tubes in each of the irrigated plots. The probe tubes were set along the center line of the plots, spaced at 20-foot (6.1 m) intervals. These tubes also served as retainers for the support apparatus of the catch cans. By monitoring the soil moisture depletion and applied water at each access tube, there would be six replicated data sites for each irrigation treatment. Five yield samples would be taken in between the six water use monitoring sites in the undisturbed portions of each irrigation treatment. Detailed maps of the daily, extended interval and the weekly plots are shown in Figures 11, 12, 13, and 14.

A small weather station was established at the experimental site during installation of the irrigation system. The station was initially designed to measure climatic data to schedule irrigations using the Penman ET model (Jensen, 1973). This approach was abandoned because the readings were inaccurate and incomplete for a variety of reasons. The irrigations were scheduled on the basis of the Class A

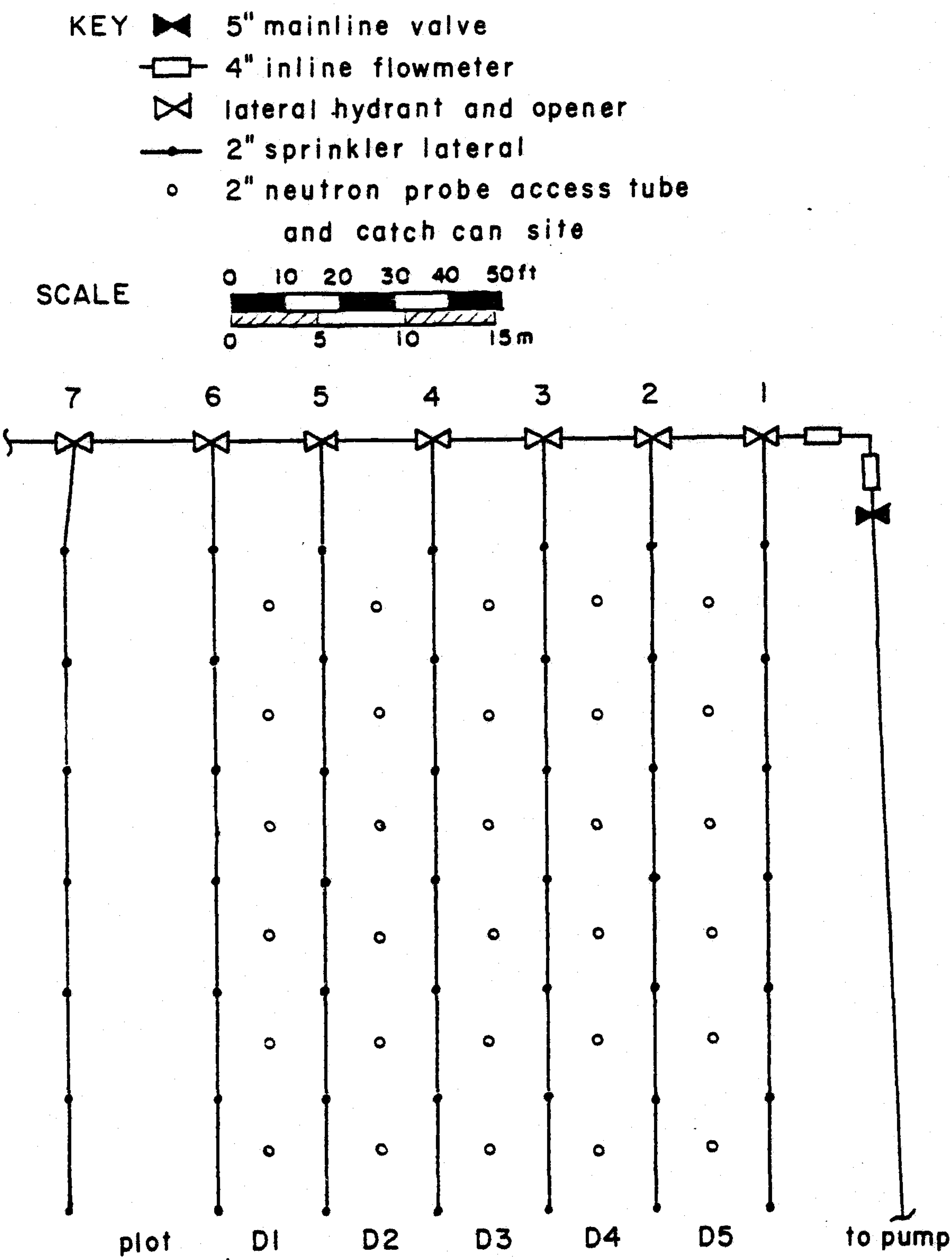

Figure 11. Plot layout for daily interval treatments (D1, D2, D3, D4, and D5).

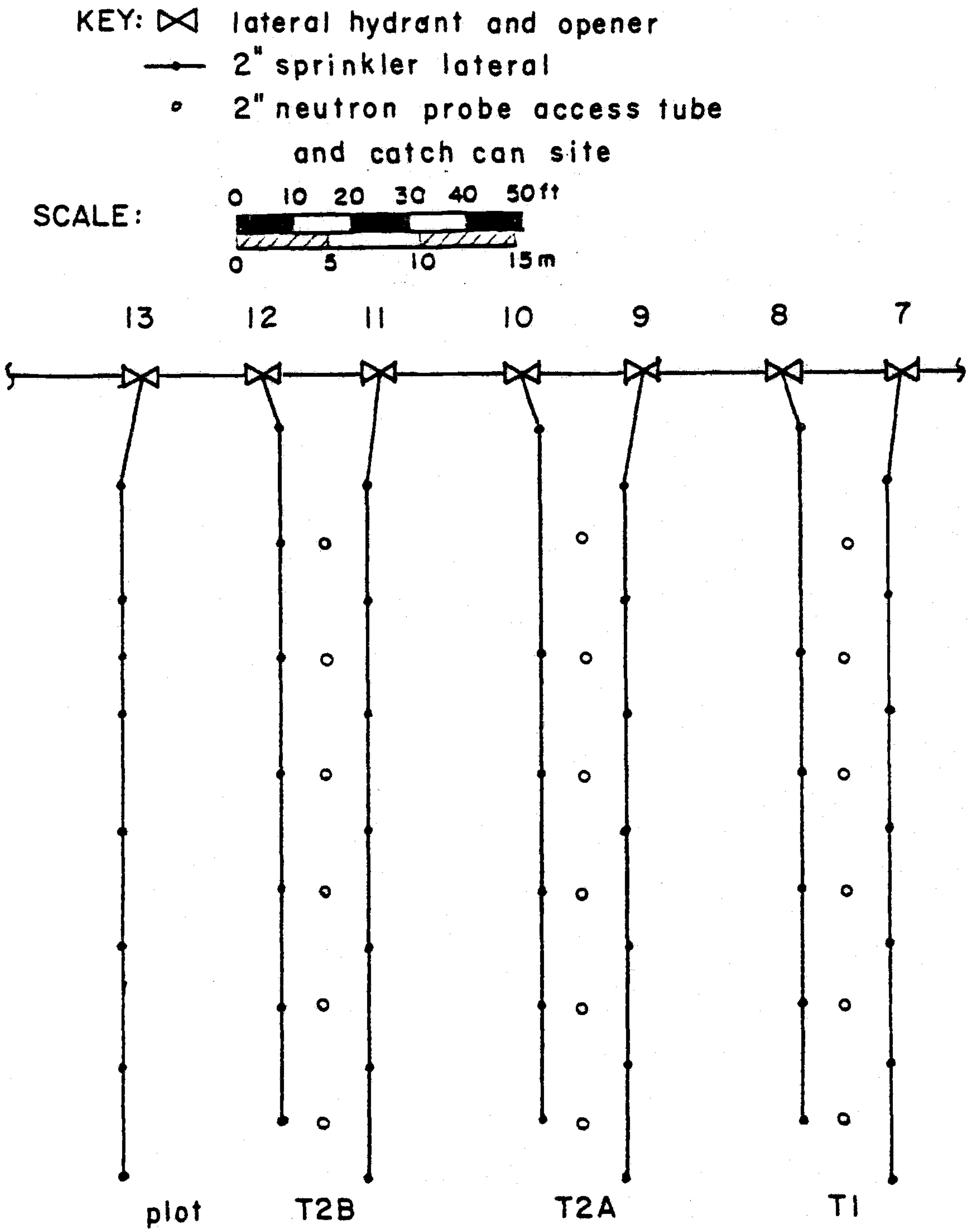

Figure 12. Plot layout for variable interval treatments (T1, T2A, and T2B).

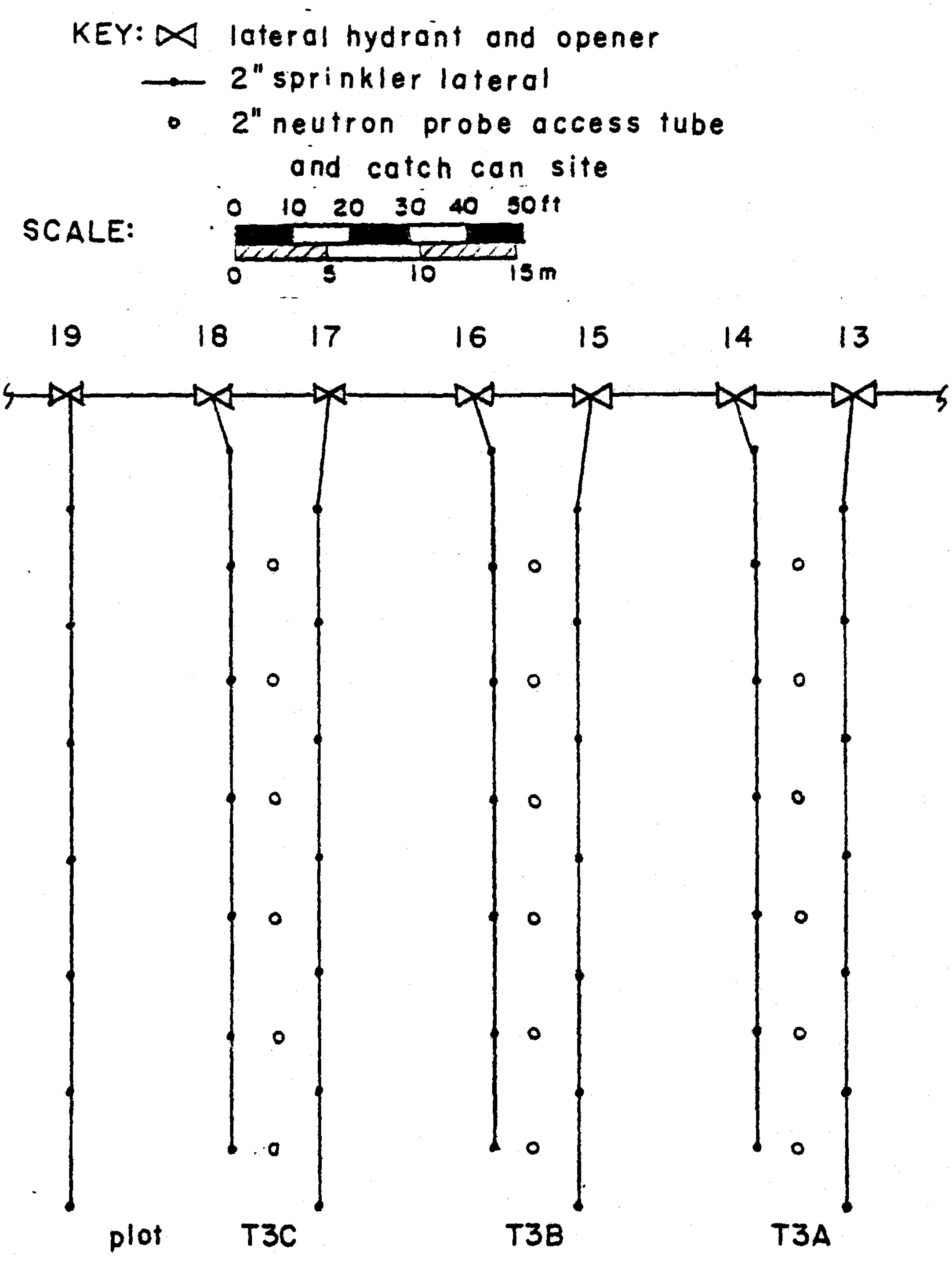

Figure 13. Plot layout for variable interval treatments (T3A, T3B, and T3C).

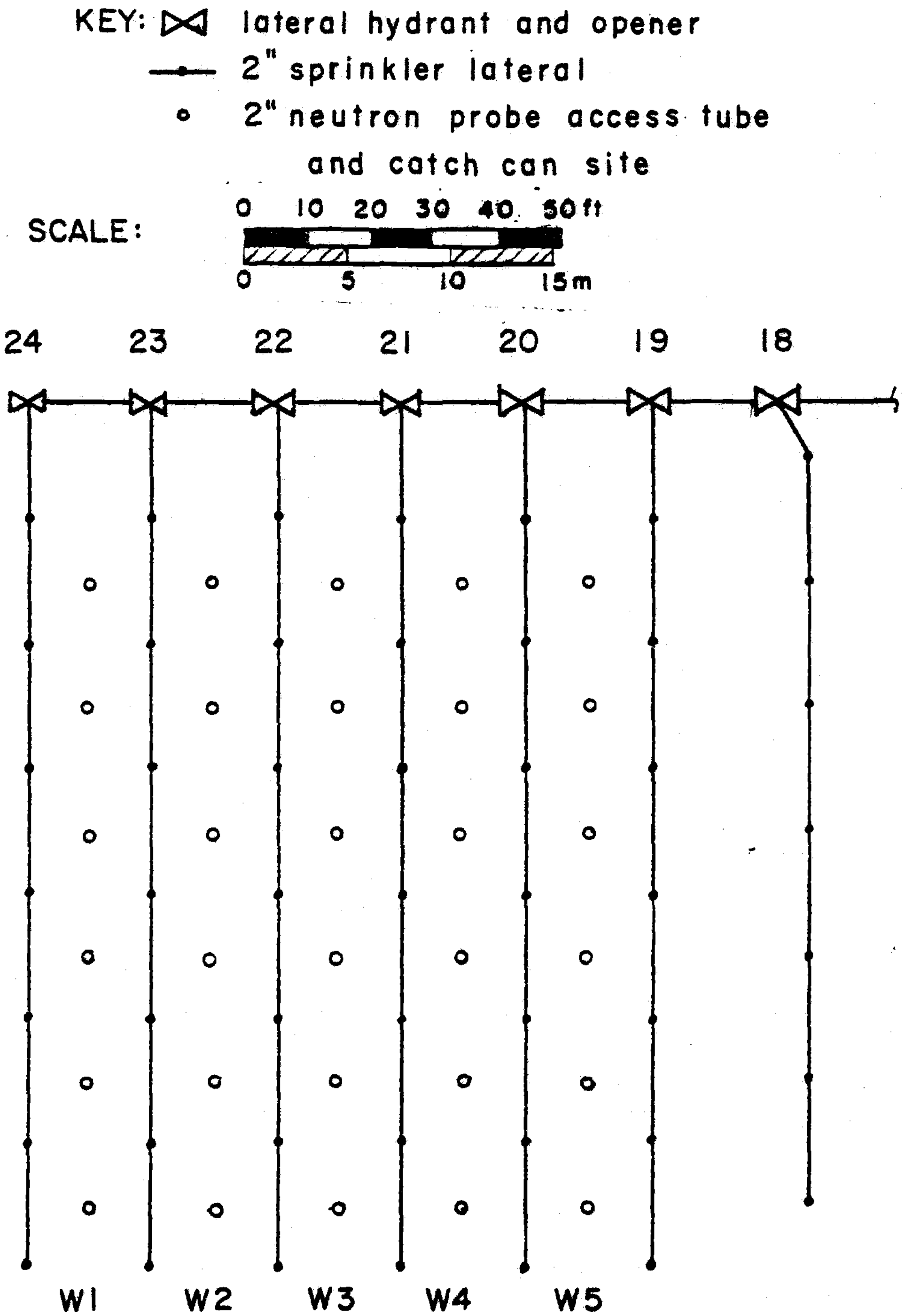

Figure 14. Plot layout for weekly interval treatments (W1, W2, W3, W4, and W5).

type U.S. Weather Bureau evaporation pan and a standard eight-inch (20 cm) rain gauge for the remainder of the season.

Water Use

Water use over the irrigation season was calculated on a water balance basis. The soil profile was assumed to be at field capacity following preirrigation of the plots in the spring (March 30 and 31, 1981). Soil moisture was monitored using a neutron probe. Initial measurements were taken the first week of April. Applied irrigation water was measured with the catch cans positioned over each neutron probe access tube. Runoff was negligible due to the low sprinkler application rate and the high soil infiltration rate. Deep drainage was a concern early in the season and irrigations were scheduled in such a way as to minimize the potential problem. As a result, this parameter was also found to be insignificant. Precipitation was measured at the site with a rain gauge. All these factors were used in a water balance equation (3) for determining evapotranspiration over the irrigation season.

$$WU = (SMi - SMf) + P + IRR - R - D \qquad (3)$$

where:

WU = ET over the irrigation season

SMi = initial soil moisture

SMf = final soil moisture

P = precipitation over the irrigation season

IRR = applied irrigation water over the season

R = runoff over the season, considered negligible

D = drainage over the season, considered negligible

Soil Moisture Measurements

Soil moisture was monitored with a neutron probe (Campbell Pacific Nuclear, model #503). The probe measures the activity of fast neutrons emitted into the soil from a radioactive source. The 503 Hydroprobe has an Americum/ Berylium source. The fast neutrons collide with various nuclei in the soil, gradually losing energy. Since hydrogen is a particularly effective element for slowing down neutrons in the soil, the degree of slowing down of the neutrons is a measure of the soil water content.

