WATER-USE PRODUCTION FUNCTIONS OF SELECTED AGRONOMIC CROPS IN NORTHWESTERN NEW MEXICO, PHASE III

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This report is the final technical completion report of the synthesis and analysis of three seasons of field research that began in 1980 and ended in 1982. Partial technical completion reports have been published on an annual basis for the 1980 and 1981 results (Kallsen, C. E., E. J. Gregory, and T. W. Sammis, 11, 12).

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ABSTRACT

The water requirement for growth of the crops alfalfa, corn, spring barley and pinto beans was investigated in northwestern New Mexico. Results strongly suggest that the level of nitrogen fertility does not alter the seasonal transpiration requirement associated with the production of a given level of yield. The seasonal evapotranspiration requirement, however, required to produce that yield, may differ in response to factors affecting the evaporation component of evapotranspiration. Crop coefficients based on various methods of calculating potential evapotranspiration were found to vary as much as 50 percent between years for identical yield levels. Evidence presented suggests that to adequately predict the evapotranspirational requirement of a targeted yield level, soil-water evaporation will have to be separated from transpiration experimentally, and the factors affecting each component will have to be identified and quantified. Consequently, relying solely on crop coefficients to predict seasonal and intraseasonal water requirements for full and deficit irrigation under conditions requiring frequent light irrigation in an environment of high atmospheric evaporative demand, is subject to error and caution is needed when using this approach.

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WATER-USE PRODUCTION FUNCTIONS OF SELECTED AGRONOMIC CROPS IN NORTHWESTERN NEW MEXICO, PHASE III

INTRODUCTION

The potentially serious situation that exists with respect to the water which is available for growth in New Mexico has been well documented by Bahr and Herman (2). Because agricultural use of water accounts for a considerable percentage of the total use in New Mexico, it is imperative that the economic benefits derived from the water allocated to agriculture be maximized. To determine this allocation accurately, the relationship between economic crop yield and crop evapotranspiration (ET) will have to be known. For the purpose of this report, the relationship between economic yield and seasonal ET will be referred to as the water-production function. Economic yield is defined as that portion of the crop which is normally harvested for sale. For crops such as barley (*Hordeum* sp.) and corn (*Zea mays* L.), economic yield refers to the yield of grain, while for a crop such as alfalfa (*Medicago sativa* L.) economic yield is the total biomass produced above ground when harvested at one-tenth full bloom.

The elucidation of the water-production function, recently, has become a prominent objective of scientific investigation. This investigation to date, as reviewed below, suggests that a water-production function developed for a given cultivar within a crop species in a given season and location is not generally transferable, with the possible exception of alfalfa, to other cultivars, seasons, or locations. This nontransferability includes not only the maximum yields achievable, which one would expect to vary among cultivars and seasons, but also the quantity of water that is required to produce a given level of yield (i.e. the water-use efficiency, WUE).

Various investigators (3, 4, 5, 7, 17, 18, 19) have presented data demonstrating that the water production function is linear, however, concave-upward curvilinear relationships have been published by Turk et al. (21) and strongly suggested by the data of Hanks (7) and Garrity et al. (6). Generally this curvilinearity is associated with the lower yield and ET levels.

The water-use efficiency, defined as the weight of economic yield produced per depth of water utilized as ET, is constant for a water-production function only if the function passes through the origin. For water-production functions having a positive x-intercept, water-use efficiency increases as the level of ET increases. For functions with identical y-intercepts, the function with the steeper slope has the greater WUE at any given level of yield. A curvilinear water-production function that is concave-upward denotes an increase in the rate of increase in WUE as the level of ET increases.

Those instances where economic yield is not well correlated with measured ET may be the result of imposing a severe water stress on plants which have not been previously conditioned to stress. Singh (18) suggests that "nonconditioned" plants possess "critical" developmental stages where an identical level of water deficit will have a relatively more severe detrimental effect than would occur in a "conditioned" plant. His data implied than an imposition of a sudden water deficit in a nonconditioned crop may result in a significant departure of that crop's yield from that predicted by a water-production function developed for a water-stress conditioned crop. The data of Garrity et al. (5, 6) support Singh's results. Garrity et al., using grain sorghum (Sorghum bicolor L.), established water deficits at various developmental stages and throughout the growing season. They found that yield and ET generally remained highly correlated, but the slopes and intercepts varied with the water-deficit treatment and the cultivar.

To further complicate the use of the water-production function Garrity et al. (6) with grain sorghum and Miller et al. (13) with wheat (Triticum aestivum L.) demonstrate that the regression parameters of the water-production function vary between seasons for an identical cultivar. Sammis (17) demonstrated that the water production functions of cotton (Gossypium hirsutum L.), and to a lesser extent with alfalfa, varied among locations, although it should be noted that different cultivars of the respective crops were grown in different locations.

Differences in the regression parameters of the water production functions signify differences in the evapotranspiration efficiency (unit of economic yield produced per unit of ET) of the crop. Rasmussen et al. (14) and Retta et al. (15) suggest, utilizing modeled data, that differential evaporation (E), not differential transpiration (T), probably is responsible for the yearly differences. Yield per unit of T is a better indicator of the physiological consequence of interseasonal variability extant in the plant environment, than is yield per unit of ET (Tanner, 20). Soil-water E is highly and directly dependent on the frequency of irrigation, soil properties, atmospheric evaporative demand and other variables, whereas the plant is able to ameliorate the effects of these variables through complex physiological adjustment of stomata, and internal water potential. The greater stability of the regression parameters of the water production functions of alfalfa in response to seasonal changes in location and cultivar (Sammis, 17) may be the result of the ability of the alfalfa-leaf canopy to shade the ground quickly and completely, greatly reducing soil-water evaporation and its differential effect on the water-production function.

Researchers have presented data suggesting factors other than differential soil-water E, from season to season or within a season, that affect the water-production function. Tanner (20) noted that the regression parameters of the yield versus estimated T relationship of potato (Solanum tuberosum L.) were dependent on the seasonal vapor pressure deficit, indicating that differences in the water-production functions between years, cultivars and locations may not be entirely due to differential E. Unfortunately, the difficulties encountered in separating E from T experimentally in the field, results in relying on modeling techniques to provide estimates of crop T. Furthermore, Hexem and Heady (9) have shown that the level of soil fertility may affect the water-production function. These authors presented data, collected from a variety of crops and in a variety of locations, showing that the level of available nitrogen (N) greatly influences the yield versus applied water relationship. Apparently, ET data were not available to Hexem and Heady.

OBJECTIVES

1. Develop the water-production function for the crops; spring barley (*Hordeum vulgare* L.), alfalfa (*Medicago sativa* L.), pinto beans (*Phaseolus vulgaris* L.), and grain corn (*Zea mays* L.).
2. Determine how the level of nitrogen fertility in the field affects the water-production function.
3. Measure the driving climatological variables used in the Blaney-Criddle, Priestly-Taylor, Jensen-Haise, and Penman equations to evaluate the utility of these formulae in estimating crop evapotranspiration requirement.

CONCLUSIONS

The regression parameters of the water-production functions of the crops investigated demonstrate significant differences among and within growing seasons. The magnitude of the differences, although allowing general estimates, makes an accurate prediction of the intra-seasonal or interseasonal ET requirements of a targeted yield level unlikely. Attempting to increase the accuracy of the prediction by developing crop coefficients, based solely on measuring the driving climatological variables necessary for calculation of various PET methods, generally will not improve the accuracy of the estimate. As discussed in this report, many of the measured differences probably are attributable to differences in the soil-water evaporation component of ET. In northwestern New Mexico, the evaporative demand of the atmosphere is great. When this large evaporative demand interacts with the frequent irrigations necessitated by the sandy-loam soils of the region, soil-water evaporation becomes a large percentage of measured ET. Factors such as frequency of irrigation, the quantity of water stored in the profile when ET measurements are initiated, or the leaf area index (LAI) of the crop when irrigations are applied, can alter the parameters of the water-production functions by their individual effects on the rate of soil-water evaporation. Thus, although the evaporative demand as measured by PET calculations based on measured weather variables influences soil-water evaporation and transpiration, it cannot by itself be expected to account for differences in ET that are the result of these other factors. Also, the effect of increased evaporative demand on plant transpiration is not understood well. The measured modified-Penman potential evapotranspiration (PET), as used in this report, appeared to have no correlation to estimated spring barley transpiration. Unfortunately, with no means of separating soil-water evaporation from transpiration in the field, it is difficult to determine to what degree observed differences in the water-production functions are attributable to physiological changes in the plant. These changes include a multitude of factors such as partitioning of photosynthates into roots or shoots in alfalfa, increasing transpiration or soil-water evaporation as a result of increased evaporative demand, and increasing evaporation as a result of more frequent irrigations and the associated greater stage-one evaporation losses.

The bulk of the evidence produced in this investigation supports the hypothesis that the level of N fertility can alter the parameters of the water-production function, but that nitrogen's effect is attributable to difference in soil-water evaporation associated with the LAI achieved by the crop, and not any effects associated with physiological changes in water-use efficiency caused by nitrogen metabolism within the plant.

RECOMMENDATIONS

The effective utilization of the water-production function requires that the variables influencing crop ET be explained clearly and that the cumulative effect on measured ET of the variables appropriately be partitioned in a manner having predictive value.

To accomplish this task, transpiration will have to be separated from soil-water evaporation. When this is accomplished, the opportunity will exist to determine if current methods of measuring PET are sufficiently accurate to be used in predicting plant response to changes in atmospheric evaporative demand. Once the transpiration component is removed from measured ET, soil-water, evaporation can be modeled accurately.

The separation of transpiration from evaporation should be made a priority research effort, as it will facilitate the ability to predict crop water-use requirements.

MATERIALS AND METHODS

The Site

The study was conducted at the San Juan Agricultural Experiment Station (New Mexico State University) located 11 km southwest of the city of Farmington, New Mexico. This experiment station is leased from and is surrounded by the lands of the Navajo Indian Irrigated Project (NIIP). The elevation at this site is 1,719 m and the prevailing wind direction is from the west.

Climatological Data

The climatological data obtained included daily maximum and minimum temperature (using thermometers) and humidity (using a hygrothermograph). Psychrometric readings were taken at weekly intervals to ensure proper calibration of the hygrothermograph. The collected climatological data further included solar radiation measured by a pyronometer, 24-hour total wind accumulation measured at a height of 2 m using a cup anemometer, evaporation from a U.S. Weather Bureau Class A Evaporation Pan, and precipitation using a standard 8-inch rain gauge.

The 1980 climatological data have been collected at a weather station that was surrounded by bare soil. This situation tended to result in pan evaporation losses and relative humidities that were not characteristic of irrigated farmlands. Thus, in 1981, the weather station was moved to an area surrounded by irrigated crops. The vegetation immediately surrounding this weather station in both 1981 and 1982 consisted of alfalfa which was maintained at a 10 cm height.

The Bureau of Reclamation maintains a complete weather station for collection of potential evapotranspiration related climatological parameters that is located approximately 5 km from our experimental plots. The Bureau's weather station is located in the center of a large alfalfa field. When the 1981 climatological data obtained from the Bureau of Reclamation and from the San Juan Agricultural Experiment Station were calculated using the PET formulae presented in Appendix A, they yielded similar values (Table 1). Thus, the PET values that resulted from data collected in 1980 by personnel of the Bureau of Reclamation likely would yield values more characteristic of the PET values actually impinging upon the crops grown in our 1980 plots than would the values obtained from data collected in 1980 at the bare soil surrounding the climatological station.

Hence, all PET and growing-degree-day (GDD) values contained in this final report with respect to the 1980 results have been recalculated using climatological data supplied by the Bureau of Reclamation. The 1981 and 1982 PET and GDD values have been calculated from data collected at the San Juan Branch Agricultural Experiment Station at the new site.

Soil

The experimental site utilized in 1980 was approximately 1 km from the site used during 1981 and 1982. Appendix L contains maps of the experiment station showing the location of the experimental plots for each of the three years. In 1980, the plots were located on a virgin, and as yet not correctly associated, soil type. This soil is a fine-sandy loam and has been pedologically classified as a Typic

Table 1. Comparison of calculated monthly potential evapotranspiration using climate data measured by the Bureau of Reclamation (B.R.) and the San Juan Experiment Station (S.J.E.S.) for 1981.

Method	Agency	Month						
		April	May	June	July	August	September	October*
		mm						
Penman	B.R.	189	195	229	232	198	145	45
	S.J.E.S.	185	199	241	220	194	153	48
Jensen-Haise	B.R.	168	184	252	266	231	159	47
	S.J.E.S.	176	195	289	289	248	178	51
Priestly-Taylor	B.R.	170	180	225	222	195	135	39
	S.J.E.S.	175	191	253	242	205	149	43
Pan	B.R.	195	219	221	248	195	135	38
	S.J.E.S.	193	214	290	273	223	178	104
Vapor Pressure Deficit	B.R.	281	293	503	569	465	319	89
	S.J.E.S.	294	354	481	445	424	348	103

* Only partial PET accumulation presented; October 1 through 14.

Calciorthid of the coarse loamy, mixed, calcareous and mesic family. In 1981 and 1982, the plots were established on a Wall sandy loam, which previously had been in crop production. The Wall sandy loam is classified as a Typic Camborthid of the coarse loamy, mixed, calcareous, mesic family. Both soils are well drained and moderately permeable with a water table greater than 20 m below the soil surface. The water holding capacity of these soils is approximately 20 percent by volume in the upper 1.2 m of profile and 15-20 percent by volume in the next 1.2-3 m depth of profile one week after a soil-saturating irrigation. Plant available water is approximately 10 percent by volume. These estimates of water holding capacity and plant available water were obtained by gravimetric sampling and by neutron attenuation measurements on fallow land and on land containing nonirrigated mature crops, respectively. Previous to planting, the land was plowed to a depth of 50 cm, disked, fertilized as required, harrowed or listed into beds. Fertilizer, when applied, was applied in pelleted form.

Design of the Sprinkler-Line-Source (SLS) Plots

The design of the SLS plots was similar between the 1980 and 1981 seasons. In 1982, selected SLS plots were redesigned with the intended purpose of increasing the scope of the results.

The basic SLS plot design of 1980 and 1981 is diagrammed in Figure 1, however, only the alfalfa plot contained lysimeters. The basic design of the system was developed by Hanks et al. (8). The irrigation source was a single sprinkler line passing through the center of the plot. The sprinklers were spaced at intervals of 6.1

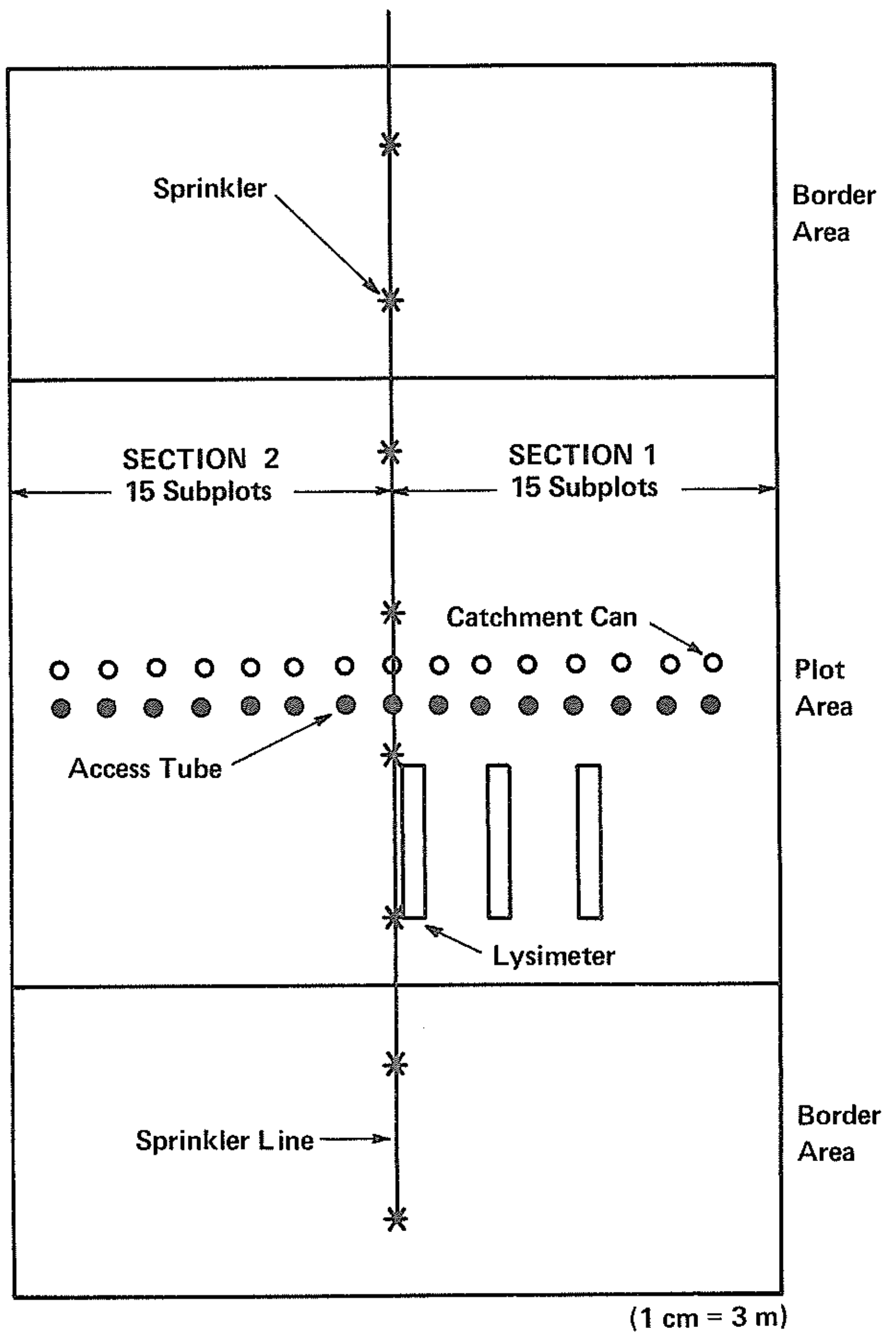

Figure 1. The design of the alfalfa sprinkler-line-source plots, 1981 and 1982.

m with each sprinkler having a water distribution pattern of 15 m at a pressure of 0.3 MPa. Each sprinkler discharged approximately 0.5 liters per second. The overlapping sprinkler pattern created a plot 24.3 m by 30.3 m in which was provided an equal application of water at points equidistant from the sprinkler-line-source. As distance from the sprinkler-line-source increased, a decrease in the application rate occurred. A border area 12.2 m in length on each end of the actual plot area also existed as a result of providing the necessary overlap of sprinkler-distribution pattern within the actual plot area. The plot was further divided into two sections, one section on each side of the sprinkler-line source. The eastern section of each plot was identified as "section 1", the western section as "section 2".

Each section was divided into subplots. The length of the subplot was measured parallel to the sprinkler line, while the width was measured at right angles to it. The width of the subplot was determined by the row spacing of the crop, while the length was determined by the limit imposed by the 24.4 m width of the SLS plot. The subplot was further divided into three equal parts along the 24.4 m length of the subplot to allow three yield subsamples in the subplot. The length of the subsampled areas varied slightly from crop to crop depending on the space required for auxiliary measurements made within the subplot area. The width and length of the subsampled areas within the subplot, and the number of subplots within the SLS plots, are tabulated in Table 2 and Table 3, for economic and biomass yields, respectively, of the crops. The

Table 2. Sampling information on which calculation of economic yield and evapotranspiration is based. Dimensions and number of sampled areas within subplots, numbers of subplots, distance between and depth of access tubes of the SLS plots of 1980, 1981, and 1982.

Crop	Year	Sample Width	Dimensions Length	No. Samples per Subplot	No. of Subplots	Dist. Between Access Tubes	Depth of Access Tube
		m	m			m	m
Alfalfa**	1981, 1982	0.91	6.10	3	29	1.82	3.04
Pinto Bean*	1980	0.86	8.13	3	29	1.72	1.51
Pinto Bean*	1981	0.86	7.60	3	29	1.72	1.51
Corn#	1982	0.86	8.13	3	15	1.72	2.13
Corn+	1982	0.86	3.66	1	30	3.45	2.13
Barley*	1980	0.91	7.51	3	29	1.82	1.51
Barley*	1981	1.00	7.11	3	29	2.00	1.51
Barley#	1982	1.00	12.21	1	7	2.00	1.51
Barley+	1982	1.00	3.66	1	42	2.00	1.51

** 1 two-sectioned SLS plot established per year.

* 3 two-sectioned SLS plots established per year. Each SLS plot differs in quantity of applied N.

1 one-sectioned SLS plot established per year, with one level of N fertility.

+ 1 one-sectioned SLS plot established per year, with three levels of N fertility twice replicated.

Table 3. Sampling information on which calculation of biomass yield and evapotranspiration is based. Dimensions and number of sampled areas within subplots, number of subplots, distance between and depth of access tubes of the SLS plots of 1980, 1981, and 1982.

Crop	Year	Sample Width	Dimensions Length	No. Samples per Subplot	No. of Subplots	Dist. Between Access Tubes	Depth of Access Tube
		m	m			m	m
Alfalfa**	(Above-ground biomass and economic yield are the same - see Table 2)						
Pinto Bean*	1980	0.86	8.13	3	29	1.72	1.51
Pinto Bean*	1981	Biomass data not taken				1.72	1.51
Corn#	1982	0.86	8.13	3	15	1.72	2.13
Corn+	1982	0.86	3.66	1	30	3.45	2.13
Barley*	1980	Biomass data not taken				1.82	1.51
Barley*	1981	1.00	1.50	2	29	2.00	1.51
Barley#	1982	1.00	12.21	1***	7	2.00	1.51
Barley+	1982	1.00	3.66	1	42	2.00	1.51

** 1 two-sectioned SLS plot established per year.

* 3 two-sectioned SLS plots established per year.

1 one-sectioned SLS plot established per year.

+ 1 one-sectioned SLS plot established per year.

*** Only one sample was taken due to leakage of unmeasured water into the plot which reduced the area available for harvest.

subplot under the sprinkler line was shared by the two sections of each SLS plot. Certain subplots were not harvested in some plots due to a nonrepresentative plant population, rodent damage, or unmeasured water leaking into the plots.

The total water applied at an irrigation of the plot was measured volumetrically by catchment cans in every other subplot, beginning at the subplot situated under the sprinkler line. These catchment cans were attached to metal poles and could be raised as the crop grew. Aluminum access tubes 5 cm in diameter and of various lengths, depending upon the crop (Table 2 and Table 3), were installed adjacent to each catchment can. A neutron scattering device (neutron depth moisture probe, Troxler Electronic Lab. Model 2601 or 3400) was used to measure the soil moisture status through the rhizosphere at time intervals of one to two weeks. The seasonal ET of the subplots among the plots containing access tubes was estimated as the average of the two adjacent subplots. Yields were measured in all subplots. Irrigations were scheduled based on depletion of soil-water in the rhizosphere of the subplot directly under the sprinkler line of each SLS plot. The quantity of water applied was that amount necessary to restore the soil moisture of the rhizosphere of this subplot to a conservative estimate of field capacity on, at minimum, a weekly basis. The calculation of ET for the crops of the SLS plots and of the lysimeters will be discussed in detail in a later section.

In 1980, the crops investigated utilizing the SLS plot as described above were spring barley and pinto beans. In 1981, the crops were alfalfa, spring barley and pinto beans. During these two years, three SLS plots existed for each crop (except alfalfa with only one SLS plot), which differed in the quantity of nitrogen that was applied to each of the plots.

In 1982, three different SLS systems were used. One, the alfalfa SLS plot, was identical to that shown in Figure 1. Because alfalfa is a perennial crop, the SLS plot was not changed from that which existed in 1981. The second system was similar to that shown in Figure 1 with the only change being that only one section of each plot was utilized for measurement of yield and ET. The third design of 1982 was different in that three differing N-fertilizer treat-ments were applied in strips or bands perpendicular to the sprinkler line within a plot, instead of a single fertilizer level being applied to a single plot as was done in 1980 and 1981. This third design is presented in Figure 2 as it existed for corn. A similar plot was established for spring barley in 1982 that differed only in the number of subplots present within each fertility treatment replication. Fertilizer treatments were completely randomized within blocks. Two blocks were established in each of these plots, with each of the three fertilizer treatments applied per block. Irrigation of the crops in this design were scheduled based on water depletion in the rhizosphere of the two subplots with the low-level N fertility treatment located under the sprinkler line. The quantity of water applied was that needed to restore these subplots to a conservative estimate of field capacity on a weekly basis.

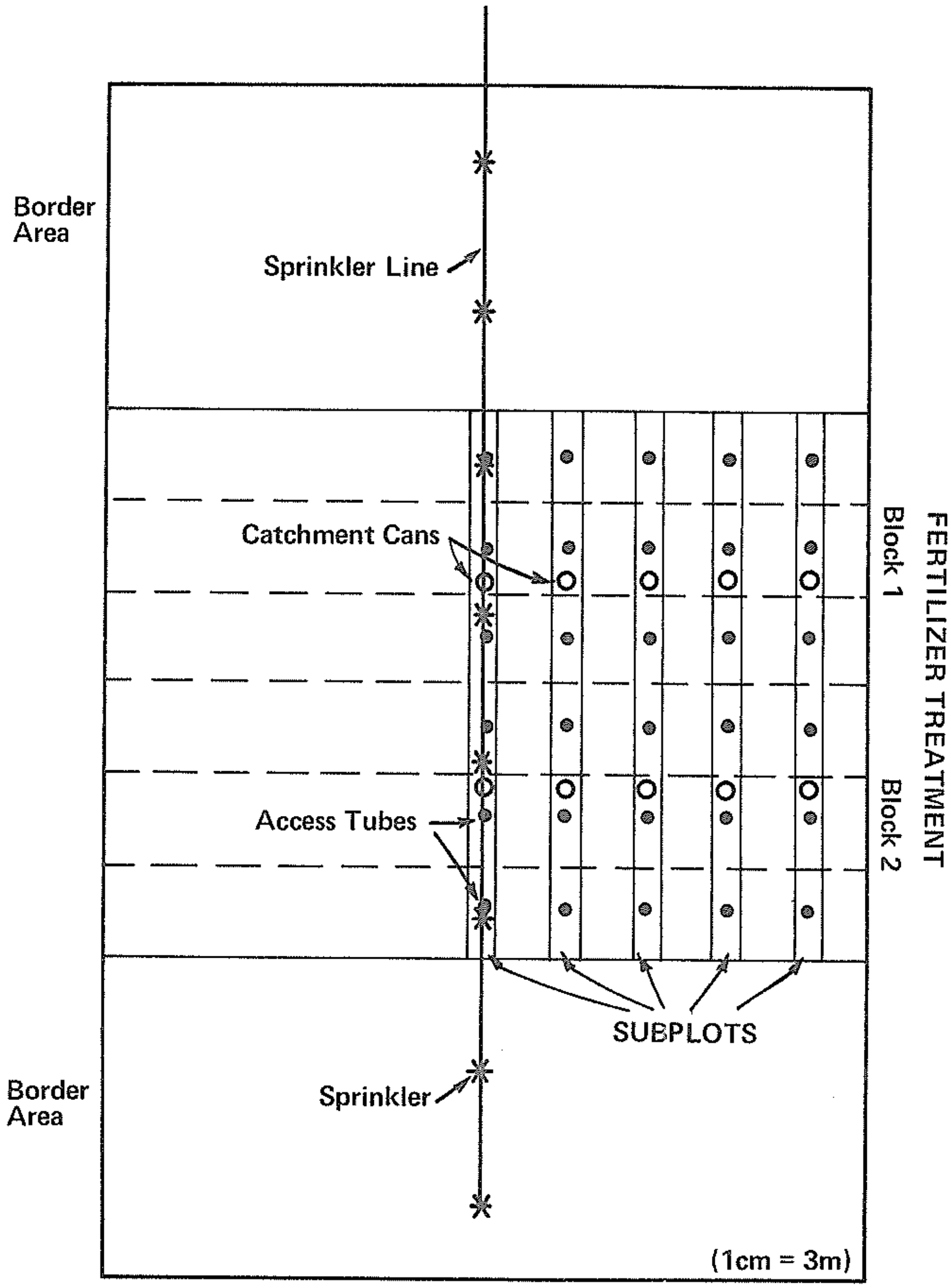

Figure 2. The design of the banded various-N level corn SLS plots, 1982.

The second and third designs were utilized only for the barley and corn experiments and only during 1982. Pinto beans were not investigated in 1982.

The 1982 procedure for measuring applied water and soil-moisture status was similar to 1980 and 1981 designs, however, in the third SLS design utilized in 1982, yield data was collected only in subplots having access tubes. One line of catchment cans was installed in each block for measurement of applied water.

The Alfalfa SLS Plot

The cultivar "WL-309" was planted in the SLS plot August 22, 1980. The seed was planted at a rate of 45 kg/ha and was coated with a nitrogen-fixing bacterial innoculant. Prior to planting, three drainage type lysimeters were constructed in the plot. The plan of construction of the alfalfa lysimeters is presented in Figure 3. All plot areas, both inside and outside the lysimeters, were planted during the same period. The alfalfa seedlings emerged from the soil August 26, 1980. In March 1981, 50 kg/ha of P_2O_5 was applied broadcast to the plot in the form of pelleted triple super-phosphate. In April 1982, 55 kg/ha of P_2O_5 was applied to the plot in the same manner. Evapotranspiration measurements were not initiated in the spring until the first new growth appeared. Crop management and production data for the alfalfa crop for 1981 and 1982 are presented in Table 4.

The alfalfa was harvested using a walking-type sickle-bar mower. However for the plants in the lysimeters were cut with a manually operated hedge clipper. All alfalfa plants were cut approximately 4 cm

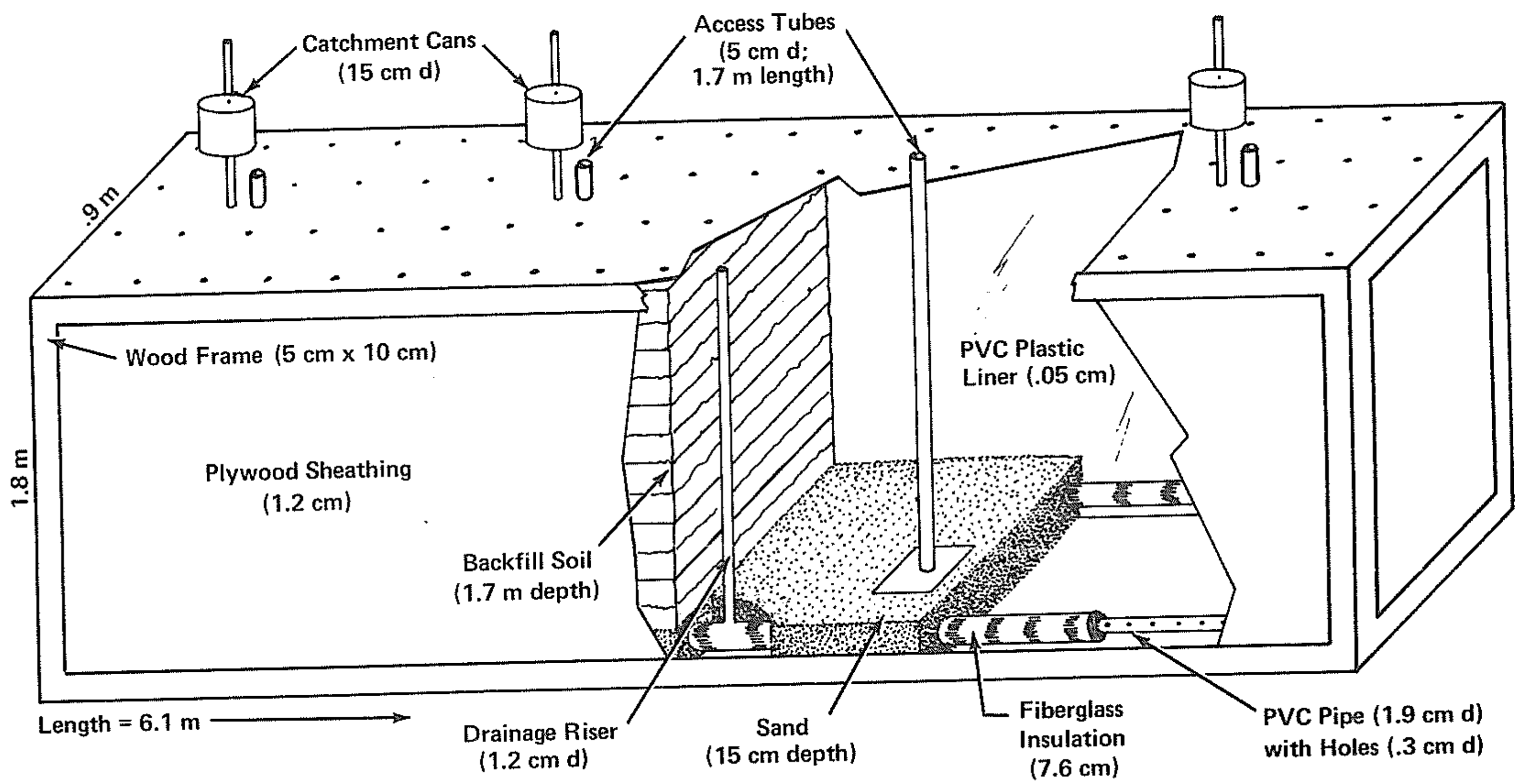

Figure. 3. The design of the alfalfa lysimeters; diameter (d).

Table 4. Alfalfa crop production data, 1981 and 1982.

Initial Probe Reading	Cutting Dates				Final Probe Reading
	First	Second	Third	Fourth	
04/09/81	06/16/81	07/23/81	08/25/81	10/13/81	10/14/81
03/16/82	06/07/82	07/20/82	08/30/82	10/04/82*	10/05/82

* This cutting was made before the crop bloomed to prevent loss due to frost.

above ground level. All reported harvest weights of alfalfa are adjusted to 0 percent moisture based on a gravimetric sample from each subplot at each cutting. Gravimetric samples were dried for four days at $80^{0}C$ for determination of dry weight.