The slowed neutrons form a cloud around the source and some randomly return to a detector near the source. The receiver records pulses in a charged wire as it is struck by the neutrons. The number of pulses is counted over a given time span (one minute was used for this experiment) and is displayed on a readout.

To monitor the soil moisture at different levels in the profile, the probe source/receiver was inserted in an access tube suspended by a cable. Two-inch, seamless aluminum tubing was used as access tubing for the probe.

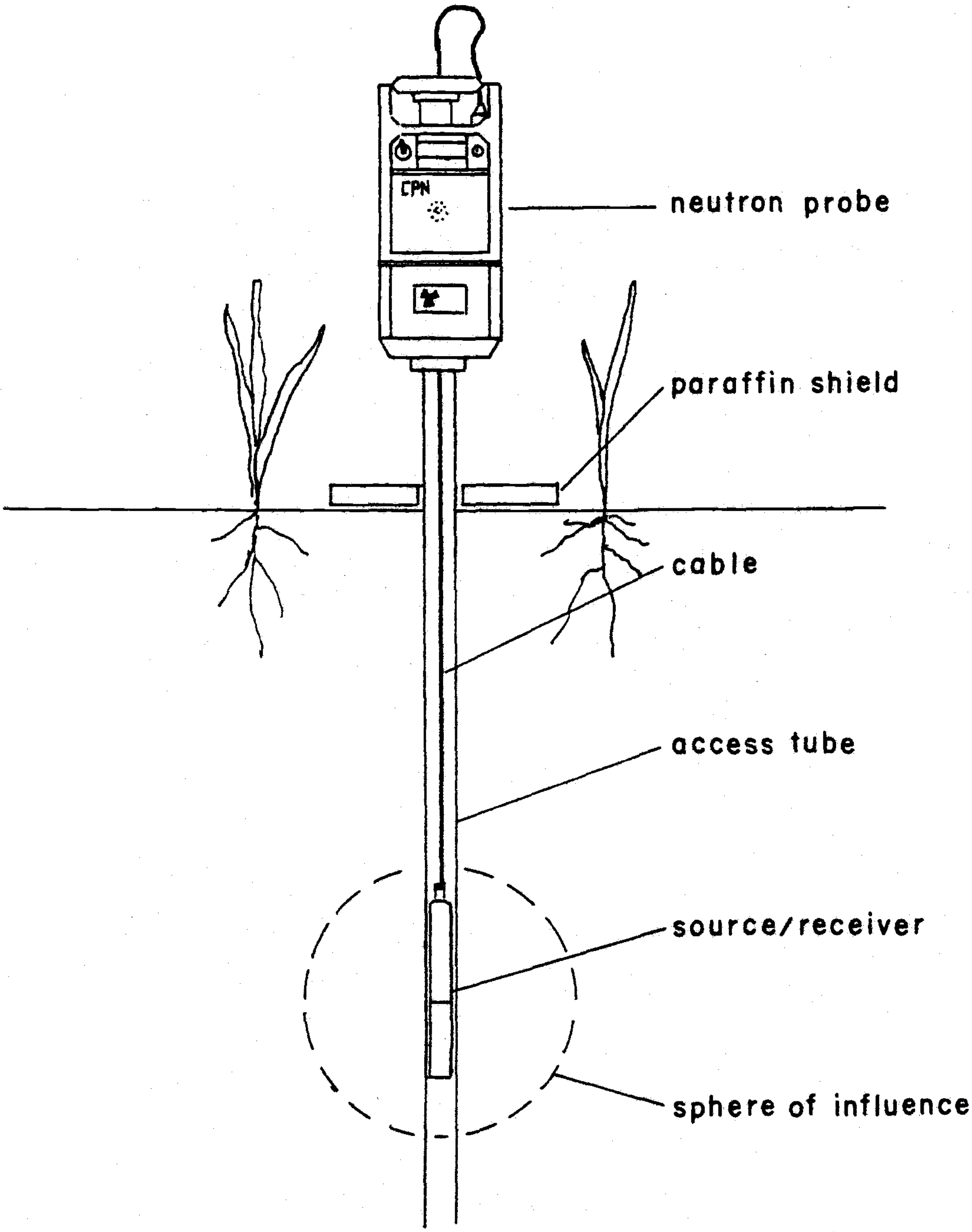

Figure 15. Representation of neutron probe on access tube ready for soil moisture measurements.

The tubing was inserted in the holes drilled with the hydraulic auger. The cable supported the source/receiver as well as provided the connection to the probe body and controls. Clamps on the cable, spaced at one foot (30.5 cm) intervals, provided a means of taking measurements at consistent depths in the profile. Six to eight readings were taken in an access tube, depending on the depth of the hole. Figure 15 shows the probe, with the source/receiver lowered in an access tube ready for measurements.

Systematic errors are introduced by the probe due to instrument variation and source decay. To standardize readings, a ratio of probe counts is used instead of the absolute counts. A material high in hydrogen, such as paraffin, surrounds the probe source when it is not in use. Multiple readings with the source inside the probe are taken to obtain an average "standard" count. Sample count readings taken after this first set are divided by the standard count to calculate probe count ratios.

To determine the soil moisture content, the count ratio is referred to a calibration curve. With variability of hydrogen and organic content of different soils, the probe needs to be calibrated for each site and soil type. Field calibration is the best method to use. Gravimetric samples are taken at different depths at a sample site. Netron probe readings are taken at the same site and at the same depths of the soil samples. Testing a variety of sites within a field helps produce a calibration curve for a wide range of soil moisture conditions.

The calibration curve used in this experiment was developed from two field calibration trials. An initial attempt, early in April, 1981, failed to provide satisfactory data to develop a reliable curve. A second, successful attempt was made in May, 1981.

In the second trial, soil sampling and probe measurements were carefully monitored. Soil samples were taken every three inches down to four feet in eight separate test holes and placed in soil cans. Each sample can was weighed at the field site to minimize moisture loss. Returning to Corvallis, the samples were dried in a forced convection oven at 105°C for 24 hours to evaporate the available water in the soil. The samples in the soil cans were reweighed after drying, then the cans were emptied and weighed. The percentage of moisture, by weight, in each sample was then compared to the corresponding probe count ratio.

For more accuracy using the probe, separate calibration curves were used for the top foot of soil and the deeper portions of the soil profile. Measurements near the surface are not very accurate due to loss of neutrons into the atmosphere through the soil surface. A shield of paraffin was used to cover the ground over the access tube, thus introducing a standardizing upper bround for the probe. Thus, the readings taken near the surface with the shield require a separate calibration curve than the rest of the profile (deeper than one foot).

The calibration curve for the upper one foot (30.5 cm) of soil is listed in Equation (4):

$$\theta_w = (20.736 \times CR) - 2.0575 \quad (R^2 = 0.99) \qquad (4)$$

Equation (5) is the resulting calibration curve for the remainder of the soil profile:

$$\theta_w = = (19.563 \times CR) - 2.288 \quad (R^2 = 0.97) \qquad (5)$$

where

θ_w = soil water content, percent by weight

CR = ratio of neutron probe measurement count to standard count

R^2 = coefficient of correlation

The two curves from the field calibration are presented in Figures 16 and 17.

All the precipitation occurring during the spring and summer of 1981 at the experimental site was in the form of rain. Instead of using the weighing bucket of the rain gauge, a simple volumetric conversion was used. The rainfall caught in the rain gauge was converted to the equivalent rainfall depth using equation (4):

$$R = 0.001215 \times Vrg \qquad (4)$$

where

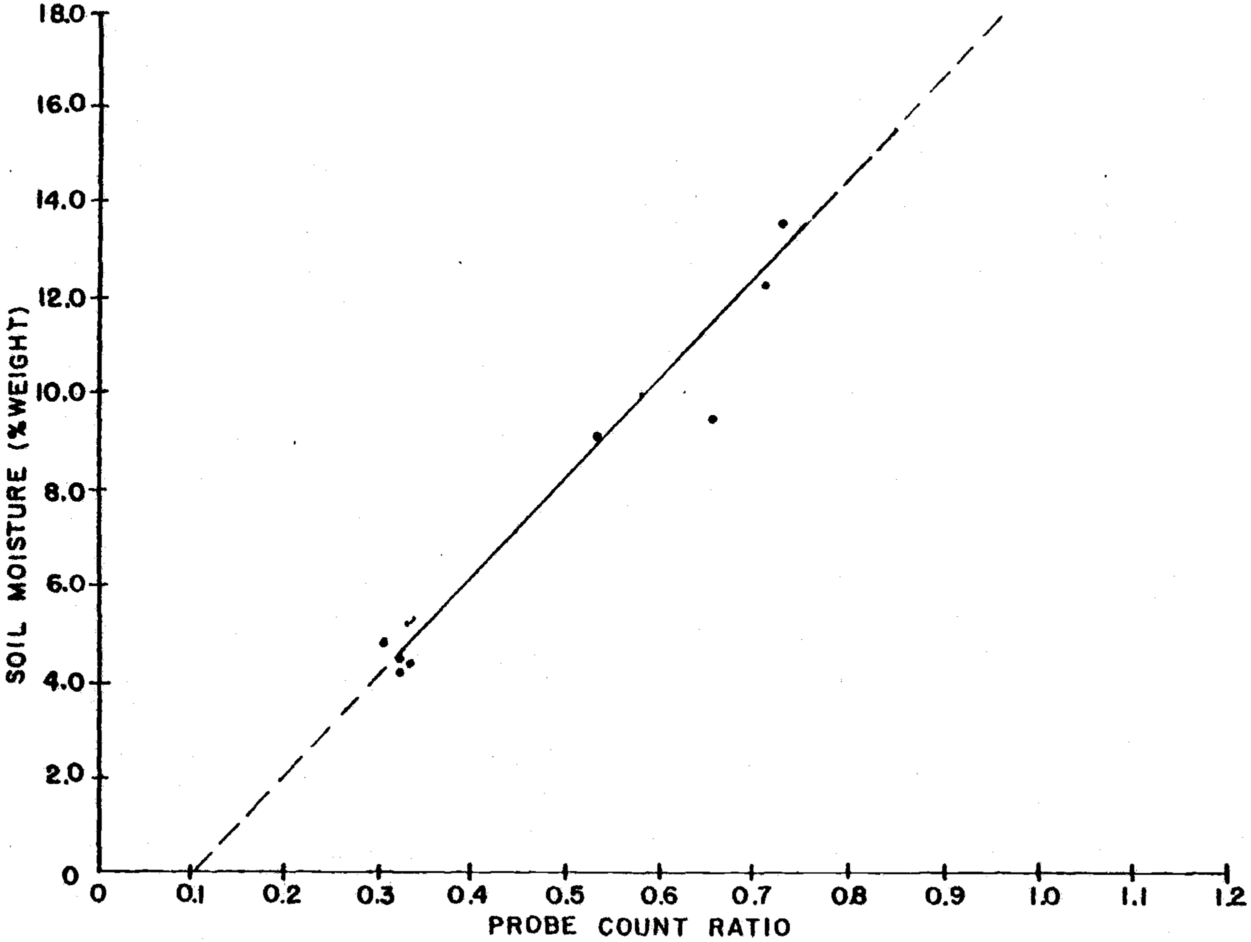

Figure 16. Calibration curve for neutron probe for a depth of 0-1 foot.

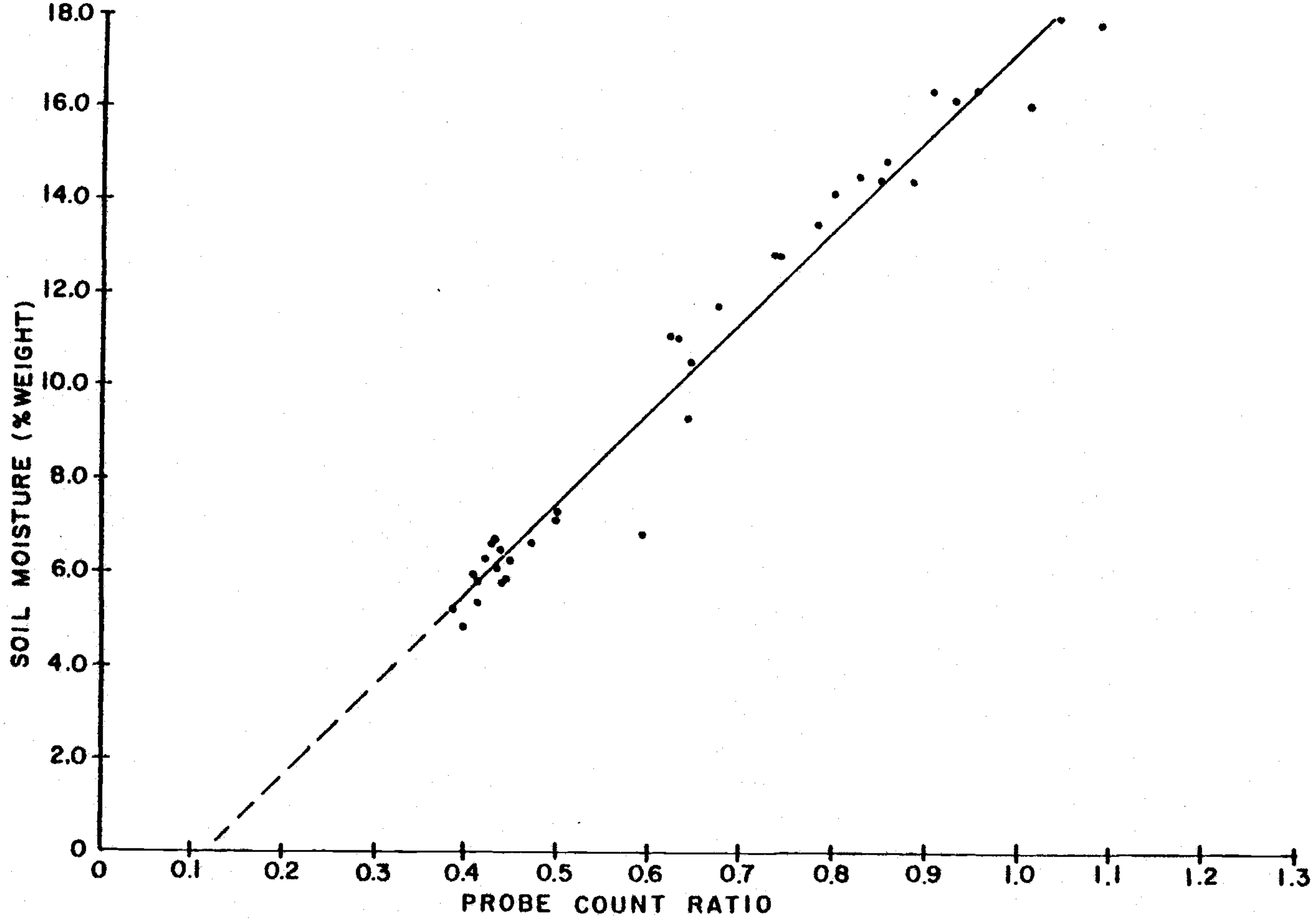

Figure 17. Calibration curve of neutron probe for a depth of 1-4 feet.

R = depth of rainfall (inches)

Vrg = volume of water caught in rain gauge (milliliters)

The constant in this equation was derived from the measured diameter of the catch can.

Applied Water

Applied water was measured in catch cans fabricated from eight-inch (20.3 cm) lengths of four-inch (11.6 cm) diameter PVC pipe. A plastic plate glued to one end served as a base for the catch can and an attachment base for the extendable stand inserted in each neutron probe access tube (Figure 18). The water caught after each irrigation was converted from a volume measurement to a depth of application with a simple conversion formula (Equation 5):

$$AD = 0.00725 * Vic \qquad (5)$$

where

AD = depth of application (inches)

Vic = volume of water caught (milliliters)

During the season it was found that some catch cans leaked, some broke off at their plates and others fell off their stands. The measurements of applied water recorded at each irrigation were therefore subject to close scrutiny. Any value that was more than 50 percent outside the plot average was disregarded and a new average calculated

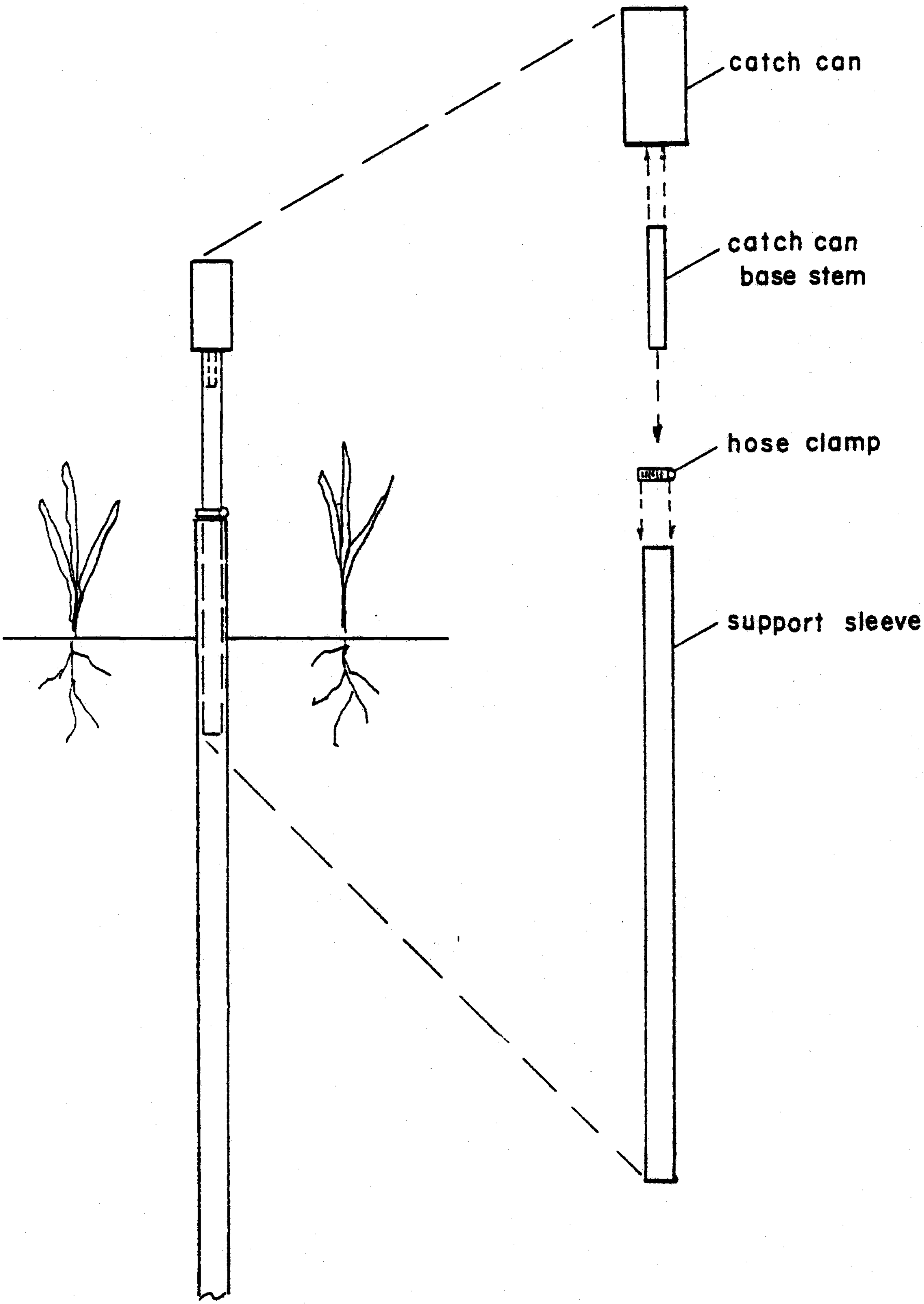

Figure 18. Representation of catch can assembly on access tube ready for measuring applied water.

from the remaining values. The new average was then substituted for the questionable number.

Operations

A field technician was responsible for operating the neutron probe, applying irrigations, and other required jobs during the irrigation season. Weather readings were taken each morning at the Hermiston Experiment Station and at the field site. Evapotranspiration estimates were derived from the weather data using modified Penman Equation (Jensen, 1973). Due to lack of reliable instrument data at the field site, this method was abandoned in favor of the pan evaporation method (Jensen, 1973). Local calibration of both methods was accomplished using a crop coefficient curve for winter wheat grown in a locale similar to the experiment site (James Wright, 1981). Precipitation amounts were measured at the site with a rain gauge and subtracted from crop water use estimates to compute the daily application depth.

The high frequency plots were irrigated six days a week. No irrigations took place on Sunday, but the irrigation on Saturday was doubled to compensate for the missing day. Soil moisture readings were taken before the irrigations and catch cans were measured following the irrigations.

Every Wednesday, the technician would measure soil moisture in all the weekly irrigated plots. The depth of application was based on the weekly total of estimated crop water use and the measured soil moisture depletion. The weekly irrigations were carried out the next day (Thursday) and the catch cans measured immediately following the irrigation.

A set of operating procedures was developed for the two sets of six lateral networks of the fixed interval plots (daily and weekly). The fully irrigated plots (D1 and W1) were refilled each irrigation while the remaining four plots in each set received proportionally smaller amounts of water. The required time of operation of each line of the six-line networks was calculated from these five application depths.

The application rate of the sprinklers depended on the operating pressure of the system. The relationship between pressure and flowrate for the sprinklers was derived from manufacturers data (Rain Bird Corporation, 1981). Equation (6) represents this relationship:

$$Q = 0.491 \times Pr + 0.0125 \tag{6}$$

where

Q = sprinkler flowrate (gallons per minute)

Pr = sprinkler operating pressure (pounds per square inch)

The application rate over the area covered by a system of sprinklers depends on the lateral and sprinkler spacing as well as the sprinkler flow rate. Equation (7) was used for calculating the application rate at the spacings used in this experiment:

$$P = \frac{96.3 \times Q}{S_l + S_m} \qquad (7)$$

where

P = application rate (inches per hour)

Q = sprinkler discharge (gallons per minute)

S_l = lateral spacing (feet)

S_m = mainline spacing (feet)

Equations (6) and (7) can be combined to express the application rate as a function of pressure at the lateral valve. For the 20-foot (6.1 m) by 20-foot (6.1 m) spacing in the fixed interval networks, equation (8) represents this relationship:

$$P = 0.118 \times Pr + 0.003 \qquad (8)$$

where

P = application rate (inches per hour)

Pr = pressure at lateral valve (pounds per square inch)

A partial list of the pressure, wetted diameter, sprinkler flowrate, and application rate relationships are presented in Table 4.

Table 4. Design information of the Rain Bird 14 VH, 50, 5/64-inch nozzle sprinkler (Rain Bird Corporation, 1981) with calculated application rates for 20-foot by 20-foot sprinkler spacing

Pressure (psi)	Wetted Diameter (ft)	Sprinkler Flow Rate (gpm)	Application Rate (in/hr)
25	39	0.81	0.20
30	40	0.88	0.21
35	41	0.92	0.22
40	42	0.99	0.24
45	43	1.06	0.26
50	44	1.11	0.27

The time required for a system to apply 100 percent of the estimated water use from the previous period (daily or weekly) was calculated from equation (9):

$$T = \frac{60 \times ET}{P} \tag{9}$$

where

T = time of application for 100 percent ET requirement (minutes)

ET = estimated crop water use (inches)

P = application rate (inches per hour)

The time of operation of the six laterals in the networks was based on this 100 percent operating time. A set of ratios as listed in Table 5, were multiplied by the 100 percent value to calculate the individual operating times of each lateral.

Table 5. Operating time ratios for fixed interval lateral networks

Line	Ratio to 100% Operating Time
1 or 24	0.1
2 or 23	0.3
3 or 22	0.5
4 or 21	0.7
5 or 20	0.9
6 or 19	1.1

Scheduling the stress plots was based on the soil moisture readings and the intended interval between irrigations. The depth of application required to refill the soil profile was estimated from the measured depletion. Most of the irrigations for the stress plots ran over night, without continuous observation as in the weekly and daily plots. The catch cans were read immediately following the irrigation. Missing and erroneous catch can values were more frequent per irrigation event than in the normal and high frequency treatments, probably due to the long periods of unobserved water application.

Plots in treatment T1 were irrigated once every 10 to 14 days. Plots in T2A and T2B were irrigated at three-week intervals. To compensate for some of the expected yield reduction associated with timing of irrigations over longer intervals, the two treatments were irrigated on a staggered cycle. That is, plots in T2A would be irrigated, then one and one-half weeks later plots in T2B would be irrigated, then the sequence would be repeated. A similar schedule was used to irrigate the plots in treatments T3A, T3B, and T3C. The full interval for the T3 plots was about four weeks. Treatment T3C received water first, ten days later plots in T3B, ten days later plots in T3A, and the cycle was repeated. The irrigation calendar for the season starting April 1st as shown in Table 6 for the stress and weekly treatments.

Table 6. Irrigation calendar for stress (extended interval) and weekly treatments

Plot	Irrigation Event Dates
T1	3/30, 4/18, 5/17, 5/19, 5/30, 6/12
T2A	3/30, 5/17, 5/19
T2B	3/30, 4/18, 5/30
T3A	3/30, 5/30
T3B	3/30, 4/18, 6/6
T3C	3/30, 4/18, 5/17, 5/19, 6/12, 6/13
W1 - W5	3/30, 4/7, 4/14, 4/21, 4/28, 5/5 5/12, 5/21, 5/28, 5/30, 5/14

As part of a parallel experiment, soil moisture readings were taken at ten sites, two in each of five plots; D4, W1, T2A, T1, and T3A. These sites were monitored four times a week on Monday, Wednesday, Friday, and Saturday.

This additional data was used in this experiment to monitor short term soil moisture depletion.

Data taken at the field site was transmitted from Hermiston to the CYBER computer at the OSU campus. Handwritten field notes and daily weather data from the Hermiston field station were mailed to Corvallis once a month to backup the computer link. Upon receipt of the raw data, it was stored temporarily until it could be processed by a program to separate the neutron probe, catch can, and weather data into separate files. A series of programs converted the neutron probe readings to soil moisture levels, the catch can readings to applied water depths, and the weather data to estimates of daily ET.

Irrigations were discontinued the week of June 17th. The irrigation system, catch cans, and weather station were then put into storage for the next season. Probe readings were taken in the ten monitor tubes until the middle of July. All probe tubes were then measured over a three-day period (July 14, 15, 16) immediately before harvest.

Harvest operations were carried out July 17, 18, and 19. Five yield samples were harvested in each irrigation treatment. The samples were taken between the six neutron probe access tubes in each treatment. Three samples were taken from each of the two dryland plots.

Yield samples were individually harvested, then measured for the equivalent weight of grain per unit area. Water use values for each plot were taken from probe, catch can, and precipitation data. Data from the two probe tubes adjacent to each plot were averaged to calculate soil water uptake for each harvest plot.

A small gasoline powered Jacobs cutter bar was used to assist in the harvest operations. A buffer strip between each of the treatments was clipped with the cutter bar. The cut wheat was raked toward the center of each buffer strip for pickup later by a field combine. The sample plots were then cut from the area between the six probe tubes and thrashed.

The cut wheat from each plot was transported on a tarpaulin to a portable gasoline powered "Vogel" thrasher. The thrasher was set as close to the plots as possible to minimize loss of grain during transfer of the wheat to the thrasher. While the wheat from a plot was fed through the thrasher, the plot was gleaned for loose wheat heads. The grain emerging from the thrasher was transferred to sacks, marked with the plot designation, and loaded on a truck for shipment back to Corvallis.

The wheat from one sample (Treatment D5, plot number five) was mishandled during thrashing operations. The cut wheat was taken by rake to the thrasher with a large loss of wheat stalks. A large portion of the grain sample was misplaced, leading to an inaccurate sample of the plot yield.

The wheat left standing in the treatments was used to mark the borders of the harvested plots. Measurements of the plot areas were taken from the width of the plot and the number of rows cut by the cutter bar. Most of the plots measured about 12 feet on the sides and ten rows (spaced at one-foot intervals) across.

The other yield indices were measured from the harvest samples. Test weight, the grain density was measured for two grain samples from each harvest sample. The average values of each pair of samples was recorded.

Fifty heads were taken from two rows in each plot. The 500 head samples were taken back to Corvallis for threshing and seed counts. The average number of seeds per head was taken from these samples.

IV. RESULTS

Winter wheat yields in the Hermiston area were exceptionally high in 1981. The high level of yields is illustrated by production from the dryfarmed acreage of the Madison Farm. Dryland wheat areas of the farm yielded an average of 45 bushels per acre (2610 kg/ha) where normally 25 bushels per acre (1450 kg/ha) would be expected (John Madison, 1982). Similar high yields were noted in the irrigated treatments as well as the two dryfarmed plots of the experiment.

There was an apparent compression in the range of yields of the fixed interval (daily and weekly) plots. The yields varied from 59 to 112 bushels per acre (3420 to 6500 kg/ha) in the daily plots and from 68 to 112 bushels per acre (3950 to 6500 kg/ha) in the weekly plots.

The extended interval plots did not appear to develop stress to the degree expected by the reduction in irrigation frequency. As an example, the T3A plots, which received two irrigations during the season, yielded an average of 77 bushels per acre (4460 kg/ha), a considerable increase over the dryfarmed yield average. Similar yield results were noted in all of the extended interval, stress treatments.

Mild weather conditions prevailed throughout the irrigation season. As listed in Table 7, daily temperatures were consistently cooler than the long term averages. An

Table 7. Monthly maximum and minimum air temperatures, Hermiston Experiment Station during the 1981 irrigation season (April - July)

Month	Maximum				Minimum			
	Long Term (1931-60)		Crop Year (1981)		Long Term (1931-60)		Crop Year (1981)	
	°F	(°C)	°F	(°C)	°F	(°C)	°F	(°C)
April	68.2	(20.1)	64.9	(18.3)	38.9	(0.3)	38.8	(3.8)
May	76.8	(24.9)	71.7	(22.1)	46.1	(3.8)	46.6	(8.1)
June	82.9	(28.3)	74.9	(23.8)	52.4	(11.3)	51.4	(10.8)
July	92.1	(33.4)	83.7	(28.7)	54.8	(12.7)	54.6	(12.6)

unusually large amount of rain fell during the irrigation season as shown in Table 8. The long term average precipitation values, taken from records at the Hermiston Experiment Station, are compared to the seasonal (1981) data at the field experiment site as well as at the Experiment Station.

Water use by the wheat crop was affected by the mild weather conditions. Seasonal evaporation at the Hermiston Experiment Station was 33.8 inches (85.6 cm) compared to a long term average of 34.1 inches (86.6 cm) (National Climatic Center, 1982). This was not a significant difference, though the rainfall total during this period was 76 percent higher than normal.

Differences in the amount of applied water within each irrigation treatment were offset by corresponding differences in soil moisture depletion. The precipitation total for the irrigation season was 3.91 inches (10 cm). The amount of applied water ranged from 1.38 inches (3.5 cm) to 12.2 inches (31 cm). The total water use average of each set of five subplots in each treatment was within ten percent of any of the five values, except for the W3 plots. Comaprisons of the total water use for different sets of five subplots are illustrated in Figure 19.

The majority of water used by the wheat crop came from soil moisture depletion. Applied water was only a small portion of the total water use in the deficit, fixed

Table 8. Monthly precipitation, long term Hermiston Experiment Station (1931-60), Experiment Station (1981), and experimental field site (1981) during the irrigation season (April - July)

Month	Long Term Precipitation (inches)	Experiment Station Precipitation (inches)	Experimental Site Precipitation (inches)
April	0.68	0.09	0.03
May	0.66	1.58	1.68
June	0.75	1.46	1.63
July	0.19	0.57	0.57
Total	2.22	3.70	3.91

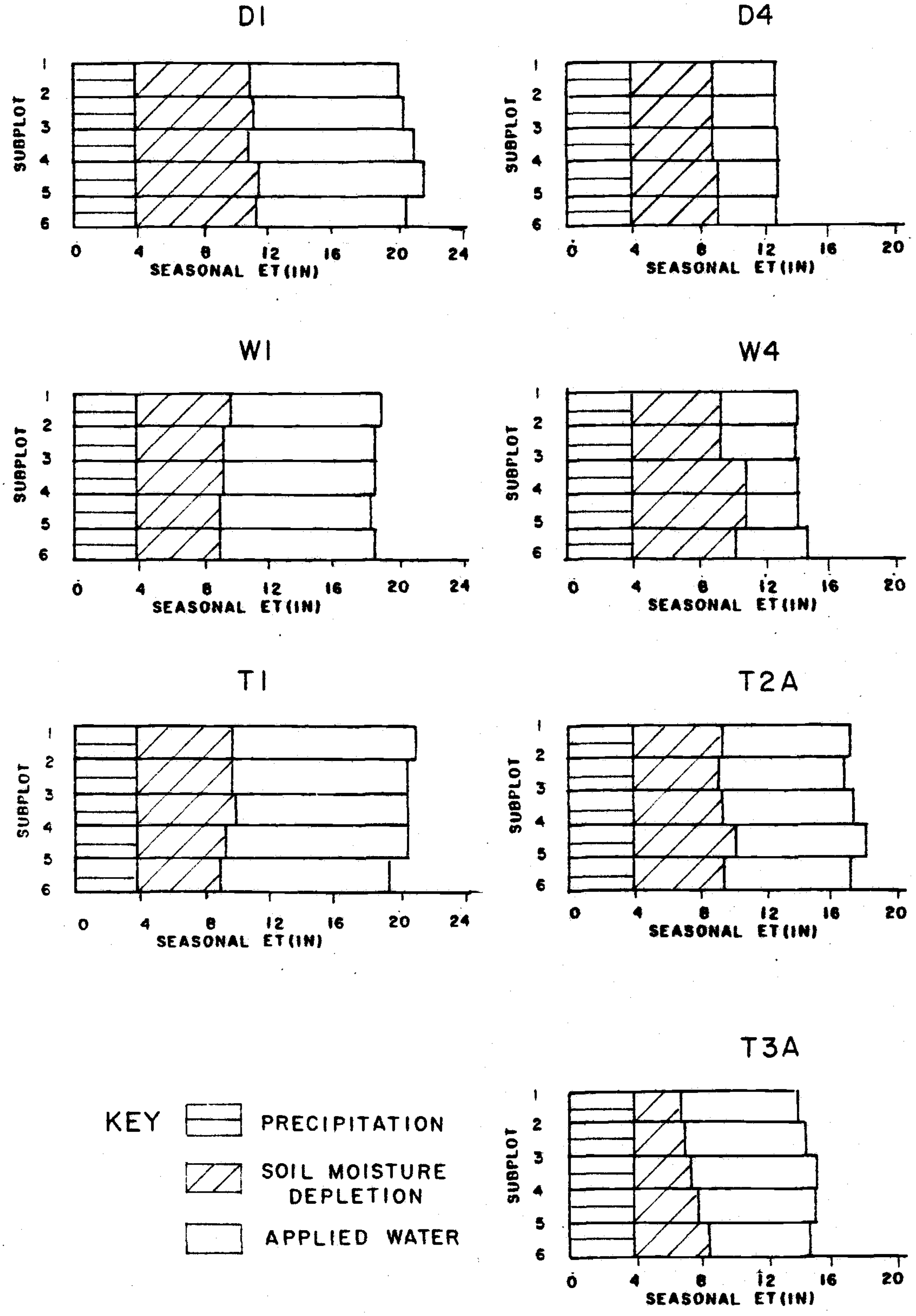

Figure 19. Total water use of different sets of five subplots from seven irrigation treatments.

interval plots. Instead of a range of 20 to 100 percent of the total ET as planned by the water applications, there was a compression of the range of water use. As a percentage of the targeted 100 percent treatments (D1 and W1), the actual range for the fixed interval plots was from 52.3 to 100 percent in the daily and from 51.7 to 100 percent in the weekly plots.