Growing-degree-day accumulation by alfalfa was calculated by Equation 1:

$$GDD = \frac{(\text{daily temp. max.} + \text{daily temp. min.})}{2} - 5 \qquad (1)$$

The temperatures were reported in degrees centigrade. Maximum and minimum temperatures, above or below which no further GDD are accumulated, were placed at 30 and 5 degrees centigrade, respectively. Daily temperature values beyond these limits were given the limit value when GDD were calculated.

The Spring Barley SLS Plots

The cultivar "Steptoe" was grown every season of this study. Fertilizer and residual N that were readily available at planting have been summarized in Table 5. Nitrogen was applied at planting as prilled ammonium nitrate. In this report, spring barley SLS plots will be identified by the year, the plot N level (column 2 of Table 5), and by the applicable section of the plot (i.e., section 1). A cover crop of barley was planted on the 1981 low and medium level N-plot areas during August and September of 1980, to remove residual N from the soil prior to the 1981 growing season. Also at planting, 55 kg/ha in 1980 and 100 kg/ha in 1981 and 1982 of P_2O_5 were applied to the SLS plots in the form of pelleted triple superphosphate. Significant

Table 5. Nitrogen available to the spring barley by plot at planting, 1980, 1981, and 1982.

Year	Plot N Level	N Applied	N Present[1/]	Total N[2/]
		kg/ha*	kg/ha*	kg/ha*
1980	Low	0	30	30
1980	Medium	95	30	125
1980	High	195	30	225
1981	Low	0	45	45
1981	Medium	80	45	125
1981	High	180	120	300
1982	High	230	70	300
1982	Various	0	30	30
		115	30	145
		230	30	260

1/ Nitrate-N present to a depth of 1 m in the soil profile before any supplemental N application.

2/ Total readily available N at planting.

* All values have been rounded to the nearest 5 kg/ha.

dates relating to the production of the spring barley for the three years is presented in Table 6.

All biomass data are reported adjusted to the 0 percent moisture. Yield of grain however, is adjusted to 14 percent moisture. Dry weight of the biomass samples was determined by gravimetric sampling. Percent moisture of the grain was determined with an automatic moisture meter (Burrows Digital Moisture Computer, Model 700).

In 1980 and 1981, grain yield was obtained by harvesting the subplots with a self-cleaning, self-propelled, small-plot combine. However, it was impossible to obtain nongrain biomass samples with this machine. Thus in 1981, the second season of research, biomass samples were taken by hand-harvesting an additional smaller area (for dimensions see Table 3) adjacent to the larger areas of the subplots which were harvested by combine. Plant material gathered from these smaller areas was weighed, gravimetric samples were taken, and the grain separated from the nongrain biomass by a stationary thresher was weighed. Harvestable grain yield in kg/ha was similar in magnitude between that harvested by the small plot combine and that harvested by hand and threshed by the stationary machine (Kallsen et al., 12), with most of the variability present probably attributable to the difference in harvested surface area of the samples.

To obtain a more representative sample of the total above ground biomass, the entire subplot was harvested by hand in 1982. Grain was separated from nongrain biomass in the same manner as in 1981.

Table 6. Spring barley crop production data, 1980, 1981, and 1982.

Year	Planting[1/] Date	Emergence Date	Jointing Date	Heading Date	Physiological Maturity	Final Probe Reading	Harvest Date
1980*	04/09	04/18	05/20	06/10	07/13	07/28	07/31
1981*	04/03	04/14	05/16	06/03	07/01	07/12	07/28
1982*	04/07	04/15	05/17	06/09	07/07	07/14	07/27

1/ Initial probe readings took place on 04/11/80, 04/08/81, and 04/07/82, except for the randomized N-treatment SLS plot of 1982 which became flooded. This necessitated the restarting of the ET balance calculation (05/10/82). 100 kg/ha of seed was drilled at a depth of 6.5 cm to yield approximately 130 plants m^2.

* Event dates are averages of all subplots. Developmental dates should be considered estimates only.

In 1981, all green leaf tissue was removed at weekly intervals from two random samples of 0.1 m^2 area in high, middle, and low yielding subplots within each plot, and in 1982 in the SLS plot with the single, heavy application of fertilizer-N. Tissue removed included the entire leaf blade clipped at its attachment to the sheath. Very light green leaves or those that had begun to yellow or brown were discarded. Leaves were removed from all tillers as well as the primary culm. These samples were oven dried at $80^{o}C$ for one week to determine dry weight. Leaf-area-index was obtained by developing a factor relating dry weight of collected leaf material to LAI. Leaves were traced on cardboard and the dry weight of the leaves correlated to the area of cardboard tracing cutout. The cardboard area cutout was obtained by weighing both the cardboard cutout and a piece of cardboard of known area. This factor (1 g of dry leaf blade tissue = 326 cm^2) was obtained after jointing, but before heading, in 1980 and was rechecked in 1981 with similar results.

Physiological maturity was determined by weekly sampling of all grain spikes produced in the samples taken for LAI as described earlier. When the spikes of the samples ceased to increase in dry weight, they were deemed to be physiologically mature. The developmental growth stages of jointing and heading were determined visually. Timing of developmental stages should be considered only estimates. Growing-degree-days accumulated by spring barley were calculated according to Equation 1, with the difference that the maximum cutoff temperature above which no further GDD are accumulated was placed at

$25^{o}C$. In the partial completion report of 1981 (Kallsen et al., 12), GDD for barley were reported based on a maximum cutoff temperature of $30^{o}C$. However, a comparison of the two methods determined very little difference between the two methods with respect to their ability to predict observed developmental stages. This result suggested that setting the upper limit of accumulation at $30^{o}C$ was unnecessary.

Plot diagrams of the 1980, 1981, and 1982 barley SLS plot layouts and immediate environs is presented in Appendix K.

The Pinto Bean SLS Plots

A Womack Seed Company selection from the cultivar "Luna" was planted in 1980, and the cultivar "San Juan Red" in 1981. The planting rate was 45 kg/ha of seed in 1980 and 60 kg/ha in 1981. Pinto beans were not investigated in 1982. Nitrogen fertilizer applied at planting and residual nitrate-N available at planting are summarized in Table 7. The low and medium level N-plot areas were deeply leached by irrigation to remove residual N from the soil prior to the 1981 season. However, the pinto bean roots in 1981 were found to be well nodulated and it is strongly suspected that the beans of both years were fixing N from the atmosphere.

Phosphorous was applied as pelleted triple superphosphate. Eighty-five kg/ha of P_2O_5 was applied to the three SLS plots of 1980 and 110 kg/ha in 1981. The herbicide profluralin was incorporated into the soil preplant in 1980, while trifluralin was used in the same manner in 1981.

Table 7. Nitrogen available to the pinto beans by plot at planting, 1980 and 1981.

Year	Plot N Level 1/	Relative Location 2/	N Applied	N Present 3/	Total N 4/
			kg/ha*	kg/ha*	kg/ha
1980	Low	East	40	25	65
1980	Medium	Center	125	25	150
1980	High	West	160	25	185
1981	Low	Center	0	40	40
1981	Medium	East	40	40	80
1981	High	West	200	100	300

1/ In 1981 it was discovered that the bean plants were nodulated. It is suspected that the plants of both seasons were fixing atmospheric nitrogen, thus largely negating the effects of the differential N availability.

2/ See Appendix K for relative plot location and compass directions.

3/ Nitrate-N present to a depth of 1 m in the soil profile before any supplemental N application.

4/ Total readily available N at planting.

* All values have been rounded to the nearest 5 kg/ha.

In 1980, a poor stand of pinto beans was produced. The stand was much improved in 1981. Crop production data are presented for the pinto beans in Table 8, including the number of plants per m^2.

The pinto beans were harvested by hand. The whole plant was pulled from the soil and allowed to air dry for a month in an empty greenhouse. In 1980, whole plant weight was recorded, gravimetric samples of the nongrain biomass were taken, and the bean plants were threshed using a stationary thresher. Seed moisture content and weight were then measured. Percent moisture of the seed was determined with the automatic moisture meter used with the barley grain. Biomass data are reported adjusted to 0 percent moisture, while all seed data are reported adjusted to 15.5 percent moisture. It was noted that in 1980 many of the dry leaves had blown from the plants before harvest. Thus in 1981, an attempt was made to harvest small areas of the subplots when it was deemed that the plant had obtained maximum leaf-area-index, and any further delay in sampling would result in the loss of a significant amount of leaf tissue. Unfortunately, later analysis revealed that so much variability was encountered among subplots that the data were not reported. At harvest in 1981 only seed yield, and not total biomass, was measured and adjusted to 15.5 percent moisture.

Growing-degree-day accumulations by pinto bean were calculated using Equation 2 as follows:

$$GDD = \frac{(\text{daily temp. max.} + \text{daily temp. min.})}{2} - 10 \qquad (2)$$

Table 8. Pinto bean crop production data, 1980 and 1981.

Year	Location	Planting Date	First Irrigation	Emergence Date	Final Probe Reading	Harvest Date	No. Plants per Square Meter
1980	Plots*	05/27/80	06/20/80	06/28/80	10/13/80	10/15/80	2.9
1981	Plots*	05/14/81	05/18/81	05/27/81	09/02/81	09/03/81	8.5

* Event dates are averages of all subplots.

The temperatures were reported in degrees centigrade. Maximum and minimum temperatures, above or below which no further GDD are accumulated, were placed at $30^{0}C$ and $10^{0}C$, respectively. Daily temperature values beyond these limits were given the limit value when GDD were calculated.

Detailed plot diagrams showing the location of the SLS plots of pinto beans are presented in Appendix K.

The Grain Corn SLS Plots

The cultivar "PX74" was planted in 1982, the only year in which corn SLS plots were established. Crop production data are presented in Table 9. Fertilizer nitrogen and residual nitrate-N available at planting are summarized in Table 10. Nitrogen was applied at planting as prilled ammonium nitrate. In addition, 55 kg/ha of P_2O_5 and K_2O, and 10 kg/ha of Zn were applied to the soil in a pelleted formula at planting in the SLS plot having the high single level of applied N fertilizer, while the SLS plot having the replicated and various levels of applied N was given 15 kg/ha of P_2O_5 and K_2O, and 3 kg/ha of Zn of this pelleted formula. The application of phosphorous, potassium, and zinc in the latter SLS plot was made with the knowledge that by scheduling irrigations in this plot based on water depletion in the subplots having the low level of N fertility, yields would be correspondingly low and the requirements for nutrients would be less. All applications of additional nutrients, other than N, were applied to ensure that nutrient deficiencies did not occur. The additional applications probably were not necessary, but were made because the heavy

Table 9. Grain corn crop production data, 1982.

Planting Date*	Emergence Date	Tassel Emergence Date	First Killing Frost Date	Final Probe Reading	Harvest Date
05/04/82	05/19/82	07/26/82	10/06/82	10/06/82	10/18/82

* Initial probe reading was made the day of planting. Event dates are averages of all subplots.

Table 10. Nitrogen available to the grain corn by plot at planting, 1982.

Year	Plot N Level	N Applied	N Present[1/]	Total N[2/]
		kg/ha*	kg/ha*	kg/ha
1982	High	210	105	315
1982	Various	0	80#	80
		70	80#	150
		210	80#	290

1/ Nitrate-N present to a depth of 1.5 m in the soil profile before any supplemental N application.

2/ Total readily available N at planting.

* All values have been rounded to the nearest 5 kg/ha.

\# Average of the plot.

leaching of the soil by irrigation for the purpose of removing residual N also may have removed trace minerals as well as the N.

The corn was planted into raised beds. These beds were 0.86 m apart. The corn was planted at a depth 6.5 cm, with a plant density of 55,800 plants/ha being achieved. To prevent runnoff, small dams were built at 3 m intervals perpendicular to the row direction within the furrows. Banvel, a herbicide, was applied to the corn crop on June 4, 1982, at a rate of 1.2 liters of product per hectare. On this date the leaf ligules of the first three leaves of the corn plant were visible. Growing-degree-day accumulations of corn were calculated by Equation 2.

All above ground portions of the plants within the subplots of the SLS plots were harvested. Above ground biomass was weighed in the field, gravimetric samples were taken for determination of dry weight of the nongrain biomass, including the cob, and the ears were removed from the plant for shelling. Shelling of the ears was accomplished with a power-take-off driven small-plot sheller. Harvest efficiency was virtually 100 percent of the grain recovered of that produced in the field. Nongrain biomass data are reported adjusted to 0 percent moisture. Yield of grain is adjusted to 15.5 percent moisture. Sampling information for the grain is presented in Table 2, and for the above ground biomass in Table 3. The location of the 1982 SLS plots is diagrammed in Appendix K.

Pinto Bean, Grain Corn, and Spring Barley Lysimeter Design and Operation

Spring barley (cultivar "Steptoe"), pinto beans (a "Luna" selection), and grain corn (cultivar "Pioneer 3195") were planted in lysimeters in 1980. Each crop was planted in two separate lysimeters. In 1981, spring barley (cultivar "Steptoe") and pinto beans (cultivar "San Juan Red") were planted again in two lysimeters each. In 1982, the lysimeters had to be abandoned due to their deterioration. The data obtained from the spring barley lysimeters had to be discarded when a test of these lysimeters proved they were leaking. A detailed description of the construction of these lysimeters was given in the partial completion report of the 1980 results (Kallsen, et al, 11). Figure 4 however, diagrams their basic construction. The lysimeters were constructed at the site shown on the maps in Appendix L. Lysimeter crop production information is given in Table 11.

These lysimeters were flood irrigated. The quantity of applied water was measured from calibrated tanks. Water that was not utilized by the crop was removed through the drainage system by suction created with a vacuum pump. The lysimeters were watered weekly to minimize moisture stress. Irrigation was monitored so that the water applied was slightly in excess of that which would be utilized by the crop in the current week.

The two lysimeters assigned to each crop were surrounded by a 15 m wide border planting on each side which consisted of a cultivar identical to that planted in the lysimeters. The lysimeters and

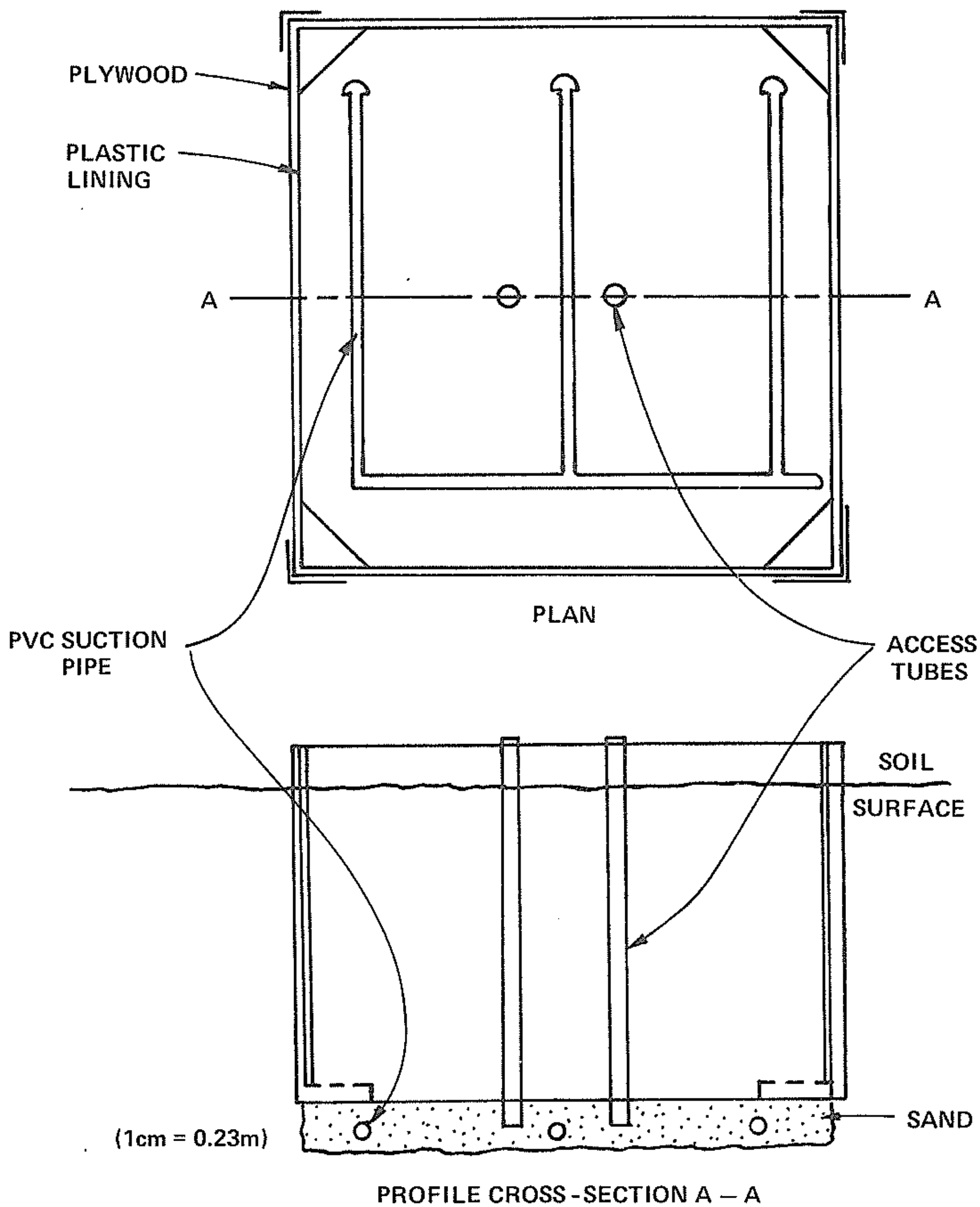

Figure 4. Plan and profile of the grain corn and pinto bean lysimeters.

Table 11. Pinto bean lysimeter data, 1980 and 1981.

Year	Planting Date	First Irrigation	Emergence Date	Final Probe Reading	Harvest Date	No. Plants per Square Meter
1980*	05/28/80	06/02/80	06/10/80	10/03/80	10/03/80	7.2
1981#	05/15/81	06/11/81	05/28/81	09/02/81	09/03/81	7.0
Grain Corn Lysimeter Data						
1980+	05/14/80	05/14/80	05/23/80	10/17/80	10/23/80	---

* 168 kg/ha of N applied in a split application 05/28/80 and 07/28/80; 85 kg/ha P_2O_5 applied at planting.

224 kg/ha of N added in a split application 05/15/81 and 06/26/81; 112 kg/ha P_2O_5 applied at planting.

+ 112 kg/ha of N applied as split application on 05/14/80 and 07/07/80; 67 kg/ha P_2O_5 applied at planting.

their surrounding plantings were bordered on the west by 150 m and by 40 m on the east by alfalfa cropland.

Plot Configurations and Adjacent Areas

Plot diagrams and the immediate surrounding environment are presented by year in Appendix K. These more detailed maps of the plots can be positioned with respect to the grounds of the experiment station by referring to the smaller scale maps in Appendix L. The corn and barley plots have been identified by the words low, high, medium, and various, that refer to the level of N fertility available to the crops at planting. Refer to Tables 5 and 10, respectively for actual N available at planting in the spring barley and corn plots, respectively. Because pinto bean roots were found to be nodulated, these plots will be referred to on the basis of their location respective to one another. Information concerning the N available at planting in the pinto bean plots can be found in Table 7.

Approximately 20,000 hectares are now under sprinkler irrigation on the plateau of the Navajo Indian Irrigation Project. Much of this land is interspaced with unirrigated rangeland or land that is fallow for at least a portion of the growing season. Therefore, data developed at the San Juan Agricultural Experiment Station are expected to reflect evapotranspiration rates representative of areas near the desert edge of large irrigated fields. The data do not reflect the rates that would occur in the center of large irrigated blocks of land.

Calculation of Crop Evapotranspiration

Evapotranspiration was calculated using the following equation:

$$ET = I + P - D \pm \Delta SM \quad (3)$$

where

I = irrigation

P = precipitation

D = drainage

ΔSM = change in soil moisture

Only in the lysimeter data did the drainage term exist. Care was taken in the sprinkler-line-source experiments to avoid deep drainage losses of applied irrigation water at the line (where maximum irrigation occurs). This precaution involved returning the rhizospheric moisture content of the subplot at the sprinkler line to a conservative estimate of field capacity on a weekly schedule. Field capacity was based on moisture depletion as measured by neutron modulation. The access tubes at the sprinkler line of the SLS plots generally were deeper by one reading depth than the other access tubes of the plot. The depth of the tubes helped determine if either deep drainage of applied water was occurring, or depletion of soil moisture was occurring at the greater depth. Some nonsaturated flow of water may have occurred but experimental results obtained in the alfalfa field, based on the similarity of the performance of the field subplots and the lysimeters, demonstrate that this loss or gain is minimal when compared to the other terms of the equation. Consequently, in calculation of ET using the SLS data, drainage and nonsaturated flow of water is assumed to be negligible. Water application of the SLS plots was closely supervised to ensure that runoff from the SLS plot was minimal.

In determining soil-moisture status, the initial reading was taken at the 15 cm depth, with each additional reading taken in 30 cm increments. In the barley and pinto bean plots, four readings were taken in each access tube each day that these data were collected except for the tube at the line in which five to six readings were taken depending on the crop. In the corn SLS plots, seven readings were taken except at the line where nine were made. Ten readings were taken in the access tubes of the alfalfa SLS plot, with the exception of the alfalfa lysimeters where five readings were made. As described earlier, irrigation was measured with catchment cans on the sprinkler-line-source plots, and from calibrated tanks before being applied by flood irrigation to the pinto, corn and barley lysimeters. Precipitation was measured with a standard U.S. Weather Bureau rain gauge.

Estimating Soil-Water Evaporation

A method of estimating soil-water evaporation was developed based on the work of Ritchie (16) and Al-Khafaf et al. (1). However, the model was modified, as discussed below, to prevent estimated seasonal evaporation from being greater than the measured ET of those subplots furthest from the SLS. The major modification made is that three degrees of ground cover are recognized in the model. An LAI between 0 and 0.5 is called the bare soil condition, values greater than 0.5 but less than or equal to 2.5 the incomplete-cover condition, and values greater than 2.5 the complete-cover condition. The ground cover condition affects the manner in which soil-water evaporation is determined by the model.

Stage-one evaporation, of irrigations and precipitations greater than or equal to 10 mm, is calculated according to Equation 4:

$$E_s = E_0 e^{0.623\ LAI} \tag{4}$$

where

E_s = soil-water evaporation, mm

E_0 = potential evapotranspiration (modified Penman's), mm

LAI = leaf area index

Stage-two evaporation, of irrigations and precipitations greater than 10 mm is calculated by Equation 5:

$$E_s = a\ (t)^{0.6} \tag{5}$$

where

t = time in days

a = alpha (a constant based on soil texture), mm

Irrigations less than 10 mm are calculated by Equation 6:

$$E_s = Q \times c \tag{6}$$

where

Q = quantity of water in the irrigation or precipitation, mm

c = soil-water evaporation constant based on LAI

When the crop is in the bare soil condition and the quantity of water in the irrigation or precipitation event is greater than 10 mm, Equation 4 is used to calculate soil-water E until the accumulated value of E has reached 6 mm. The time in days required for soil-water E to reach a value of 6 mm is noted. Then Equation 5 is used to calculate stage-two E in the time remaining after stage-one E has terminated, until the time of the next irrigation or precipitation event that is greater than 10 mm. The alpha constant for Equation 5 is set at 3.5 mm (Ritchie, 16). The quantity of available water for E at each step is limited by the total amount of water in the irrigation or precipitation event. An irrigation or precipitation event less than 10 mm is treated as if 80 percent (Equation 6, [c] = 0.8) of the event evaporates. These light irrigations or precipitations for the purpose of calculating soil-water E by Equations 4 and 5 are treated as if they never occur, but are simply multiplied by the constant of Equation 6 and summed into the calculated E for the period. This matter of treating light irrigations or precipitations was handled similarly by Ritchie (16).

The complete-cover condition is treated similarly to the bare soil condition with the following exceptions: the time in which stage-one evaporation is allowed to proceed is limited to two days; the time in which stage-two E is allowed to proceed is likewise limited to two days; and the amount of soil-water E of irrigations and precipitations of less than 10 mm is reduced to 10 percent (Equation 6, [c] = 0.1) of the event. The stage-one evaporation is limited to two days based on the observation in the field that the soil surface to a depth of 1.5 cm is dry two days after an irrigation (approximately 0.6 percent by volume depending upon atmospheric conditions). Although the plant canopy does shade the ground, the crop at complete-cover is transpiring at a very high rate that greatly reduces the water available for soil-water E in the top 20 cm of soil profile. The reduced factor (c) is based on the assumption that some of the light irrigations and precipitations decrease the quantity of water lost by the plant in the form of transpiration and should not be attributed to soil-water E loss.

The incomplete-cover condition is treated similarly to the bare soil condition with a few exceptions. The time in which stage-one E is allowed to proceed is limited to four days, and the time in which stage-two E is allowed to proceed is limited to five days. These time intervals were chosen because they were intermediate between the bare soil and complete-cover condition, and agreed reasonably well with the visual soil-surface-moisture status, as observed in the field. Estimated E as calculated by this method, was relatively insensitive to changes in the magnitude of these intervals because twice weekly irrigations or precipitations were routine. In addition, the amount of soil-water E of irrigation and precipitation events of less than 10 mm is reduced to 60 percent (Equation 6, [c] = 0.6) of the event.

This method of calculating soil-water E was utilized in estimating E from five subplots of each of the spring barley SLS plots of 1980 and 1981 and from four subplots in 1982. These subplots were selected based on their relative distance from the sprinkler line. In 1981, the subplots examined were 12, 8, and 0 m; and in 1980 11, 5.5 and 0 m from the sprinkler line in each of the two sections of the plot. In 1982, the subplots were 12, 8, 2, and 0 mm from the line, in the single section in which measurements were made. Leaf-area-index measurements were made as described earlier in the five subplots of each of the three plots of 1981, and in the four subplots of the high-N plot of 1982. The number of subplots examined was limited to the amount of time available for for collection of LAI data. Leaf-area-index values for 1980 were interpolated based on the data obtained in the subplots of 1981 by assuming similar yield levels possessed similar leaf-area-index values at similar growing-degree-day accumulations between the two seasons. Data collected in 1981 and 1982 support this assumption in that the plots varying in N fertility level showed similar LAI accumulations at similar yield levels in 1981, while yield and maximum-achieved LAI values in 1982 at a given level of yield were similar to those of 1981 (Appendix J). All irrigation and precipitation events greater than 1 mm were tabulated and placed in a data set for computer calculation. This tabulation included the day of occurrence of the event, the LAI of the plants of the subplot on that date, the number of days before the next event, and the quantity of water in the event.

Calculated soil-water E was then subtracted from the measured ET of the subplot to provide an estimate of transpiration. The resulting functions of yield expressed as a function of T for each of the plots produced in 1980, 1981, and 1982 were then compared for significant differences.

The Determination of the Mathematical Form of the Water-Production Function

The water-production functions presented in this report were based on the fit of the individual data points (with yield expressed as the dependent variable and ET as the independent variable) to an equation of the form:

$$Y = A(ET)^2 + B(ET) + C \tag{7}$$

where

Y = economic yield

ET = evapotranspiration

A,B,C = equation coefficients which result from a best-fit least-squares regression procedure

Nonsignificant coefficients, based on the magnitude of their regression associated t-statistic, were removed from the equation and the equation was re-estimated and presented with only the significant coefficient remaining. When functions were compared for significant differences with respect to function parameters, all functions were fit to an identical equation form for the purpose of the comparison.

GDD as an Index of Crop Evapotranspiration

A wide range of planting dates (or for alfalfa, cutting dates) for alfalfa, barley, pinto beans, and many other crops can provide an economically feasible crop harvest for northwestern New Mexico. However, by changing the planting or cutting date, crop ET during a given time period (as a result of the particular developmental stage falling on a different calendar day) will change significantly. Thus, tables of crop ET or crop coefficients calculated on a monthly basis have little value unless an identical planting date is chosen from the tables. Of course, in a large farming operation such as the Navajo

Indian Irrigation Project, a same day planting is not practicable because of manpower and machine limitations. Bean planting usually will take three weeks to a month. Hence, tables in this report, with respect to crop ET requirement, have been indexed to the GDD accumulation of the crop.

RESULTS

The individual observations of seasonal ET versus yield are presented in the appendices. Economic yield refers to that portion of the crop plant that is normally harvested for sale. Biomass yield refers to all above ground portions of the plant. When the biomass yield data are available, they are presented with the economic yield data. Economic yield is adjusted to a standard crop-dependent moisture content (15.5 percent for beans and corn, 14 percent for barley, and 0 percent for alfalfa) while biomass data are adjusted to 0 percent moisture.

The alfalfa ET versus yield data are presented in Appendix B by cutting and by seasonal accumulation for 1980 and 1981. Barley seasonal ET versus grain yield data are presented in Appendix C for 1980, 1981, and 1982. Biomass yield also are presented but are available only for 1981 and 1982. The SLS corn grain and biomass data of 1982 are presented in Appendix D. The pinto bean SLS seed yield data of 1980 and 1981, and the biomass data of 1980, are presented in Appendix E.

Seasonal PET calculated by different methods for the crops of 1980, 1981, and 1982 is tabulated in Appendix F, and monthly PET accumulations in Appendix G. The dates of irrigations and precipitations for selected

SLS plots of 1980, 1981, and 1982 are presented in Appendix H. Seasonal, and where applicable, intraseasonal GDD accumulations of the crops are presented in Appendix I. The measured climatological variables of 1980, 1981, and 1982 are tabulated in Appendix N.

Spring Barley

The spring barley data was the most complete set of data produced during the three seasons of research at Farmington. The cultivar "Steptoe" was grown all three years. In addition, a wide N-availability differential was achieved and LAI measurements made. The relative completeness of the data set made detailed analysis possible. For this reason the analysis of the spring barley data will be presented first as it provides a foundation whereby the performance of the other crops can be better understood.

The water-production functions of spring barley with grain yield in kg/ha expressed as a function of ET in cm for 1980, 1981, and 1982 are presented in Table 12. A water-production function was developed for each section of each of the SLS plots of 1980 and 1981. The functions have been compared between and within years for differences in slope and intercept.

The water-production functions of 1980 are plotted in Figure 5 and for 1981 in Figure 6. The lower magnitude of the maximum yields achieved in the low and medium N-level SLS plots in 1980 and 1981 demonstrate that a good range of N availability was achieved. The water-production functions of the SLS plots of 1980 are more similar among the N-fertility levels than those produced in 1981. Except for the low-N plot of 1980, the water-production functions produced in the two sections

Table 12. The water-production functions* of spring barley with grain yield in kg/ha as a function of evapotranspiration in cm, 1980, 1981, and 1982.#

N - Level 1/ and Plot Section No.	Quadratic Regression Coefficient	Linear Regression Coefficient	Intercept	r^2	Equation ID Letter	Significant Differences 2/
			1980			
High - 1	3.8	146.6	1799	1.00	A	all
High - 2	1.8	0.0	- 565	0.97	B	all
Medium - 1	2.1	0.0	- 678	0.98	C	A,B,E,H,I,J,K,L,M
Medium - 2	4.6	176.9	1933	0.96	D	A,B,E,H,I,J,K,L,M
Low - 1	0.9	0.0	- 76	0.93	E	A,B,C,D,G,H,I,J,K,L,M
Low - 2	1.3	0.0	- 95	0.97	F	A,B,I,J,K,L,M
			1981			
High - 1	0.0	143.6	-1308	0.98	G	A,B,C,D,E,H,I,J,K,L,M
High - 2	0.0	159.9	-1934	0.96	H	A,B,C,D,E,G,I,J,K,L,M
Medium - 1	2.8	0.0	- 334	0.95	I	A,B,C,D,E,F,G,H,K,L,M
Medium - 2	2.9	0.0	- 703	0.91	J	A,B,C,D,E,F,G,H,K,L
Low - 1	1.7	0.0	- 251	0.96	K	A,B,C,D,E,F,G,H,I,J,M
Low - 2	1.9	0.0	- 244	0.89	L	A,B,C,D,E,F,G,H,I,J
			1982			
High - 1	0.0	139.9	-2015	0.84	M	A,B,C,D,E,F,G,H,J,K
			Various 3/			
High	0.0	71.7	- 542	0.74	-	
Medium	0.0	85.3	- 697	0.85	-	
Low	0.0	19.7	389	0.10	-	

* Regression equations were initially fit to the form $Y = A(ET)^2 + B(ET) + C$. See text.

\# Actual data points are presented in Appendix C.

1/ Available N at planting is presented in Table 5.

2/ Equation in previous column is significantly different at the 0.05 probability level from the equations listed in this column. The null hypothesis for the pairwise comparison is that the full and reduced model of the statistical procedure have a common intercept and common linear coefficients. See text.

3/ These functions were not compared with other functions since ET was not measured over the entire season. These three equations are not significantly different from one another.