Neutron probe data indicated about a four-foot (1.2 m) depth of depletion of the soil profile in most of the irrigated plots. The depletion of the fixed interval (daily and weekly) plots was limited to this depth, while the reduced frequency plots depleted the soil moisture down to six feet (1.8). There were indications that the dryfarmed plots required water from deeper than the penetration of the access tubes. Readings from the dryfarmed plots were only taken to a depth of four to five feet, making it difficult to estimate the total depletion in these plots.

A steady decline in soil moisture in the upper portion of the fully irrigated fixed interval plots (D1 and W1) was discovered approximately the first week of April. This indicated that maximum evapotranspiration was being consistently underestimated and that the irrigations were not completely replacing soil moisture depletion. Corrections were made during subsequent scheduled irrigations to refill the soil profile in these plots. It may have been possible that the underirrigation of the weekly plots could have stressed the crop slightly and 'conditioned' it for stressful situations later in the season.

The yield and water use (ET) data were used to derive three production functions by linear regression, one relating yield to water use for a daily irrigation regime, the second for a weekly schedule of irrigations, and the third function representing yield versus ET for the plots that were fully irrigated at various intervals. The variation of grain yield with ET has been plotted in Figure 20. The numerical results from each subplot are given in Table 9.

The scatter in production functions can be expected due to growth stage effects. In this experiment, the scatter was possibly exaggerated by the compression of the intended ET levels. The high level of precipitation interfered with the planned underirrigation of the fixed interval plots, which reduced the range of the distribution of yield and water use data.

The three production functions are presented in Figures 21, 22, and 23 corresponding to the daily, weekly, and fully irrigated, variable irrigation frequencies, respectively. The fitted regression line for the weekly irrigation regime has the shallowest slope of the three functions. The fully irrigated variable frequency data points include the highest yields and water use (ET) levels. Figure 24 presents all three fitted regression lines.

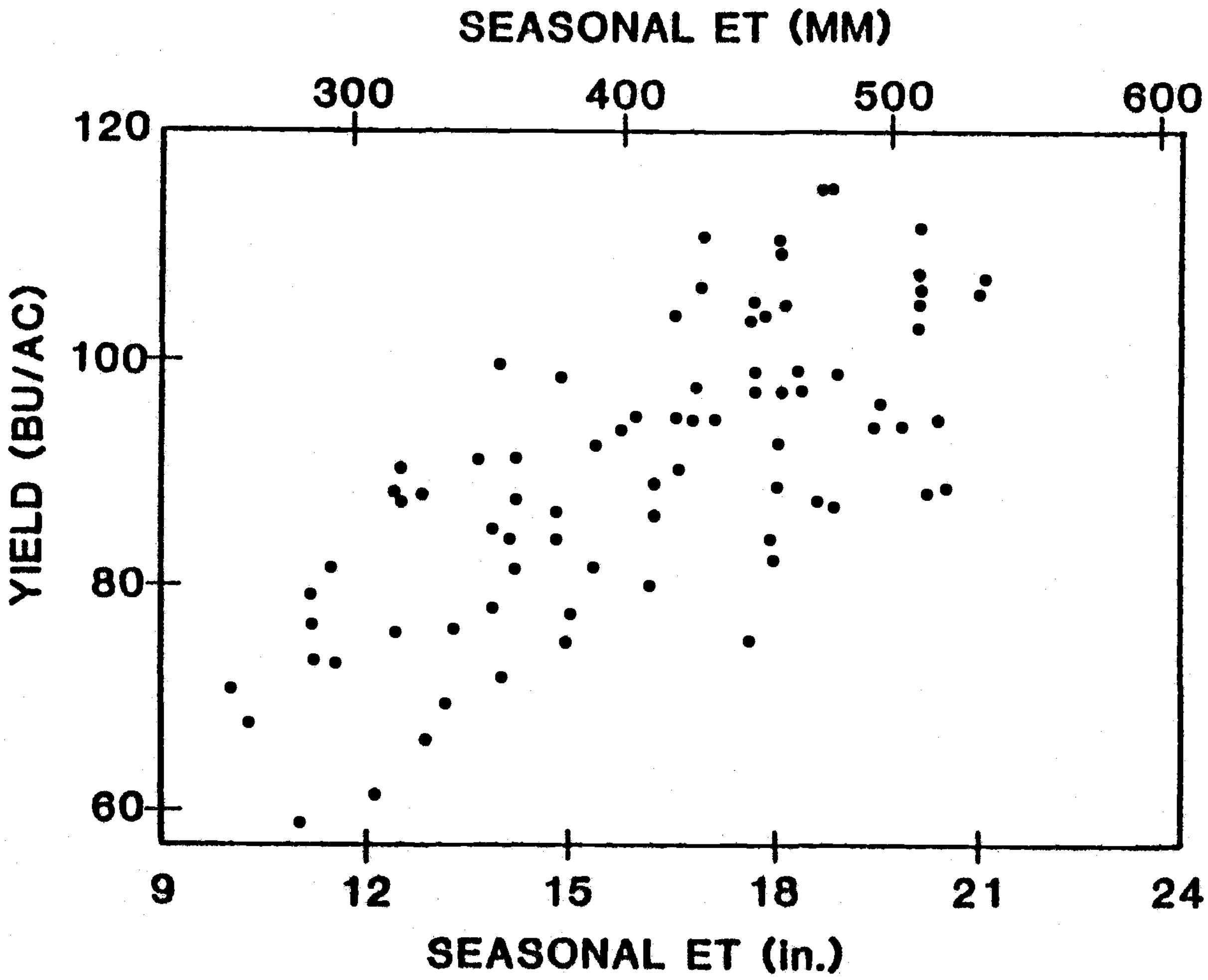

Figure 20. Seasonal total evapotranspiration and crop yield, all plots.

Table 9. Wheat grain yields and ET of each subplot

Treatment Plot	Treatment Subplot	Seasonal ET (inches)	Yield (bu/ac)
D1	1,2	20.02	96.90
	2,3	20.24	107.86
	3,4	20.83	91.48
	4,5	21.40	108.23
	5,6	20.44	109.32
D2	1,2	17.85	98.15
	2,3	17.47	91.50
	3,4	17.83	90.68
	4,5	18.52	107.48
	5,6	17.12	112.45
D3	1,2	14.50	88.14
	2,3	14.17	86.39
	3,4	14.58	81.82
	4,5	15.31	78.17
	5,6	14.83	76.79
D4	1,2	12.81	89.75
	2,3	12.80	89.82
	3,4	12.83	92.22
	4,5	13.06	89.65
	5,6	12.88	75.38
D5	1,2	11.23	59.11
	2,3	11.42	73.56
	3,4	11.90	73.82
	4,5	12.29	61.65
	5,6	11.20	--
W1	1,2	18.75	101.75
	2,3	18.44	85.19
	3,4	18.42	111.79
	4,5	18.22	99.27
	5,6	18.28	107.97
W2	1,2	17.69	96.84
	2,3	18.06	77.27
	3,4	19.11	87.91
	4,5	20.27	95.70
	5,6	19.48	87.21

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Table 9. Continued

Treatment: Plot	Treatment: Subplot	Seasonal ET (inches)	Yield (bu/ac)
W3	1,2	15.83	83.77
	2,3	16.03	94.78
	3,4	16.86	92.46
	4,5	18.29	93.53
	5,6	19.28	99.07
W4	1,2	13.84	91.90
	2,3	13,68	77.16
	3,4	14.11	84.62
	4,5	14.13	99.87
	5,6	14.60	90.27
W5	1,2	10.48	71.19
	2,3	10.73	68.02
	3,4	11.56	80.74
	4,5	11.65	77.83
	5,6	11.96	83.96
T1	1,2	20.79	91.98
	2,3	20.45	115.24
	3,4	20.43	110.42
	4,5	20.93	96.88
	5,6	19.04	118.95
T2A	1,2	16.55	88.94
	2,3	16.55	82.35
	3,4	17.37	101.59
	4,5	16.30	96.12
	5,6	15.08	100.67
T2B	1,2	17.16	97.75
	2,3	16.83	105.73
	3,4	17.34	109.68
	4,5	18.50	101.14
	5,6	17.25	108.42
T3A	1,2	13.76	72.85
	2,3	14.51	73.51
	3,4	15.43	77.71
	4,5	15.68	79.90
	5,6	14.60	85.16

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Table 9. Continued

Treatment Plot	Subplot	Seasonal ET (inches)	Yield (bu/ac)
T3B	1,2	13.30	68.35
	2,3	14.25	78.89
	3,4	15.25	89.09
	4,5	15.68	93.76
	5,6	15.20	84.86
T3C	1,2	17.64	98.68
	2,3	18.49	91.51
	3,4	18.26	107.74
	4,5	17.02	96.19
	5,6	16.63	92.82
SD	1,2	*	24.01
	2,3	*	41.22
	3,4	*	45.96
ND	1,2	*	57.19
	2,3	*	55.27
	3,4	*	58.72

*Dryland plot soil moisture readings insufficient to calculate seasonal ET.

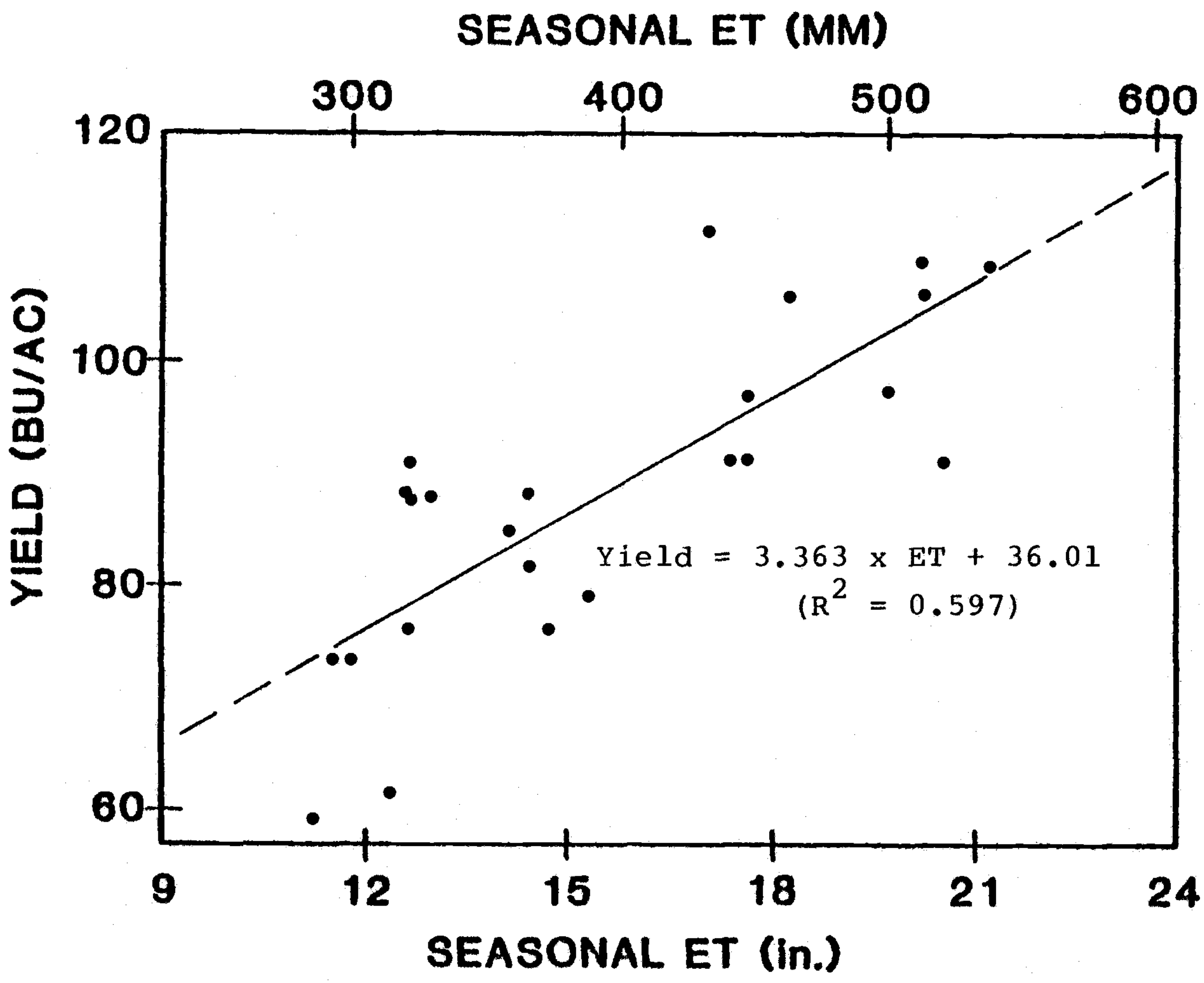

Figure 21. Seasonal total evapotranspiration and crop yield, daily irrigation treatments.

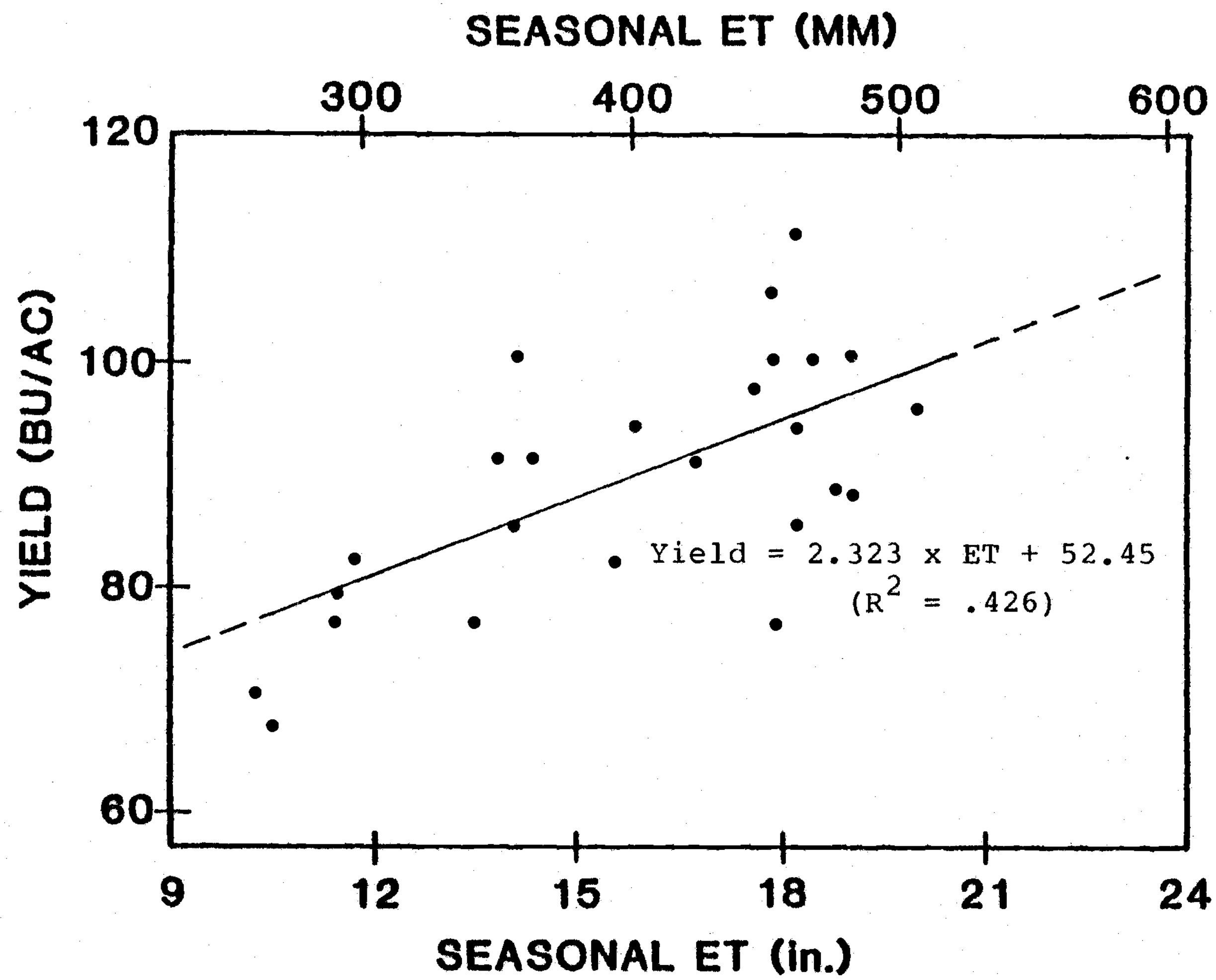

Figure 22. Seasonal total evapotranspiration and crop yield, weekly irrigation treatments.

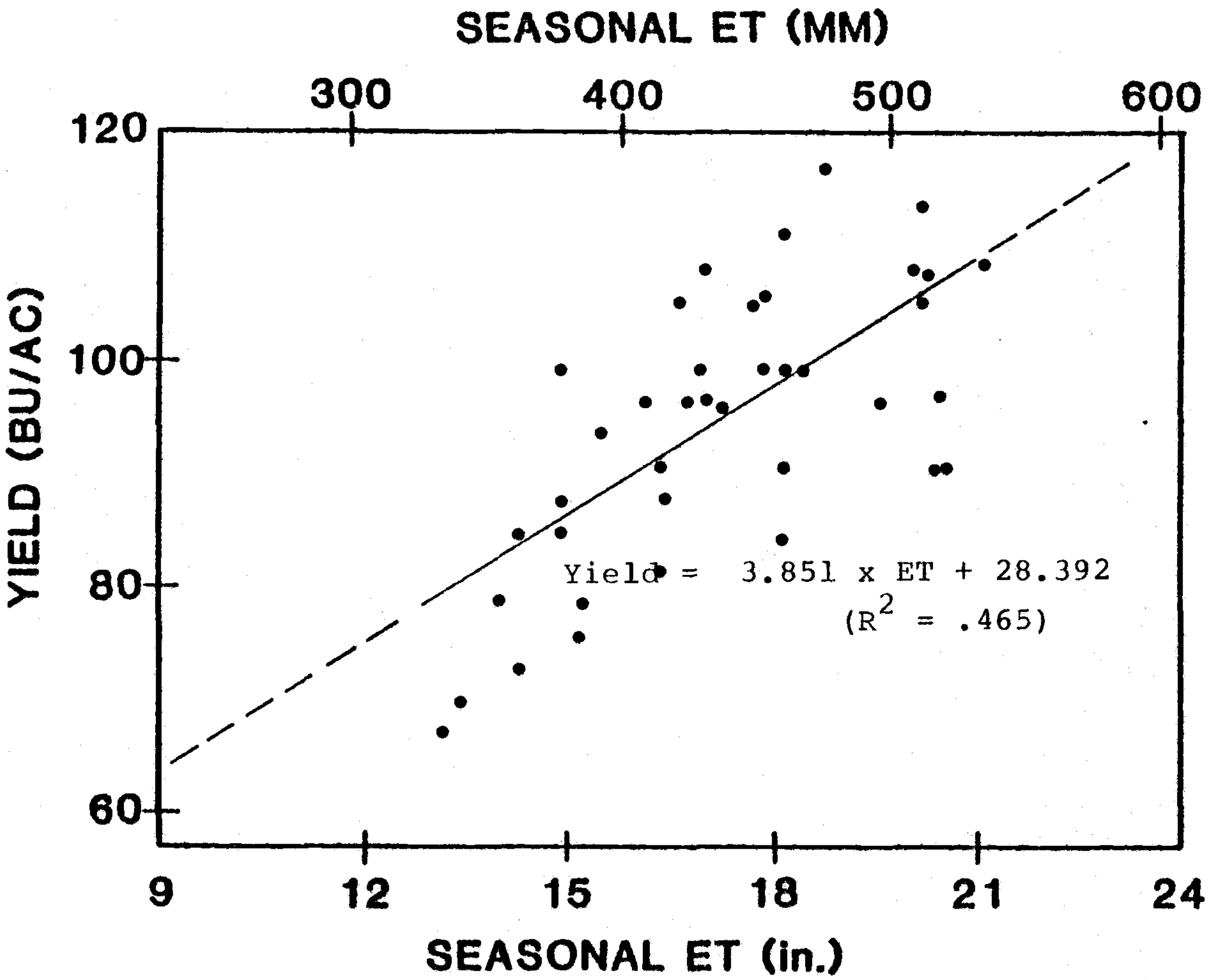

Figure 23. Seasonal total evapotranspiration and crop yield, variable frequency treatments.

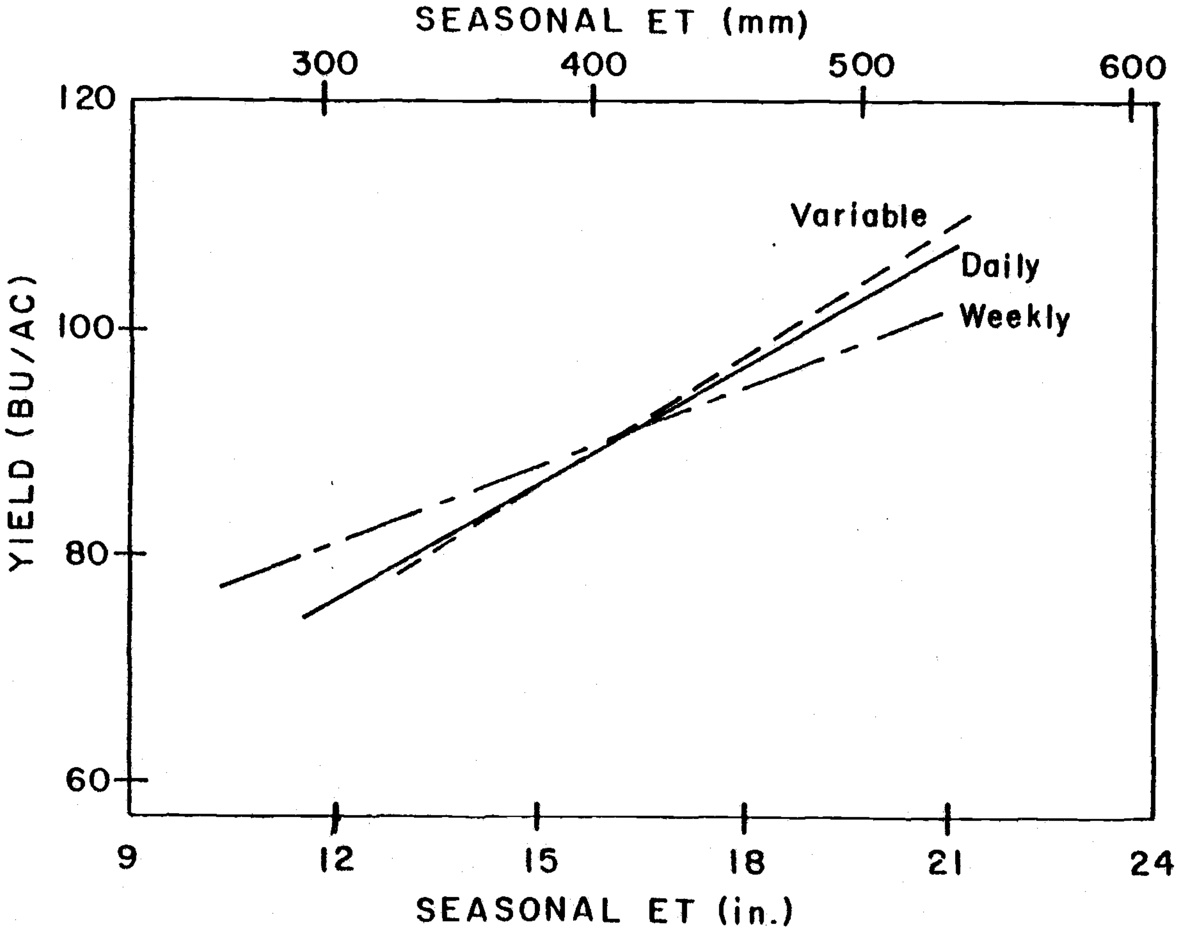

Figure 24. Production functions of the three irrigation frequency regimes (daily, weekly, and variable).

Compared to the daily irrigation regime, the two lower ET treatments (W4 and W5) exhibited a similar response to increased water use as their daily counterparts (D4 and D5). The three upper ET treatments of the weekly regime exhibited some anomalies in the results. The yields of the W1 plots were higher than the W2 plots even though the water use levels were lower. It may have been possible that the weekly, 100 percent treatment (W1) was overirrigated to some degree, incurring some yield reductions (Stewart and Hagan, 1973). Without knowledge of water movement direction in the soil profile, it cannot be as certain whether there was any water lost through deep drainage. In the sandy soil at the experiment site this may have contributed to the unexplainable difference and the wide scatter of data in the weekly irrigation regime. In addition, the errors in irrigation scheduling at the beginning of the season may have affected the yield potential of the weekly plots.

To test if the slope of two independent regressions are the same, a test statistic, t, was used.

$$t = \frac{b_1 - b_2}{\left[S_p^{\,2}\left(\frac{1}{\Sigma(X_{1_i}-\overline{X}_{1_i})} + \frac{1}{\Sigma(X_{2_i}-\overline{X}_{2_i})}\right)\right]^{1/2}}$$

where

t = test statistic
b_1 = slope of regression line 1
b_2 = slope of regression line 2

Sp^2 = square of pooled standard deviation
X_{1_i} = sample from data set 1
$\overline{X}_{1_i}$ = mean of data set 1
X_{2_i} = sample from data set 2
$\overline{X}_{2_i}$ = mean of data set 2

This test statistic was compared to a student's t-distribution using $n_1 + n_2 - 4$ degrees of freedom, where n_1 and n_2 are the number of samples in each regression. The results of the comparisons between the three lines are shown in Table 10. Differences between the three functions were not statistically significant at the five percent level.

The test weight results indicated significant differences in grain density of the three irrigation regimes. The average of the daily, weekly, and stress treatments were 55.00, 55.65, and 58.41 pounds per bushel, respectively. There was a difference between the mean density of the daily and the mean of the weekly plots at the four percent level of significance. The stress plot mean was not significantly different than either the weekly or daily means at the one percent level. The numerical results of the individual test weight samples are listed in Appendix E.

The average number of seeds per head varied significantly between irrigation treatments. There was a significant difference between the average number of seeds within treatments as well. The results are listed in Table 11.

Table 10. Comparisons of slopes of pairs of linear regressions of the three production functions

Slope b_1	b_2	Degrees of Freedom	Test Statistic	Level of Significnace
Daily 3.36	Weekly 2.32	45	1.263	0.15
Weekly 2.32	Full 3.85	60	0.548	0.30
Full 3.85	Daily 3.36	61	1.734	0.05

Table 11. Average number of seeds per head

Plot	No. of Seeds in Sample	No. of Heads in Sample	Average No. of Seeds Per Head
D1	17,390	460	37.8
D2	18,862	500	37.7
D3	18,435	520	35.5
D4	16,559	499	33.2
D5	9,094	290	31.4
W1	19,047	498	38.4
W2	18,837	500	37.7
W3	15,260	405	37.7
W4	16,309	506	32.3
W5	15,172	500	30.3
T1	16,324	496	32.9
T2A	15,668	499	37.4
T2B	16,470	503	32.8
T3A	14,826	498	29.8
T3B	13,219	400	33.0
T3C	16,258	497	32.7

V. SUMMARY AND CONCLUSIONS

Crop water use was slightly lower than normal in the 1980-81 crop season in the Hermiston area. Seasonal pan-evaporation was not significantly lower, but water use was appreciably reduced. The most pronounced abnormality in the weather, and subsequently crop water use, was the timing and magnitude of precipitation events occurring throughout the irrigation season. Rainfall was distributed so long that periods of water deficits were avoided (Figure 25).

The reduction in water use induced by the use of the two six-lateral networks of the fixed interval plots (daily and weekly) was not as pronounced as would have been possible in a "normal" year. Precipitation during the spring totaled more than the applied water over the season in the lower ET plots (W4, W5, D4, and D5). The overall boost in plot yields brought on by the spring precipitation precluded the desired wide range of water use versus yield data.

Conflicting data were produced by the field experiment. For this year, it would seem that the most efficient use of water would be a fall and spring single preplant water application. The highest yields for the amount of water used were produced by the dryland, pre-plant irrigated treatment. This could not hold true under all circumstances and would lead to false assumptions about irrigation practices in the Hermiston area.

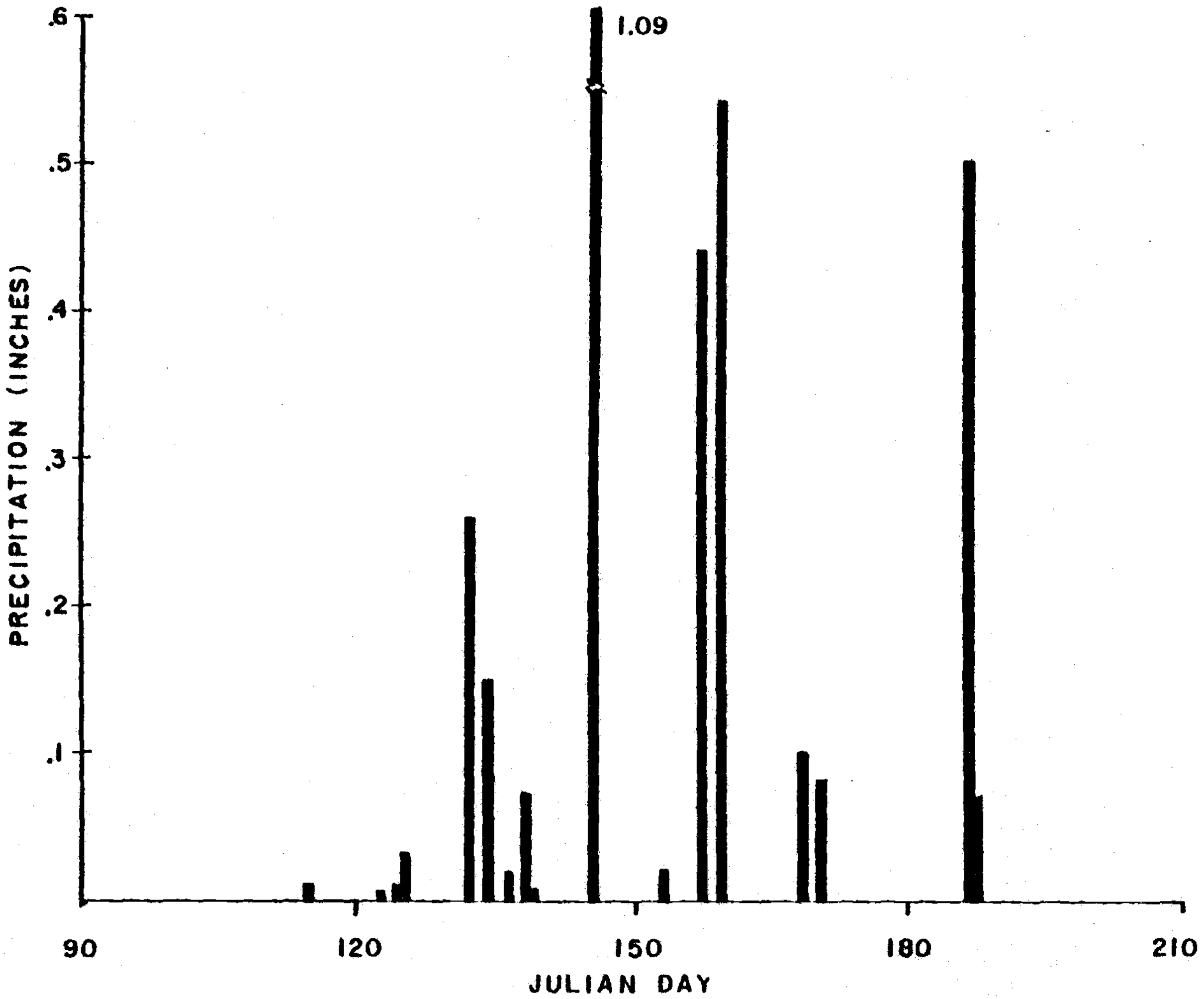

Figure 25. Date and magnitude of precipitation events during 1980 - 81 growing season.