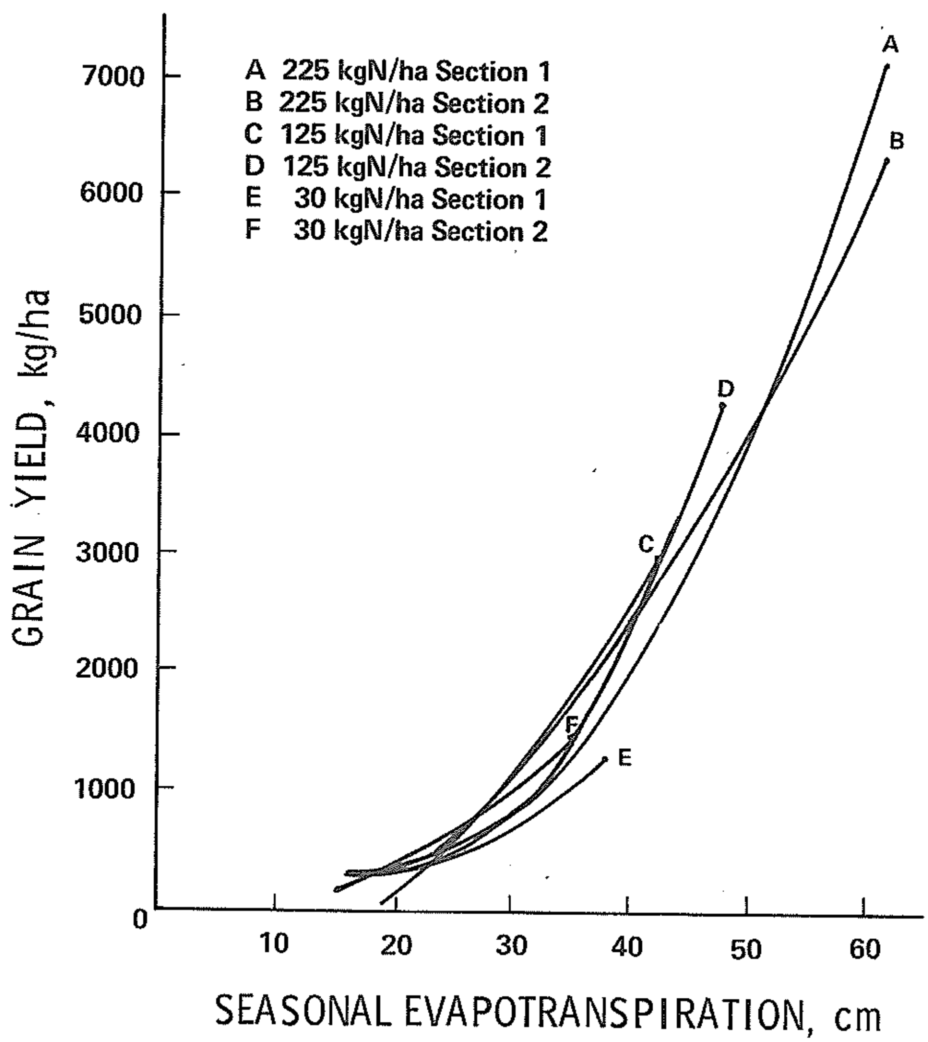

Figure 5. The water-production functions of each section of the spring barley SLS plots, 1980.

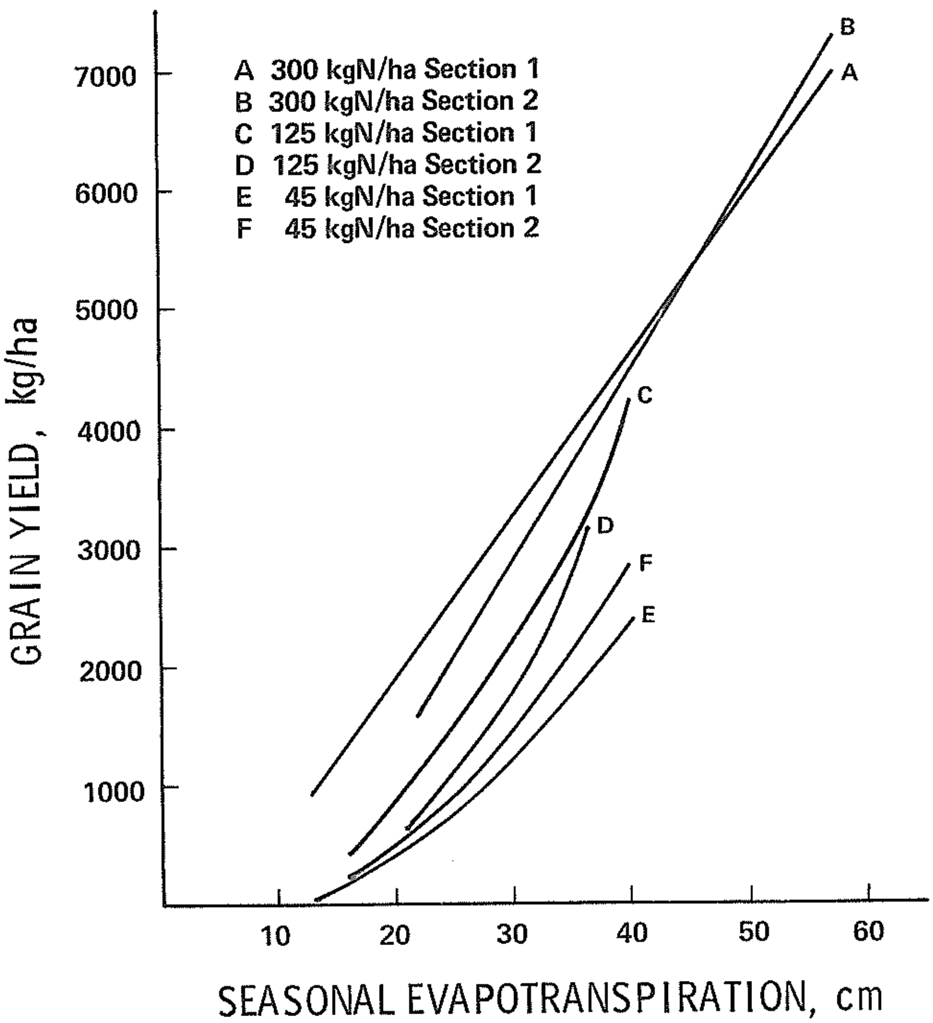

Figure 6. The water-production function of each section of the spring barley SLS plots, 1981.

of an identical plot did not differ significantly. In 1981, a clear pattern of a decrease in water-use efficiency occurred as the level of N fertility decreased. The water-production functions between years demonstrate considerable variability.

In the SLS plots of 1980 and 1981, and in the high-N plot of 1981, as is discussed in detail in the Materials and Methods section, each SLS plot was assigned a single N fertility level. The SLS plots were not randomized with respect to fertilizer level (by banding fertilizer at right angles to the sprinkler-line across the width of the plot) because if the high-N subplot on the line was watered optimally, the low-N plot would be grossly overirrigated in most of its subplots. The disadvantage of the plots not being randomized totally is that the frequency and duration of irrigation can be different among the SLS plots due to the differing water requirements of a high versus low yielding plot. In 1982, as described earlier, ammonium nitrate fertilizer was banded across the width of the plot at right angles to the sprinkler line. Thus, a single sprinkler-line irrigated three levels of N availability. Irrigations were scheduled based on depletion of water in the low-N band at the sprinkler line. This resulted in low yields in all of the N-level bands, but prevented deep percolation of water that would have occurred in the low-N bands had irrigations been scheduled based on depletion of water in the rhizosphere of the higher N bands. Unfortunately, unmeasured water from a broken pipe flooded portions of the spring barley plots including both blocks of this randomized SLS plot. One block was completely lost as a result of physical damage to the barley plants. However, the remaining block was given an irrigation to refill the soil profile evenly to offset the unequal effects of the flooding, and the ET balance calculations were restarted May 10. The water-production functions resulting from the data collected from this block are also presented in Table 12.

These three functions do not differ significantly different from one another at the 0.05 probability level, however, it should be noted that the coefficient of determination (r^2) for the low-N band is very low. These functions have been plotted in Figure 7. The low coefficient of determination and the flatter slope of the low-N band largely can be explained by the one divergent data point. The remaining points of the three fertility levels are located adjacent to a similar line. The yield that the plants with low-N availability were able to produce required a similar quantity of ET to that of the plants receiving the higher levels of applied N. However, these plants were not able to produce yields of the magnitude of the higher fertility plants, probably as a result of lack of N that prevented deeper root growth into available stored soil moisture. The similarity in the quantity of water required to produce a given level of yield in the banded-N SLS plot, independent of the level of N fertility, suggests that the differences observed in water-use efficiency among the SLS plots of 1981 may be attributable to causes other than the effects of N on the efficiency by which the plant uses absorbed water.

Differential soil-water evaporation has been suggested as one cause in the variability between seasons, and possibly between N fertility levels, in the quantity of water evapotranspired in the production of a given level of yield. For this reason soil-water E was modeled by the

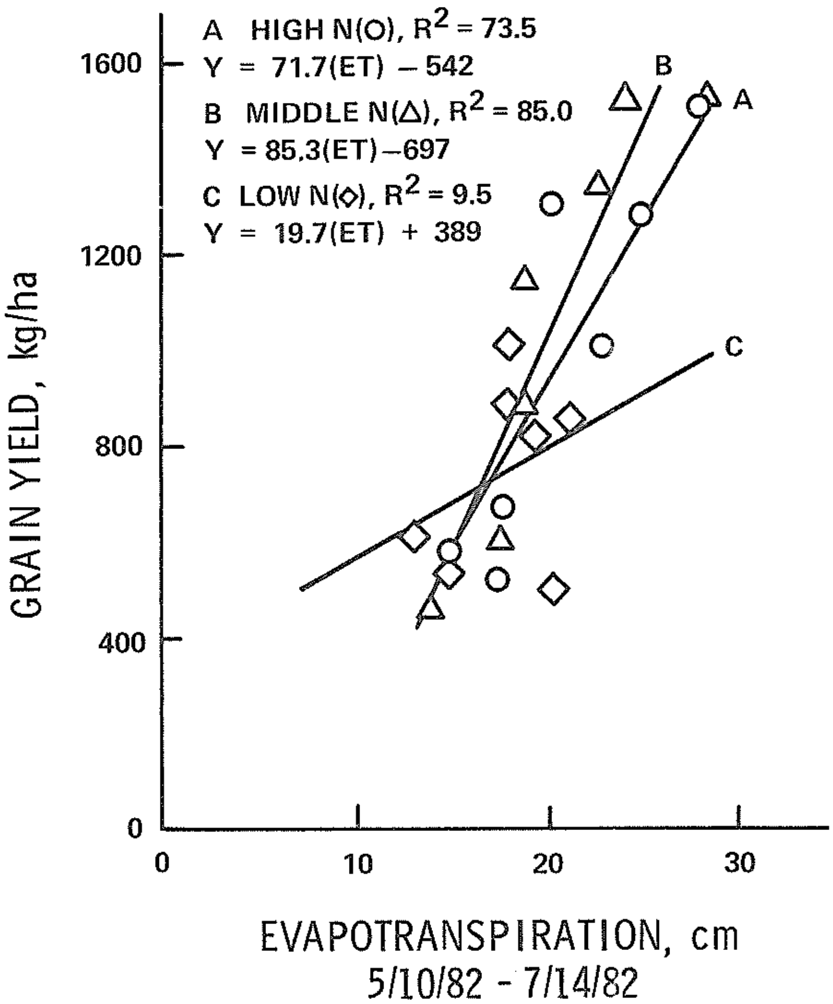

Figure 7. The water-production functions of the barley SLS plot with various N levels, 1982.

method described in the Materials and Methods section. Table 13 presents the seasonal ET and yield of the subplots in which E was estimated, the estimated soil-water E, and T, which was calculated by subtracting E from ET. Water-production functions (with yield expressed as a function of ET) were developed individually for the SLS plots of 1980, 1981, and 1982 from the data of the subplots listed in Table 13.

When the water-production functions of the seven SLS plots were compared for significant differences with respect to a common slope and intercept, an F-statistic of 4.9 (df = 12/19) was obtained indicating that significant differences existed among the functions at the 1 percent probability level. However, when functions relating yield to transpiration were developed for the seven SLS plots from data also presented in Table 13, the comparison among the functions with respect to a common slope and y-intercept resulted in an F-statistic of 1.0 (df = 12/19) which was not significant even at the 10 percent level of probability. Thus, the water-production functions developed from three seasons of data were transformed to an identical function, although the PET, as measured by a modified Penman method (as described in Appendix A), varied greatly between these seasons (712 mm in 1980, 607 in 1981, and 679 in 1982) from planting to physiological maturity. This observation further supports the hypothesis that the evaporational component of ET is responsible for much of the variability in the parameters of the water-production functions between seasons.

Because no significant differences exist among the slopes and intercepts of the functions for the individual SLS plots when yield is

Table 13. Measured evapotranspiration (ET), estimated evaporation (E), and transpiration (T) of selected subplots of the spring barley SLS plots, 1980, 1981, and 1982.

N Level	Section	Number of Irrigations	Distance from Line	Yield	ET	T	E
			m	kg/ha	cm		
			1980				
225	1	23	11	645	25.1	3.0	22.1
225	1	26	5.5	2688	42.9	21.7	21.2
225	1,2	27	0	7176	61.5	41.0	20.5
225	2	27	5.5	2855	43.9	20.7	23.2
225	2	27	11	534	22.2	4.3	17.9
125	1	21	11	364	19.7	2.5	17.2
125	1	22	5.5	1652	39.9	12.1	27.8
125	1,2	22	0	4200	48.3	28.7	19.6
125	2	22	5.5	2004	36.8	8.2	28.6
125	2	22	11	253	22.8	6.6	16.2
30	1	19	11	333	19.0	6.2	12.8
30	1	23	5.5	1021	32.0	8.5	23.5
30	2	23	5.5	773	31.9	8.4	23.5
30	2	23	11	295	18.8	5.6	13.2
			1981				
300	1	14	12	1534	19.0	8.1	10.9
300	1	17	8	3260	32.7	18.9	13.8
300	1,2	17	0	6626	57.3	44.2	13.1
300	2	17	8	3899	34.9	21.8	13.1
300	2	17	12	2322	28.9	13.8	15.1
125	1	17	12	1045	24.3	12.1	12.2
125	1	18	8	1569	29.2	11.6	17.6
125	1	18	3*	4202	39.3	19.6	19.7
125	2	18	8	2249	32.7	11.6	21.1
125	2	18	12	909	20.9	5.2	15.7
45	1	19	12	113	13.7	3.9	9.8
45	1	19	8	886	27.3	6.6	20.7
45	1,2	19	0	2431	39.9	15.1	24.8
45	2	19	8	1318	31.8	9.8	22.0
45	2	19	12	795	23.4	5.9	17.5
			1982				
300	1	17	12	1157	24.7	14.0	10.7
300	1	17	8	2163	28.1	15.4	12.7
300	1	17	2	3903	40.6	25.0	15.6
300	1	17	0	4175	46.7	32.9	13.8

* The ET data of the subplot at the line were lost as a result of unmeasured water leaking from the sprinkler line. Since the final yield in the subplot beneath the SLS was of the same magnitude of this subplot 3 m from the line, these data were substituted.

expressed as a function of T, all of the data points have been combined into a common relationship relating yield to T. This function is expressed as Equation 8.

$$\text{Yield (kg/ha)} = 210 + 161.3\ (\text{T, cm}) \tag{8}$$

Equation 8 has a coefficient of determination of 0.92 and a standard error of the estimate of 512 kg/ha.

As Table 13 shows, a large percentage of the total ET is evaporation. This is especially true in the subplots near the edge of the SLS plots. This observation is not surprising when the number of irrigation events is considered. The frequent irrigations are the result of three factors: the low water holding capacity of the sandy loam soils; the slope of the land which encouraged surface runoff; and the characteristic of the wind to rise quickly, diminishing the water application efficiency and necessitating the termination of the irrigation. The observation in Table 13 that subplots within identical SLS plots received different numbers of irrigations is the result of wind that sometimes prevented water from reaching the subplots near the edge of the SLS plots. This relationship between yield and transpiration is graphed in Figure 8 and the data points used to develop the regression equation are plotted. The function comes close to passing through the origin which is to be expected in this type of relationship. The removal of E from the ET term reduced the curvilinearity present in the water-production functions, suggesting this curvilinearity is the result of differential E rates associated with various yield levels.

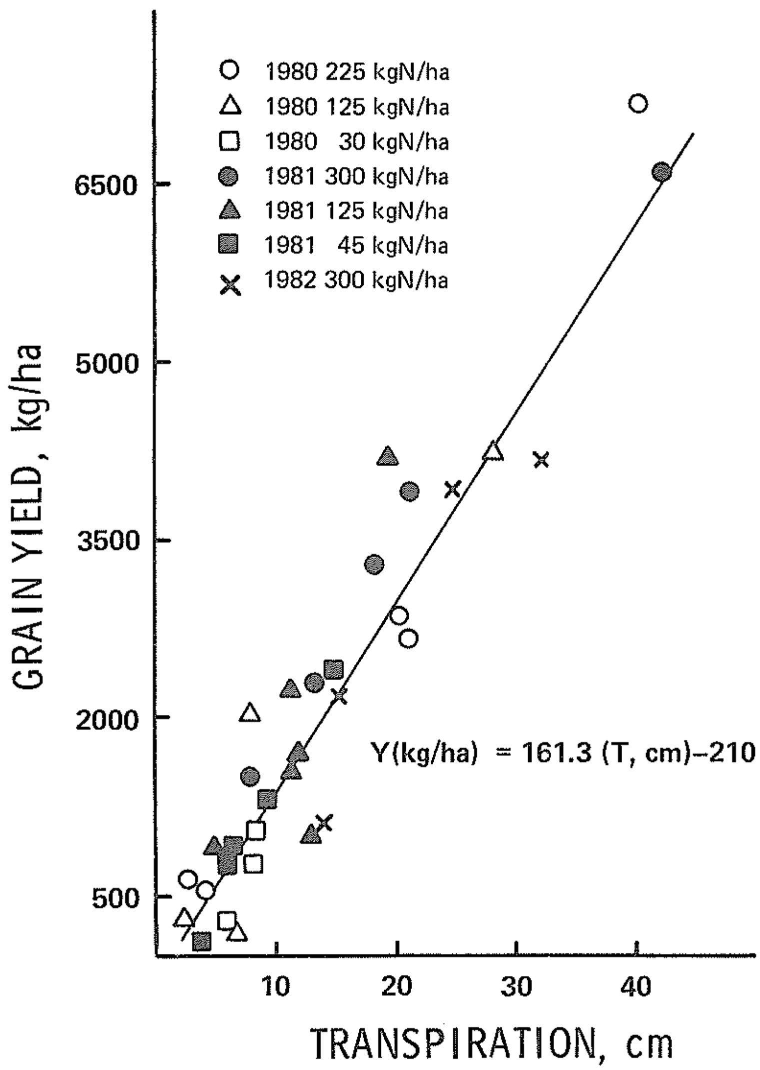

Figure 8. The relationship between grain yield of spring barley and seasonal transpiration, 1980, 1981, and 1982.

The yield versus transpiration function is graphed with the high-N plots (sections combined) of 1980, 1981, and 1982 in Figure 9. This figure demonstrates the degree to which we hypothesize that soil-water evaporation differentially can affect the water-production functions of spring barley.

Regression equations of biomass yield in kg/ha of spring barley as a function of ET in cm are presented in Table 14. As with the water-production functions significant differences exist among these functions as well.

Intraseasonal ET requirements based on developmental stages of the developing crop have been presented in Table 15. The data in these tables have been interpolated to common yield levels. Only the data from the high-N SLS plots of each season were utilized. Obviously, data from the low-N plot of 1981 would be very different from the high-N plot of that year. The developmental stages of the crop are only estimates and could be as much as a few days in error. Thus, intraseasonal ET requirements also were interpolated based on accumulations of 200 GDD. These results are presented in Table 16. In both tables, consideable variability exists in the daily ET requirements for a given level of yield. With the degree of variability existing in the data, the scheduling of irrigations in the hopes of achieving a target yield level would be a very difficult task.

To determine if observed differences in the water-production functions among years could be explained based on differences in atmospheric evaporative demand, the calculated seasonal ET of the subplots in the high-N plots of 1980, 1981, and 1982 were divided by the various methods

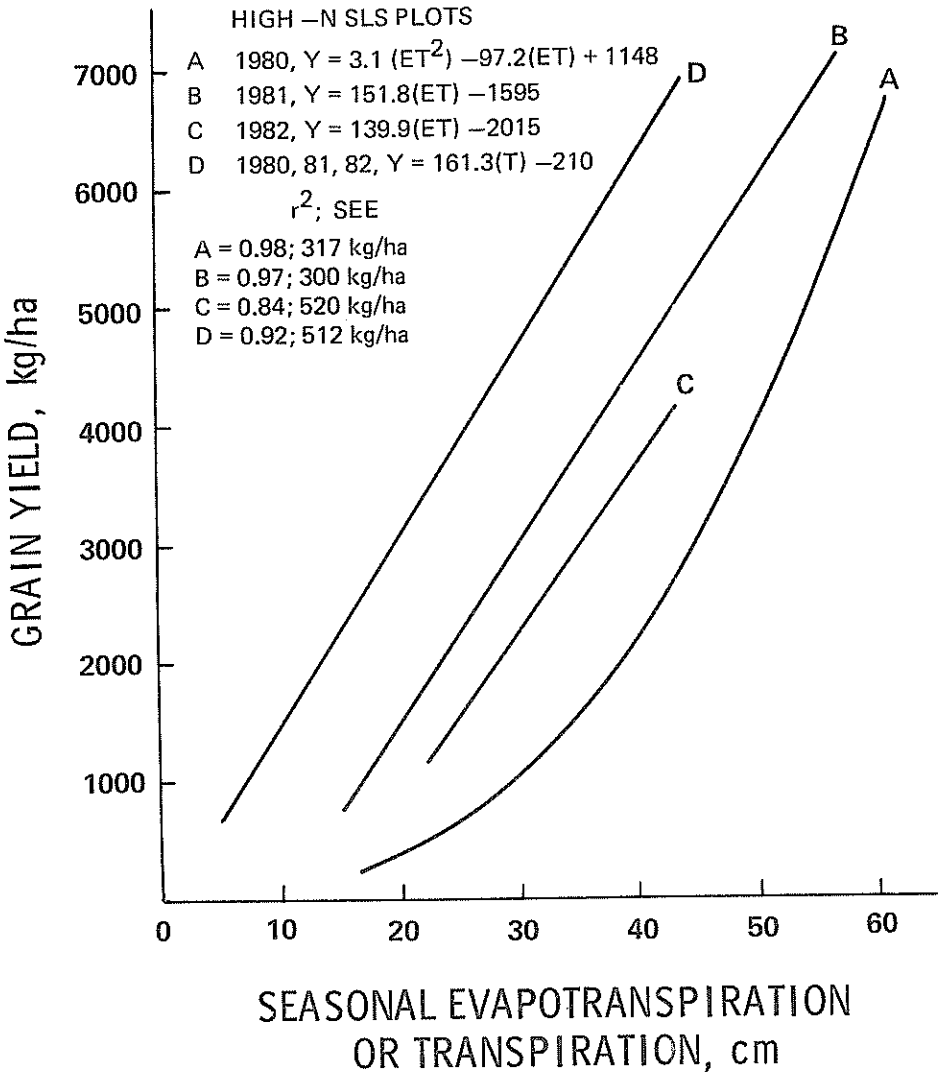

Figure 9. The water-production functions of the high-N SLS plots, of 1980, 1981, and 1982, in relation to the grain yield versus transpiration regression equation of 1980, 1981, and 1982.

Table 14. Regression equations* of biomass yield in kg/ha of spring barley as a function of evapotranspiration in cm, 1981 and 1982.#

N - Level1/ and Plot Section No.	Linear Regression Coefficient	Intercept	r^2	Equation ID Letter	Significant Differences2/
		1981			
High - 1	217.3	-1873	0.93	A	D,E,F
High - 2	235.3	-2132	0.94	B	D,E,F
Medium - 1	211.5	-1444	0.89	C	D,E,F
Medium - 2	241.9	-3430	0.85	D	all
Low - 1	125.9	-1175	0.76	E	A,B,C,D,G
Low - 2	174.7	-2221	0.80	F	A,B,C,D,G
		1982			
High - 1	232.8	-1842	0.86	G	D,E,F
		Various3/			
High	152.0	943	0.87	-	
Medium	143.2	495	0.80	-	
Low	-69.8	3489	0.21	-	

* Regression equations were initially fit to the form $Y = A(ET)^2 + B(ET) + C$, but the quadratic coefficient was not significant. See text.

\# Actual data points are presented in Appendix C.

1/ Available N at planting is presented in Table 5. Numerals refer to the applicable plot section.

2/ Equation in previous column is significantly different at the 0.05 probability level from the equations listed in this column. The null hypothesis for the pairwise comparison is that the full and reduced model of the statistical procedure have a common intercept and common linear coefficients. See text.

3/ These functions were not compared with other functions since ET was not measured over the entire season. The third equation regression of this category is not significant. The High and Medium - N regressions are not significantly different from one another but are different from the Low - N regression at the 0.05 probability level.

Table 15. Average daily ET and seasonal ET of barley, interpolated to common yield levels, as determined in the plot with the highest nitrogen availability at planting, 1980, 1981, and 1982.

Yield	Year	Seasonal ET	Planting-Jointing 1*	Planting-Jointing 2*	Jointing-Heading 1	Jointing-Heading 2	Heading-Phys.Mat. 1	Heading-Phys.Mat. 2	Phys.Mat.-Final 1	Phys.Mat.-Final 2
kg/ha		cm	ET cm/day per Period							
1000	1980	31	.11	.24	.37	.48	.54	.35	.37	.25
	1981	15	.06	.16	.27	.19	.17	.24	.08	.08
	1982	23	.17	.29	.33	.33	.21	.13	.12	.12
2000	1980	37	.09	.22	.53	.57	.63	.38	.39	.22
	1981	24	.07	.22	.22	.32	.35	.29	.18	.18
	1982	28	.17	.29	.34	.34	.54	.31	.19	.19
3000	1980	45	.09	.24	.43	.62	.72	.49	.49	.25
	1981	32	.10	.23	.30	.47	.52	.61	.20	.20
	1982	35	.16	.31	.39	.39	.62	.43	.22	.22
4000	1980	51	.10	.29	.49	.71	.86	.57	.57	.35
	1981	39	.11	.27	.39	.58	.64	.72	.27	.27
	1982	43	.16	.41	.52	.52	.79	.54	.24	.24
5000	1980	57	.08	.30	.55	.74	1.03	.67	.67	.32
	1981	44	.11	.32	.40	.70	.77	.86	.34	.34
6000	1980	61	.11	.27	.53	.79	1.05	.72	.72	.34
	1981	51	.14	.28	.42	.79	.89	1.04	.38	.38
7000	1980	64	.15	.24	.52	.84	1.08	.77	.77	.36
	1981	57	.12	.30	.42	.87	.98	1.07	.41	.41
		Seasonal GDD	Average GDD Accumulated by Barley in 1980, 1981, and 1982							
		1095	142	175	101	116	188	214	73	89

* First and second half, respectively, of the time in the applicable growth stage.

Table 16. Evapotranspiration of spring barley from planting to the time of accumulation of 1000 GDD*, at intervals of 200 GDD, for 1980, 1981, and 1982, interpolated to common yield levels as determined in the SLS plots with the highest N application.

Yield	Year	Accumulated ET#	GDD Accumulation 0-200	201-400	401-600	601-800	801-1000
kg/ha		cm	ET/Day/Period				
	1980	29.5	.11	.26	.45	.45	.34
1000	1981	13.5	.07	.12	.20	.20	.17
	1982	22.5	.23	.35	.33	.19	.14
	1980	36.6	.12	.28	.56	.62	.44
2000	1981	21.1	.08	.23	.31	.33	.24
	1982	27.4	.18	.26	.36	.45	.26
	1980	42.4	.12	.34	.69	.70	.49
3000	1981	28.7	.09	.23	.43	.53	.40
	1982	33.9	.21	.31	.44	.58	.35
	1980	46.8	.15	.37	.73	.77	.56
4000	1981	38.3	.13	.32	.58	.68	.51
	1982	43.0	.24	.46	.60	.69	.40
	1980	53.2	.13	.40	.83	.94	.67
5000	1981	43.6	.13	.34	.66	.81	.62
	1982	- - - - - - - - - - - not available - - - - - - - -					
	1980	55.1	.15	.38	.86	.97	.72
6000	1981	48.6	.16	.33	.73	.93	.72
	1982	- - - - - - - - - - - not available - - - - - - - -					
	1980	56.8	.17	.38	.89	1.00	.77
7000	1981	54.8	.18	.34	.83	1.06	.78
	1982	- - - - - - - - - - - not available - - - - - - - -					
	Year	Total Days	Days in Period				
	1980	99	27	22	19	16	15
	1981	95	26	22	19	15	13
	1982	97	30	21	17	15	14

* One thousand GDD is the accumulation from planting to physiological maturity, approximately.

\# Accumulated ET from planting to the time of accumulation of 1000 GDD. Seasonal GDD accumulations (planting to final probe reading) were 1153, 1094, and 1039 for 1980, 1981, and 1982, respectively.

of calculating seasonal PET as described in Appendix A. The seasonal PET accumulations for spring barley are presented in Appendix F. The observation that the water-production functions varied considerably within years depending upon the level of N fertility, suggests that the PET measurement by itself is limited in its ability to predict observed differences between years in the parameters of the water-functions. However, the comparison among years was conducted to determine if evaporative demand would explain differences among years if the level of N fertility in the plots was similar. The results of the comparison are presented in Table 17. When the water-production functions of the high-N plots are compared for the parameters of slope and intercept among the three seasons, an F-statistic of 37.5 is obtained. This relatively large F-value suggests that very significant differences exist among these functions. However, when grain yield is expressed as a function of the crop coefficient (ET/appropriate PET measurement), the F-values decrease markedly, indicating the functions have become more similar but that significant differences remain. The earlier observation that the T versus grain yield relationship did not vary among seasons or N-fertility levels suggests that the ability of the PET formulae to account for differences in the water-production functions among years may be explained by a correlation between the PET measurement and the soil-water evaporation component of ET. The slopes of the water production functions of the high-N plots did not differ significantly among years (Table 17, $F = 0.1$). However when the yield versus crop coefficient functions were compared, the F-value increased and

Table 17. A comparison of barley crop coefficients as calculated by various PET methods, with respect to their ability to account for seasonal differences in the parameters of the water-production functions of 1980, 1981, and 1982. Only the plots containing the high-level N application are compared.

Reduced Model#	ET	ET/ Penman	ET/Jensen-Haise	ET/Priestly-Taylor	ET/ Pan	ET/ VPD
	Value of F					
Common Intercept Common Slope (df = 4/52)	37.5*	5.4*	7.7*	11.7*	19.1*	4.7*
Common Intercept Different Slope (df = 2/52)	7.5*	7.5*	7.5*	7.5*	7.5*	7.5*
Different Intercept Common Slope (df = 2/52)	0.1	4.0*	3.0	1.7	2.4	4.9*

The null hypothesis for the three-way comparison is that the full and reduced model of the statistical procedure have the characteristics listed below. The smaller the magnitude of the value of F, the more similar are the functions between years.

* The reduced model is significantly different from the full model at the 0.05 probability level.

increased and even became significant in some cases, increasing differences in the functions among years.

The modified Penman PET measurement appeared to be the most effective in explaining differences in slope and intercept among the water-production functions of the high-N SLS plots, and so it was used to determine if intraseasonal crop coefficients based on the modified Penman method would be more similar among years than were the intraseasonal ET measurements appearing in Tables 15 and 16. These intraseasonal crop coefficients appear in Table 18, which is based on developmental stages as were listed in Table 15; and in Table 19, which is based on intervals of 200 GDD accumulations as was Table 16. At a given level of yield and stage of crop development, as much variability exists in these crop coefficients as exists in the ET data. In 1981, crop coefficients greater than the total unity were achieved routinely, indicating the measured PET was not of the necessary magnitude.

In 1981 (Kallsen et al., 12), factors associated with soil-water evaporation, and which were based on the SLS data of all of the barley SLS plot of 1980 and 1981, were subjected to stepwise multiple regression analysis to determine their relative ability to account for observed variability in the grain yield. When the observations of 1982 were placed in this multiple regression equation, which was developed from only the 1980 and 1981 data, close agreement was obtained between the yield levels estimated from the 1982 water-production function based on measured ET and predicted yields as calculated by the multiple regression equation. The

Table 18. Average daily ET/PET and seasonal ET/PET by developmental stage of barley, interpolated to common yield levels, as determined in the plot with the highest nitrogen availability at planting, 1980, 1981, and 1982.

Yield	Year	Seasonal ET/PET#	Planting-Jointing 1*	Planting-Jointing 2*	Jointing-Heading 1	Jointing-Heading 2	Heading-Phys.Mat 1	Heading-Phys.Mat 2	Phys.Mat.-Final 1	Phys.Mat.-Final 2
kg/ha		cm	Daily ET/PET							
1000	1980	.37	.18	.40	.42	.54	.59	.42	.39	.29
	1981	.22	.10	.25	.38	.35	.21	.29	.10	.11
	1982	.29	.31	.47	.44	.36	.22	.14	.14	.11
2000	1980	.44	.15	.37	.61	.64	.69	.46	.41	.25
	1981	.35	.12	.34	.31	.59	.42	.35	.23	.26
	1982	.37	.31	.47	.45	.37	.56	.32	.21	.17
3000	1980	.54	.15	.40	.49	.69	.79	.59	.51	.29
	1981	.47	.17	.35	.42	.86	.63	.74	.25	.28
	1982	.46	.29	.50	.52	.42	.64	.45	.25	.19
4000	1980	.61	.17	.48	.56	.79	.95	.68	.60	.40
	1981	.57	.19	.41	.55	1.07	.77	.88	.34	.38
	1982	.57	.29	.66	.69	.56	.82	.57	.27	.22
5000	1980	.68	.13	.50	.64	.83	1.13	.80	.70	.37
	1981	.61	.19	.49	.56	1.29	.93	1.05	.43	.48
6000	1980	.73	.18	.45	.61	.88	1.15	.86	.76	.39
	1981	.74	.24	.43	.59	1.45	1.08	1.27	.48	.54
7000	1980	.76	.25	.40	.60	.93	1.18	.92	.81	.41
	1981	.83	.20	.46	.59	1.59	1.19	1.30	.52	.58
		Seasonal GDD	Average GDD Accumulated by Barley in 1980, 1981, and 1982							
		1095	142	175	101	116	188	214	73	89

\# PET calculated by the Penman method.

* First and second half, respectively, of the time in the applicable growth stage.

Table 19. Crop coefficients (ET/PET ratios) of spring barley from planting to the time of accumulation of 1000 GDD*, at intervals of 200 GDD for 1980, 1981, and 1982, interpolated to common yield levels, as determined in the SLS plots with the highest N application.