The yield reductions from incurring water deficits in different growth stages are dependent on the water use history of previous growth periods. Generally, the amount of water available to the crop in one stage will affect yield potential in successive stages. Water deficits were avoided in most of the treatments due to the timing of the precipitation and irrigation events. It appears from Figure 26, that there should have been extensive periods of water shortages due to the irrigation schedule. This was not the case with the "perfect" timing of precipitation throughout the irrigation season.

The compressed degree of yield reduction limited the applicability of the experimental results. The bountiful crop harvested by the wheat growers in the Hermiston area was helpful to the farmers, but of dubious value to this researcher. Some elements of this experiment were very site and crop specific due to local soil, climate, and production conditions.

Conclusions

To successfully implement a deficit irrigation strategy will require pertinent knowledge of crop response to reduced water levels as well as to different irrigation frequencies. In view of the unique weather conditions in 1981, the results of this experiment were not sufficiently general to provide this information. With this caveat in mind, the following can be said about the results:

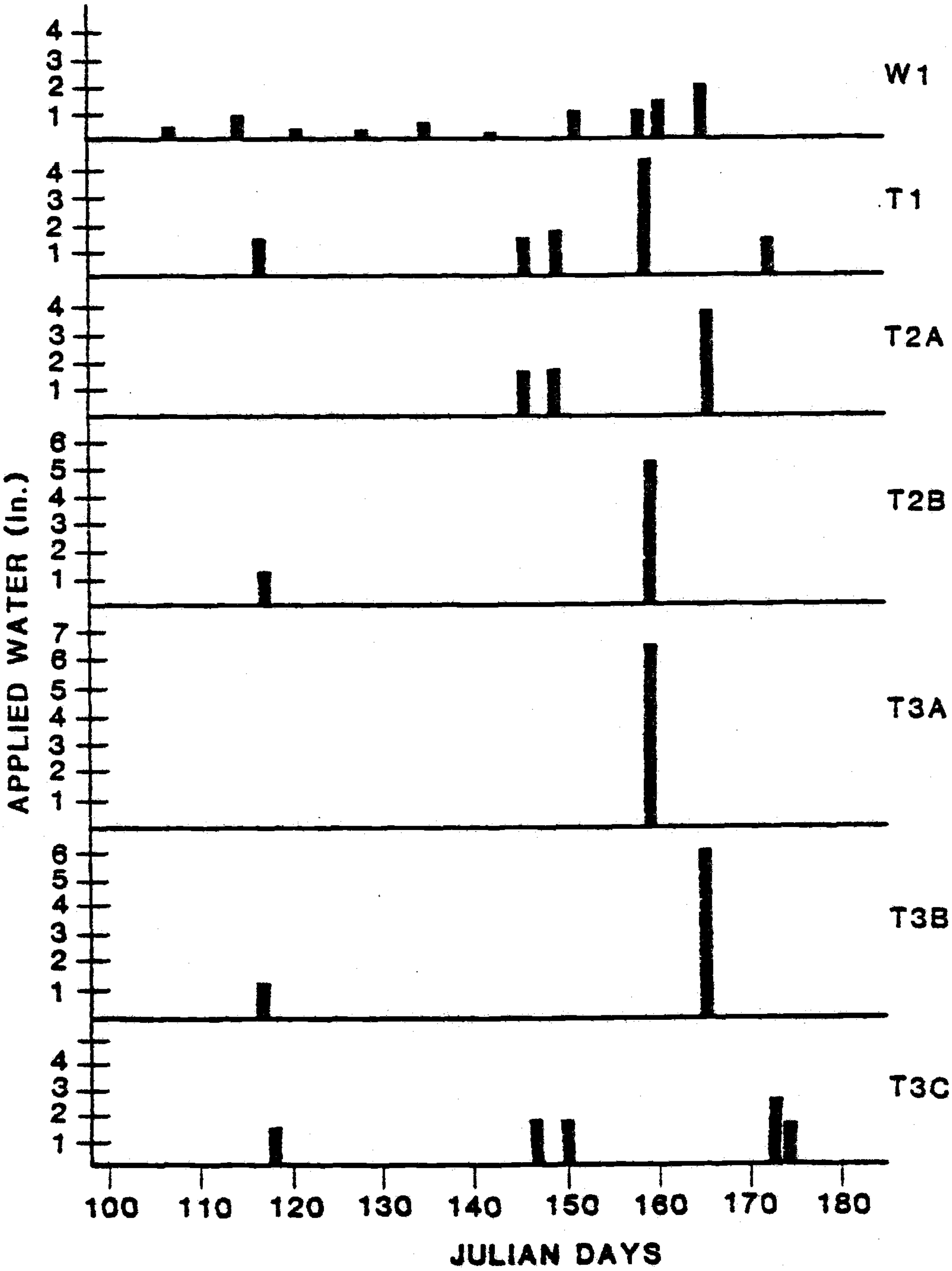

Figure 26. Date and magnitude of applied water events during 1980 - 81 growing season for weekly and stress (variable frequency) treatments.

(1) There was no apparent difference in the water use yield relationships of the three irrigation frequency regimes in 1981.

(2) There was no statistically significant difference in water use-yield relationships of the three production functions.

(3) Crop quality, as measured by kernel density was affected by irrigation frequency (a small penalty in the form of price reductions is commonly assessed for wheat that has low density).

(4) Yield potential, as expressed by the number of seeds per head, was significantly different among the irrigation frequency treatments.

At the time of this writing a second year of field research is in progress. The second year of data will provide more information on the consequencies of utilizing different irrigation frequency schedules. Further research is required to quantify the specific relationships for an understanding of the potential risks and costs associated with the use of deficit irrigation in a production oriented situation.

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APPENDIX A

THE FEEKES SCALE

The Feekes Scale is a model of wheat development stages that can be related to daily temperatures. The scale is divided into 11 stages. Each stage is identified by a cumulative total of growing degree units, where GDUs are defined as follows in Equation (10):

$$GDU = (Tmax + Tmin)/2 - Tbase \tag{10}$$

where

GDU = daily growing degree units, $^{O}F \cdot Day$

Tmax = maximum daily temperature, $^{O}F \cdot Day$

Tmin = minimum daily temperature, $^{O}F \cdot Day$

Tbase = GDU base temperature, $40^{O}F \cdot Day$

The cumulative total begins when the daily GDUs are consistently positive.

To use this model of plant development stages for winter wheat, the stages of spring wheat and winter wheat need to be correlated. Figure 26 represents the relationship for two varieties of spring wheat over a four-year span. Similarities in their growth patterns follow commencement of growth in spring wheat and reemergence from winter dormancy in winter wheat (Glenn, 1982). At the end of tillering, three on the Feekes Scale, the spring and winter wheat development stages are very similar.

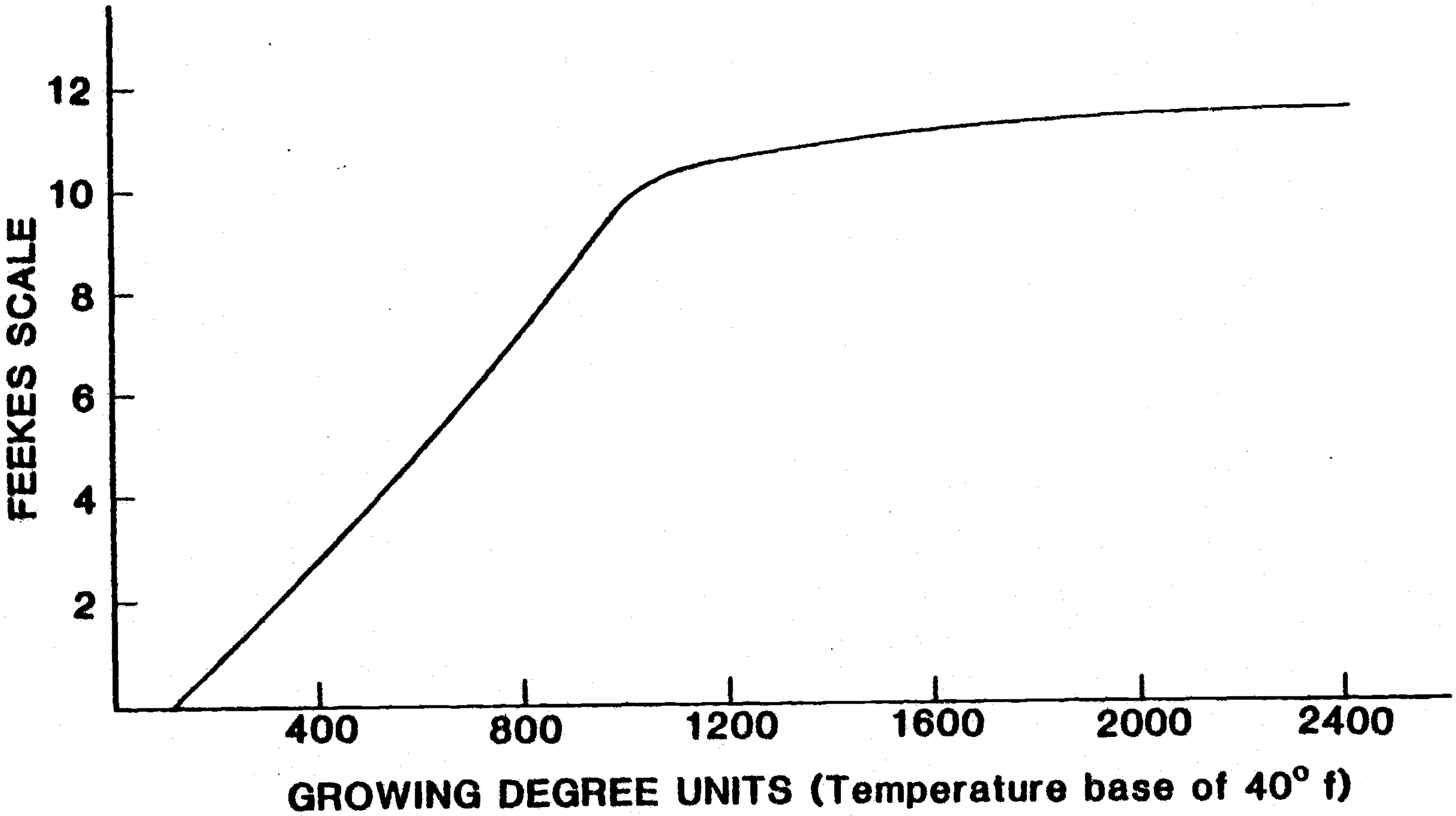

Figure 27. Growth stage of wheat as a function of GDUs according to the Feekes Scale.

APPENDIX B

Table 12. Weather data (April 1981)

Date	Tmax (^{o}F)	Tmin (^{o}F)	Tdew (^{o}F)	U24 (Mi/Dy)	SOLRAD Cal/SQCM	EPAN (in)
4/1	58.0	32.0	35.2	103.0	522.20	.12
4/2	57.0	35.0	33.8	179.0	445.10	.22
4/3	58.0	41.0	36.3	211.0	544.80	.25
4/4	60.0	36.0	39.9	47.0	445.00	.14
4/5	57.0	30.0	42.2	221.0	351.60	.23
4/6	57.0	34.0	32.6	178.0	448.80	.20
4/7	58.0	35.0	35.1	95.0	403.00	.17
4/8	57.0	37.0	39.9	168.0	191.10	.11
4/9	59.0	37.0	35.0	137.0	578.40	.24
4/10	58.0	29.0	38.7	45.0	535.90	.18
4/11	60.0	39.0	43.7	154.0	420.70	.11
4/12	60.0	35.0	39.9	122.0	548.50	.25
4/13	59.0	24.0	31.4	38.0	566.70	.16
4/14	67.0	28.0	33.8	35.0	618.70	.18
4/15	74.0	33.0	35.1	85.0	494.60	.25
4/16	68.0	45.0	35.1	72.0	614.40	.24
4/17	70.0	34.0	42.1	29.0	607.80	.23
4/18	71.0	33.0	44.6	137.0	588.70	.27
4/19	69.0	42.0	44.6	77.0	281.40	.15
4/20	65.0	50.0	42.3	224.0	433.10	.15
4/21	69.0	44.0	36.7	140.0	563.50	.26
4/22	72.0	49.0	53.6	87.0	408.10	.17
4/23	82.0	44.0	54.8	122.0	513.40	.18
4/24	84.0	47.0	42.2	90.0	630.90	.27
4/25	71.0	35.0	39.1	46.0	450.90	.14
4/26	64.0	49.0	46.5	130.0	323.10	.15
4/27	66.0	42.0	42.0	78.0	393.60	.12
4/28	76.0	47.0	51.6	131.0	449.00	.22
4/29	80.0	47.0	55.1	32.0	571.20	.20
4/30	87.0	50.0	58.7	86.0	584.20	.32

Table 13. Weather data (May 1981)

Date	Tmax (°F)	Tmin (°F)	Tdew (°F)	U24 (Mi/dy)	SOLRAD Cal/SQCM	EPAN (in)
5/1	72.0	55.0	47.2	197.0	606.30	.29
5/2	74.0	43.0	40.4	145.0	598.10	.30
5/3	66.0	41.0	41.3	123.0	574.20	.27
5/4	63.0	43.0	39.9	129.0	642.90	.20
5/5	56.0	42.0	41.0	37.0	423.70	.10
5/6	64.0	35.0	42.0	130.0	470.40	.22
5/7	64.0	44.0	36.7	119.0	586.70	.24
5/8	70.0	40.0	45.4	39.0	658.70	.24
5/9	75.0	45.0	55.7	147.0	563.70	.38
5/10	71.0	48.0	47.6	122.0	593.60	.29
5/11	68.0	49.0	43.3	80.0	553.80	.25
5/12	71.0	41.0	41.3	41.0	674.10	.26
5/13	71.0	38.0	44.3	25.0	357.00	.12
5/14	61.0	49.0	54.3	117.0	216.80	.12
5/15	62.0	41.0	42.2	143.0	582.70	.28
5/16	70.0	44.0	46.3	68.0	666.60	.21
5/17	71.0	38.0	42.5	42.0	537.60	.21
5/18	69.0	51.0	52.3	61.0	362.70	.12
5/19	70.0	52.0	52.6	102.0	499.00	.28
5/20	75.0	53.0	51.9	221.0	515.70	.33
5/21	73.0	54.0	49.2	219.0	682.90	.42
5/22	74.0	48.0	50.0	52.0	704.30	.24
5/23	82.0	42.0	55.1	47.0	644.20	.23
5/24	77.0	58.0	57.6	79.0	408.80	.32
5/25	72.0	56.0	56.8	128.0	607.70	.30
5/26	74.0	44.0	54.7	48.0	658.50	.25
5/27	79.0	48.0	50.3	57.0	641.20	.30
5/28	81.0	46.0	53.3	36.0	657.30	.28
5/29	83.0	50.0	55.5	81.0	598.30	.36
5/30	78.0	59.0	59.8	200.0	425.70	.40
5/31	75.0	48.0	52.2	51.0	719.30	.24

Table 14. Weather data (June 1981)

Date	Tmax (°F)	Tmin (°F)	Tdew (°F)	U24 (Mi/dy)	SOLRAD Cal/SQCM	EPAN (in)
6/1	81.0	41.0	49.7	105.0	625.30	.31
6/2	77.0	54.0	52.6	156.0	639.00	.45
6/3	78.0	55.0	54.8	117.0	567.10	.24
6/4	73.0	58.0	53.3	79.0	343.30	.17
6/5	81.0	52.0	58.2	74.0	526.00	.23
6/6	69.0	56.0	55.1	99.0	411.30	.25
6/7	57.0	47.0	44.9	32.0	189.80	0.00
6/8	67.0	51.0	55.0	102.0	421.00	.18
6/9	72.0	52.0	52.2	101.0	630.00	.21
6/10	73.0	53.0	54.1	95.0	638.80	.30
6/11	82.0	44.0	54.1	85.0	634.30	.30
6/12	69.0	48.0	50.8	208.0	712.80	.41
6/13	68.0	47.0	51.0	233.0	623.00	.45
6/14	73.0	52.0	52.0	110.0	668.00	.42
6/15	79.0	48.0	48.0	98.0	672.60	.37
6/16	70.0	59.0	59.0	206.0	440.40	.37
6/17	71.0	48.0	48.0	107.0	699.60	.26
6/18	67.0	55.0	55.0	73.0	256.60	.10
6/19	79.0	58.0	58.0	145.0	634.50	.45
6/20	72.0	58.0	58.0	112.0	376.40	.24
6/21	70.0	52.0	52.0	82.0	508.00	.16
6/22	72.0	58.0	58.0	112.0	376.40	.24
6/23	75.0	50.0	50.0	60.0	727.20	.25
6/24	83.0	43.0	45.5	57.0	745.20	.39
6/25	88.0	47.0	52.3	33.0	719.50	.30
6/26	83.0	67.0	53.9	205.0	786.50	.60
6/27	82.0	51.0	46.2	64.0	663.60	.30
6/28	81.0	45.0	47.5	33.0	684.80	.31
6/29	90.0	49.0	47.5	45.0	722.90	.30
6/30	86.0	59.0	60.3	97.0	626.70	.45

Table 15. Weather data (July 1981)

Date	Tmax (^{O}F)	Tmin (^{O}F)	Tdew (^{O}F)	U24 (Mi/dy)	SOLRAD Cal/SQCM	EPAN (in)
7/1	78.0	50.0	49.2	97.0	715.20	.33
7/2	87.0	45.0	47.1	31.0	706.40	.30
7/3	95.0	47.0	52.0	27.0	718.80	.39
7/4	99.0	60.0	60.3	44.0	611.20	.40
7/5	78.0	73.0	62.0	77.0	226.20	.18
7/6	62.0	59.0	59.4	167.0	209.30	.22
7/7	69.0	50.0	47.8	148.0	695.50	.36
7/8	79.0	40.0	47.8	48.0	724.00	.30
7/9	81.0	49.0	54.1	117.0	660.00	.36
7/10	73.0	53.0	48.4	119.0	706.20	.40
7/11	75.0	46.0	52.9	38.0	679.00	.28
7/12	82.0	48.0	51.5	104.0	634.70	.31
7/13	73.0	56.0	46.7	148.0	668.50	.38
7/14	84.0	47.0	50.7	36.0	692.10	.30
7/15	90.0	48.0	56.1	42.0	670.50	.35
7/16	92.0	50.0	51.7	39.0	654.80	.34
7/17	93.0	54.0	51.7	102.0	662.30	.45
7/18	87.0	63.0	59.1	135.0	655.90	.45
7/19	88.0	62.0	61.9	111.0	643.20	.39

APPENDIX C

CATCH CAN READINGS

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810407	.1740	.2211	.1958	.2393	.2146*	.2429	.2146
810408	.2393	.2320	.2465	.3045	.1921	.2030	.2362
810409	.0580	.0580	.0544	.0580	.0653	.0798	.0622
810410	.2175	.2828	.2356	.2683	.2538	.2175	.2459
810411	.0798	.0798	.0653	.0870	.0725	.0834	.0779
810412	.0725	.0761	.0870	.0798	.0870	.1015	.0840
810413	.0870	.0870	.1015	.1378	.1523	.1160	.1136
810414	.0834	.0870	.0979	.1160	.1051	.0870	.0961
810415	.0943	.1160	.1233	.1124	.1233	.1088	.1130
810416	.0580	.0834	.0761	.0979	.0979	.0870	.0834
810417	.0761	.0870	.0761	.0761	.0798	.0689	.0773
810418	.0508	.0580	.0580	.0761	.0761	.0580	.0628
810419	.1015	.1051	.1196	.1233	.0870	.1088	.1075
810420	.0145	.0435	.0254	.0870	.0725	.0435	.0477
810422	.0616	.0798	.0653	.0798	.0653	.0508	.0671
810424	.0218	.0290	.0218	.0290	.0218	.0363	.0266
810425	.1160	.1088	.1305	.1233	.1885	.1776	.1408
810427	.0363	.0290	.0544	.0326	.0471	.0399	.0399
810428	.0363	.0363	.0508	.0508	.0435	.0399	.0429
810429	.1051	.0943	.1305	.1015	.1160	.1015	.1081
810430	.0870	.0725	.1088	.0943	.1088	.0943	.0943
810501	.0870	.0725	.0653	.0943	.0580	.0580	.0725
810502	.0725	.0653	.0870	.1088	.0653	.0580	.0761
810504	.1631	.1089	.1305	.1740	.1305	.1088	.1359
810505	.9643	.9715	.7975	1.1020	.6309	.5743	.8567
810512	.1595	.1813	.0870	.2030	.1595	.2175	.1680
810513	.0290	.0290	.0218	.0363	.0363	.0471	.0332
810517	.2030	.1958	.2211	.2030	.2248	.1813	.2048
810521	.5800	.5728	.2755	.5438	.5046*	.5510	.5046
810522	.3770	.3553	.3118	.3190	.3045	.2538	.3202
810523	.4350	.3553	.4060	.4205	.3698	.3625	.3915
810527	.3190	.3045	.3118	.3770	.3263	.2538	.3154
810528	.2683	.2973	.3045	.3118	.3263	.2248	.2888
810530	1.1238	1.1818	1.2035	1.2035	1.0658	1.2253	1.1673
810601	.8193	1.0078	1.1238	1.3730	.9135	.7975	.9558
810602	.2538	.2900	.2973	.3190	.2465	.3190	.2876
810603	.3988	.3915	.5365	.4785	.4278	.4495	.4471
810604	.1595	.1305	.2175	.1885	.1595	.1813	.1728
810605	.2030	.1378	.2393	.2393	.2175	.2320	.2115
810615	.4133	.3335	.3698	.5003	.4205	.4785	.4193
810617	.1378	.1088	.1233	.1595	.1088	.1523	.1317
810619	.2030	.1885	.1958	.2465	.2175	.2103	.2103
TOTAL APPLIED WATER - PLOT D1	9.2401	9.3452	9.4504	10.6756	9.1836	9.1821	9.5128

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810407	.1631	.1595	.1559	.1559	.1523	.1813	.1613
810408	.1740	.1776	.1559	.0761	.1015	.0725	.1263
810409	.0399	.0471	.0508	.0725	.0508	.0471	.0514
810410	.1595	.1740	.1631	.1776	.1668	.1233	.1607
810411	.0435	.0616	.0363	.0616	.0689	.0580	.0550
810412	.0363	.0580	.0290	.0508	.0435	.0653	-.0471
810413	.0834	.0653	.0725	.0653	.0798	.0725	.0731
810414	.0725	.0689	.0689	.0725	.0653	.0508	.0665
810415	.0798	.0798	.0725	.0761	.0761	.0580	.0737
810416	.0544	.0544	.0435	.0870	.0834	.0725	.0659
810417	.0471	.0580	.0544	.0471	.0471	.0508	.0508
810418	.0363	.0435	.0363	.0508	.0435	.0399	.0417
810419	.0761	.0870	.0834	.0798	.0834	.0725	.0804
810420	.0290	.0653	.0399	.0544	.0544	.0435	.0477
810422	.0689	.0616	.0653	.0653	.0580	.0580	.0628
810424	.0181	.0145	.0145	.0326	.0254	.0290	.0224
810425	.0943	.0943	.1015	.1160	.1196	.1305	.1094
810427	.0326	.0363	.0290	.0290	.0290	.0326	.0314
810428	.0290	.0218	.0218	.0290	.0363	.0254	.0272
810429	.0870	.0798	.0798	.0870	.0725	.0435	.0749
810430	.0725	.0580	.0653	.0653	.0689	.0544	.0640
810501	.0580	.0580	.0508	.0653	.0363	.0363	.0508
810502	.0689	.0653	.0580	.0906	.0363	.0363	.0592
810504	.0798	.0870	.0798	.1305	.0870	.0580	.0870
810505	.9063	.7033	.9063	.3918	.6960	.4133	.7528
810512	.2175	.2030	.2103	.2755	.1523	.1958	.2091
810513	.0290	.0363	.0435	.0435	.0290	.0363	.0363
810517	.1450	.1269	.0740	.1559	.1486	.1233	.1239
810521	.3770	.2610	.4002*	.4930	.4735	.3915	.4002
810522	.2393	.2683	.2509*	.2683	.2900	.1885	.2509
810523	.2610	.3480	.2610	.3480	.3263	.2828	.3045
810527	.3118	.3118	.2813*	.3263	.2973	.1595	.2813
810528	.2755	.3190	.2320	.3118	.2465	.2175	.2670
810530	.9135	1.0440	.8265	1.1238	.9208	.8048	.9389
810601	.6453	.8120	1.0150	.6815	.8918	.8555	.8168
810602	.2465	.2755	.2175	.3480	.2755	.2610	.2707
810603	.4205	.4568	.3843	.4858	.3988	.3843	.4217
810604	.1740	.1668	.1450	.1885	.1450	.1305	.1583
810605	.2103	.2030	.1740	.2393	.2030	.1450	.1958
810613	.2320	.1958	.2030	.3263	.2828	.2248	.2441
810615	.5220	.5438	.4640	.5438	.5293	.3263	.4882
810617	.1378	.1450	.1305	.1740	.1595	.1595	.1510
810619	.2103	.2103	.1378	.2465	.2248	.1740	.2006
TOTAL APPLIED WATER - PLOT D2	8.1780	8.4064	7.9844	9.3090	8.3810	6.9854	8.2074

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

---- CORRECTED CATCH CAN READINGS ----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810407	.1088	.1160	.0870	.1196*	.1196*	.1305	.1196
810408	.1305	.1378	.1269	.1196	.1414	.1269	.1305
810409	.0363	.0290	.0254	.0181	.0363	.0326	.0296
810410	.0906	.1233	.1450	.1269	.1305	.1015	.1196
810411	.0435	.0399	.0508	.0363	.0399	.0471	.0429
810412	.0290	.0290	.0290	.0290	.0290	.0290	.0290
810413	.0544	.0508	.0508	.0435	.0544	.0326	.0477
810414	.0471	.0508	.0508	.0471	.0544	.0326	.0471
810415	.0544	.0471	.0508	.0508	.0544	.0363	.0489
810416	.0471	.0435	.0290	.0363	.0435	.0399	.0399
810417	.0435	.0435	.0435	.0290	.0435	.0218	.0375
810418	.0254	.0326	.0254	.0290	.0435	.0145	.0284
810419	.0435	.0580	.0399	.0508	.0544	.0326	.0465
810420	.0218	.0218	.0181*	.0036	.0290	.0145	.0181
810422	.0326	.0616	.0254	.0363	.0508	.0326	.0399
810424	.0109	.0109	.0109	.0145	.0181	.0218	.0145
810425	.0689	.0725	.0508	.0616	.0580	.0435	.0592
810427	.0218	.0181	.0181	.0218	.0218	.0218	.0205
810428	.0145	.0145	.0181	.0218	.0181	.0218	.0181
810429	.0544	.0580	.0471	.0508	.0399	.0363	.0477
810430	.0471	.0580	.0363	.0435	.0508	.0363	.0453
810501	.0326	.0363	.0218	.0326	.0290	.0290	.0302
810502	.0363	.0399	.0254	.0363	.0218	.0290	.0314
810504	.0435	.0725	.0363	.0363	.0290	.0363	.0423
810505	.4423	.4133	.3915	.3553	.4350	.4350	.4120
810512	.1595	.1088	.0363	.0653	.1088	.0870	.0943
810513	.0290	.0218	.0181*	.0145	.0218	.0218	.0181
810517	.1015	.1160	.1037	.1088	.1015	.0761	.1013
810521	.2828*	.2248	.2248	.3190	.2828	.3625	.2828
810522	.1711*	.1740	.1668	.1958	.1668	.1523	.1711
810523	.1523	.2175	.2030	.2393	.2465	.1305	.1982
810527	.2030	.2030	.1595	.1740	.2103	.1740	.1873
810528	.1994	.1885	.1813	.1885	.2175	.1378	.1855
810530	.6453	.6598	.6308	.6569*	.7105	.6380	.6569
810601	.5800	.5655	.7178	.6235*	.7105	.5438	.6235
810602	.1668	.1813	.1595	.1668	.2030	.1755*	.1755
810603	.3045	.2900	.3190	.2871*	.2755	.2465	.2871
810604	.1030*	.1305	.0943	.0943	.1160	.0798	.1030
810605	.1378	.1233	.1015	.1233	.1523	.1015	.1233
810613	.1450	.1378	.1305	.0508	.1378	.1885	.1317
810615	.3263	.3335	.2175	.2956*	.2755	.3263	.2958
810617	.1015	.0943	.0653	.0290	.0870	.1088	.0810
810619	.1523	.1450	.1015	.1160	.1305	.1291*	.1291
TOTAL APPLIED WATER - PLOT D3	5.5412	5.5934	5.0844	5.1892	5.7909	5.1149	5.3826

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

CORRECTED CATCH CAN READINGS

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810407	.0725	.0943	.0906	.0943	.0761	.0906	.0864
810408	.0979	.0979	.1051	.0653	.0725	.0877*	.0877
810409	.0290	.0218	.0218	.0254	.0218*	.0326	.0218
810410	.0798	.0870	.0725	.0653	.0798	.0870	.0785
810411	.0109	.0363	.0290	.0326	.0290	.0363	.0290
810412	.0109*	.0109	.0073	.0145	.0109	.0218	.0109
810413	.0435	.0218	.0363	.0254	.0435	.0290	.0332
810414	.0290	.0290	.0290	.0254	.0290	.0399	.0302
810415	.0290	.0290	.0326	.0254	.0326	.0290	.0296
810416	.0218	.0254	.0326	.0290	.0290	.0326	.0284
810417	.0254	.0181	.0181	.0218	.0181	.0254	.0211
810418	.0145	.0109	.0109	.0145	.0145	.0073	.0121
810419	.0363	.0290	.0290	.0363	.0399	.0435	.0356
810420	.0109	.0109	.0290	.0145	.0218	.0218	.0181
810422	.0290	.0218	.0363	.0218	.0290	.0254	.0272
810424	.0060*	.0073	.0073	.0073	.0109	.0036	.0060
810425	.0363	.0471	.0471	.0326	.0363	.0254	.0375
810427	.0048*	.0073	.0073	.0036	.0073	.0036	.0048
810428	.0036	.0073	.0036	.0036	.0073	.0073	.0054
810429	.0290	.0363	.0363	.0290	.0363	.0290	.0326
810430	.0290	.0363	.0363	.0290	.0326	.0290	.0320
810501	.0218	.0218	.0326	.0290	.0290	.0145	.0248
810502	.0290	.0363	.0363	.0363	.0363	.0181	.0320
810504	.0290	.0435	.0435	.0508	.0508	.0218	.0399
810505	.4060	.3625	.3625	.3915	.3698	.1523	.3408
810512	.1378	.1015	.1015	.0798	.0725	.0145	.0846
810513	.0218	.0218	.0145	.0145	.0145	.0073	.0157
810517	.0551	.0725	.0711	.0616	.0580	.0341	.0587
810521	.1523	.2248	.2248	.2393	.2175	.1740	.2054
810522	.0943	.1305	.1378	.1378	.1450	.1015	.1245
810523	.1595	.1595	.1450	.1523	.1450	.1015	.1438
810527	.1595	.1450	.1378	.1305	.1233	.0870	.1305
810528	.1523	.1450	.1378	.1378	.1233	.1015	.1329
810530	.4785	.5075	.4423	.4423	.3770	.4930	.4568
810601	.4278	.4350	.3625	.4060	.3770	.4640	.4120
810602	.1233	.1305	.1595	.1450	.1450	.1015	.1341
810603	.1740	.1958	.1813	.1958	.2030	.1668	.1861
810604	.0508	.0580	.0508	.0580	.0725	.0653	.0592
810605	.0943	.0870	.0798	.0870	.0798	.0870	.0858
810613	.1015	.1015	.1015	.1088	.1088	.0943	.1027
810615	.2393	.2248	.2374*	.2374*	.2538	.2320	.2374
810617	.0653	.0725	.0711*	.0725	.0798	.0653	.0711
810619	.0943	.0943	.0943	.0943	.1160	.0943	.0979
TOTAL APPLIED WATER - PLOT D4	3.9157	4.0564	3.9429	3.9241	3.8751	3.3989	3.8449

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810407	.3843	.3408	.3625	.2320	.5220	.7178	.4265
810414	1.0368	1.1310	.9280	1.0150	.9643	.7758	.9751
810421	.4060	.3625	.3698	.4205	.3698	.5220	.4064
810428	.4350	.2538	.2465	.4495	.4785	.3698	.3722
810505	.8265	.9425	.7830	.6453	.7613	.6380	.7661
810512	.3480	.3770	.3770	.3335	.3625	.1885	.3311
810521	1.0513	1.1238	.9860	1.4428	.9063	1.5080	1.1697
810528	1.0948	1.0585	1.3703	1.2470	1.1020	1.0513	1.1540
810530	1.5479*	1.5479*	1.5479*	1.5479*	1.3703	1.7255	1.5479
810604	2.0880	2.0953	2.1968	1.7038	2.1533	2.1300	2.0445
TOTAL APPLIED WATER - PLOT #1	9.2184	9.2329	9.1676	9.0371	8.9930	9.5265	9.1954

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810407	.3843	.4568	.3915	.6416	.5075	.5945	.4960
810414	1.0223	.6163	.6598	.7250	1.0658	.8120	.8168
810421	.2175	.2900	.3190*	.3480	.3263	.4133	.3190
810428	.3480	.1160	.0290	.3988	.3983	.3915	.2803
810505	.5655	.5075	.6975*	.8193	.9353	.6598	.6975
810512	.2320	.0653	.2610	.2103	.2683	.2828	.2199
810521	.6453	1.0716*	.9353	1.5225	1.0005	1.2543	1.0716
810528	.7540	.8700	1.0600*	1.1600	1.3123	1.2035	1.0600
810530	1.3775	1.6893	1.1673	1.6240	1.7618	1.5370	1.5261
810604	1.6168	2.2403	1.7473	1.8270	2.4868	1.5153	1.9055
TOTAL APPLIED WATER - PLOT #2	7.1630	7.9228	7.2674	9.2764	10.0630	8.6637	8.3927