Yield	Year	Accumulated ET/PET#	GDD Accumulation 0-200	201-400	401-600	601-800	801-1000
kg/ha			ET/PET/Day/Period				
	1980	.39	.18	.37	.49	.53	.38
1000	1981	.21	.12	.18	.30	.22	.27
	1982	.30	.40	.51	.35	.19	.15
	1980	.48	.20	.39	.61	.73	.49
2000	1981	.33	.13	.35	.47	.37	.39
	1982	.36	.32	.38	.39	.45	.28
	1980	.56	.20	.48	.75	.83	.55
3000	1981	.45	.15	.35	.65	.60	.66
	1982	.45	.37	.45	.47	.58	.38
	1980	.61	.25	.52	.79	.92	.63
4000	1981	.60	.22	.49	.88	.76	.84
	1982	.57	.42	.67	.65	.69	.43
	1980	.70	.21	.56	.90	1.12	.75
5000	1981	.69	.22	.52	1.00	.91	1.02
	1982	- - - - - - - - - - not available - - - - - - - -					
	1980	.72	.25	.54	.93	1.15	.18
6000	1981	.76	.27	.51	1.11	1.04	1.18
	1982	- - - - - - - - - - not available - - - - - - - -					
	1980	.74	.28	.54	.97	1.19	.87
7000	1981	.86	.30	.52	1.25	1.19	1.27
	1982	- - - - - - - - - - not available - - - - - - - -					
	Year	Total Days	Days in Period				
	1980	99	27	22	19	16	15
	1981	95	26	22	19	15	13
	1982	97	30	21	17	15	14

* One thousand GDD is the accumulation from planting to physiological maturity, approximately.

\# ET/PET ratio as calculated from planting to the time of accumulation of 1000 GDD. Seasonal GDD accumulations (planting to final probe reading) were 1153, 1094, and 1039 for 1980, 1981, and 1982, respectively.

results of this comparison and the form of the multiple regression equation utilized are presented in Appendix M. This close agreement between the best-fit water-production function of 1982 and the multiple regression equation was obtained without reference to the level of N fertility, further suggesting that the level of N fertility is not an important factor in predicting the yield obtainable from a seasonal ET measurement. These results also suggest that once the factors associated with seasonal T and soil-water E are explained more fully, accurately predicting a targeted yield level with a given level of deficit irrigation will become possible. However, this prediction will require input information in addition to ET and PET.

Alfalfa

Equation 9 is the 1981 alfalfa water production function developed from the lysimeter and nonlysimeter results of seasonal ET versus seasonally accumulated yield, of the SLS plot.

$$Y(\text{metric tons/ha}) = -6.32 + 0.164\ (\text{ET, cm}) \tag{9}$$
$$r^2 = 0.95$$
$$\text{SEE} = 1.1 \text{ metric tons}$$

Equation 10 is the 1982 alfalfa water-production function developed from only the lysimeter results of seasonal ET versus seasonally accumulated yield of the SLS plot.

$$Y(\text{metric tons/ha} = -17.73 + 0.284\ (\text{ET, cm}) \tag{10}$$
$$r^2 = 0.96$$
$$\text{SEE} = 1.9 \text{ metric tons}$$

Equation 10 was developed from only the lysimeter results because the nonlysimeter portions of the SLS plots were subjected to a flood of unmeasured water during the first cutting that made ET data collected during the first cutting unuseable. However, all comparisons of water-production functions between lysimeter and nonlysimeter ET versus yield data during the four cuttings of 1981 and the second, third and fourth cut of 1982, demonstrated no significant differences between the two areas for the regression parameters of slope and intercept. This close agreement between lysimeter and nonlysimeter results indicates that Equation 10 provides a reasonable estimate of the quantity of ET that was required to produce the yield levels achieved in the SLS plot during 1982.

Equations 9 and 10 have been plotted and are presented in Figure 10. When the two equations are compared in association for the regression parameters of slope and intercept, they differ at the 1 percent level of probability. When compared for differences only in intercept, they differ at the 5 percent but not the 1 percent level, and when compared for only differences in slope, they again differ at the 1 percent level.

The water-production functions of each of the cuttings of 1981 and 1982 are presented in Table 20. Additionally, these functions have been compared for significant differences of slope and intercept. This table shows that the water-production functions demonstrate considerable variability among and within years. The water-production functions of the cuttings of 1981 have been plotted in Figure 11 and the functions of 1982 in Figure 12. Evapotranspiration rates at intervals within a cutting are not available for 1982 but are presented in Table 21

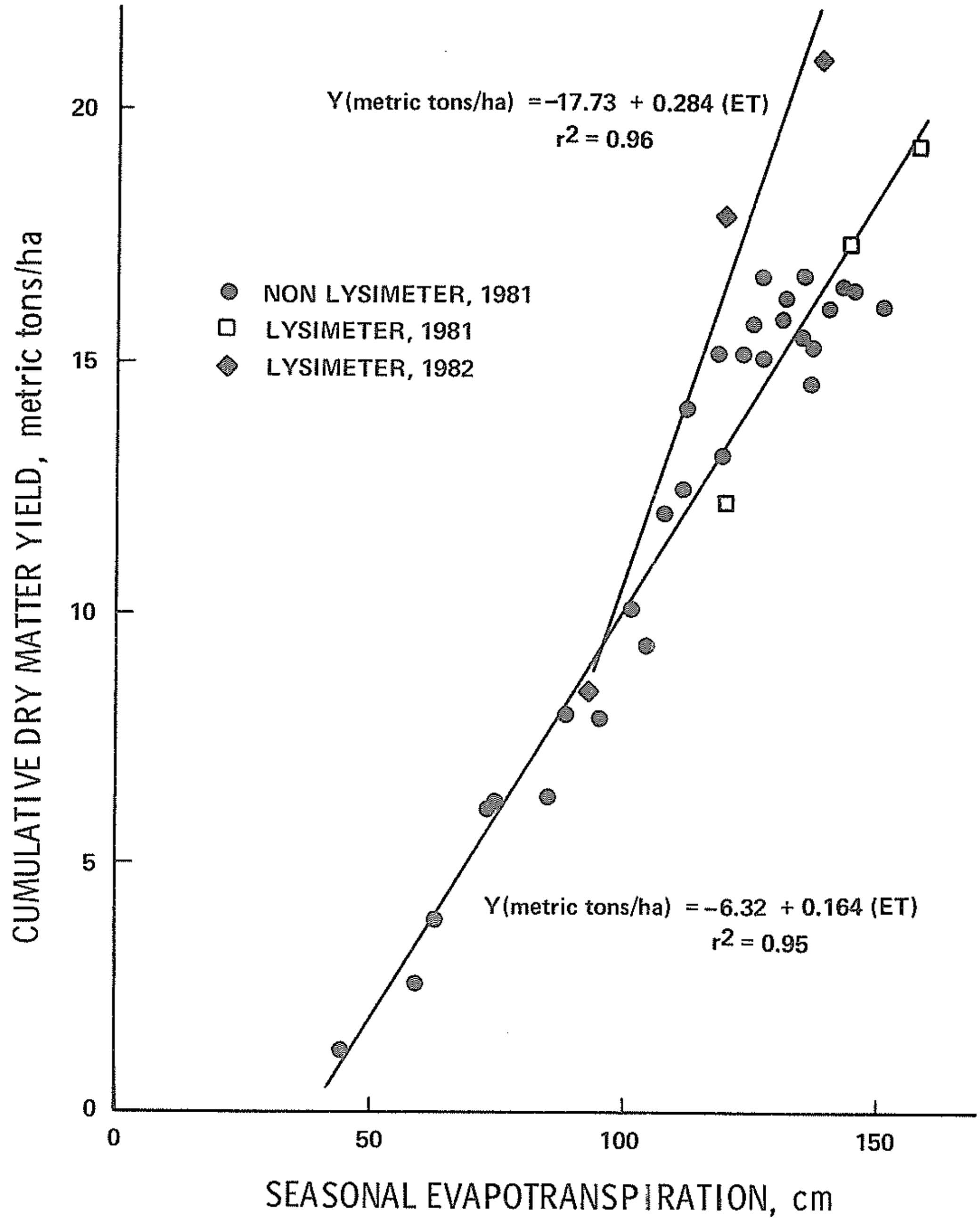

Figure 10. The seasonal cumulative water-production functions of alfalfa, 1981 and 1982.

Table 20. The water-production functions* of alfalfa, with dry matter production in metric tons/ha as a function of evapotranspiration in cm, for each cutting based on the lysimeter and nonlysimeter results and with function parameters compared between and within years 1981 and 1982.

Harvest	Linear Regression Coefficient	Intercept	r^2	Equation ID Letter	Significant Differences#
1st cutting - 1981	.118	.03	.92	A	all
2nd cutting - 1981	.201	-3.58	.83	B	all
3rd cutting - 1981	.154	- .78	.81	C	all
4th cutting - 1981	.155	-1.41	.84	D	all
1st cutting - 1982	.323	-7.76	.99	E	A,B,C,D,G,H
2nd cutting - 1982	.235	-3.29	.83	F	A,B,C,D,H
3rd cutting - 1982	.211	-2.28	.81	G	A,B,C,D,E,H
4th cutting - 1982	.233	-1.46	.80	H	all

* Regression equations were compared in the form Y = A(ET) + B. Individual yield versus ET observations for the cuttings are presented in Appendix B.

Equation in previous column is significantly different at the 0.05 probability level from the equations listed in this column. The null hypothesis for the pairwise comparison is that the full and reduced model of the statistical procedure have a common intercept and a common linear coefficient.

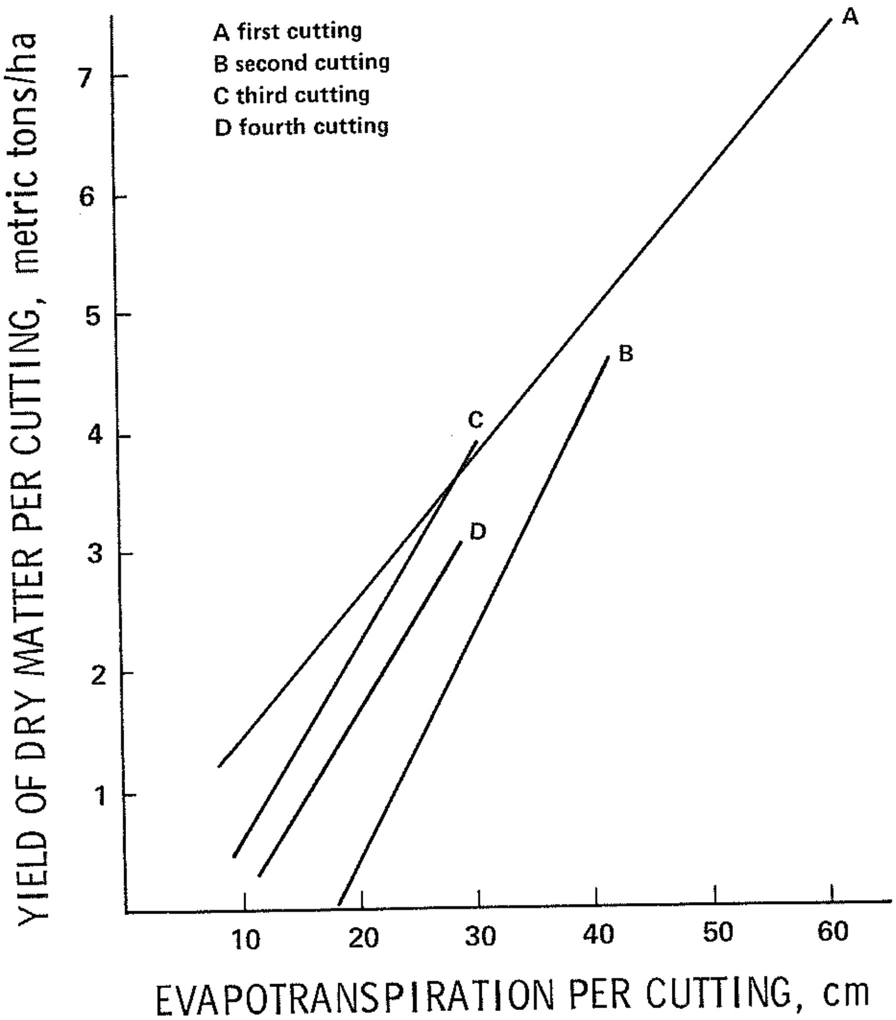

Figure 11. The water-production functions, with respect to the individual cuttings, of the alfalfa SLS plots, 1981.

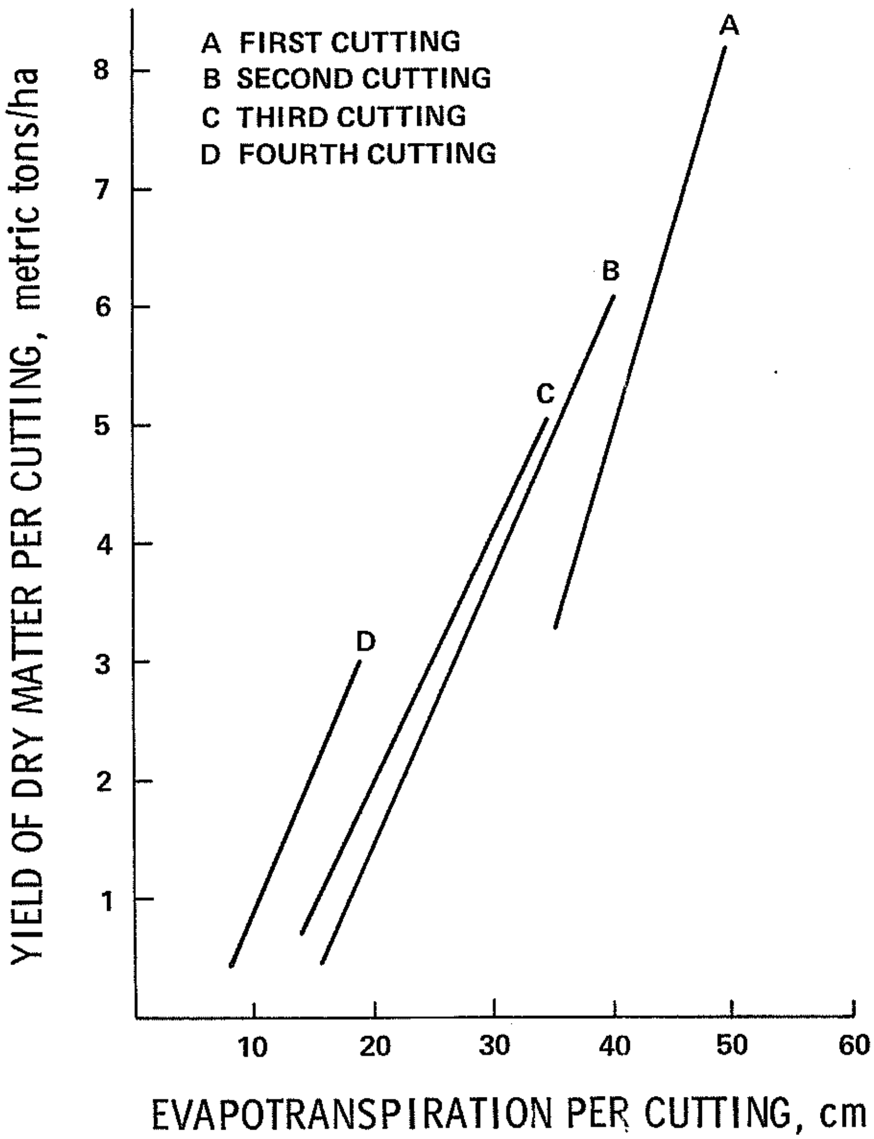

Figure 12. The water-production functions, with respect to the individual cuttings, of the alfalfa SLS plots, 1982.

for 1981. These values were obtained by interpolating calculated ET rates as measured in specific subplots to equivalent yield levels. The quantity of ET associated with equivalent yield levels varies considerably among the cuttings.

To determine if differences in the seasonal water-production functions could be partially explained by differences in potential evaporative demand, the seasonal ET values were divided by the seasonal PET values given in Appendix F. The results are presented in Table 22. The water-production functions based on crop coefficients show greater significant differences between seasons than do the yield versus ET relationships. The regression parameters of the water-production functions of the cuttings produced within a growing season for 1981 and 1982 are compared in Table 23. Again, the crop coefficients do not explain the observed differences within years.

Crop coefficients expressed at intervals within the cutting periods of 1981 are presented in Table 24. These crop coefficients were obtained by dividing the average daily ET rates/period listed in Table 21 by calculated average daily Penman PET rates/periods for identical periods. The Penman PET coefficients show considerable variability and again are not of the same magnitude as the ET rates. Crop coefficients greater than two were obtained during the second cutting.

Some of the differences between the seasonal water-production functions of alfalfa and among the cuttings between years could be the result of changes in WUE of the crop as a result of differences in carbohydrate partitioning and root proliferation. Alfalfa is a perennial crop and in 1981 was becoming established.

Table 21. Average daily evapotranspiration of new alfalfa interpolated to similar yield levels at selected intervals within each cutting, 1981.

Yield	Seasonal ET	First Cutting				Second Cutting			Third Cutting			Fourth Cutting		
		GDD/Period												
		200	200	206	105	196	196	226	197	202	188	205	199	189
t/ha*		Daily ET cm/day												
1.00	44.4	.17	.20	.04	.04	.22	.34	.71	.34	.24	.19	.22	.22	.23
4.00	62.1	.22	.25	.38	.38	.48	.21	.68	.30	.25	.17	.24	.31	.18
6.00	79.4	.22	.40	.43	.43	.51	.88	.79	.46	.34	.37	.32	.30	.30
10.00	102.0	.28	.54	.61	.61	.79	1.12	.76	.65	.47	.48	.41	.42	.37
12.00	120.0	.38	.71	.90	.90	.56	1.06	.54	.61	.43	.46	.50	.53	.48
13.00	119.0	.29	.64	.61	.61	.98	1.17	.97	.84	.64	.49	.50	.44	.48
14.00	124.0	.29	.52	.79	.79	.96	1.30	.67	.99	.68	.55	.47	.60	.51
15.00	130.5	.31	.69	.75	.75	1.05	1.36	.73	1.02	.80	.59	.46	.55	.50
16.00	140.4	.33	.77	.72	.72	1.07	1.44	.74	1.00	.81	.66	.61	.69	.61
17.00	144.8	.38	.74	1.03	1.03	.74	1.52	.88	.92	.57	.48	.46	.61	.56
19.00	159.4	.38	.74	1.16	1.16	1.09	1.68	.68	1.13	.77	.67	.46	.79	.61
		GDD Accumulated/Cutting												
		201	401	607	711	196	392	618	197	399	588	205	404	593
		GDD Accumulated/Season												
		200	401	607	711	907	1103	1329	1527	1729	1917	2122	2321	2510

* Adjusted to 0 percent moisture.

Table 22. A comparison of alfalfa crop coefficients as calculated by various PET methods, with respect to their ability to account for differences between seasons in the parameters of the seasonal water-production functions of 1981 and 1982.

Reduced Model#	ET	ET/ Penman	ET/Jensen-Haise	ET/Priestly-Taylor	ET/ Pan	ET/ VPD
	Value of F					
Common Intercept Common Slope (df = 2/31)	13.4*	35.1*	32.0*	29.5*	13.8*	39.4*
Common Intercept Different Slope (df = 1/31)	6.9*	6.9*	6.9*	6.9*	6.9*	6.9*
Different Intercept Common Slope (df = 1/31)	10.9*	14.9*	14.4*	14.0*	11.0*	13.6*

The null hypothesis for the pairwise comparison is that the full and reduced model of the statistical procedure have the characteristics listed in this column. The smaller the magnitude of the value of F, the more similar are the functions between years.

* The reduced model is significantly different from the full model at the 0.05 probability level.

Table 23. A comparison of alfalfa crop coefficients as calculated by various PET methods, with respect to their ability to account for differences within years among cuttings, in the parameters of the water-production functions, 1981 and 1982.

Reduced Model#	ET	ET/ Penman	ET/Jenson-Haise	ET/Priestly-Taylor	ET/ Pan	ET/ VPD
	Value of F					
Common Intercept						
Common Slope						
1981 (df = 6/120)	20.4*	148.2*	119.9*	149.1*	141.6*	87.2*
1982 (df = 6/91)	11.4*	36.5*	28.5*	35.7*	56.7*	27.2*
Common Intercept						
Different Slope						
1981 (df = 3/120)	15.6*	15.6*	15.6*	15.6*	15.6*	15.6*
1982 (df = 3/91)	4.35*	4.35*	4.35*	4.35*	4.35*	4.35*
Different Intercept						
Common Slope						
1981 (df = 3/120)	9.3*	11.3*	10.6*	13.6*	12.2*	5.7*
1982 (df = 3/91)	1.5	13.0*	11.5*	13.2*	15.1*	9.6*

The null hypothesis for the four-way comparison is that the full and reduced model of the statistical procedure have the characteristics listed in this column. The smaller the magnitude of the value of F, the more similar are the functions between years.

* The reduced model is significantly different from the full model at the 0.05 probability level.

Table 24. Average daily ET/PET of new alfalfa interpolated to similar yield levels at selected intervals within each cutting, 1981.

		GDD/Period												
	Seasonal	First Cutting				Second Cutting			Third Cutting			Fourth Cutting		
Yield	ET/PET	200	200	206	105	196	196	226	197	202	188	205	199	189
t/ha*		Daily ET/PET												
1.00	.37	.28	.30	.06	.05	.25	.48	1.01	.48	.39	.28	.44	.43	.59
4.00	.52	.36	.38	.60	.44	.54	.29	.97	.43	.40	.25	.48	.60	.46
6.00	.67	.36	.60	.68	.50	.58	1.24	1.12	.66	.55	.54	.65	.58	.77
10.00	.86	.46	.81	.96	.71	.90	1.57	1.08	.93	.75	.70	.83	.82	.95
12.00	1.01	.62	1.07	1.42	1.04	.64	1.49	.77	.88	.69	.67	1.01	1.03	1.23
13.00	.99	.47	.96	.96	.71	1.11	1.64	1.38	1.21	1.03	.71	1.01	.85	1.23
14.00	1.04	.47	.78	1.25	.91	1.09	1.83	.95	1.42	1.09	.80	.95	1.17	1.30
15.00	1.09	.50	1.04	1.18	.87	1.19	1.91	1.04	1.47	1.28	.86	.93	1.07	1.28
16.00	1.18	.54	1.16	1.14	.83	1.21	2.02	1.05	1.44	1.30	.96	1.23	1.33	1.56
17.00	1.21	.62	1.11	1.62	1.19	.84	2.13	1.25	1.32	.91	.76	.93	1.18	1.43
19.00	1.34	.62	1.11	1.83	1.34	1.24	2.36	.97	1.62	1.24	.98	.93	1.53	1.56
		GDD Accumulated/Cutting												
		200	401	607	711	196	392	618	197	399	588	205	404	593
		GDD Accumulated/Season												
		200	401	607	711	907	1103	1329	1527	1729	1917	2122	2321	2510

* Adjusted to 0 percent moisture.

Grain Corn

The water-production functions of the high-N SLS plot and the replicated various-N level SLS plot of 1982 are presented in Table 25. The high-N water-production function is plotted in Figure 13. The results of the replicated corn SLS plot, in which three levels of nitrogen were banded at right angles to the sprinkler line show considerable variability. Some of this variability can be attributed to the small areas available for harvest (Table 2), and the relatively small number of observations made within a band. The observations made have been plotted in Figure 14. The extremely high yields achieved in the high-N band of Block 1 are probably the result of leakage of water into this plot. On August 25, 1982, more than 2.5 cm of rain was collected in the rain gauge. This rain fell over a short period of time. The corn plots were located at the bottom of a slope and runoff from this thunderstorm flooded the subplots on the edge of the various-N level plot. The corn had been planted in furrows and it was thought at the time that the water had not penetrated the other furrows. However, the results suggest that the water had flooded into the high-N band of Block 1, which was the first band the runoff would have encountered. Dams within the furrows had been built every three meters to prevent irrigation water from running and these, no doubt, prevented the runoff from the thunderstorm from contaminating the other bands. This is the most likely explanation for the extremely high yields of this band without an associated increase in ET. The r^2 values

Table 25. The water-production functions* of corn, with grain yield in kg/ha as a function of seasonal evapotranspiration in cm, 1982.

N - Level	Linear Regression Coefficient	Intercept	r^2	n	Equation ID Letter	Significant Differences#
High	238.9	- 7309	.90	15	-	Not Compared
Various						
High - Block 1	499.5	-15491	.65	4	A	D
Medium - Block 1	160.4	- 3761	.93	4	B	D
Low - Block 1	131.0	- 1996	.58	4	C	D
High - Block 2	122.0	- 3800	.62	4	D	A,B,C,E
Medium - Block 2	214.2	- 6449	.89	4	E	D
Low - Block 2	20.5	1657	.02	4	F	none

* Regression equations were statistically compared in the form $Y = A(ET) + B$. Individual observations for each N-level are presented in Appendix D.

Equation in previous column is significantly different at the 0.05 probability level from the equations listed in this column. The null hypothesis for the pairwise comparison is that the full and reduced model of the statistical procedure have a common intercept and a common linear coefficient.

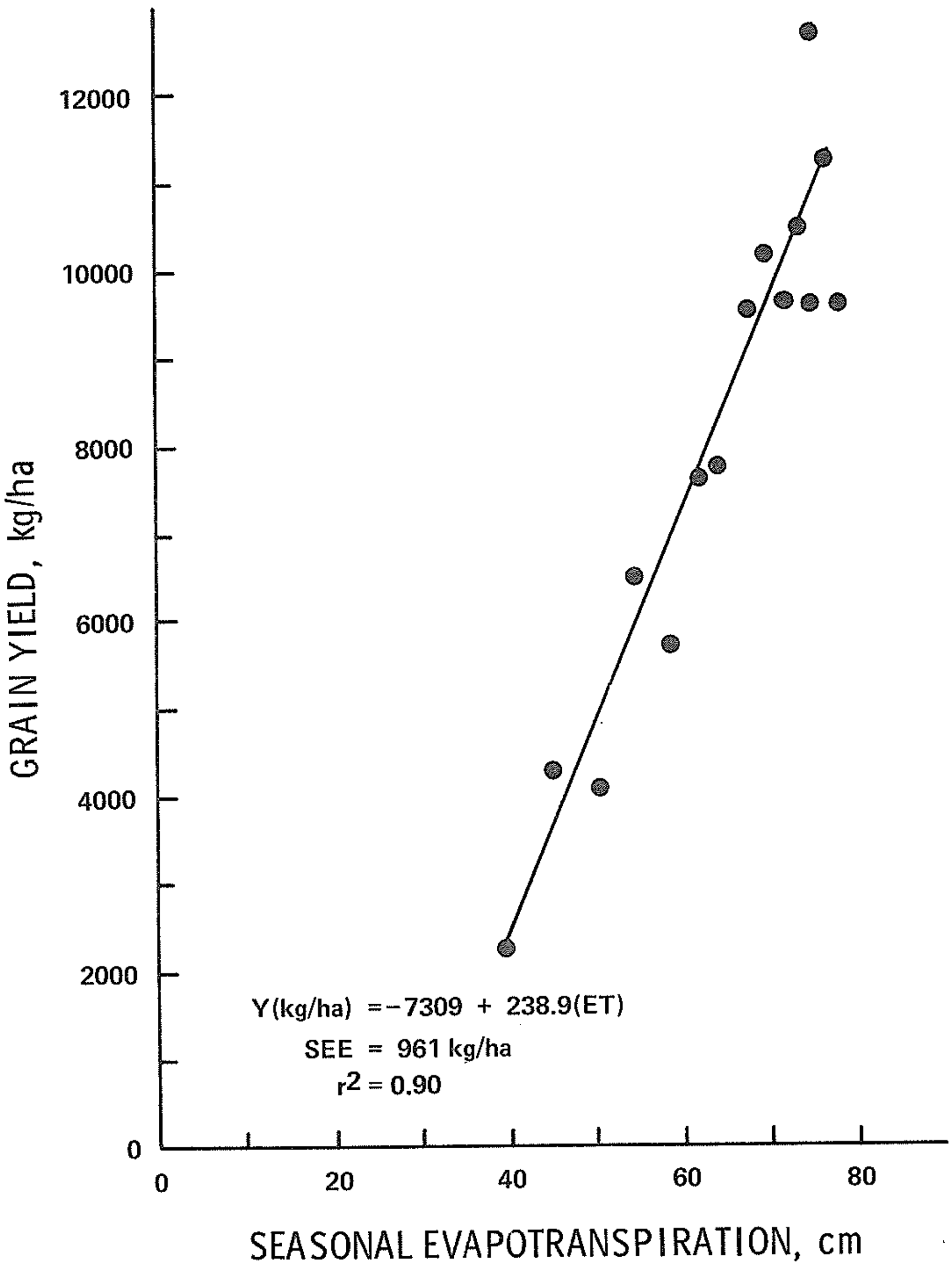

Figure 13. The water-production function of the high-N corn SLS plot, 1982.

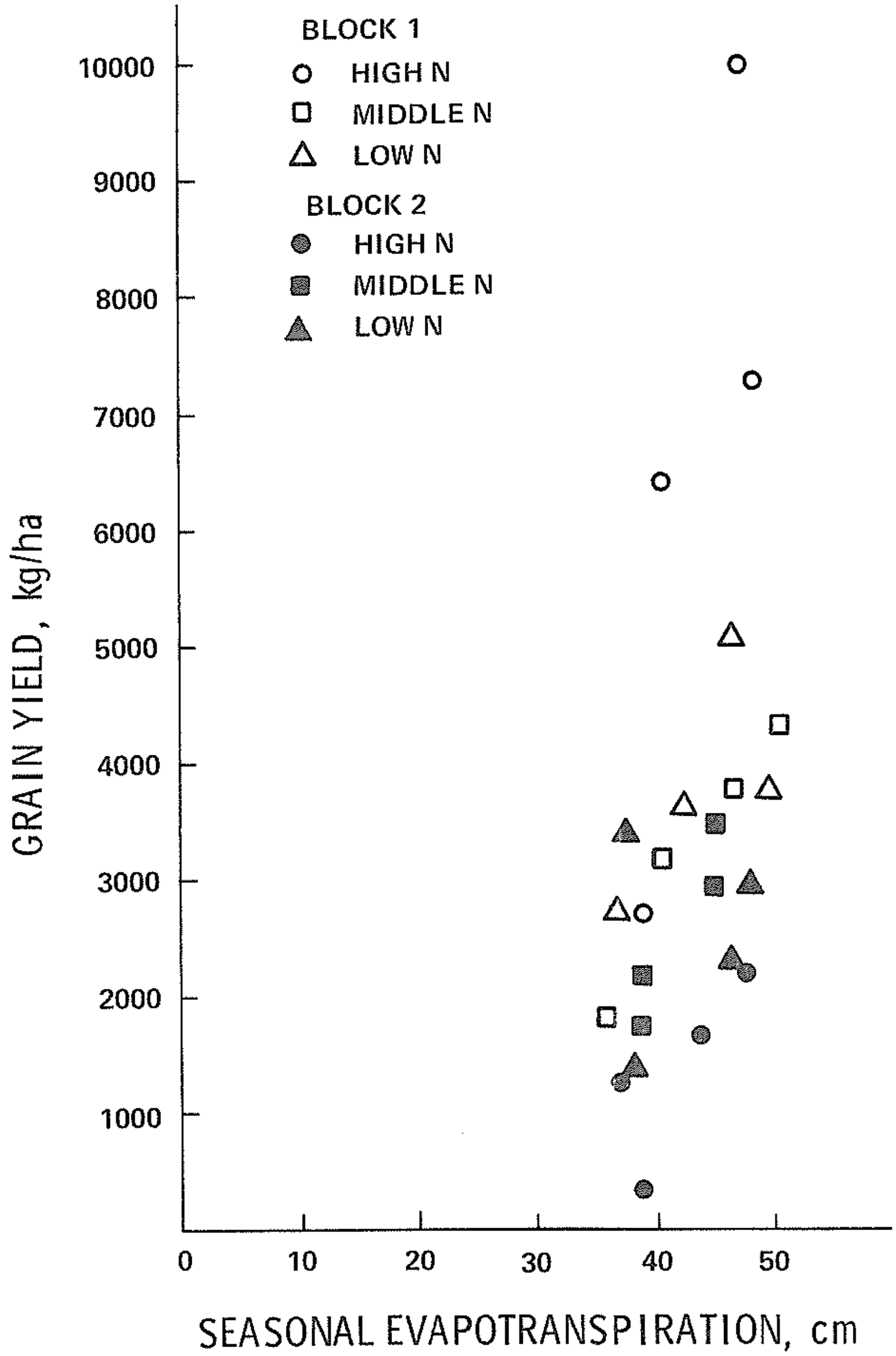

Figure 14. The plot of data points of grain yield versus seasonal ET of the corn SLS plot having various levels of N availability, 1982.

of these functions are generally low, and the only function significantly different from the others is the high-N band of Block 2. Corn growth in Block 2 was particularly poor and other factors, such as a nutrient deficiency, may have biased the results. Generally however, most of the points again are concentrated in the same area, suggesting that when irrigation frequency and initial soil moisture conditions are similar, the quantity of yield produced per quantity of water is the same, independent of the level of N fertility.

The regression equations of biomass yield versus seasonal evapotranspiration are presented in Table 26. The regression equation of biomass yield versus seasonal ET and the water-production function of the high-N SLS plot are plotted together in Figure 15. The x-intercepts of the two functions are similar, as was the case with the pinto beans (Kallsen et al., 11) and the spring barley (Kallsen et al., 12).

The results of the lysimeter corn data of 1980 are presented in Table 27. The quantity of grain corn produced per unit of ET in the lysimeters is much less than that produced in the high-N SLS plot of 1982.

Pinto Beans

The water-production functions of pinto beans are presented in Table 28. Although it was originally planned that the pinto bean data would assist in the determination of the effect of N on the water-production function, this objective had to be abandoned when nitrogen-fixing nodules were discovered on the bean roots. Thus, in 1980 and 1981,

Table 26. Regression equations* of corn biomass yield in kg/ha as a function of seasonal evapotranspiration in cm, 1982.

N - Level	Linear Regression Coefficient	Intercept	r^2	n
High	465.4	-11977	.88	15
Various				
High - Block 1	880.0	-23994	.83	4
Medium - Block 1	356.7	- 6344	.97	4
Low - Block 1	188.1	19	.36	4
High - Block 2	508.5	-12749	.97	4
Medium - Block 2	595.2	-14879	.93	4
Low - Block 2	88.7	3999	.34	4

* Individual observations for each N-level are presented in Appendix D.