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810407	.0254	.0290	.0363	.0435	.0363	.0435	.0356
810408	.0580	.0508	.0544	.0580	.0689	.0544	.0574
810409	.0109	.0109	.0073*	.0145	.0073*	.0073	.0073
810410	.0326	.0290	.0363	.0326	.0290	.0435	.0338
810411	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
810412	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
810413	.0073	.0060*	.0145	.0060*	.0060*	.0145	.0060
810414	.0036	.0036	.0073	.0073	.0054*	.0109	.0054
810415	.0073	.0066*	.0109	.0109	.0066*	.0109	.0066
810416	.0073	.0073	.0109	.0145	.0073	.0073	.0091
810417	.0073	.0030*	.0073	.0030*	.0030*	.0036	.0030
810418	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
810419	.0073	.0109	.0145	.0073	.0145	.0109	.0109
810420	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
810422	.0181	.0218	.0218	.0109	.0218	.0181	.0187
810424	.0036	.0036	.0012*	.0012*	.0012*	.0012*	.0012
810425	.0254	.0218	.0073	.0073	.0181	.0160*	.0160
810427	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
810428	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000
810429	.0145	.0181	.0181	.0073	.0145*	.0145*	.0145
810430	.0109	.0109	.0145	.0073	.0145	.0073	.0109
810501	.0054*	.0073	.0073	.0109	.0073	.0054*	.0054
810502	.0109	.0218	.0218	.0181	.0218	.0181	.0187
810504	.0218	.0290	.0218	.0508	.0254	.0218	.0284
810505	.2030	.2538	.1813	.1668	.2103	.2248	.2066
810512	.0653	.0725	.0580	.0435	.0653	.0290	.0556
810513	.0036	.0073	.0042*	.0073	.0073	.0042*	.0042
810517	.0152	.0218	.0218	.0203	.0160	.0131	.0180
810521	.0653	.1305	.0725	.0943	.1015	.0363	.0834
810522	.0653	.0725	.0653	.0580	.0580	.0290	.0580
810523	.0725	.0943	.0653	.0580	.0508	.0508	.0653
810527	.0725	.1015	.0725	.0725	.0689	.0363	.0707
810528	.0653	.0798	.0653	.0580	.0508	.0290	.0580
810530	.2175	.2538	.2030	.1900*	.1450	.1305	.1900
810601	.2393	.2465	.2030	.2030	.1378	.1523	.1970
810602	.0435	.0653	.0508	.0689	.0254	.0508*	.0508
810603	.0798	.0798	.0798	.0711*	.0870	.0290	.0711
810604	.0218	.0290	.0290	.0218*	.0218	.0073	.0218
810605	.0399	.0471	.0363	.0363	.0218	.0218	.0338
810613	.0508	.0725	.0544	.0580	.0580	.0109	.0508
810615	.0943	.1305	.1015	.1015	.0943	.0290	.0918
810617	.0290	.0435	.0363	.0363	.0435	.0218	.0350
810619	.0363	.0508	.0580	.0399	.0435	.0218	.0417
TOTAL APPLIED WATER - PLOT D5	1.7570	2.1436	1.7708	1.7162	1.6152	1.2361	1.6924

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810407	.3299	.3190	.2900	.3915	.3118	.3988	.3401
810414	.5655	.5800	.5729	.5583	.5365	.5918	.5691
810421	.2393	.2755	.2828	.2755	.2823	.4205	.2960
810428	.3408*	.2393	.2900	.2828	.4205	.4713	.3408
810505	.5728	.5365	.5438	.5655	.8628	.7323	.6356
810512	.2393	.1740	.1595	.2248	.2393	.3045	.2235
810521	.6235	.8773	.8773	.9933	1.1528	1.2253	.9582
810528	.9048	.7830	.8628	.8265	1.0078	1.0653	.8918
810530	1.1093	1.1310	1.0150	1.2833	1.5080	1.6488	1.3159
810604	1.2760	1.1963	1.1963	1.4790	2.1750	1.9503	1.5455
TOTAL APPLIED WATER - PLOT #3	6.1089	6.1118	6.0900	6.3803	8.4970	9.0190	7.1165

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810407	.1885	.1885	.1958	.1668	.1051	.1740	.1698
810414	.3408	.1813	.2393	.3553	.3770	.3553	.3081
810421	.1740	.0725	.1668	.0363	.1523	.0363	.1063
810428	.1668	.0653	.1015	.1305	.1523	.1595	.1293
810505	.3625	.4205	.3118	.2755	.2538	.3480	.3287
810512	.1595	.1450	.0943	.0943	.0580	.0653	.1027
810521	.4640	.6163	.6308	.7033	.4278	.6235	.5776
810528	.6018	.6453	.5003	.3480	.5003	2.2983	.8156
810530	1.1165	.9788	.7903	.6670	.6743	.7540	.8331
810604	.9425	.9135	.9498	.5220	.6743	.9353	.8229
TOTAL APPLIED WATER - PLOT #4	4.5168	4.2268	3.9803	3.2988	3.3749	5.7493	4.1911

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

CORRECTED CATCH CAN READINGS

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810407	.0508	.0544	.0906	.0834	.0870	.0979	.0773
810414	.1740	.1379	.1305	.1523	.1523	.1450	.1486
810421	.0725	.0145	.0145	.0218	.0363	.0725	.0387
810428	.0798	.0290	.0725	.0363	.0580	.0943	.0616
810505	.1523	.1958	.1088	.1088	.0943	.2103	.1450
810512	.0943	.0798	.0435	.0363	.0580	.0653	.0628
810521	.2132*	.3480	.1668	.1233	.1885	.2393	.2132
810528	.3480	.3045	.1740	.2175	.1813	.1958	.2368
810530	.5148	.5220	.3553	.3480	.3625	.4133	.4193
810604	.3625	.3843	.2248	.2828	.4278	.5510	.3722
TOTAL APPLIED WATER - PLOT W5	2.0619	2.0699	1.3811	1.4101	1.6458	2.0844	1.7755

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

CORRECTED CATCH CAN READINGS

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810418	1.1390	1.7473	1.1818	1.6893	1.4645	1.4355	1.4512
810517	1.7400	1.8850	.8338	1.4863	.5075	1.6313	1.3473
810520	1.7473	1.7980	1.7038	1.6965	1.7364*	1.7364*	1.7364
810530	4.3935	5.0968	4.4003	4.8140	3.4003	4.8575	4.4938
810612	1.1238	1.5950	1.3775	1.7763	2.1025	1.4863	1.5769
TOTAL APPLIED WATER - PLOT T1	10.1935	12.1220	9.4975	11.4623	9.2111	11.1469	10.6055

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810517	1.6313	1.5588	1.7400	1.8125	1.6675	1.5225	1.6554
810520	1.6675	1.7908	1.6965	1.5878	1.6856*	1.6856*	1.6856
810606	3.4075	4.2050	4.1688	4.4950	.7613	3.6250	3.4438
TOTAL APPLIED WATER - PLOT T2A	6.7063	7.5545	7.6053	7.8953	4.1144	6.8331	6.7848

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810418	1.5878	1.4790	1.3558	1.0513	1.6530	1.5805	1.4512
810530	4.5313	5.4230	5.5463	5.4883	4.7633	6.2205	5.3288
810619	1.5660	2.1388	2.2765	2.7768	1.9285	2.2258	2.1520
TOTAL APPLIED WATER - PLOT T2B	7.6850	9.0408	9.1785	9.3163	8.3448	10.0268	8.9320

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810530	6.3438	7.2283	7.7213	7.9388	7.1630	4.9229	6.8863
TOTAL APPLIED WATER - PLOT T3A	6.3438	7.2283	7.7213	7.9388	7.1630	4.9228	6.8863

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810418	1.3703	1.1963	1.5080	1.4863	1.2905	1.3993	1.3751
810616	5.6188	6.1625	6.8150	6.6700	6.2350	6.6700	6.3619
TOTAL APPLIED WATER - PLOT T3B	6.9890	7.3588	8.3230	8.1563	7.5255	8.0693	7.7370

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

----- CORRECTED CATCH CAN READINGS -----

APPLIED WATER (INCHES)

DATE	CAN 1	CAN 2	CAN 3	CAN 4	CAN 5	CAN 6	AVERAGE
810418	.8773	1.5225	1.4935	1.3848	1.2108	1.2978*	1.2978
810517	1.7763	1.9865	1.9938	1.6023	1.4500	1.3775	1.6977
810520	1.7038	1.7835	1.8850	1.5515	1.5588	1.5225	1.6675
810612	2.1025	2.5738	2.3200	2.3055	1.5588	2.7768	2.2729
810613	2.0663	1.6313	1.5225	1.4500	1.1238	1.4863	1.5467
TOTAL APPLIED WATER - PLOT T3C	8.5260	9.4975	9.2148	8.2940	6.9020	8.4608	8.4825

* INDICATES MISSING OR ERRONEOUS VALUE REPLACED BY AVERAGE OF OTHER VALUES FOR THAT IRRIGATION EVENT

APPENDIX D

Table 16. Soil Moisture Depletion

Plot	Plot Tube	Initial Soil Moisture (inches)	Final Soil Moisture (inches)	Depth Adjustment (inches)	Probe Site Depletion (inches)	Subplot Depletion (inches)
D1	1	13.60	8.92	-1.43	5.87	6.82
	2	14.61	7.81	-0.97	7.77	7.12
	3	13.04	6.57	0	6.47	6.86
	4	16.36	9.12	0	7.24	7.56
	5	13.62	8.22	-2.47	7.87	7.35
	6	15.08	8.26	0	6.82	
D2	1	10.67	5.46	0	5.21	5.65
	2	12.03	5.95	0	6.08	5.37
	3	11.03	5.32	1.06	4.65	5.27
	4	14.28	8.39	0	5.89	5.76
	5	12.71	7.08	0	5.63	5.54
	6	14.75	9.31	0	5.44	
D3	1	9.42	5.67	-1.14	4.89	5.03
	2	11.67	6.51	0	5.16	4.92
	3	10.33	5.65	0	4.68	5.53
	4	12.99	6.61	0	6.38	5.91
	5	12.24	6.80	0	5.44	5.47
	6	10.42	4.93	0	5.49	
D4	1	10.04	5.24	0	4.80	4.92
	2	11.52	6.49	0	5.03	4.89
	3	11.22	6.47	0	4.75	4.99
	4	13.59	8.36	0	5.23	5.25
	5	11.63	6.36	0	5.27	5.33
	6	14.27	8.88	0	5.39	
D5	1	12.03	7.36	0	4.67	5.58
	2	13.20	7.14	0	6.06	5.33
	3	10.45	5.41	0	5.04	5.41
	4	14.78	7.33	0	7.45	5.29
	5	13.65	7.68	0	5.97	5.10
	6	13.00	7.25	0	5.75	
W1	1	13.30	6.01	1.75	5.54	5.58
	2	14.61	8.99	0	5.62	5.33
	3	14.28	9.24	0	5.04	5.41
	4	14.69	8.92	0	5.77	5.29
	5	12.56	7.75	0	4.81	5.10
	6	15.21	9.83	0	5.38	

Table 16. Continued

Plot	Plot Tube	Initial Soil Moisture (inches)	Final Soil Moisture (inches)	Depth Adjustment (inches)	Probe Site Depletion (inches)	Subplot Depletion (inches)
W2	1	11.67	5.55	0	6.12	6.24
	2	14.77	8.41	0	6.36	6.56
	3	13.94	7.19	0	6.75	6.93
	4	16.85	9.75	0	7.10	6.69
	5	15.30	9.03	0	6.27	6.22
	6	16.14	9.97	0	6.17	
W3	1	11.65	6.10	0	5.55	5.81
	2	13.53	7.46	0	6.07	6.02
	3	13.45	7.48	0	5.97	6.46
	4	15.13	8.18	0	6.95	6.70
	5	15.56	9.12	0	6.44	6.61
	6	15.54	8.76	0	6.78	
W4	1	12.76	7.23	0	5.53	5.56
	2	12.42	6.84	0	5.58	5.67
	3	13.96	8.21	0	5.75	6.56
	4	15.82	8.45	0	7.37	6.88
	5	12.77	6.38	0	6.39	6.13
	6	14.24	8.38	0	5.86	
W5	1	12.63	7.48	0	5.15	4.50
	2	12.26	8.41	0	3.85	5.09
	3	13.89	7.56	0	6.33	6.26
	4	14.89	8.71	0	6.18	6.22
	5	15.11	8.86	0	6.25	6.18
	6	14.72	8.61	0	6.11	
T1	1	10.69	5.62	0	5.07	5.68
	2	14.69	8.41	0	6.28	5.72
	3	13.64	8.49	0	5.15	6.08
	4	13.00	6.00	0	7.00	6.69
	5	13.01	6.64	0	6.37	4.96
	6	10.18	6.64	0	3.54	
T2A	1	10.75	5.24	0	5.51	5.51
	2	14.16	8.65	0	5.51	5.07
	3	10.23	5.61	0	4.62	5.71
	4	17.80	11.00	0	6.80	6.39
	5	15.03	9.06	0	5.97	5.70
	6	13.36	7.93	0	5.43	

Table 16. Continued

Plot	Plot Tube	Initial Soil Moisture (inches)	Final Soil Moisture (inches)	Depth Adjustment (inches)	Probe Site Depletion (inches)	Subplot Depletion (inches)
T2B	1	10.23	5.54	0	4.69	4.89
	2	12.46	7.38	0	5.08	3.82
	3	10.16	6.08	1.54	2.55	4.19
	4	15.52	9.70	0	5.82	5.77
	5	14.30	8.59	0	5.71	4.15
	6	12.24	7.89	0	2.59	
T3A	1	11.33	8.44	0	2.89	3.07
	2	13.60	10.65	0	3.25	3.13
	3	12.15	9.14	0	3.01	3.70
	4	16.69	12.31	0	4.38	4.06
	5	14.01	10.28	0	3.73	4.65
	6	13.77	8.21	0	5.56	
T3B	1	10.48	8.86	0	1.62	1.03
	2	11.71	8.80	0	2.91	2.50
	3	13.41	11.33	0	2.08	3.10
	4	15.62	11.50	0	4.12	3.93
	5	14.00	10.26	0	3.74	3.50
	6	13.21	9.95	0	3.26	
T3C	1	12.67	8.12	0	4.55	4.74
	2	11.81	6.89	0	4.92	5.25
	3	9.48	5.20	-1.30	5.58	5.60
	4	12.39	6.78	0	5.61	5.51
	5	13.55	8.14	0	5.41	5.04
	6	12.65	7.99	0	4.66	

APPENDIX E

Table 17. Test Weights (30 November 1981)

Plot		Quart Grain Wt	Daily Test Wt lb/bu
D1	1,2	778.9	54.95
	2,3	787.4	55.55
	3,4	787.9	55.58
	4,5	794.4	56.04
	5,6	774.4	54.63
D2	1,2	771.4	54.42
	2,3	769.9	54.31
	3,4	767.15	54.12
	4,5	781.4	55.13
	5,6	785.4	55.41
D3	1,2	805.4	56.82
	2,3	771.4	54.42
	3,4	723.65	51.05
	4,5	731.4	51.6
	5,6	721.65	50.91
D4	1,2	798.4	56.33
	2,3	809.9	57.14
	3,4	793.05	55.95
	4,5	793.2	55.96
	5,6	738.8	52.12
D5	1,2	800.25	56.456
	2,3	797.4	56.255
	3,4	811.85	57.274
	4,5	781.4	55.126
	5,6	763.4	53.856

Table 17. Continued

Plot	Quart Grain Wt	Weekly Test Wt lb/wt
W1 1,2	780.4	55.06
2,3	796.4	56.18
3,4	787.9	55.58
4,5	778.4	54.91
5,6	784.9	55.37
W2 1,2	800.4	56.47
2,3	785.9	55.44
3,4	787.4	55.55
4,5	789.9	55.73
5,6	770.4	54.35
W3 1,2	785.9	55.44
2,3	795.4	56.11
3,4	768.4	54.2
4,5	796.4	56.18
5,6	786.9	55.51
W4 1,2	775.9	54.74
2,3	781.9	55.16
3,4	803.4	56.68
4,5	801.4	56.54
5,6	789.4	55.69
W5 1,2	808.9	57.07
2,3	800.4	56.47
3,4	768.4	54.21
4,5	804.9	56.78
5,6	791.9	55.87

Table 17. Continued

Plot		Stress Quart Grain Wt	Stress Test Wt lb/bu
T1	1,2	820.9	57.91
	2,3	826.4	58.3
	3,4	822.9	58.05
	4,5	843.4	59.5
	5,6	820.9	57.9
T2A	1,2	831.9	58.69
	2,3	809.9	57.14
	3,4	843.3	59.5
	4,5	834.9	58.9
	5,6	840.9	59.32
T2B	1,2	833.44	58.79
	2,3	825.9	58.28
	3,4	841.4	59.36
	4,5	836.9	59.04
	5,6	829.9	58.55
T3A	1,2	822.4	58.02
	2,3	822.9	58.05
	3,4	823.4	58.09
	4,5	820.4	57.88
	5,6	830.4	58.58
T3B	1,2	798.4	56.32
	2,3	808.9	57.07
	3,4	837.4	59.08
	4,5	834.9	58.9
	5,6	830.4	58.50
T3C	1,2	830.9	58.62
	2,3	824.9	58.19
	3,4	828.4	58.44
	4,5	825.4	58.27
	5,6	834.4	58.87