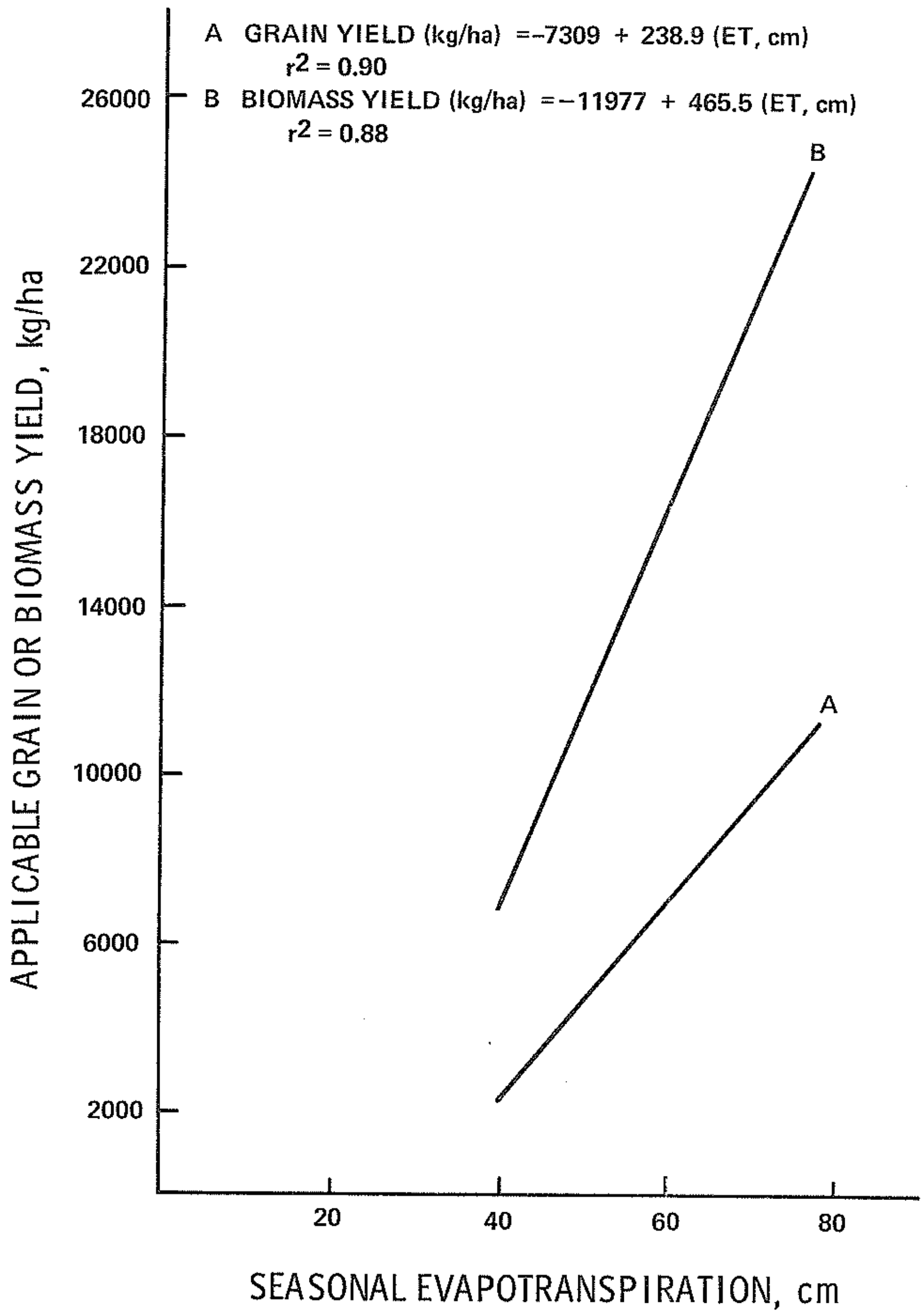

Figure 15. The relationship between the corn water-production function and the regression equation of biomass yield as a function of seasonal ET, of the high-N SLS plot, 1982.

Table 27. Average daily ET, ET/PET ratio, seasonal ET, yield, and GDD of the lysimeter-grown grain corn, 1980.

Lysimeter Number	Yield	Seasonal ET	May 14-31	June 1-15	June 16-30	July 1-16	July 17-31	August 1-16	August 17-31	September 1-15	September 16-30	October 1-17
	kg/ha	cm	Daily ET cm/day									
5	8534	78.5	.16	.32	.29	.75	.86	1.02	.81	.44	.36	.15
6	10395	100.5	.24	.44	.64	1.15	1.14	1.02	.92	.60	.39	.07
		Seasonal ET/PET*	Daily ET/PET									
5	8534	.68	.21	.35	.34	.88	1.00	1.29	1.27	.88	.55	.32
6	10395	.87	.31	.48	.75	1.35	1.32	1.29	1.44	1.20	.60	.15
			GDD									
		1572	125	151	174	194	193	207	148	139	123	118

* PET calculated by Penman method.

Table 28. The water-production functions* of seed yield in kg/ha of pinto beans as a function of evapotranspiration in cm, 1980 and 1981.#

Location[1/] and Plot Section No.	Quadratic Regression Coefficient	Linear Regression Coefficient	Intercept	r^2	Equation ID Letter	Significant Differences[2/]
			1980			
East - 1	0.0	56.2	- 572	.94	A	C,D,E,F,G,H,J,L
East - 2	0.0	51.7	- 396	.80	B	C,D,F,G,H,J,L
Central - 1	0.0	70.7	- 615	.89	C	A,B,E,I,J,K,L
Central - 2	0.0	64.1	- 416	.94	D	A,B,E,G,H,I,J,K,L
West - 1	0.0	49.2	- 183	.94	E	A,C,D,G,H,J,K,L
West - 2	0.0	58.8	- 364	.96	F	A,B,G,H,I,J,K,L
			1981			
East - 1	0.0	84.5	-1038	.94	G	A,B,D,E,F,J,K,L
East - 2	0.0	90.2	-1537	.87	H	A,B,D,E,F,G,J,K,L
Central - 1	1.0	0.0	323	.84	I	C,D,F,G,J,K,L
Central - 2	1.4	0.0	- 612	.95	J	all
West - 1	0.9	0.0	75	.95	K	C,D,E,F,G,H,I,J,L
West - 2	0.0	105.8	-2860	.98	L	all

* Regression equations were initially fit to the form $Y = A(ET)^2 + B(ET) + C$. See Text.

\# Actual data points are presented in Appendix E.

1/ Available N can be ascertained in Table 7; relative plot locations in Appendix K.

2/ Equation in previous column is significantly different at the 0.05 probability level from the equations listed in this column. The null hypothesis for the pairwise comparison is that the full and reduced model of the statistical procedure have a common intercept and common linear and quadratic coefficients. See text.

three SLS plots were established that, although differing in the level of applied N, demonstrated no N deficiency symptoms. As would be expected, maximum yields among the SLS plots within years did not vary substantially. Maximum yields in the SLS plots of 1981 were larger than those of 1980 because a much better stand of beans was achieved in 1981 as opposed to 1980. Although maximum yields were not very different within years among the SLS plots, the parameters of the water-production functions did demonstrate significant differences (Table 28). Usually, the two sections of the same SLS plot were not significantly different, but sections in different SLS plots generally were. This observation suggests again that it is the management of the sprinkler-line with respect to irrigation scheduling that results in at least part of these differences. The data points of 1980 and 1981 were combined within years and the resulting water-production functions plotted in Figure 16. The lysimeter data points of 1980 and 1981, presented in Table 29, were not included in the regression but are shown in relation to the water-production functions. Biomass data were collected in 1980 and the regression equations are shown in Table 30.

To determine if differences in the water-production functions could be explained by seasonal PET differences, they were compared by recalculating seed yield as a function of the appropriate crop coefficient. The results are presented in Table 31. While the F-statistics were slightly smaller using the crop coefficients rather than the ET, the differences were not substantial. For

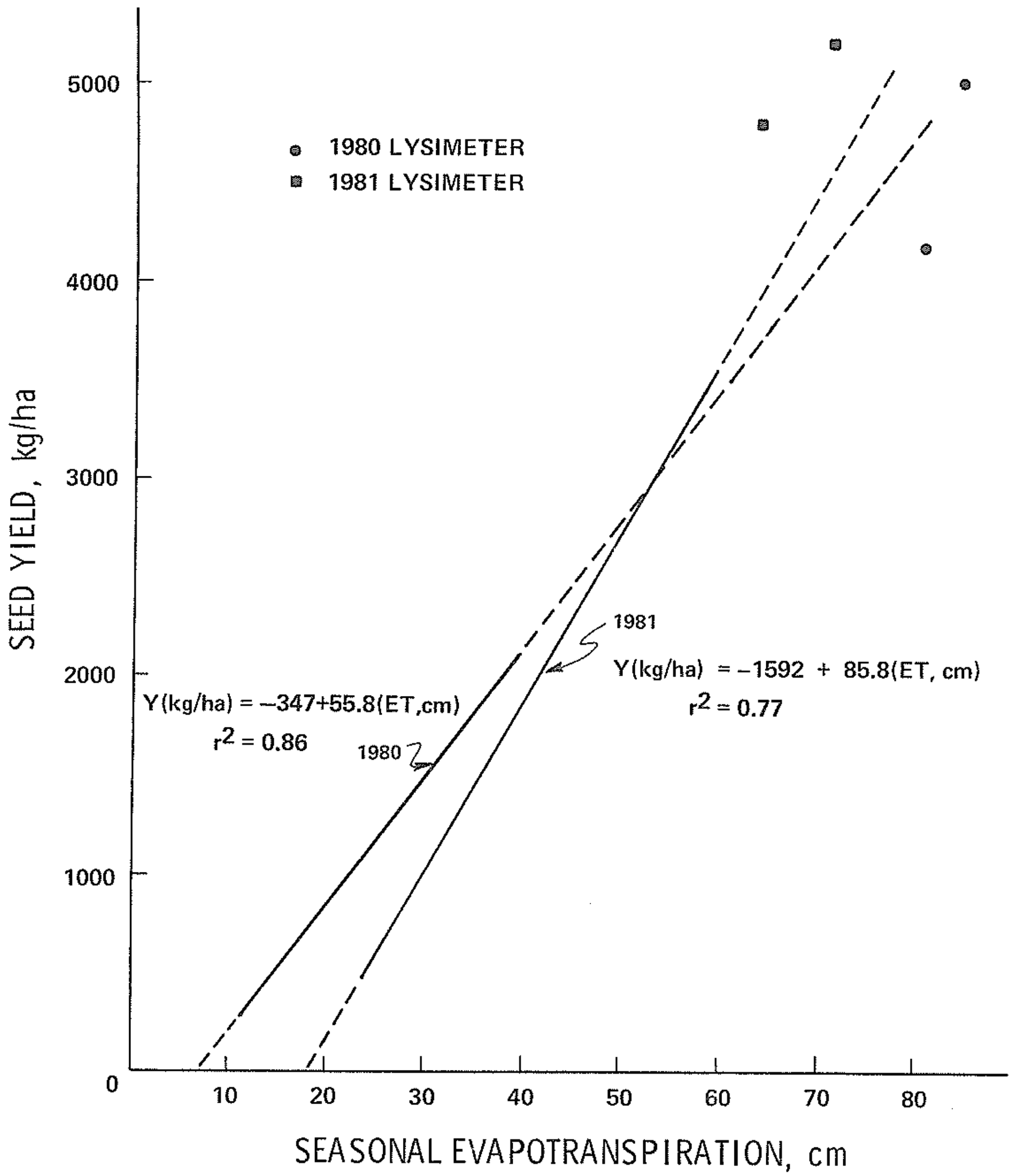

Figure 16. The water-production functions of pinto beans developed from all SLS plot data of 1980 and 1981.

Table 29. Yield, average daily, and seasonal ET and ET/PET of lysimeter-grown pinto beans at intervals of 200 GDD, 1980 and 1981.

Year and Lysimeter Number	Yield	Seasonal ET	GDD Accumulation 0-200	201-400	401-600	601-800	801-1000	1001-Final Probe Reading
	kg/ha	cm	Daily ET cm/day					
1980/1	4987	85.6	.33	.56	.74	1.14	1.02	.47
1980/2	4147	81.2	.31	.50	.71	1.14	1.01	.45
1981/1	5314	71.5	.20	.52	.97	1.16	1.01	.47
1981/2	4775	64.7	.23	.53	.90	1.03	.83	.33
		Seasonal ET/PET*	Daily ET/PET					
1980/1	4987	.88	.36	.65	.86	1.44	1.58	.60
1980/2	4147	.83	.34	.58	.83	1.44	1.57	.57
1981/1	5314	.96	.29	.64	1.39	1.60	1.56	.75
1981/2	4775	.88	.33	.65	1.29	1.42	1.28	.53
		Total Days	Days in Period					
1980		122	21	18	18	17	22	26
1981		106	27	17	17	15	18	12

* PET calculated by the Penman method.

Table 30. Regression equations* of biomass yield in kg/ha of pinto beans as a function of evapotranspiration in cm, 1980.#

Location 1/ and Plot Section No.	Linear Regression Coefficient	Intercept	r^2	Equation ID Letter	Significant Differences 2/
			1980		
East - 1	111.2	-410	.86	A	E
East - 2	135.1	-882	.87	B	E,F
Central - 1	125.9	-857	.89	C	E
Central - 2	110.7	-360	.88	D	none
West - 1	75.0	74	.84	E	A,B,C
West - 2	95.6	-231	.92	F	B

* Regression equations were initially fit to the form $Y = A(ET)^2 + B(ET) + C$, but the quadratic coefficient was not significant. See text.

Actual data points are presented in Appendix E.

1/ Available N at planting can be ascertained in Table 7, relative plot locations in Appendix K.

2/ Equation in previous column is significantly different at the 0.05 probability level from the equations listed in this column. The null hypothesis for the pairwise comparison is that the full and reduced model of the statistical procedure have a common intercept and common linear coefficients. See text.

Table 31. A comparison of pinto bean crop coefficients as calculated by various PET methods, with respect to their ability to account for seasonal differences in the parameters of the water production functions of 1980 and 1981. The yield versus ET or appropriate crop coefficient of all subplots have been combined for each season.

Reduced Model[#]	ET	ET/ Penman	ET/Jensen-Haise	ET/Priestly-Taylor	ET/ Pan	ET/ VPD
	Value of F					
Common Intercept Common Slope (df = 2/167)	21.9*	31.5*	18.5*	18.8*	18.4*	20.6*
Common Intercept Different Slope (df = 1/167)	36.9*	36.9*	36.9*	36.9*	36.9*	36.9*
Different Intercept Common Slope (df = 1/167)	24.1*	15.3*	27.7*	27.0*	27.9*	26.0*

The null hypothesis for the pairwise comparison is that the full and reduced model of the statistical comparison have the characteristics listed below. The smaller the magnitude of the value of F, the more similar are the functions between years.

* The reduced model is significantly different from the full model at the 0.05 probability level.

example, the water-production functions, with yield expressed as a function of ET, were significantly different with an F-value of 21.9 between years, and when expressed with yield as a function of ET/Jensen-Haise PET, were significantly different with an F-value of 18.5. For the functions to have been similar statistically, the F-value would have had to be less than 3.07.

Substantial differences existed between years in the intra-seasonal ET requirements necessary to produce a given level of yield (Table 32) and again the Penman PET calculations did little to account for the differences (Table 33).

<u>Potential Evapotranspiration</u>

Table 34 presents the coefficients of determinations of correlations among monthly accumulated potential ET as calculated by different methods. The coefficients of determinations are generally high, suggesting that the various methods would serve equally well as denominators of crop coefficients. This observation is supported by the results presented in Tables 17, 22, and 31. The results demonstrate that the PET methods perform similarly in accounting for differences in the water-production functions.

Table 32. Average daily and seasonal evapotranspiration of pinto beans at intervals of 200 growing-degree-days interpolated to common yield levels, 1980 and 1981.

Yield	Year	Seasonal ET	GDD Accumulation					
			0-200	201-400	401-600	601-800	801-1000	1001-1100
kg/ha		cm	ET/Day/Period					
500	1980	17.0	.07	.11	.16	.25	.19	.09
	1981	27.0	.18	.22	.45	.31	.24	.12
1000	1980	24.0	.12	.15	.22	.33	.26	.29
	1981	31.0	.18	.23	.44	.43	.35	.17
1500	1990	32.0	.16	.20	.30	.46	.30	.12
	1981	42.0	.19	.28	.56	.56	.61	.26
2000	1980	not available						
	1981	42.0	.19	.28	.56	.56	.61	.26
2500	1980	not available						
	1981	46.0	.20	.29	.64	.64	.57	.42
3000	1980	not available						
	1981	50.0	.24	.31	.65	.71	.67	.35
3500	1980	not available						
	1981	54.0	.27	.36	.74	.74	.69	.36
	Year	Total Days	Days in Period					
	1980	114	19	18	17	22	25	13
	1981	106	27	17	17	15	18	12

Table 33. Average daily and seasonal ET/PET of pinto beans at intervals of 200 growing-degree-days interpolated to common yield levels, 1980 and 1981.*

Yield	Year	Seasonal ET/PET	GDD Accumulation 0-200	201-400	401-600	601-800	801-1000	1001-1100
kg/ha			ET/PET/Day/Period					
500	1980	.23	.08	.12	.20	.38	.34	.16
	1981	.33	.26	.27	.64	.43	.37	.19
1000	1980	.32	.14	.17	.27	.50	.47	.16
	1981	.38	.26	.28	.63	.59	.54	.27
1500	1980	.43	.19	.22	.37	.69	.54	.22
	1981		.27	.34	.80	.77	.94	.42
2000	1980	- not available - - - - - - - - -						
	1981	.52	.27	.34	.80	.77	.94	.42
2500	1980	- not available - - - - - - - - -						
	1981	.52	.29	.36	.91	.89	.88	.67
3000	1980	- not available - - - - - - - - -						
	1981	.61	.35	.38	.93	.98	1.04	.56
3500	1980	- not available - - - - - - - - -						
	1981	.66	.39	.44	1.06	1.02	1.07	.58
	Year	Total Days	Days in Period					
	1980	114	19	18	17	22	25	13
	1981	106	27	17	17	15	18	12

* PET calculated by a modified Penman method (Appendix A).

Table 34. Simple correlation of monthly PET among different methods of calculating PET, 1980, 1981, and 1982.

Method	Jensen-Haise	Priestly-Taylor	Pan	VPD
	r^2			
	April 1, 1980, to October 24, 1980			
Penman*	.94	.97	.97	.74
Jensen-Haise	-	.96	.88	.91
Priestly-Taylor	-	-	.95	.77
Pan	-	-	-	.67
	April 1, 1981, to October 14, 1981			
Penman	.89	.98	.91	.89
Jensen-Haise	-	.96	.96	.97
Priestly-Taylor	-	-	.96	.93
Pan	-	-	-	.90
	April 5, 1982, to October 15, 1982			
Penman	.97	.99	.91	.89
Jensen-Haise	-	.97	.78	.96
Priestly-Taylor	-	-	.68	.88
Pan	-	-	-	.68

* See Appendix A for methods of calculating PET.

LIST OF ABBREVIATIONS

E	evaporation
ET	evapotranspiration
GDD	growing-degree-days
LAI	leaf-area-index
N	nitrogen
PET	potential evapotranspiration
T	transpiration
SD	standard deviation
SLS	sprinkler-line-source
SEE	standard error of the estimate
WUE	water-use efficiency
Y	yield

DEFINITION OF TERMS

access tube - A metal tube, usually aluminum, placed in the ground for the purpose of providing access to the rhizosphere for neutron probe measurement.

advection - Horizontal transfer of heat energy by large-scale motions of the atmosphere.

biomass - Refers to the above ground portion of the plant. Used interchangeably with dry matter in this report.

crop coefficient - The ratio of evapotranspiration, occurring with a specific crop at a specific stage of growth, to potential evapotranspiration occurring at that time.

economic yield - The portion of the crop normally harvested for sale.

evapotranspiration - The quantity of water transpired by plants, retained in plant tissue, and evaporated from adjacent soil surfaces in a specified time period.

harvest efficiency - The weight of the economic yield harvested as compared to the weight of the economic yield produced in the field.

leaf-area-index - The ratio of the total live leaf lamina surface area (based on the measurement of one side of each leaf measured only) compared to a unit area of soil surface.

potential evapotranspiration - The rate of evapotranspiration from an extended surface of a short green crop actively growing, completely shading the ground and growing with nonlimiting soil moisture conditions.

neutron probe - An instrument, based upon the principle of neutron moderation for determination of soil-moisture content.

water-production function - The relationship between economic yield and the seasonal evapotranspiration of a crop.

water-use efficiency - The weight of economic yield produced to the depth of water which evapotranspired.

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APPENDIX A

Equations describing the computation of potential evapotranspiration evaluated in the investigation.

APPENDIX A

Equations describing the computation of potential evapotranspiration used in the text are as follows:

Method 1 - Penman

$$E_o = \frac{\Delta Rn + \gamma Ea}{\Delta + \gamma} \tag{1}$$

$$Ea = 15.36\ (1.0 + 0.0062U_2)\ (e_s - e) \tag{2}$$

where

E_o is potential evaporation (cm/day)

Ea is an aerodynamic component

Δ is slope of the saturation vapor pressure versus temperature curve at the air temperature (mb $^oC^{-1}$)

Rn is net radiation, expressed (ly day $^{-1}$) or (cal cm^{-2} day^{-1}); ly = cal cm^{-2}. To convert Rn from cal cm^{-2} day^{-1} to cm day^{-1}, Rn is divided by L.

L is latent heat of vaporization (cal g^{-1})

U_2 is wind speed (km/day) at a height of 2 m

e_s is saturation vapor pressure (mb)

e is actual vapor pressure (mb)

γ is a psychrometric constant (mb $^oC^{-1}$)

$$\gamma = \frac{C_p P}{0.622L} \tag{3}$$

where

C_p is specific heat of air (cal g^{-1} $^oC^{-1}$)

P is atmospheric pressure (mb).

Method of Calculating Vapor Pressure Deficit (VPD)

Assumptions:

Minimum relative humidity occurs at the maximum daily temperature, and this is when the minimum daily vapor pressure occurs.

Maximum relative humidity occurs at the minimum daily temperature, and this is when the maximum daily vapor pressure occurs.

Saturated daily vapor pressure is calculated at the mean of the daily high and low temperatures.

Actual daily vapor pressure is calculated as the average of the minimum and maximum daily vapor pressures.

The daily vapor pressure deficit is calculated as the daily saturated vapor pressure minus the actual daily vapor pressure.

Method 2 - Jensen-Haise

$$E_o = C_T \; (T - Tx) \; Rn \quad (4)$$

$$C_T = \frac{1}{C_1 + C_2 \cdot CH} \quad (5)$$

$$CH = \frac{50 \text{ mb}}{(e_2 - e_1)} \quad (6)$$

where e_2 and e_1 are saturation vapor pressure at mean maximum and mean minimum temperatures, respectively, for the warmest month of the year in the area.

$$C_2 = 13^{o}F \text{ or } 7.6^{o}C$$

$$C_1 = 68^{o}F - (3.6^{o}F \times \text{elev. in ft}/1000) \quad (7)$$

$$C_1 = 38 - (2^{o}C \times \text{elev. in m}/305) \quad (8)$$

$$Tx = 27.5^{o}F - (0.25\ (e_2 - e_1) - \text{elev. in ft}/1000 \quad (9)$$

$$Tx = 2.5^{o}F - (0.14\ (e_2 - e_1) - \text{elev. in m}/550 \quad (10)$$

T is average air temperature.

Method 3 - Priestly-Taylor

$$E_o = \alpha\left(\frac{\Delta}{\Delta + \gamma}\right) . Rn \quad (11)$$

where

Rn is net radiation expressed (cm/day)

α is a proportionality constant equal to 1.40 ± 0.10

Δ and γ are defined as in Equation 1.

Method 4 - Pan

$$E_o = Pan$$

Pan is evaporation in cm/day measured from a U.S. Weather Bureau Class A Pan.

Method 5 - Blaney-Criddle

$$u = kf \text{ or } U = (KF) \tag{12}$$

where

u = monthly consumptive-use, inches depth

$f = \frac{t \times p}{100}$ = monthly consumptive-use factor

k = empirical consumptive-use crop coefficient for the month

p = monthly percentage of annual daytime hours

U = consumptive-use, in inches, for the season or period

K = empirical consumptive-use crop coefficient for the season or period

F = sum of monthly consumptive-use factors for the season or period $(\Sigma \frac{t \times p}{100})$

t = mean monthly temperature in degrees Fahrenheit.

APPENDIX B

Alfalfa ET versus yield observations, by

cutting and seasonal accumulation,

1981 and 1982.

Table B1. Evapotranspiration and yield of the first cutting of alfalfa, 1981.

Distance from the line	Yield kg/ha	SD	ET
m			cm
	Section 1 #		
12.8	929	387	9.3
11.9	1557	328	15.3
11.0	3414	369	21.2
10.1	3701	505	27.0
9.1	4671	163	32.8
8.2	4752	429	34.8
7.3	4138	348	36.7
7.1*	5613	---	50.7
6.4	4807	480	38.3
5.5	4971	387	39.9
4.6	5217	23	41.6
3.8*	6744	---	54.9
3.7	5244	226	43.3
2.7	5053	404	43.0
1.8	4780	263	42.7
0.9	5982	997	44.5
0.5*	6924	---	60.1
0.0	6009	400	46.2
	Section 2 #		
12.8	2240	237	20.3
11.9	3141	95	24.6
11.0	3250	263	28.8
10.1	3851	426	32.1
9.1	4479	95	35.3
8.2	4944	250	34.8
7.3	4889	533	34.2
6.4	4998	434	38.3
5.5	4998	410	42.5
4.6	5189	331	41.8
3.7	5490	498	41.1
2.7	5326	217	42.3
1.8	5517	657	43.4
0.9	5763	189	44.8
0.0	6009	400	46.2

Section 1 and Section 2 designate east and west sides of the plot, respectively.

* Lysimeters 1, 2, and 3, respectively.

Table B2. Evapotranspiration and yield of the second cutting of alfalfa, 1981.

Distance from the line	Yield kg/ha	Yield SD	ET
m			cm
	Section 1 #		
12.8	191	95	16.4
11.9	328	82	19.8
11.0	983	217	23.2
10.1	1502	171	26.5
9.1	2376	375	29.8
8.2	3605	1002	33.8
7.3	3715	620	37.9
7.1*	1704	----	28.7
6.4	4725	520	37.3
5.5	4288	581	36.8
4.6	4506	498	36.5
3.8*	4138	----	41.9
3.7	4403	990	36.3
2.7	4179	246	35.6
1.8	4015	295	35.0
0.9	4178	469	37.8
0.5*	4646	----	40.5
0.0	3851	394	40.5
	Section 2 #		
12.8	1284	237	22.9
11.9	1584	189	26.7
11.0	1939	171	30.6
10.1	1748	494	32.5
9.1	1830	263	34.3
8.2	3086	884	34.5
7.3	3960	824	34.7
6.4	4615	331	36.7
5.5	4452	404	38.7
4.6	4370	331	39.4
3.7	3906	420	40.1
2.7	4343	357	37.8
1.8	3988	546	35.5
0.9	3851	394	38.0
0.0	3851	394	40.5

Sections 1 and 2 designate east and west sides of the plot, respectively.

* Lysimeters 1, 2, and 3, respectively.

Table B3. Evapotranspiration and yield of the third cutting of alfalfa, 1981.

Distance from the line	Yield kg/ha	Yield SD	ET
m			cm
	Section 1 #		
12.8	66	28	8.2
11.9	492	217	11.1
11.0	1093	125	13.9
10.1	1693	47	16.3
9.1	1775	206	18.7
8.2	2294	75	20.5
7.3	2950	156	22.2
7.1*	2499	---	17.4
6.4	3387	47	25.3
5.5	3250	206	28.3
4.6	3387	70	30.1
3.8*	3319	---	22.4
3.7	3359	75	32.0
2.7	3523	142	30.8
1.8	3359	426	29.6
0.9	3441	475	29.6
0.5*	4392	---	29.8
0.0	3523	220	29.7
	Section 2 #		
12.8	137	47	7.9
11.9	137	47	10.1
11.0	710	47	12.4
10.1	1639	700	15.1
9.1	1939	341	17.9
8.2	2321	501	19.7
7.3	3031	886	21.5
6.4	3114	456	22.1
5.5	3633	206	22.7
4.6	4042	331	22.8
3.7	3878	171	22.9
2.7	4015	82	28.1
1.8	3469	47	33.4
0.9	3947	430	31.5
0.0	3523	220	29.7

Section 1 and Section 2 designate east and west sides of the plot, respectively.

* Lysimeters 1, 2, and 3, respectively.

Table B4. Evapotranspiration and yield of the fourth cutting of alfalfa, 1981.

Distance from the line	Yield kg/ha	SD	ET
m			cm
	Section 1 #		
12.8	36	19	10.5
11.9	164	142	13.2
11.0	669	144	15.8
10.1	1065	142	18.0
9.1	1311	217	20.2
8.2	1855	93	21.2
7.3	2294	17	22.3
7.1*	2393	---	23.1
6.4	2294	246	22.6
5.5	2567	206	22.9
4.6	2759	261	24.1
3.8*	3171	---	25.6
3.7	2540	17	25.3
2.7	2622	217	27.2
1.8	2404	125	29.1
0.9	2950	150	31.7
0.5*	3351	---	29.0
0.0	2759	180	34.3
	Section 2 #		
12.8	191	95	11.2
11.9	246	142	12.1
11.0	437	263	13.0
10.1	628	451	14.7
9.1	1038	331	16.5
8.2	1721	537	18.8
7.3	2185	576	21.0
6.4	2485	387	21.9
5.5	2731	171	22.8
4.6	3114	142	24.6
3.7	2977	95	26.5
2.7	3059	171	27.1
1.8	3141	125	27.8
0.9	2950	141	31.0
0.0	2759	180	34.3

Section 1 and Section 2 designate east and west sides of the plot, respectively.

* Lysimeters 1, 2, and 3, respectively.

Table B5. Accumulated seasonal evapotranspiration and yield of alfalfa, 1981.

Distance from the line	Seasonal Yield	Seasonal ET
m	kg/ha	cm
	Section 1 #	
12.8	1221	44.4
11.9	2540	59.4
11.0	6159	74.0
10.1	7962	87.8
9.1	10133	101.5
8.2	12537	110.3
7.3	13097	119.0
7.1*	12209	120.0
6.4	15213	123.5
5.5	15077	127.9
4.6	15869	132.3
3.8*	17371	144.8
3.7	15547	136.8
2.7	15377	136.6
1.8	14558	136.5
0.9	16552	143.6
0.5*	19313	159.4
0.0	16142	150.6
	Section 2 #	
12.8	3851	62.1
11.9	5108	73.5
11.0	6337	84.8
10.1	7866	94.4
9.1	9286	104.0
8.2	12072	107.8
7.3	14066	111.4
6.4	15213	119.0
5.5	15814	126.7
4.6	16716	128.6
3.7	16251	130.6
2.7	16743	135.3
1.8	16115	140.0
0.9	16511	145.3
0.0	16142	150.6

Section 1 and Section 2 designate east and west sides of the plot, respectively.

* Lysimeters 1, 2, and 3, respectively.

Table B6. Evapotranspiration and yield of the first[#] cutting of alfalfa, 1982.

Distance from the line	Yield	ET
m	kg/ha	cm
7.1*	3640	35.2
3.8*	7460	47.7
0.5*	8537	50.0

Yield and ET data from the nonlysimeter portions of the plot were invalidated because of leakage of unmeasured water into subplots.

* Lysimeters 1, 2, and 3, respectively.

Table B7. Evapotranspiration and yield of the second cutting of alfalfa, 1982.

Distance from the line	Yield kg/ha	SD	ET
m			cm
	Section 1 #		
12.8	772	650	15.9
11.9	1683	1041	22.9
11.0	2541	1026	61.9
10.1	2721	1279	28.8
9.1	2821	1234	27.7
8.2	4039	554	31.2
7.3	4901	343	35.1
7.1*	1261	----	20.4
6.4	5235	252	33.7
5.5	5435	965	32.3
4.6	5673	23	31.1
3.8*	3513	----	27.6
3.7	5697	934	29.9
2.7	5573	57	35.2
1.8	5698	708	40.4
0.9	6751	497	40.1
0.5*	5167	----	40.8
0.0	5293	243	39.7
	Section 2 #		
12.8	896	241	16.9
11.9	1190	223	20.5
11.0	1520	395	24.2
10.1	2015	410	25.6
9.1	2683	600	26.9
8.2	3211	141	28.8
7.3	3803	474	30.7
6.4	4346	885	31.4
5.5	5077	566	32.2
4.6	5081	614	34.4
3.7	5304	141	36.5
2.7	6135	232	38.5
1.8	5830	357	40.4
0.9	5664	100	40.8
0.0	5293	243	39.7

Section 1 and Section 2 designate east and west sides of the plot, respectively.

* Lysimeters 1, 2, and 3, respectively.

Table B8. Evapotranspiration and yield of the third cutting of alfalfa, 1982.

Distance from the line	Yield kg/ha	Yield SD	ET
m			cm
	Section 1 #		
12.8	612	255	15.3
11.9	1366	263	18.6
11.0	2215	581	21.8
10.1	3965	449	24.7
9.1	2892	572	27.4
8.2	3406	3	27.2
7.3	3914	59	27.0
7.1*	2463	----	25.9
6.4	4153	121	28.8
5.5	3888	215	30.6
4.6	4343	512	32.8
3.8*	4651	----	28.4
3.7	4422	173	35.0
2.7	4003	301	29.9
1.8	3733	342	24.7
0.9	4468	543	27.6
0.5*	4444	----	30.1
0.0	3998	65	30.5
	Section 2 #		
12.8	546	145	14.2
11.9	1171	105	17.2
11.0	1698	91	20.0
10.1	2040	182	22.9
9.1	2617	342	25.8
8.2	3387	66	26.4
7.3	3447	148	26.9
6.4	3454	377	29.5
5.5	4136	302	32.2
4.6	3927	175	31.8
3.7	4069	9	31.4
2.7	4359	136	28.8
1.8	4077	443	26.2
0.9	4064	75	28.4
0.0	3998	65	30.5

Section 1 and Section 2 designate east and west sides of the plot, respectively.

* Lysimeters 1, 2, and 3, respectively.

Table B9. Evapotranspiration and yield of the fourth cutting of alfalfa, 1982.

Distance from the line	Yield kg/ha	Yield SD	ET
m			cm
	Section 1 #		
12.8	389	28	8.1
11.9	698	542	9.1
11.0	1729	---	10.1
10.1	1607	396	12.1
9.1	1488	243	14.1
8.2	2100	125	14.8
7.3	1915	---	15.5
7.1*	1040	---	13.0
6.4	2415	44	17.0
5.5	2556	81	18.4
4.6	2741	173	16.8
3.8*	2364	---	16.7
3.7	2795	43	15.2
2.7	2668	211	16.3
1.8	2436	145	17.3
0.9	2672	87	18.2
0.5*	2931	---	19.0
0.0	2595	196	19.2
	Section 2 #		
12.8	256	---	10.1
11.9	484	4	10.3
11.0	815	59	10.6
10.1	995	102	11.2
9.1	1351	265	11.9
8.2	1781	87	13.4
7.3	2022	59	14.9
6.4	2339	342	15.4
5.5	2614	124	16.0
4.6	1666	218	15.6
3.7	2586	65	15.2
2.7	2812	56	15.9
1.8	2534	43	16.6
0.9	2345	---	17.9
0.0	2595	196	19.2

Section 1 and Section 2 designate east and west sides of the plot, respectively.

* Lysimeters 1, 2, and 3, respectively.

Table B10. Accumulated seasonal# evapotranspiration and yield of alfalfa, 1982.

Distance from the line	Yield	ET
m	kg/ha	cm
7.1*	8404	94.4
3.8*	17988	120.4
0.5*	21079	140.0

First cutting yield and ET data from the nonlysimeter portions of the plot were invalidated because of leakage of unmeasured water into subplots. As a result, seasonal accumulation of data were possible only in the lysimeter.

* Lysimeters 1, 2, and 3, respectively.

APPENDIX C

Spring barley seasonal ET versus grain and
biomass yield observations,
1980, 1981, and 1982.

Table C1. Seasonal evapotranspiration and yield of spring barley having 30 kg/ha of nitrogen available at planting, 1980.

Subplot Distance from the Line	Seasonal ET	Yield Mean*	Yield SD
m	cm	kg/ha	
	Section 1		
12.8	14.5	220	145
11.0	18.8	295	74
10.1	20.6	244	76
8.2	25.6	444	132
7.3	28.3	619	201
5.5	31.9	773	157
3.7	32.4	837	79
2.7	35.1	1300	282
1.8	38.0	1213	237
	Section 2		
12.8	14.5	187	64
11.9	16.8	232	156
11.0	19.0	333	135
7.3	21.7	607	282
6.4	30.4	1090	519
5.5	31.9	1021	424
4.6	32.0	1291	262
3.7	32.1	1161	408
2.7	35.0	1581	407

* Average of three subsamples per subplot adjusted to 14 percent moisture.

Table C2. Seasonal evapotranspiration and yield of spring barley having 125 kg/ha of nitrogen available at planting, 1980.

Subplot Distance from the Line	Seasonal ET	Yield Mean*	Yield SD
m	cm	kg/ha	
	Section 1		
11.9	19.0	217	8
11.0	22.8	253	78
10.1	23.5	329	41
9.1	24.2	619	74
8.2	28.0	1009	122
6.4	34.2	1527	40
5.5	36.8	2004	8
4.6	39.0	2144	220
3.7	41.9	2822	147
0.9	44.2	3531	491
0.0	48.3	4200	373
	Section 2		
12.8	15.8	170	37
11.0	19.7	364	124
10.1	23.2	399	219
9.1	26.5	631	68
8.2	30.0	870	169
7.3	33.4	1165	149
6.4	36.5	1574	252
5.5	39.9	1652	201
4.6	40.4	2539	339
2.7	42.2	3257	340
1.8	43.5	3210	78
0.0	48.3	4200	373

* Average of three subsamples per subplot adjusted to 14 percent moisture

Table C3. Seasonal evapotranspiration and yield of spring barley having 225 kg/ha of nitrogen available at planting, 1980.

Subplot Distance from the Line	Seasonal ET	Yield Mean*	Yield SD
m	cm	kg/ha	
12.8	16.8	352	178
11.9	19.4	324	74
11.0	22.2	534	166
9.1	29.9	799	115
8.2	33.4	1106	135
6.4	40.6	2082	71
5.5	43.9	2855	261
3.7	50.9	3912	231
2.7	54.0	4838	447
0.9	59.4	6498	421
0.0	61.5	7176	160
	Section 2		
11.9	22.6	581	194
11.0	25.1	645	74
10.0	28.0	799	108
9.1	30.9	1000	239
8.2	33.1	1617	239
6.4	39.1	2314	152
5.5	42.9	2688	520
4.6	48.2	3922	145
2.7	55.3	4401	297
1.8	57.2	5051	491
0.0	61.5	7176	160

* Average of three subsamples per subplot adjusted to 14 percent moisture.

Table C4. Seasonal evapotranspiration, grain and biomass yield of spring barley having 45 kg/ha of nitrogen available at planting, 1981.

Subplot Distance from the Line	Seasonal ET	Grain Yield* Mean	Grain Yield* SD	Biomass # Mean	Biomass # SD
m	cm	kg/ha		kg/ha	
		Section 1			
14.0	13.3	250	39	1031	566
13.0	13.5	136	68	429	202
12.0	13.7	113	39	573	----
11.0	16.2	204	68	587	20
10.0	20.0	273	118	1303	182
9.0	23.7	568	219	1432	0
8.0	27.3	886	68	2004	405
7.0	29.7	1090	0	2863	405
6.0	32.0	1545	172	3436	810
5.0	34.7	1227	491	3006	1012
4.0	37.4	2249	613	2863	2424
3.0	38.4	2453	594	3722	1215
2.0	39.5	2476	142	2004	2430
1.0	39.3	2226	454	4868	810
0.0	39.1	2431	464	5011	607
		Section 2			
14.0	15.7	136	118	716	202
13.0	19.6	704	350	1718	0
12.0	23.4	795	433	1718	0
11.0	25.3	909	284	2004	405
10.0	27.2	1090	236	2291	0
9.0	29.5	1431	297	2577	0
8.0	31.8	1318	239	2434	1417
7.0	31.5	1636	360	3865	607
6.0	31.2	1567	180	3150	405
5.0	32.8	1817	39	2720	607
4.0	34.5	2340	172	4009	405
3.0	35.6	2794	312	5297	202
2.0	37.4	2407	432	3865	202
0.0	39.1	2430	464	5011	607

* Average of three subsamples per subplot adjusted to 14 percent moisture.

\# Average of the two hand-harvested subsamples per subplot adjusted to 0 percent moisture.

Table C5. Seasonal evapotranspiration, grain and biomass yield of spring barley having 125 kg/ha of nitrogen available at planting, 1981.

Subplot Distance from the Line	Seasonal ET	Grain Yield* Mean	Grain Yield* SD	Biomass # Mean	Biomass # SD
m	cm	kg/ha		kg/ha	
		Section 1			
14.0	16.3	1022	297	2577	405
13.0	18.6	522	172	1718	405
12.0	20.9	909	142	3579	1012
11.0	24.0	1113	79	3006	607
10.0	27.1	1295	180	4152	203
9.0	29.9	2112	118	4724	1012
8.0	32.7	2249	312	5154	810
7.0	33.3	2975	208	6156	607
6.0	34.0	3225	416	6442	607
5.0	36.4	3657	454	6156	1012
4.0	38.9	3904	629	6013	1214
3.0	39.3	4201	307	7301	2632
		Section 2			
14.0	21.2	522	322	1575	607
13.0	22.8	1068	275	2863	810
12.0	24.3	1045	307	2577	405
11.0	24.9	954	272	1861	1012
10.0	25.5	1499	204	3293	1417
9.0	27.5	1454	315	3293	607
8.0	29.2	1569	184	2720	1012
7.0	32.0	1790	376	3722	1620
6.0	34.9	2771	611	5154	2429
5.0	35.5	2816	930	5583	2632
4.0	36.2	3657	343	5583	607

* Average of three subsamples per subplot adjusted to 14 percent moisture.

Average of the two hand-harvested subsamples per subplot adjusted to 0 percent moisture.

Table C6. Seasonal evapotranspiration, grain and biomass yield of spring barley having 300 kg/ha of nitrogen available at planting, 1981.

Subplot Distance from the Line	Seasonal ET	Grain Yield* Mean	Grain Yield* SD	Biomass# Mean	Biomass# SD
m	cm	kg/ha		kg/ha	
		Section 1			
14.0	15.4	1278	242	2148	203
13.0	17.2	1278	133	1861	203
12.0	19.0	1534	226	2004	----
11.0	22.9	1512	384	2434	203
10.0	26.7	2578	712	3865	1012
9.0	29.7	2535	616	4295	1215
8.0	32.7	3260	406	5583	607
7.0	36.6	4048	449	5011	607
6.0	40.4	4325	994	7731	0
5.0	44.4	5092	942	8304	1619
4.0	48.4	5709	580	9449	1214
3.0	49.3	6200	683	8447	2227
2.0	50.5	6008	258	10451	3036
1.0	53.9	6562	90	8017	0
0.0	57.3	6626	181	10594	2025
		Section 2			
14.0	22.0	1853	98	3150	810
13.0	25.5	2152	111	3436	0
12.0	28.9	2322	184	4295	405
11.0	30.6	2578	352	4724	1012
10.0	32.3	3132	224	4724	1012
9.0	33.6	3494	169	6013	405
8.0	34.9	3899	98	6442	1822
7.0	38.4	3664	258	7874	203
6.0	41.8	5411	256	8303	1214
5.0	45.0	5433	385	9306	607
4.0	48.2	6136	352	8590	2025
3.0	50.0	6029	471	9306	1417
2.0	51.7	6413	226	11167	2430
1.0	54.5	6926	493	10021	2430
0.0	57.3	6626	181	10594	2025

* Average of three subsamples per subplot adjusted to 14 percent moisture.

\# Average of the two hand-harvested subsamples per subplot adjust to 0 percent moisture.

Table C7. Seasonal evapotranspiration, grain yield and biomass yield, of spring barley in the high-N SLS plot, 1982.

Subplot Distance from the Line	Seasonal ET	Grain Yield*	Biomass Yield#
m	cm	kg/ha	kg/ha
12	24.7	1157	3675
10	28.1	1656	4057
8	28.1	2163	5280
6	36.9	2680	5809
4	35.6	3826	7520
2	40.6	3903	8199
0	46.7	4175	8595

* Grain yield adjusted to 14 percent moisture.

Biomass yield adjusted to 0 percent moisture.

Table C8. Partial seasonal evapotranspiration, grain and biomass yield of spring barley in the various-N SLS plot, 1982.

Subplot Distance from the Line	Seasonal ET	Grain Yield*	Biomass Yield#
m	cm	kg/ha	kg/ha
		Low-N	
12	13.2	623	2534
10	15.2	551	2188
8	18.6	880	2473
6	19.6	805	2739
4	20.6	495	1377
2	21.7	852	1909
0	18.1	1015	2343
		Middle-N	
12	14.2	472	3010
10	17.9	608	3069
8	19.1	897	3487
6	19.2	1158	4257
4	22.9	1349	4105
2	24.2	1535	4706
0	28.3	1535	4836
		High-N	
12	18.2	515	3444
10	15.1	578	2609
8	17.8	669	3108
6	23.0	1000	3952
4	20.3	1300	3946
2	25.0	1278	3849
0	28.0	1429	4942

* Grain yield adjusted to 14 percent moisture.

Nongrain biomass yield is adjusted to 0 percent moisture.

APPENDIX D

Corn seasonal ET versus grain and biomass
yield observations, 1982 (SLS plots).

Table D1. Seasonal evapotranspiration, grain yield, and biomass yield of corn in the high-N SLS plot, 1982.

Subplot Distance from Line	Seasonal ET	Grain Yield* kg/ha	Grain Yield* SD	Biomass Yield# kg/ha	Biomass Yield# SD
m	cm				
12.0	40.6	2259	538	8478	615
11.2	45.5	4246	1123	9315	583
10.4	50.4	4075	683	11179	1157
9.5	55.2	6453	1005	13942	1608
8.6	59.9	5716	507	13295	1389
7.8	62.4	7632	708	15287	782
6.9	64.9	7722	677	17617	884
6.0	67.5	9520	560	20432	424
5.2	70.0	10109	540	20128	443
4.3	71.8	9672	857	20204	1929
3.5	73.6	10394	712	22653	1849
2.6	74.2	9786	904	24835	244
1.7	74.8	12677	2137	28211	1380
0.9	76.4	11108	1327	22525	1442
0.0	77.9	9581	1013	21464	750

* Adjusted to 15.5 percent moisture.

\# Adjusted to 0 percent moisture.

Table D2. Seasonal evapotranspiration, grain yield, and biomass yield of grain corn in the various-N SLS plot, 1982.

Subplot Distance from Line	Seasonal ET	Grain Yield*	Biomass Yield#
m	cm	kg/ha	kg/ha
		Low-N	
Block 1			
13.8	37.0	2730	6952
10.4	42.7	3619	7619
6.9	47.8	5079	10921
0.0	49.5	3778	7873
Block 2			
13.8	37.5	3397	7873
10.4	38.7	1397	6921
6.9	46.3	2381	7492
0.0	48.0	2952	8825
		Middle-N	
Block 1			
13.8	36.6	1810	6857
10.4	40.9	3175	7810
6.9	46.6	3810	10762
0.0	51.8	4381	11937
Block 2			
13.8	39.1	1746	8825
10.4	39.0	2095	7937
6.9	44.8	2889	11206
0.0	45.1	3460	12508
		High-N	
Block 1			
13.8	39.2	2698	9683
10.4	41.0	6444	12730
6.9	49.0	7270	16921
0.0	47.8	10032	20444
Block 2			
13.8	37.0	1238	6286
10.4	39.0	318	6635
6.9	44.8	1651	10540
0.0	47.8	2151	11270

* Grain yield adjusted to 15.5 percent moisture.

Biomass yield adjusted to 0 percent moisture.

APPENDIX E

Pinto bean seasonal ET versus seed and biomass yield observations, 1980 and 1981.

Table E1. Seasonal evapotranspiration and yield of pinto beans grown in the east sprinkler-line-source plot, 1980.

Subplot Distance from the Line	Seasonal ET	Seed Yield Mean*	Seed Yield SD	Biomass Yield Mean#	Biomass Yield SD
m	cm	kg/ha		kg/ha	
		Section 1			
12.8	16.0	409	72	1362	336
11.9	18.2	392	120	1195	409
11.0	20.7	657	108	2033	278
10.1	21.9	618	159	2139	189
9.1	23.5	716	125	2401	493
8.2	24.8	703	54	2185	115
7.3	26.3	892	181	2559	322
6.4	28.8	1171	123	3781	244
5.5	31.3	1195	49	3376	383
4.6	33.9	1244	214	3181	402
3.7	36.7	1607	276	4403	394
2.7	37.8	1612	295	3882	217
1.8	38.9	1781	222	4092	157
0.9	38.9	1346	363	3021	772
		Section 2			
12.8	14.3	519	37	1340	12
11.9	17.0	453	91	1307	202
11.0	19.9	598	108	1768	105
10.1	20.6	563	135	1297	188
9.1	21.5	789	65	1785	77
8.2	22.5	602	144	2380	403
7.3	23.7	1088	208	2815	314
6.4	26.4	758	73	2374	626
5.5	29.1	1155	272	3661	426
4.6	32.1	1096	62	3336	426
3.7	35.7	1073	162	3063	171
2.7	36.0	1521	171	4167	93
1.8	36.5	1544	89	4224	435
0.9	37.4	1961	166	4480	720

* Average of three subplots adjusted to 15.5 percent moisture.

Average of three subplots with biomass yield adjusted to 0 percent moisture.

Table E2. Seasonal evapotranspiration and yield of pinto beans grown in the central sprinkler-line-source plot, 1980.

Subplot Distance from the Line	Seasonal ET	Seed Yield Mean*	Seed Yield SD	Biomass Yield Mean#	Biomass Yield SD
m	cm	kg/ha		kg/ha	
		Section 1			
12.8	15.9	494	87	1114	134
11.9	17.4	663	94	1323	135
11.0	19.2	785	40	1624	150
10.1	19.6	685	65	1484	246
9.1	22.9	1197	105	2399	231
8.2	23.6	825	102	1697	156
7.3	27.2	1516	233	2946	229
6.4	29.2	1177	353	2551	634
5.5	31.2	1748	86	3411	401
4.6	32.9	1620	172	3098	378
3.7	34.7	1502	187	2805	381
2.7	34.7	2071	268	3744	308
1.8	34.6	1906	60	3643	417
0.9	36.5	2034	325	3944	406
		Section 2			
12.8	11.4	329	64	957	244
11.9	13.2	539	125	1234	137
11.0	15.6	510	116	1126	208
10.1	17.4	766	135	1795	235
9.1	19.3	646	123	1492	136
8.2	20.2	1094	14	2252	301
7.3	21.8	673	238	1449	226
6.4	24.9	1319	72	2698	203
5.5	28.3	1433	219	2793	317
4.6	29.1	1351	315	2671	293
3.7	30.3	1525	139	3072	293
2.7	32.6	1659	160	3151	218
1.8	35.5	1962	187	4224	794
0.9	37.0	1927	262	3881	151

* Average of three subplots adjusted to 15.5 percent moisture.

Average of three subplots adjusted to 0 percent moisture.

Table E3. Seasonal evapotranspiration and yield of pinto beans grown in the west sprinkler-line-source plot, 1980.

Subplot Distance from the Line	Seasonal ET	Seed Yield Mean*	Seed Yield SD	Biomass Yield Mean#	Biomass Yield SD
m	cm	kg/ha		kg/ha	
		Section 1			
12.8	14.7	488	60	1057	134
11.9	15.7	624	96	1236	135
11.0	17.1	697	62	1317	88
10.1	19.4	854	71	1667	35
9.1	22.3	1020	95	1927	262
8.2	23.4	718	147	1390	286
7.3	24.9	1116	173	2134	216
6.4	29.0	1183	310	2421	216
5.5	31.7	1273	241	2460	411
4.6	33.5	1472	285	2730	377
3.7	35.6	1579	257	2803	332
2.7	35.1	1701	176	2998	216
1.8	34.9	1472	431	2761	411
0.9	36.2	1620	330	2128	548
		Section 2			
12.8	11.5	228	57	650	70
11.9	14.5	407	89	1033	213
11.0	14.5	494	94	1147	66
10.1	15.4	555	116	1327	328
9.1	16.5	653	107	1433	236
8.2	19.2	687	118	1462	329
7.3	22.4	870	177	1884	222
6.4	23.4	1098	155	2287	140
5.5	24.8	1088	64	2130	109
4.6	25.8	1320	284	2510	562
3.7	26.8	1181	195	2350	341
2.7	30.0	1555	191	3027	333
1.8	33.3	1413	245	2547	218
0.9	35.4	1689	125	2956	187

* Average of three subplots adjusted to 15.5 percent moisture.

\# Average of three subplots adjusted to 0 percent moisture.

Table E4. Seasonal evapotranspiration and yield of pinto beans grown in the east sprinkler-line-source plot, 1981.

Subplot Distance from the Line	Seasonal ET	Yield Mean*	Yield SD
m	cm	kg/ha	
	Section 1#		
11.9	23.9	760	201
11.1	26.4	1178	249
10.2	28.9	1266	267
9.4	31.4	1570	116
8.5	33.9	1621	266
7.7	34.6	2102	191
6.8	35.2	2254	44
6.0	38.4	2305	158
5.1	41.6	2583	474
4.3	44.0	2685	267
3.4	46.5	2837	244
2.6	47.1	3090	351
1.7	47.8	3330	209
0.9	52.0	3115	211
0.0	56.2	3419	395
	Section 2#		
11.9	29.3	1076	122
11.1	33.9	1444	114
10.2	38.4	1570	316
9.4	37.7	1760	258
8.5	37.0	1912	368
7.7	39.2	2267	420
6.8	41.3	1874	232
6.0	42.9	2406	316
5.1	44.6	3001	237
4.3	48.0	2809	384
3.4	51.4	2975	365
2.6	50.3	2913	267
1.7	49.1	3432	309
0.9	52.7	2887	431
0.0	56.2	3419	395

* Average of three subsamples per subplot adjusted to 15.5 percent moisture.

\# Section 1 and Section 2 designate east and west sides of the plot, respectively.

Table E5. Seasonal evapotranspiration and yield of pinto beans grown in the central sprinkler-line-source plot, 1981.

Subplot Distance from the Line	Seasonal ET	Yield Mean*	Yield SD
m	cm	kg/ha	
	Section 1#		
11.9	24.2	1165	44
11.1	26.7	1304	171
10.2	29.2	1228	406
9.4	30.2	836	201
8.5	31.1	1393	458
7.7	33.3	1355	19
6.8	35.5	1621	343
6.0	37.6	1520	331
5.1	39.7	1596	263
4.3	42.1	2102	761
3.4	44.5	2039	365
2.6	44.8	2127	821
1.7	45.1	2989	1049
0.9	47.4	2583	331
0.0	49.8	2989	175
	Section 2#		
11.9	26.6	342	58
11.1	28.1	507	219
10.2	29.6	737	167
9.4	30.9	709	133
8.5	32.1	709	244
7.7	34.0	962	488
6.8	36.0	1314	490
6.0	38.1	1393	539
5.1	40.2	1596	622
4.3	41.2	1418	614
3.4	42.2	2241	646
2.6	44.0	2267	742
1.7	45.8	1963	546
0.9	47.8	2609	488
0.0	49.8	2989	175

* Average of three subsamples per subplot adjusted to 15.5 percent moisture.

\# Section 1 and Section 2 designate east and west sides of the plot, respectively.

Table E6. Seasonal evapotranspiration and yield of pinto beans grown in the west sprinkler-line-source plot, 1981.

Subplot Distance from the Line	Seasonal ET	Yield Mean*	Yield SD
m	cm	kg/ha	
	Section 1#		
11.9	25.0	709	44
11.1	27.9	583	44
10.2	30.7	1038	116
9.4	33.8	988	131
8.5	36.9	1545	43
7.7	38.4	1140	131
6.8	39.9	1773	116
6.0	42.6	1596	76
5.1	45.3	1722	418
4.3	49.1	1912	305
3.4	52.9	2761	614
2.6	53.5	2545	611
1.7	54.1	2457	833
0.9	56.8	3128	735
0.0	59.5	3204	932
	Section 2#		
11.9	26.7	203	44
11.1	28.4	152	132
10.2	30.0	291	96
9.4	31.6	393	122
8.5	33.1	684	152
7.7	35.9	772	79
6.8	38.8	1178	38
6.0	41.8	1469	158
5.1	44.8	1849	244
4.3	47.0	1760	323
3.4	49.3	2545	559
2.6	51.2	2773	625
1.7	53.1	3026	556
0.9	56.3	3178	979
0.0	59.5	3204	932

* Average of three subsamples per subplot adjusted to 15.5 percent moisture.

\# Section 1 and Section 2 designate east and west sides of the plot, respectively.

APPENDIX F

Seasonal PET calculated by different
methods for the crops of 1980, 1981, and 1982.

Table F1. Seasonal PET calculated by different methods for the crops of 1980, 1981, and 1982.

Method	Units	Year	Crop							
						Alfalfa Cuttings				
			Corn 1/	Pinto Beans 2/	Spring Barley 1/	First 3/	Second	Third	Fourth	Seasonal Accumulation
Penman	mm	1980	-	814	841	-	-	-	-	-
		1981	-	747	686	465	273	233	221	1193
		1982	1193	-	759	428	411	312	207	1358
Jensen-Haise	mm	1980	-	890	889	-	-	-	-	-
		1981	-	920	746	488	351	296	254	1388
		1982	1332	-	791	424	455	380	230	1489
Priestly-Taylor	mm	1980	-	767	794	-	-	-	-	-
		1981	-	782	694	463	296	245	211	1216
		1982	1171	-	745	424	398	326	197	1344
Blaney-Criddle*	mm	1980	-	641	572	-	-	-	-	-
		1981	-	608	497	-	-	-	-	951
		1982	824	-	484	-	-	-	-	999
Pan	mm	1980	-	841	898	-	-	-	-	-
		1981	-	871	771	519	330	267	251	1368
		1982	1175	-	797	478	408	275	211	1372
VPD	mb	1980	-	1835	1555	-	-	-	-	-
		1981	-	1875	1243	767	549	478	496	2291
		1982	2509	-	1342	660	856	703	446	2665

1/ Calculated from planting date to the final probe reading.

2/ The 1980 table values refer only to the SLS plots and are calculated from the day after the initial irrigation to the day before the final probe reading.

3/ PET accumulations for first cut beginning April 1, 1981, and April 5, 1982.

* These values represent the F values only. They were not multiplied by the crop constant.

APPENDIX G

Potential evapotranspiration accumulated by month for the different methods, 1980, 1981, and 1982.

Table G1. Monthly potential evapotranspiration, 1980 and 1981.

Method	Year	April*	May	June	July	August	September	October*
		mm						
Penman	1980	173	216	269	267	223	173	105
	1981	185	199	241	220	194	153	48
	1982	149	213	291	278	229	177	76
Jensen-Haise	1980	137	202	284	302	247	180	93
	1981	176	195	289	289	248	178	51
	1982	136	223	307	326	278	198	67
Priestly-Taylor	1980	149	202	260	256	210	159	88
	1981	175	191	253	242	205	149	43
	1982	144	217	277	276	232	167	67
Pan	1980	196	234	270	292	236	173	99
	1981	193	214	290	273	223	178	104
	1982	186	223	305	254	201	182	91
VPD	1980	237	308	511	609	499	365	222
	1981	294	354	481	445	424	348	103
	1982	214	333	562	632	495	384	141

* Only partial PET accumulations presented; 1980 - October 1-19; 1981 - October 1-14; 1982 - April 5-30; 1982 - October 1-15.

APPENDIX H

The dates of irrigations and precipitations of the crops in selected SLS plots of 1980, 1981, and 1982.

Table H1. Dates of alfalfa irrigation and precipitation, 1981 and 1982.

Irrigation				Precipitation	
1981		1982		1981	1982
04/20	07/18	04/13	07/02	04/19	03/20
04/23	07/20	04/14	07/07	05/01	03/26
04/25	07/27	04/22	07/08	05/02	03/29
04/27	07/29	04/23	07/09	05/04	04/20
04/29	07/31	04/26	07/13	05/06	04/22
04/30	08/02	04/27	07/14	05/13	04/23
05/04	08/04	04/28	07/16	05/17	05/04
05/06	08/06	04/29	07/23	05/27	05/05
05/07	08/08	05/06	07/26	05/28	05/11
05/12	08/10	05/07	07/27	05/29	05/12
05/13	08/12	05/11	07/29	06/02	07/17
05/16	08/14	05/17	08/03	06/03	07/25
05/18	08/17	05/18	08/04	06/05	07/26
05/21	08/18	05/19	08/05	06/27	07/27
05/26	08/19	05/24	08/11	06/30	07/28
05/27	09/01	05/25	08/12	07/01	07/30
06/01	09/04	05/26	08/17	07/07	07/31
06/04	09/08	05/31	08/18	07/12	08/02
06/10	09/11	06/03	08/20	07/25	08/07
06/11	09/12	06/04	09/01	07/26	08/12
06/19	09/13	06/10	09/02	08/11	08/16
06/22	09/14	06/11	09/03	08/16	08/17
06/26	09/16	06/18	09/07	08/21	08/20
06/28	09/18	06/22	09/08	09/04	08/21
06/30	09/20	06/23	09/09	09/05	08/22
07/07	09/22	06/28	09/24	09/06	08/23
07/10	09/28	06/29	10/01	09/09	08/24
07/12	09/30			09/17	08/25
07/15	10/02			09/23	09/11
07/17	10/08			10/01	09/12
				10/02	09/13
				10/12	09/20
					09/28

Table H2. Dates of spring barley# irrigation and precipitation, 1980, 1981, 1982.

Irrigation			Precipitation		
1980*	1981*	1982*	1980	1981	1982
04/17	04/18	04/07	04/25	04/19	04/20
04/18	04/23	04/08	04/29	05/01	04/22
04/25	04/25	04/14	05/01	05/02	04/23
05/12	05/08	05/18	05/06	05/04	05/04
05/16	05/12	05/21	05/07	05/06	05/05
05/23	05/16	05/26	05/08	05/13	05/11
05/27	05/25	06/02	06/07	05/17	05/12
05/30	06/01	06/03		05/27	
05/31	06/04	06/04		05/28	
06/05	06/10	06/06		05/29	
06/06	06/11	06/08		06/02	
06/09	06/18	06/11		06/03	
06/11	06/19	06/18		06/05	
06/13	06/22	06/21		06/27	
06/16	06/26	06/23		06/30	
06/20		06/29		07/01	
06/23		07/07		07/07	
06/27				07/12	
07/03					
07/04					
07/10					
07/11					
07/16					
07/18					

These dates are applicable to the subplot under the SLS of the plot with the highest nitrogen application.

* The subplot was irrigated twice, once in the morning and once in the afternoon of 06/06, 06/20, and 06/27 of 1980; and 06/11 and 06/26 of 1981.

Table H3. Dates of pinto beans irrigation and precipitation, 1980 and 1981.

Irrigation		Precipitation	
1980	1981	1980	1981
06/19	05/18	06/07	05/17
06/23	05/25	07/31	05/27
06/27	06/09	08/06	05/28
06/30	06/18	08/14	05/29
07/03	06/19	08/18	06/02
07/04	06/22	08/22	06/03
07/10	06/29	08/23	06/05
07/11	07/10	08/24	06/27
07/18	07/12	09/05	06/30
07/25	07/14	09/08	07/01
08/02	07/20	09/09	07/07
08/05	07/29	09/10	07/12
08/14	07/30	10/12	07/16
08/28	07/31		07/24
09/04	08/01		07/25
09/18	08/02		07/26
09/29	08/04		08/10
	08/07		08/11
	08/10		08/21
	08/12		
	08/15		
	08/17		
	08/18		
	08/20		
	08/25		

Table H4. Dates of high-N corn irrigation and precipitation, 1982.

Irrigations	Precipitations
05/26	05/04
06/08	05/05
06/10	05/11
06/11	05/12
06/21	07/17
06/29	07/25
07/07	07/26
07/08	07/27
07/13	07/28
07/14	07/30
07/16	07/31
07/19	08/02
07/20	08/07
07/21	08/12
07/22	08/16
07/26	08/17
07/27	08/20
07/29	08/21
08/03	08/22
08/04	08/23
08/05	08/24
08/12	08/25
08/16	09/11
08/18	09/12
08/20	09/13
08/24	09/20
08/31	09/28
09/02	
09/08	
09/09	
09/17	
09/24	
09/28	
10/01	

APPENDIX I

Seasonal growing-degree-day accumulations

for the crops of 1980, 1981, and 1982.

Table II. Seasonal GDD accumulations for the crops of 1980, 1981, and 1982.

Crop	Year	Seasonal GDD Accumulation	Alfalfa Cuttings: First	Second	Third	Fourth
Pinto Beans[1/]	1980	1109				
	1981	1131				
Spring Barley[2/]	1980	1154				
	1981	1094				
	1982	1039				
Corn[2/]	1982	1516				
Alfalfa[3/]	1981	2510	711	618	588	593
	1982	2398	537	694	711	454

1/ The 1980 table values refer only to the SLS plots, and not the lysimeter, and are calculated from the day after the initial irrigation to the day before the final probe reading.

2/ Calculated from planting date to the final probe reading.

3/ GDD accumulations for first cutting beginning April 1, 1981, and April 5, 1982.

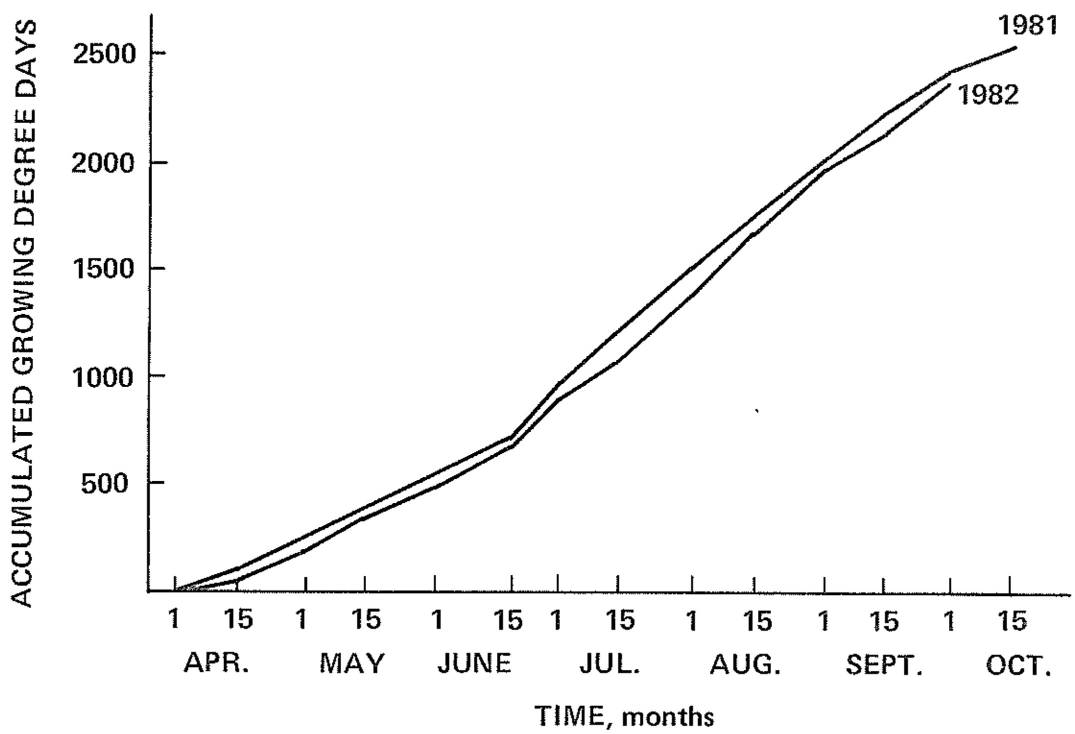


Figure I1. Seasonal GDD accumulation versus time during the growing season for alfalfa, 1981 and 1982.

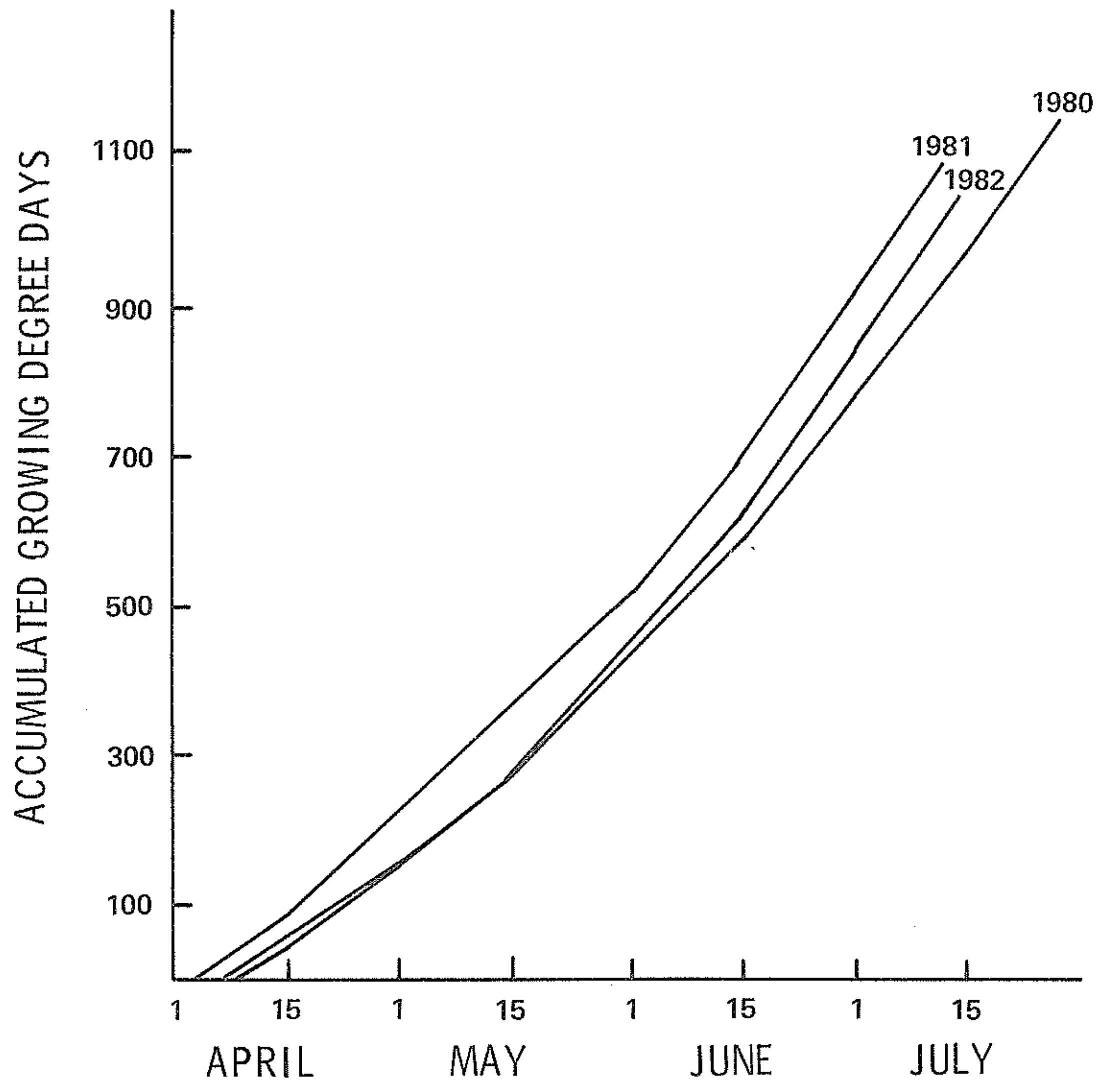


Figure I2. Seasonal GDD accumulation versus time during the growing season for spring barley, 1980, 1981, and 1982.

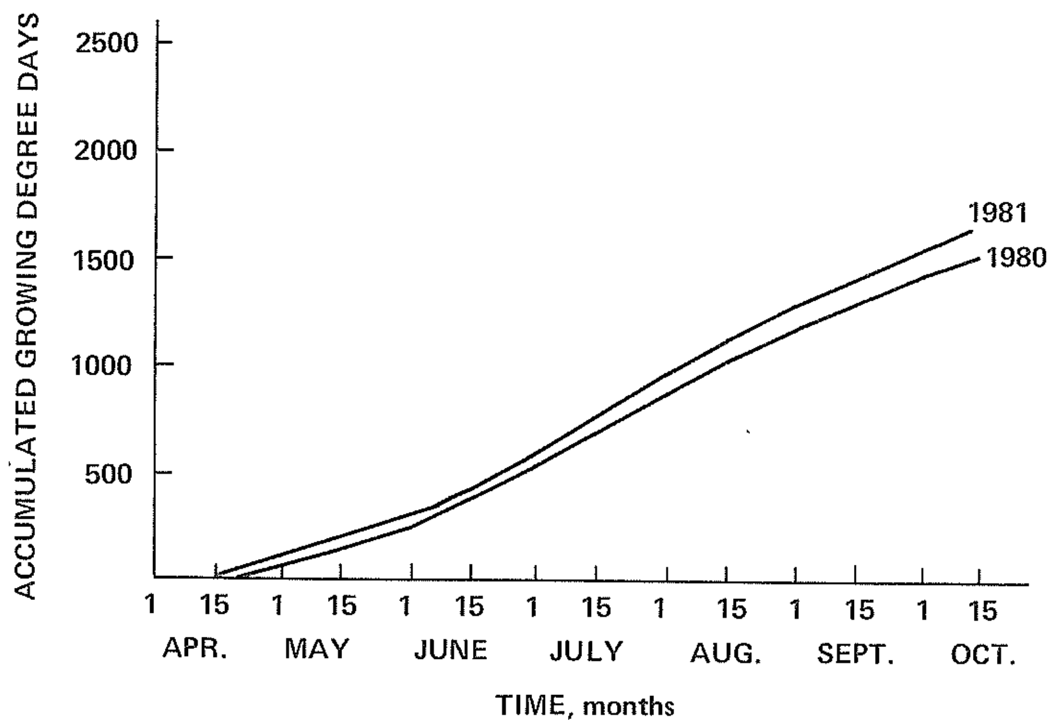


Figure I3. Seasonal GDD accumulation versus time during the growing season for pinto beans, 1980 and 1981.

APPENDIX J

Maximum leaf area index of selected yield levels of spring barley, 1981 and 1982.

Table J1. Maximum leaf area index (LAI) of selected yield levels of spring barley, 1981 and 1982.

Yield kg/ha	Maximum LAI
	1981 High Nitrogen
1,534	2.4
2,322	2.2
3,260	3.4
3,899	3.7
6,626	4.1
6,626	3.2
	1981 Middle Nitrogen
909	1.7
1,045	1.3
1,569	2.1
2,249	3.2
3,672	3.6
3,672	3.3
	1981 Low Nitrogen
113	0.9
886	1.3
795	1.8
1,318	1.5
2,431	2.1
2,431	1.9
	1982 High Nitrogen
1,157	2.4
2,163	3.5
3,903	4.7
4,175	4.4

APPENDIX K

Detailed maps fo the layout of the SLS plots

for 1980, 1981, and 1982.

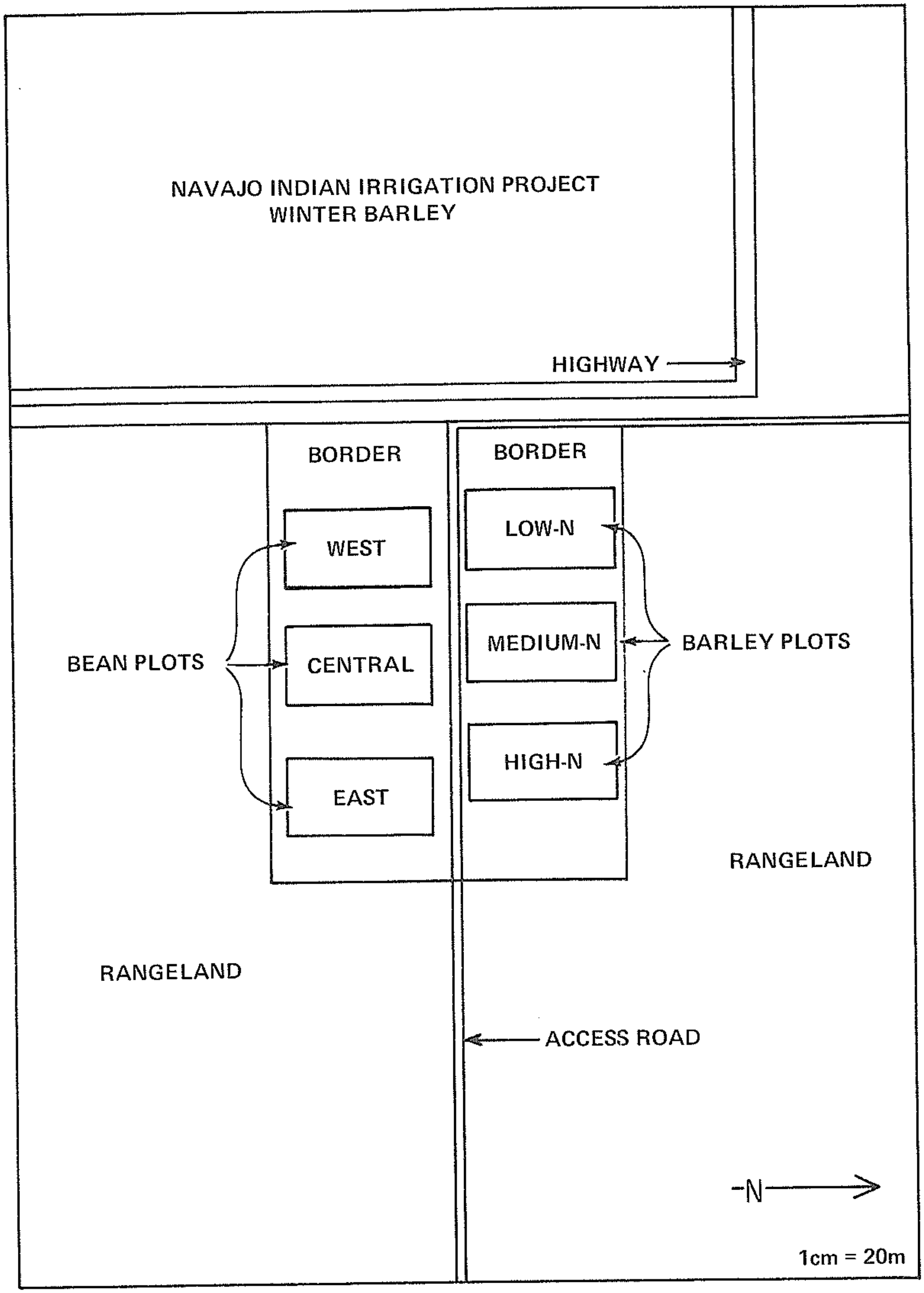


Figure K1. Detailed map of plot locations and adjacent areas, 1980.

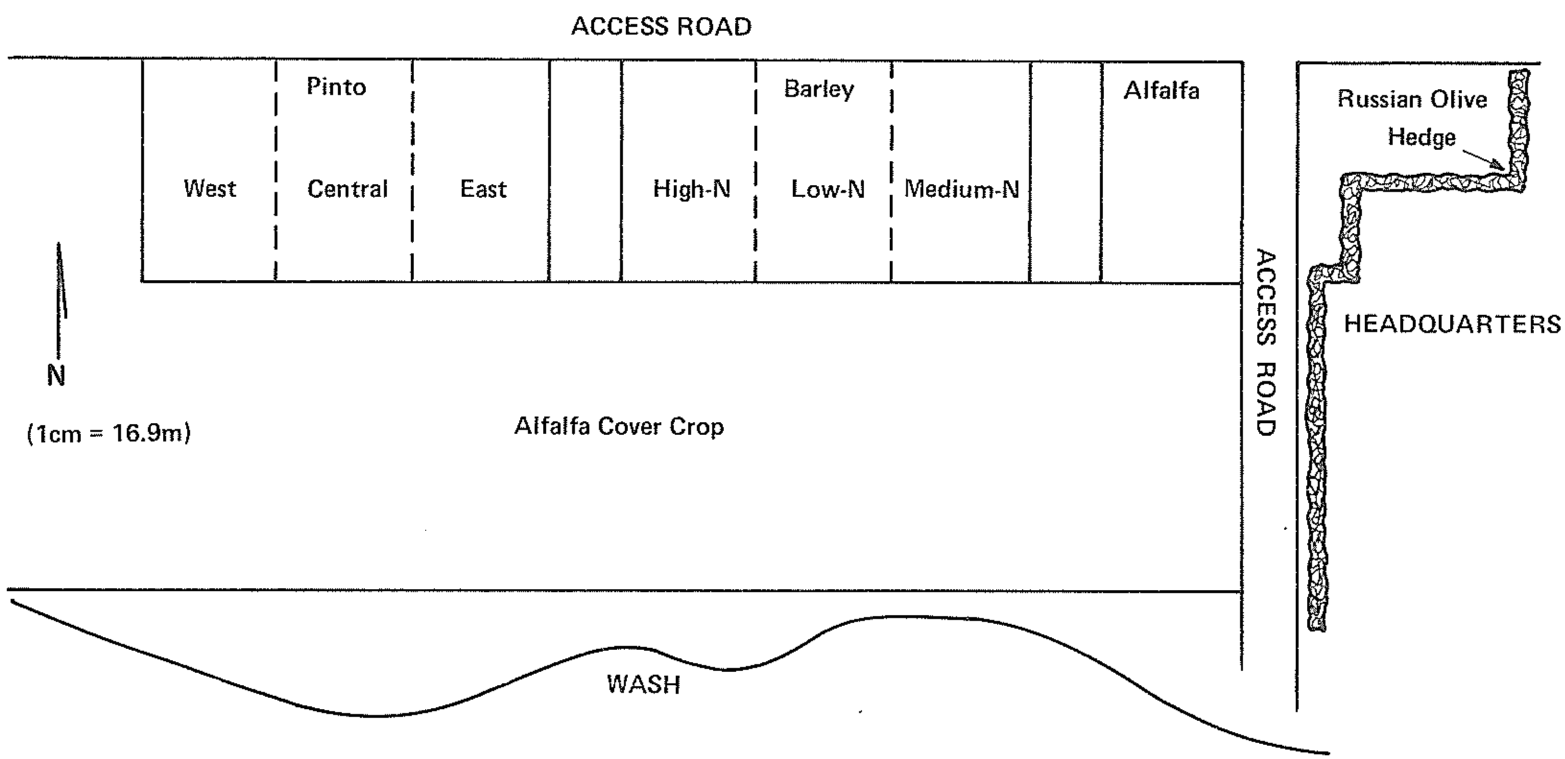


Figure K2. Detailed map of plot locations and adjacent areas, 1981.

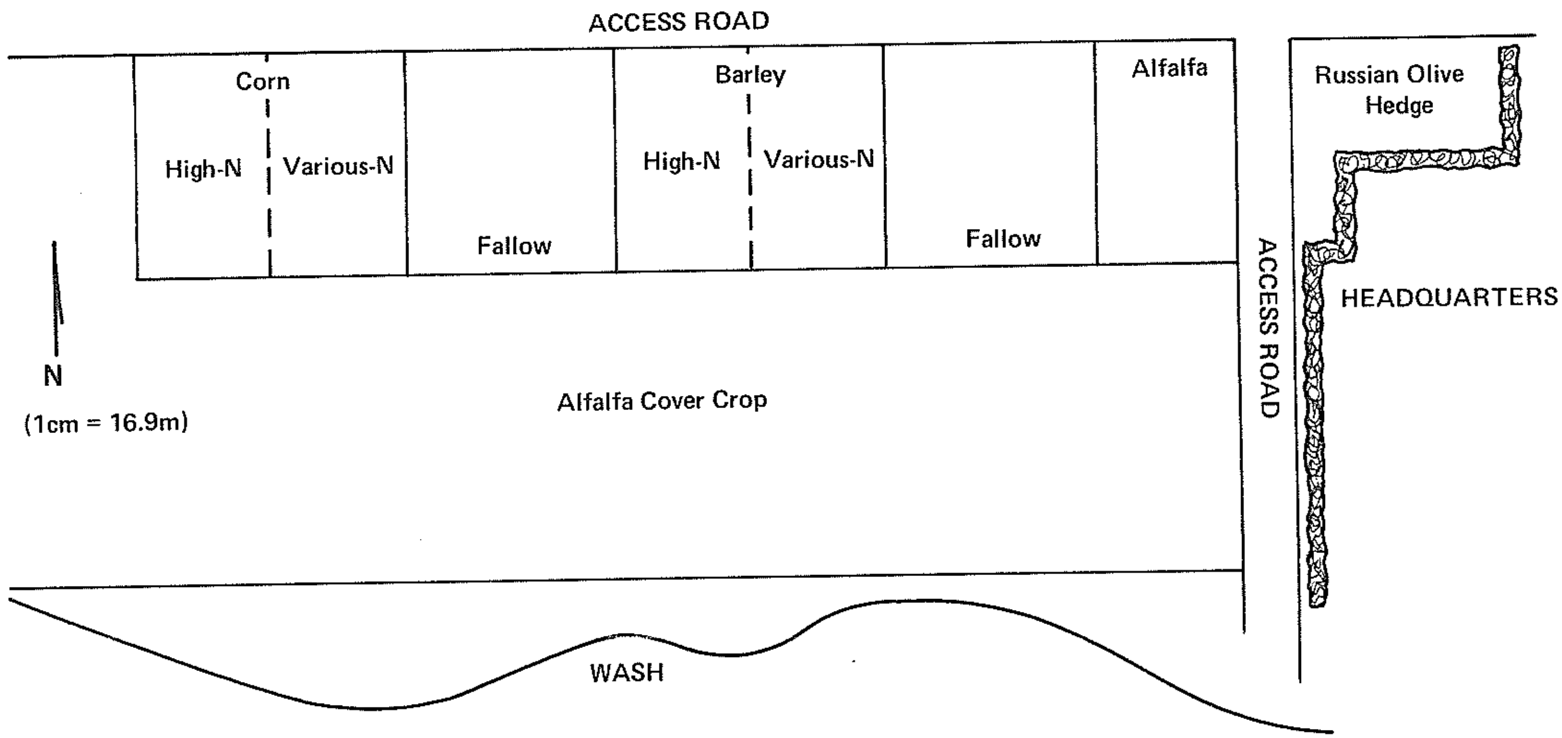
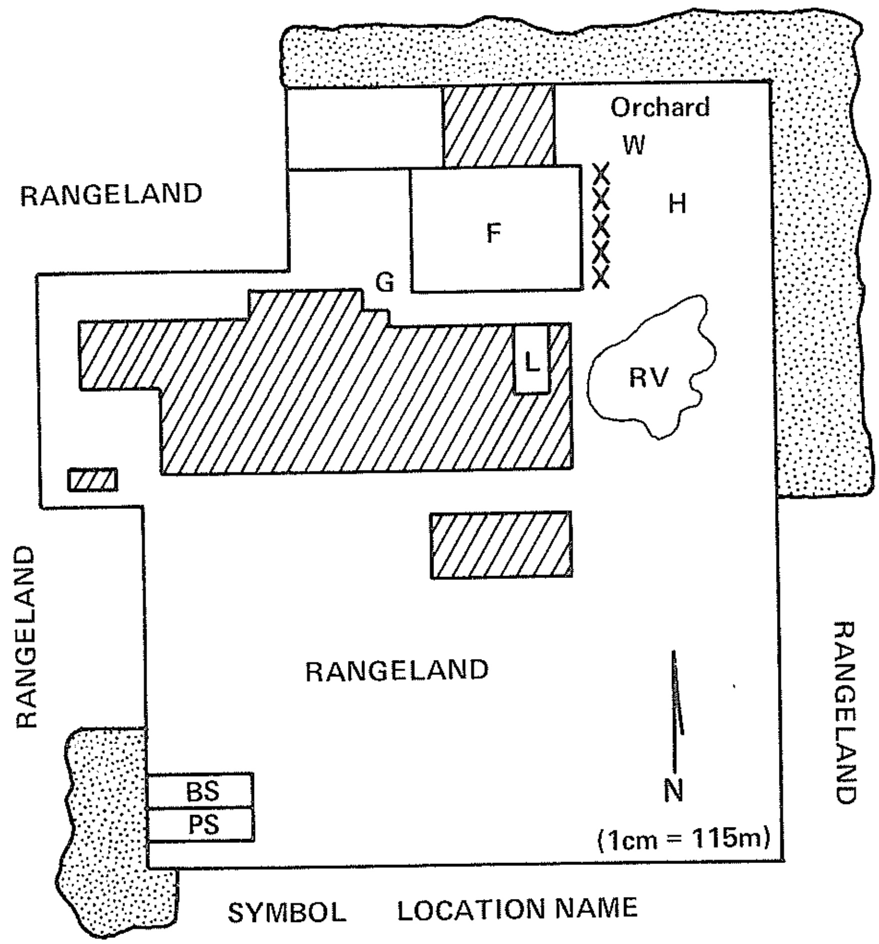


Figure K3. Detailed map of plot locations and adjacent areas, 1982.

APPENDIX L

Maps of the San Juan Agricultural Experiment

Station, 1980, 1981, and 1982.



SYMBOL	LOCATION NAME
BS	Barley sprinkler-line-source
F	Fallow field
G	Gully
H	Headquarters
L	Lysimeters
NIIP	Navajo Indian Irrigation Project
XX	Russian olive hedge
PS	Pinto bean sprinkler-line-source
RV	Reservoir
W	Weather station
(hatched)	Crops (alfalfa, corn, beans, small grains, vegetables, others)
(stippled)	NIIP cropland

L1. Map of the San Juan Agricultural Experiment Station and surrounding lands, 1980.

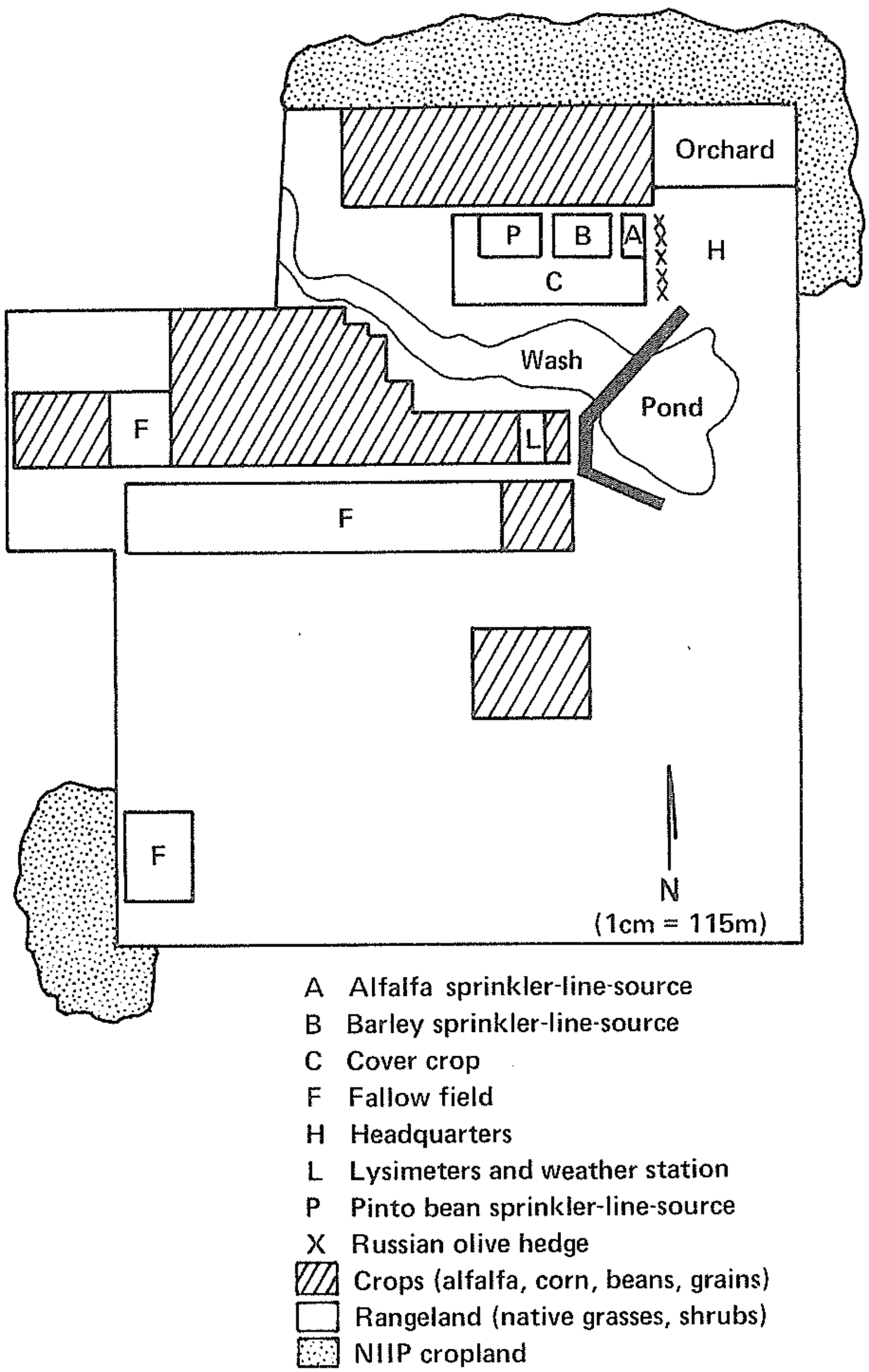


Figure L2. Map of the San Juan Agricultural Experiment Station and surrounding lands, 1981.

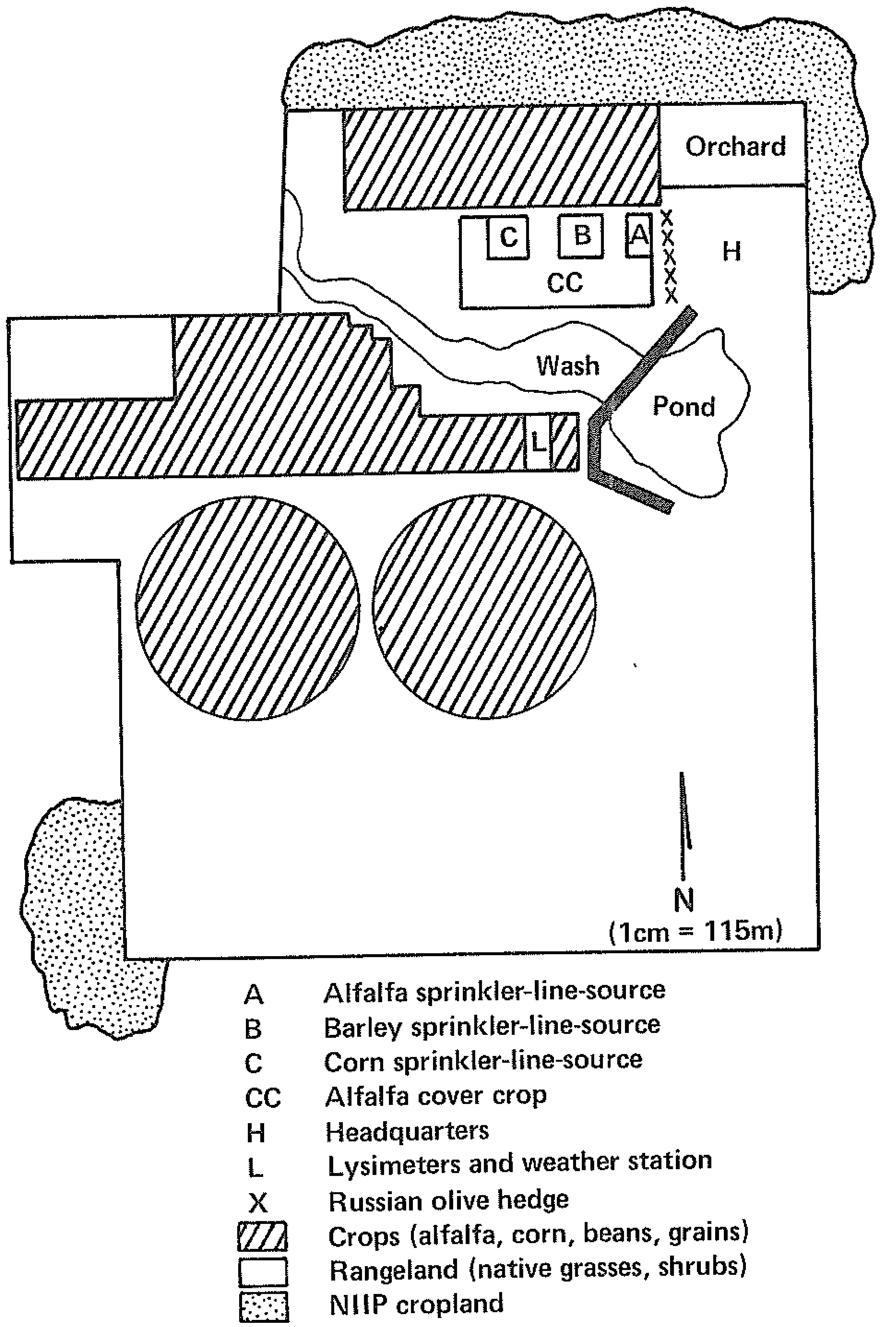


Figure L3. Map of the San Juan Agricultural Experiment Station and surrounding lands, 1982.

APPENDIX M

Using the multiple regression equation developed from the 1980 and 1981 barley data to predict the 1982 grain yield based on ET and other variables measured in 1982.

Table M1. Using the multiple regression equation developed from the 1980 and 1981 barley data to predict the 1982 grain yield, based on ET and other variables measured in 1982.

ET	Measured Yield	Water Production Function[1/]	Predictive Regression Functions: Single Variable[2/]	Predictive Regression Functions: Multiple Variables[3/]
cm	kg/ha	kg/ha	kg/ha	kg/ha
24.74	1157	1446	1038	1734
28.08	1656	1913	1391	1972
28.13	2163	1920	1397	1693
36.85	2680	3140	2530	2906
35.56	3826	2960	2343	2443
40.55	3903	3658	3103	3204
46.73	4175	4523	4181	4326

1/ Yield as estimated based on best-fit water-production function of 1982 data.
(Yield(kg/ha) = 139.9(ET) - 2015, $r^2 = 0.84$, SEE = 520 kg/ha)

2/ Yield as predicted by a best-fit equation based solely on ET.
(Yield(kg/ha) = $2(ET^2) - 186$, $r^2 = 0.79$, SEE = 817 kg/ha)

3/ Yield as predicted by a multiple regression equation as follows:

$$Y = 2.03(ET^2) - 0.03(I/ET \times PET) + 1282,\ r^2 = 0.94,$$
SEE = 448 kg/ha

where

Y = grain yield (kg/ha)

ET = seasonal evapotranspiration (cm)

I/ET = ratio of applied water to total ET and multiplied by 100 to get percentage

PET = potential evapotranspiration (mm, Penman method) from planting date to date of physiological maturity

APPENDIX N

Measured climatological variables on which potential evapotranspiration has been calculated.

Table N1. Climate data for Farmington, New Mexico, 1980.

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
40180	NIIP	0800	8.3	-8.9	100.0	25.0	126.0	520.	0.66	0.36	0.66
40280	NIIP	0800	5.6	-9.4	100.0	50.0	633.0	314.	0.69	0.08	1.35
40380	NIIP	0800	8.9	-10.6	100.0	28.0	417.0	135.	0.66	0.00	2.01
40480	NIIP	0800	13.6	-4.4	100.0	20.0	530.0	269.	0.74	0.00	2.74
40580	NIIP	0800	16.7	1.1	70.0	20.0	530.0	171.	0.74	0.00	3.48
40680	NIIP	0800	16.7	-0.0	89.0	20.0	520.0	507.	0.91	0.00	4.39
40780	NIIP	0800	10.0	-1.1	64.0	34.0	553.0	296.	0.58	0.00	4.98
40880	NIIP	0800	14.4	-8.9	81.0	24.0	631.0	195.	0.56	0.00	5.54
40980	NIIP	0800	17.8	-6.1	90.0	25.0	574.0	195.	0.48	0.00	6.02
41080	NIIP	0800	20.0	-1.1	74.0	22.0	470.0	323.	0.84	0.00	6.86
41180	NIIP	0800	11.1	-2.8	94.0	32.0	547.0	314.	0.97	0.00	7.82
41280	NIIP	0800	8.9	-5.6	100.0	33.0	465.0	349.	0.48	0.00	8.31
41380	NIIP	0800	10.6	-4.4	100.0	24.0	572.0	282.	0.41	0.00	8.71
41480	NIIP	0800	20.0	-2.8	44.0	20.0	602.0	229.	0.71	0.00	9.42
41580	NIIP	0800	21.7	-3.9	69.0	20.0	646.0	340.	1.04	0.00	10.46
41680	NIIP	0800	20.6	-0.0	72.0	19.0	574.0	198.	0.76	0.00	11.23
41780	NIIP	0800	22.2	-5.6	69.0	18.0	759.0	190.	0.71	0.00	11.94
41880	NIIP	0800	25.0	-1.1	70.0	16.0	397.0	161.	0.66	0.00	12.60
41980	NIIP	0800	26.1	1.7	60.0	20.0	540.0	183.	0.48	0.00	13.08
42080	NIIP	0800	25.0	2.8	68.0	30.0	573.0	259.	0.63	0.00	13.72
42180	NIIP	0800	23.3	6.7	89.0	40.0	326.0	378.	0.41	0.00	14.12
42280	NIIP	0800	22.2	6.1	100.0	24.0	428.0	307.	0.66	0.00	14.78
42380	NIIP	0800	16.1	6.1	80.0	34.0	430.0	378.	0.86	0.00	15.65
42480	NIIP	0800	3.9	0.6	100.0	69.0	365.0	323.	0.33	0.00	15.98
42580	NIIP	0800	16.7	1.1	100.0	32.0	556.0	248.	0.46	0.00	16.43
42680	NIIP	0800	18.9	2.2	100.0	30.0	524.0	270.	0.58	0.00	17.02
42780	NIIP	0800	22.2	3.3	92.0	34.0	420.0	283.	0.56	0.00	17.58
42880	NIIP	0800	24.4	5.6	100.0	40.0	556.0	188.	0.79	0.00	18.36
42980	NIIP	0800	19.4	8.3	100.0	39.0	354.0	227.	0.58	0.00	18.95
43080	NIIP	0800	16.7	1.7	100.0	30.0	637.0	227.	0.63	0.00	19.58
	MEAN		17.1	-1.1	85.8	28.7	508.4	275.	0.65		
	STANDARD DEV		5.8	5.3	16.0	11.0	122.2	92.	0.17		

(continued)

Table N1. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
50180	VIIP	0800	16.7	1.7	100.0	39.0	458.0	201.	0.46	0.08	20.04
50280	VIIP	0800	20.6	1.1	100.0	27.0	609.0	146.	0.61	0.00	20.65
50380	NIIP	0800	21.1	3.3	100.0	32.0	648.0	245.	0.71	0.00	21.36
50480	NIIP	0800	22.8	4.4	100.0	29.0	777.0	195.	0.48	0.00	21.84
50580	VIIP	0800	23.9	3.9	100.0	10.0	492.0	192.	0.97	0.76	22.81
50680	NIIP	0800	21.7	5.0	100.0	37.0	533.0	126.	0.43	0.13	23.24
50780	NIIP	0800	20.0	7.2	100.0	12.0	524.0	222.	0.38	0.08	23.62
50880	VIIP	0800	20.0	4.4	100.0	36.0	394.0	145.	0.43	0.00	24.05
50980	VIIP	0800	18.9	4.4	89.0	30.0	421.0	394.	0.76	0.00	24.82
51080	VIIP	0800	20.0	10.6	49.0	39.0	292.0	319.	0.51	0.00	25.32
51180	NIIP	0800	20.0	10.0	80.0	34.0	537.0	414.	0.63	0.00	25.96
51280	VIIP	0800	15.6	-1.1	100.0	13.0	406.0	206.	0.48	0.00	26.44
51380	NIIP	0800	20.0	-1.7	100.0	29.0	577.0	142.	0.58	0.00	27.03
51480	NIIP	0800	18.9	7.8	90.0	42.0	462.0	307.	0.25	0.00	27.28
51580	VIIP	0800	13.0	3.9	100.0	51.0	385.0	142.	0.25	0.00	27.53
51680	VIIP	0800	20.6	2.9	100.0	33.0	571.0	285.	0.56	0.00	28.09
51780	NIIP	0800	17.8	7.2	81.0	36.0	605.0	230.	0.74	0.00	28.83
51880	NIIP	0800	18.3	1.1	100.0	32.0	846.0	203.	0.71	0.00	29.54
51980	NIIP	0800	22.8	2.2	100.0	32.0	559.0	140.	0.69	0.00	30.23
52080	VIIP	0800	25.6	1.7	92.0	26.0	630.0	145.	0.63	0.00	30.86
52180	VIIP	0800	28.9	3.9	94.0	21.0	675.0	175.	0.84	0.00	31.70
52280	VIIP	0800	30.0	10.6	70.0	20.0	699.0	291.	0.97	0.00	32.66
52380	NIIP	0800	25.6	2.8	90.0	29.0	543.0	212.	1.24	0.00	33.91
52480	NIIP	0800	22.2	8.9	54.0	22.0	587.0	475.	1.50	0.00	35.41
52580	VIIP	0800	20.0	-3.3	72.0	32.0	728.0	278.	0.91	0.00	36.32
52680	VIIP	0800	25.6	-2.8	89.0	40.0	653.0	261.	1.07	0.00	37.39
52780	NIIP	0800	25.6	3.3	60.0	22.0	571.0	269.	1.12	0.00	38.51
52880	VIIP	0800	25.6	2.8	70.0	22.0	621.0	280.	1.19	0.00	39.70
52980	VIIP	0800	22.2	1.7	84.0	27.0	686.0	187.	0.86	0.00	40.56
53080	NIIP	0800	26.1	1.7	72.0	23.0	773.0	307.	1.27	0.00	41.83
53180	VIIP	0800	25.6	5.6	53.0	22.0	765.0	254.	1.17	0.00	43.00
	MEAN		21.8	3.7	86.7	31.6	579.6	238.	0.76		
	STANDARD DEV		3.7	3.6	16.3	8.0	128.0	86.	0.32		

(continued)

Table N1. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
60180	NIIP	0800	24.4	1.7	52.0	25.0	623.0	251.	1.12	0.00	44.12
60280	NIIP	0800	26.1	3.9	58.0	30.0	677.0	240.	1.30	0.00	45.41
60380	NIIP	0800	27.2	6.1	40.0	28.0	745.0	333.	1.30	0.00	46.71
60480	NIIP	0800	28.3	4.4	62.0	29.0	676.0	219.	1.09	0.00	47.80
60580	NIIP	0800	28.9	6.1	69.0	29.0	661.0	243.	0.84	0.00	48.64
60680	NIIP	0800	27.2	5.4	53.0	29.0	578.0	225.	0.97	0.00	49.61
60780	NIIP	0800	24.4	5.6	70.0	42.0	704.0	158.	0.97	0.36	50.57
60880	NIIP	0800	30.6	6.7	100.0	21.0	658.0	277.	1.04	0.00	51.61
60980	NIIP	0800	30.0	12.8	100.0	30.0	678.0	227.	0.89	0.00	52.50
61080	NIIP	0800	31.1	10.0	80.0	18.0	653.0	150.	0.74	0.00	53.24
61180	NIIP	0800	30.0	6.7	54.0	17.0	718.0	190.	0.97	0.00	54.20
61280	NIIP	0800	30.0	6.7	50.0	21.0	916.0	217.	1.09	0.00	55.30
61380	NIIP	0800	29.4	6.7	65.0	18.0	616.0	156.	0.99	0.00	56.29
61480	NIIP	0800	28.9	6.1	57.0	17.0	638.0	182.	0.94	0.00	57.23
61580	NIIP	0800	26.7	1.7	56.0	25.0	819.0	113.	0.56	0.00	57.78
61680	NIIP	0800	23.9	5.0	56.0	30.0	633.0	126.	0.74	0.00	58.52
61780	NIIP	0800	30.6	7.2	65.0	34.0	740.0	159.	0.81	0.00	59.33
61880	NIIP	0800	30.6	9.4	71.0	23.0	604.0	220.	1.04	0.00	60.38
61980	NIIP	0800	28.9	12.8	69.0	21.0	679.0	182.	0.97	0.05	61.34
62080	NIIP	0800	26.3	5.6	66.0	29.0	538.0	185.	0.97	0.00	62.31
62180	NIIP	0800	26.9	11.7	67.0	29.0	719.0	137.	0.69	0.00	62.99
62280	NIIP	0800	29.4	8.9	72.0	28.0	646.0	108.	0.74	0.00	63.73
62380	NIIP	0800	31.1	7.2	77.0	27.0	687.0	167.	0.97	0.00	64.69
62480	NIIP	0800	31.1	7.8	62.0	29.0	682.0	129.	0.81	0.00	65.51
62580	NIIP	0800	33.3	8.9	70.0	25.0	700.0	103.	0.76	0.00	66.27
62680	NIIP	0800	32.2	11.7	78.0	30.0	631.0	121.	0.76	0.00	67.03
62780	NIIP	0800	30.0	11.1	92.0	27.0	674.0	124.	0.74	0.00	67.77
62880	NIIP	0800	30.6	8.3	75.0	27.0	625.0	114.	0.69	0.00	68.45
62980	NIIP	0800	33.9	10.6	68.0	25.0	731.0	103.	0.74	0.00	69.19
63080	NIIP	0800	32.3	10.1	70.0	32.0	591.0	203.	0.79	0.00	69.98
	MEAN		29.5	7.9	67.5	26.2	674.7	179.	0.90		
	STANDARD DEV		2.5	3.3	13.7	5.3	72.5	58.	0.18		

(continued)

Table N1. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
70180	NIIP	0800	27.2	15.0	76.0	46.0	481.0	148.	0.51	0.00	70.48
70280	NIIP	0800	27.2	10.6	90.0	29.0	629.0	116.	0.69	0.00	71.17
70380	NIIP	0800	31.1	10.0	68.0	22.0	642.0	69.	0.61	0.00	71.78
70480	NIIP	0800	31.1	7.8	75.0	20.0	740.0	87.	0.74	0.00	72.52
70580	NIIP	0800	32.2	7.8	61.0	19.0	652.0	92.	0.76	0.00	73.28
70680	NIIP	0800	33.0	7.8	71.0	22.0	555.0	190.	0.79	0.00	74.07
70780	NIIP	0800	30.6	17.2	60.0	32.0	493.0	216.	0.81	0.36	74.88
70880	NIIP	0800	31.1	11.1	85.0	20.0	598.0	201.	0.84	0.00	75.72
70980	NIIP	0800	33.9	12.8	80.0	14.0	609.0	146.	1.04	0.00	76.76
71080	NIIP	0800	33.9	15.0	26.0	20.0	648.0	238.	1.17	0.00	77.93
71180	NIIP	0800	30.1	12.8	68.0	17.0	657.0	183.	1.30	0.00	79.22
71280	NIIP	0800	34.4	15.0	63.0	19.0	476.0	183.	1.14	0.00	80.37
71380	NIIP	0800	26.7	14.4	72.0	39.0	476.0	163.	0.61	0.00	80.97
71480	NIIP	0800	31.1	11.7	80.0	43.0	627.0	140.	0.99	0.00	81.97
71580	NIIP	0800	32.2	10.0	61.0	18.0	686.0	146.	1.07	0.00	83.03
71680	NIIP	0800	33.3	8.9	54.0	12.0	783.0	167.	1.83	0.00	84.96
71780	NIIP	0800	36.1	10.6	56.0	18.0	563.0	122.	0.99	0.00	85.95
71880	NIIP	0800	35.6	12.8	62.0	20.0	607.0	262.	1.12	0.00	87.07
71980	NIIP	0800	31.7	17.2	84.0	24.0	426.0	179.	1.12	0.05	88.19
72080	NIIP	0800	32.2	11.7	84.0	20.0	796.0	179.	1.12	0.00	89.31
72180	NIIP	0800	33.3	12.2	80.0	30.0	625.0	237.	1.09	0.00	90.40
72280	NIIP	0800	32.2	13.9	78.0	29.0	607.0	175.	0.79	0.00	91.19
72380	NIIP	0800	33.3	12.8	84.0	25.0	657.0	154.	0.91	0.00	92.10
72480	NIIP	0800	31.7	13.9	85.0	28.0	611.0	169.	0.94	0.00	93.04
72580	NIIP	0800	33.9	15.6	77.0	28.0	689.0	232.	1.07	0.00	94.11
72680	NIIP	0800	31.1	11.7	55.0	26.0	618.0	146.	0.84	0.00	94.94
72780	NIIP	0800	33.3	12.2	81.0	24.0	566.0	85.	0.86	0.00	95.81
72880	NIIP	0800	35.0	10.6	74.0	30.0	684.0	111.	0.86	0.00	96.67
72980	NIIP	0800	33.9	13.3	89.0	29.0	521.0	121.	0.66	0.00	97.33
73080	NIIP	0800	32.2	13.9	81.0	25.0	644.0	101.	0.84	0.00	98.17
73180	NIIP	0800	33.9	12.8	74.0	27.0	615.0	132.	0.89	0.00	99.06
	MEAN		32.5	12.3	73.2	25.0	612.3	158.	0.94		
	STANDARD DEV		2.4	2.5	13.4	7.6	86.6	49.	0.26		

(continued)

Table N1. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
80180	NIIP	0800	35.6	13.9	83.0	25.0	635.0	180.	0.94	0.00	100.00
80280	NIIP	0800	31.1	16.7	86.0	19.0	529.0	166.	0.76	0.10	100.76
80380	NIIP	0800	31.1	15.9	82.0	40.0	603.0	161.	0.94	0.00	101.70
80480	NIIP	0800	30.6	13.3	90.0	29.0	546.0	177.	0.89	0.00	102.59
80580	NIIP	0800	32.8	14.4	86.0	30.0	584.0	121.	0.76	0.00	103.35
80680	NIIP	0800	31.7	12.8	84.0	28.0	617.0	113.	0.71	0.00	104.06
80780	NIIP	0800	33.3	13.9	90.0	40.0	710.0	196.	0.84	0.00	104.90
80880	NIIP	0800	30.0	16.1	90.0	23.0	397.0	177.	0.66	0.25	105.56
80980	NIIP	0800	31.7	13.3	80.0	12.0	547.0	85.	0.74	0.00	106.30
81080	NIIP	0800	33.9	11.7	74.0	30.0	652.0	151.	0.89	0.00	107.19
81180	NIIP	0800	35.0	9.4	74.0	22.0	708.0	341.	1.30	0.00	108.48
81280	NIIP	0800	32.2	14.4	80.0	26.0	523.0	261.	1.12	0.00	109.60
81380	NIIP	0800	31.7	14.4	84.0	35.0	467.0	182.	0.81	0.00	110.41
81480	NIIP	0800	27.8	14.4	83.0	19.0	299.0	145.	0.43	0.13	110.84
81580	NIIP	0800	28.3	12.2	71.0	18.0	511.0	192.	0.91	0.00	111.76
81680	NIIP	0800	23.3	11.1	70.0	16.0	572.0	171.	0.84	0.00	112.60
81780	NIIP	0800	31.1	7.2	54.0	22.0	616.0	145.	0.94	0.00	113.54
81880	NIIP	0800	28.3	10.0	69.0	24.0	406.0	159.	0.76	0.00	114.30
81980	NIIP	0800	26.7	14.4	75.0	22.0	667.0	211.	0.76	0.05	115.06
82080	NIIP	0800	25.0	5.6	77.0	12.0	582.0	214.	0.89	0.00	115.95
82180	NIIP	0800	29.4	2.8	73.0	13.0	661.0	158.	0.86	0.00	116.81
82280	NIIP	0800	29.4	7.8	84.0	28.0	447.0	319.	0.46	0.03	117.27
82380	NIIP	0800	25.6	15.0	85.0	39.0	317.0	246.	0.56	0.74	117.83
82480	NIIP	0800	20.6	14.4	86.0	55.0	270.0	116.	0.48	0.76	118.31
82580	NIIP	0800	26.1	12.2	100.0	46.0	459.0	56.	0.43	0.00	118.74
82680	NIIP	0800	26.7	10.0	100.0	35.0	555.0	108.	0.66	0.00	119.40
82780	NIIP	0800	28.3	10.6	100.0	31.0	601.0	116.	0.61	0.00	120.01
82880	NIIP	0800	27.8	10.0	100.0	35.0	548.0	116.	0.58	0.00	120.60
82980	NIIP	0800	26.7	10.0	100.0	11.0	475.0	174.	0.63	0.00	121.23
83080	NIIP	0800	26.1	10.0	99.0	36.0	418.0	217.	0.76	0.00	122.00
83180	NIIP	0800	26.7	6.7	89.0	33.0	574.0	148.	0.66	0.00	122.66
	MEAN		29.4	11.7	83.4	28.5	532.1	172.	0.76		
	STANDARD DEV		3.3	3.3	11.0	10.3	114.5	62.	0.19		

(continued)

Table N1. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
90180	NIIP	0800	26.1	5.6	100.0	35.0	602.0	142.	0.61	0.00	123.27
90280	NIIP	0800	28.9	6.7	92.0	27.0	583.0	116.	0.53	0.00	123.80
90380	NIIP	0800	27.8	6.1	90.0	27.0	565.0	122.	0.51	0.00	124.31
90480	NIIP	0800	29.4	5.6	83.0	28.0	583.0	142.	0.56	0.00	124.87
90580	NIIP	0800	27.8	11.1	100.0	42.0	275.0	163.	0.38	0.18	125.25
90680	NIIP	0800	25.0	13.9	100.0	50.0	331.0	180.	0.28	0.13	125.53
90780	NIIP	0800	26.7	10.6	100.0	40.0	516.0	98.	0.36	0.00	125.88
90880	NIIP	0800	23.3	11.7	100.0	60.0	329.0	227.	0.38	0.00	126.26
90980	NIIP	0800	18.3	13.9	100.0	79.0	113.0	270.	0.58	2.16	126.85
91080	NIIP	0800	23.3	13.3	100.0	62.0	270.0	188.	0.66	0.99	127.51
91180	NIIP	0800	22.8	8.9	100.0	40.0	447.0	93.	0.36	0.00	127.86
91280	NIIP	0800	24.4	8.9	98.0	33.0	498.0	85.	0.43	0.00	128.29
91380	NIIP	0800	25.0	8.3	96.0	30.0	476.0	159.	0.30	0.00	128.60
91480	NIIP	0800	27.8	8.9	97.0	31.0	490.0	87.	0.41	0.00	129.01
91580	NIIP	0800	26.7	8.9	100.0	39.0	424.0	79.	0.36	0.00	129.36
91680	NIIP	0800	27.2	9.4	100.0	20.0	508.0	238.	0.99	0.00	130.35
91780	NIIP	0800	27.2	4.4	88.0	18.0	515.0	262.	0.99	0.00	131.34
91880	NIIP	0800	30.6	4.4	83.0	18.0	597.0	132.	0.66	0.00	132.00
91980	NIIP	0800	30.6	8.3	86.0	19.0	492.0	243.	1.12	0.00	133.12
92080	NIIP	0800	27.2	6.7	86.0	18.0	469.0	135.	0.76	0.00	133.88
92180	NIIP	0800	27.2	5.6	60.0	16.0	519.0	200.	0.94	0.00	134.82
92280	NIIP	0800	24.4	2.2	70.0	24.0	518.0	126.	0.56	0.00	135.38
92380	NIIP	0800	23.9	2.2	86.0	21.0	461.0	116.	0.58	0.00	135.97
92480	NIIP	0800	23.9	0.6	76.0	19.0	508.0	177.	0.66	0.00	136.63
92580	NIIP	0800	26.1	1.1	68.0	20.0	477.0	229.	0.56	0.00	137.18
92680	NIIP	0800	22.8	9.4	95.0	42.0	346.0	214.	0.46	0.00	137.64
92780	NIIP	0800	25.0	9.4	97.0	32.0	445.0	121.	0.51	0.00	138.15
92880	NIIP	0800	25.6	7.2	91.0	23.0	494.0	130.	0.53	0.00	138.68
92980	NIIP	0800	26.1	4.4	72.0	22.0	480.0	190.	0.71	0.00	139.39
93080	NIIP	0800	26.1	4.4	67.0	23.0	172.0	129.	0.53	0.00	139.93
	MEAN		25.9	7.4	89.1	31.9	460.1	160.	0.58		
	STANDARD DEV		2.5	3.6	12.0	15.1	108.7	56.	0.21		

(continued)

Table N1. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
100180	NIIP	0800	27.8	3.3	67.0	41.0	458.0	204.	0.76	0.00	140.68
100280	NIIP	0800	26.7	4.4	74.0	25.0	466.0	121.	0.53	0.00	141.22
100380	NIIP	0800	24.4	1.7	80.0	23.0	484.0	156.	0.58	0.00	141.81
100480	NIIP	0800	25.0	1.1	70.0	22.0	438.0	158.	0.58	0.00	142.39
100580	NIIP	0800	26.1	-0.6	80.0	27.0	488.0	201.	0.61	0.00	143.00
100680	NIIP	0800	26.1	4.4	67.0	29.0	423.0	156.	0.46	0.00	143.46
100780	NIIP	0800	23.3	5.0	84.0	30.0	430.0	111.	0.51	0.00	143.97
100880	NIIP	0800	27.2	4.4	78.0	28.0	430.0	122.	0.51	0.00	144.47
100980	NIIP	0800	24.4	4.4	80.0	29.0	358.0	151.	0.58	0.00	145.06
101080	NIIP	0800	25.6	1.7	80.0	26.0	428.0	229.	0.63	0.00	145.69
101180	NIIP	0800	23.9	6.7	71.0	34.0	407.0	121.	0.41	0.00	146.10
101280	NIIP	0800	23.3	5.6	81.0	36.0	286.0	161.	0.36	0.00	146.46
101380	NIIP	0800	20.0	7.8	100.0	34.0	428.0	126.	0.30	0.23	146.76
101480	NIIP	0800	16.1	5.0	94.0	52.0	135.0	177.	0.23	0.13	146.99
101580	NIIP	0800	8.9	-0.6	96.0	48.0	205.0	295.	0.23	0.51	147.22
101680	NIIP	0800	7.8	-0.6	94.0	34.0	253.0	127.	0.23	0.00	147.45
101780	NIIP	0800	10.0	-4.4	86.0	30.0	353.0	55.	0.23	0.00	147.67
101880	NIIP	0800	12.8	-5.6	91.0	32.0	378.0	68.	0.25	0.00	147.93
101980	NIIP	0800	15.0	-3.3	91.0	26.0	407.0	89.	0.23	0.00	148.16
102080	NIIP	0800	17.2	-3.3	84.0	23.0	399.0	74.	0.28	0.00	148.44
102180	NIIP	0800	16.1	-3.3	88.0	29.0	371.0	109.	0.28	0.00	148.72
102280	NIIP	0800	17.2	-3.3	79.0	30.0	357.0	148.	0.33	0.00	149.05
102380	NIIP	0800	11.1	-5.0	84.0	17.0	378.0	267.	0.53	0.00	149.58
102480	NIIP	0800	11.7	-8.4	81.0	22.0	335.0	113.	0.25	0.00	149.83
102580	NIIP	0800	18.3	-5.0	72.0	18.0	348.0	169.	0.36	0.00	150.19
102680	NIIP	0800	11.7	0.6	58.0	32.0	59.0	275.	0.08	0.63	150.27
102780	NIIP	0800	5.0	0.6	94.0	70.0	124.0	275.	0.05	0.38	150.32
102880	NIIP	0800	8.3	-0.6	94.0	38.0	276.0	116.	0.18	0.00	150.49
102980	NIIP	0800	10.0	-6.7	92.0	38.0	326.0	68.	0.13	0.00	150.62
103080	NIIP	0800	15.0	-3.9	93.0	31.0	345.0	259.	0.15	0.00	150.77
	MEAN		17.9	0.1	84.1	31.1	352.4	157.	0.36		
	STANDARD DEV		7.0	4.6	9.4	10.6	107.3	67.	0.19		

Table N2. Climate data for Farmington, New Mexico, 1981.

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
40181	FARMING	0830	19.4	3.3	53.0	14.0	534.0	270.	0.59	0.00	0.59
40281	FARMING	0830	19.4	5.0	100.0	18.0	395.0	393.	0.89	0.00	1.48
40381	FARMING	0830	10.0	-0.0	100.0	38.0	506.0	517.	0.55	0.00	2.03
40481	FARMING	0830	10.0	-3.3	78.0	25.0	607.0	241.	0.59	0.00	2.63
40581	FARMING	0830	14.4	-7.2	90.0	21.0	393.0	193.	0.41	0.00	3.04
40681	FARMING	0830	13.9	2.2	42.0	18.0	570.0	142.	0.58	0.00	3.61
40781	FARMING	0830	20.0	1.1	57.0	17.0	487.0	492.	0.99	0.00	4.60
40881	FARMING	0830	17.2	2.8	45.0	24.0	578.0	246.	0.75	0.00	5.35
40981	FARMING	0830	21.1	1.1	59.0	20.0	582.0	117.	0.57	0.00	5.92
41081	FARMING	0830	24.4	2.8	100.0	20.0	712.0	217.	0.74	0.00	6.66
41181	FARMING	0830	22.2	2.8	64.0	23.0	591.0	154.	0.77	0.00	7.43
41281	FARMING	0830	20.0	1.7	76.0	31.0	222.0	101.	0.54	0.00	7.98
41381	FARMING	0830	17.8	4.4	64.0	22.0	572.0	212.	0.17	0.00	8.15
41481	FARMING	0830	18.9	12.2	98.0	48.0	312.0	406.	0.88	0.00	9.03
41581	FARMING	0830	17.2	3.9	99.0	42.0	391.0	238.	0.45	0.00	9.48
41681	FARMING	0830	22.8	5.0	99.0	26.0	679.0	227.	0.45	0.00	9.93
41781	FARMING	0830	23.3	5.6	97.0	22.0	518.0	137.	0.88	0.00	10.81
41881	FARMING	0830	21.1	6.1	100.0	38.0	319.0	248.	0.37	0.00	11.18
41981	FARMING	0830	17.2	6.1	100.0	23.0	533.0	134.	0.44	0.53	11.62
42081	FARMING	0830	18.3	4.4	100.0	23.0	470.0	47.	0.56	0.00	12.18
42181	FARMING	0830	18.9	2.2	100.0	26.0	613.0	77.	0.52	0.00	12.70
42281	FARMING	0830	20.0	2.8	97.0	26.0	628.0	291.	1.06	0.00	13.76
42381	FARMING	0830	21.1	1.1	100.0	29.0	628.0	97.	0.80	0.00	14.55
42481	FARMING	0830	22.2	5.0	80.0	26.0	678.0	103.	1.19	0.00	15.75
42581	FARMING	0830	26.7	15.0	64.0	28.0	516.0	39.	0.45	0.00	16.19
42681	FARMING	0830	24.4	6.1	64.0	24.0	546.0	76.	0.04	0.00	16.23
42781	FARMING	0830	23.3	3.9	60.0	32.0	555.0	50.	0.90	0.00	17.13
42881	FARMING	0830	23.9	5.0	78.0	30.0	618.0	158.	0.60	0.00	17.74
42981	FARMING	0830	25.0	6.1	24.0	32.0	636.0	100.	0.68	0.00	18.41
43081	FARMING	0830	26.1	17.2	83.0	30.0	649.0	132.	0.87	0.00	19.28
	MEAN		20.2	4.3	79.0	26.5	534.3	195.	0.64		
	STANDARD DEV		4.0	4.7	21.9	7.6	118.5	125.	0.25		

(continued)

Table N2. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
50181	FARMING	0830	26.7	8.3	100.0	39.0	591.0	295.	0.58	0.03	19.86
50281	FARMING	0830	24.4	8.3	100.0	34.0	584.0	151.	0.69	0.13	20.55
50381	FARMING	0830	23.3	9.4	100.0	25.0	411.0	201.	0.80	0.00	21.34
50481	FARMING	0830	20.0	3.3	92.0	29.0	641.0	150.	0.55	0.00	21.90
50581	FARMING	0830	23.9	15.0	92.0	28.0	510.0	243.	1.20	0.00	23.09
50681	FARMING	0830	27.2	3.9	94.0	24.0	591.0	172.	0.48	0.00	23.58
50781	FARMING	0830	16.1	1.1	68.0	28.0	669.0	163.	0.88	0.80	24.46
50881	FARMING	0830	18.3	1.1	69.0	30.0	640.0	343.	1.21	0.00	25.67
50981	FARMING	0830	17.2	-1.7	100.0	36.0	675.0	143.	0.34	0.00	26.01
51081	FARMING	0830	23.6	2.2	78.0	30.0	643.0	106.	0.80	0.00	26.81
51181	FARMING	0830	22.2	4.4	63.0	36.0	539.0	220.	0.77	0.00	27.58
51281	FARMING	0830	22.2	2.8	69.0	38.0	317.0	222.	0.54	0.00	28.13
51381	FARMING	0830	17.8	6.1	77.0	32.0	664.0	261.	0.95	0.00	29.08
51481	FARMING	0830	23.9	3.9	84.0	37.0	576.0	193.	0.91	0.91	29.98
51581	FARMING	0830	20.6	7.8	100.0	33.0	379.0	288.	0.59	0.15	30.57
51681	FARMING	0830	13.3	3.3	100.0	50.0	362.0	172.	0.73	0.25	31.30
51781	FARMING	0830	14.4	3.3	100.0	44.0	584.0	167.	0.44	0.63	31.74
51881	FARMING	0830	20.6	3.3	100.0	32.0	646.0	114.	0.66	0.00	32.40
51981	FARMING	0830	23.9	8.9	63.0	28.0	547.0	563.	0.77	0.00	33.17
52081	FARMING	0830	20.0	12.2	70.0	25.0	236.0	404.	0.76	0.00	33.93
52181	FARMING	0830	17.2	-0.0	100.0	33.0	671.0	201.	0.66	0.00	34.59
52281	FARMING	0830	18.9	2.2	97.0	39.0	664.0	220.	0.51	0.00	35.10
52381	FARMING	0830	21.7	4.4	94.0	36.0	636.0	113.	0.74	0.00	35.84
52481	FARMING	0830	23.3	5.0	98.0	35.0	655.0	72.	0.58	0.00	36.42
52581	FARMING	0830	22.8	13.3	76.0	41.0	493.0	79.	0.80	0.00	37.22
52681	FARMING	0830	24.4	10.0	100.0	35.0	461.0	87.	0.45	0.00	37.67
52781	FARMING	0830	26.1	6.1	100.0	30.0	636.0	31.	1.07	0.74	38.75
52881	FARMING	0830	23.3	8.9	100.0	26.0	510.0	35.	0.34	0.25	39.08
52981	FARMING	0830	20.0	7.2	100.0	38.0	329.0	39.	0.37	0.63	39.45
53081	FARMING	0830	23.9	8.3	100.0	30.0	651.0	61.	0.60	0.00	40.06
53181	FARMING	0830	22.2	10.6	100.0	43.0	560.0	211.	0.59	0.00	40.65
	MEAN		21.5	6.1	88.9	33.7	550.7	185.	0.69		
	STANDARD DEV		3.3	3.9	14.8	6.1	122.1	114.	0.23		

(continued)

Table N2. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
60181	FARMING	0830	22.2	8.9	56.0	28.0	628.0	190.	0.54	0.00	41.19
60281	FARMING	0830	26.1	8.9	99.0	24.0	541.0	69.	0.92	0.03	42.11
60381	FARMING	0830	17.8	10.0	100.0	60.0	255.0	80.	0.82	0.36	42.93
60481	FARMING	0830	22.8	10.0	100.0	28.0	643.0	10.	0.75	0.00	43.68
60581	FARMING	0830	27.2	8.9	100.0	28.0	666.0	159.	1.29	0.00	44.96
60681	FARMING	0830	28.9	12.8	95.0	28.0	690.0	80.	1.31	0.00	46.27
60781	FARMING	0830	27.8	10.6	100.0	37.0	611.0	138.	0.96	0.00	47.23
60881	FARMING	0830	32.2	11.7	100.0	33.0	658.0	64.	0.69	0.00	47.92
60981	FARMING	0830	32.2	12.2	50.0	18.0	691.0	64.	1.24	0.00	49.16
61081	FARMING	0830	32.8	12.2	50.0	20.0	690.0	48.	0.84	0.00	50.00
61181	FARMING	0830	32.8	13.9	46.0	22.0	688.0	61.	1.24	0.00	51.24
61281	FARMING	0830	31.7	11.1	55.0	18.0	695.0	132.	1.34	0.00	52.58
61381	FARMING	0830	25.9	12.2	70.0	16.0	670.0	241.	1.31	0.00	53.89
61481	FARMING	0830	20.0	8.3	55.0	33.0	682.0	303.	0.85	0.00	54.74
61581	FARMING	0830	18.9	3.3	64.0	34.0	688.0	163.	0.85	0.00	55.58
61681	FARMING	0830	26.1	2.8	64.0	20.0	632.0	108.	0.74	0.00	56.33
61781	FARMING	0830	27.8	10.0	50.0	23.0	695.0	90.	0.96	0.00	57.29
61881	FARMING	0830	28.9	8.9	46.0	24.0	646.0	82.	1.07	0.00	58.36
61981	FARMING	0830	28.9	11.1	44.0	24.0	684.0	127.	0.89	0.00	59.26
62081	FARMING	0830	31.1	15.0	43.0	26.0	701.0	90.	1.10	0.00	60.36
62181	FARMING	0830	31.1	15.6	44.0	24.0	718.0	166.	1.29	0.00	61.65
62281	FARMING	0830	31.7	18.9	54.0	32.0	699.0	193.	1.05	0.00	62.70
62381	FARMING	0830	32.2	18.9	54.0	32.0	687.0	135.	0.93	0.00	63.63
62481	FARMING	0830	32.8	15.6	58.0	32.0	692.0	206.	1.29	0.00	64.92
62581	FARMING	0830	33.3	20.0	58.0	37.0	660.0	230.	1.00	0.00	65.92
62681	FARMING	0830	31.1	18.9	74.0	41.0	709.0	238.	0.92	0.00	66.84
62781	FARMING	0830	30.6	18.3	100.0	44.0	537.0	116.	0.88	0.03	67.72
62881	FARMING	0830	27.8	16.1	100.0	40.0	540.0	106.	0.69	0.00	68.40
62981	FARMING	0830	28.3	14.4	100.0	12.0	583.0	145.	0.78	0.00	69.18
63081	FARMING	0830	27.2	16.7	100.0	41.0	348.0	60.	0.43	1.12	69.61
	MEAN		28.4	12.5	72.3	30.3	642.9	130.	0.97		
	STANDARD DEV		4.3	4.4	23.4	9.6	91.2	68.	0.24		

(continued)

Table N2. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
70181	FARMING	0830	20.0	14.4	100.0	78.0	555.0	34.	0.38	0.74	69.99
70281	FARMING	0830	26.7	13.3	100.0	34.0	685.0	42.	0.82	0.00	70.81
70381	FARMING	0830	23.9	12.8	100.0	30.0	596.0	103.	1.05	0.00	71.86
70481	FARMING	0830	30.0	13.3	82.0	29.0	661.0	153.	1.13	0.00	72.99
70581	FARMING	0830	32.2	15.6	79.0	32.0	630.0	119.	0.76	0.00	73.75
70681	FARMING	0830	32.2	13.9	62.0	24.0	659.0	47.	1.14	0.00	74.89
70781	FARMING	0830	30.0	15.0	67.0	34.0	659.0	150.	0.67	0.28	75.57
70881	FARMING	0830	33.0	14.4	98.0	34.0	631.0	193.	1.02	0.00	76.59
70981	FARMING	0830	26.7	15.6	58.0	50.0	520.0	100.	0.74	0.00	77.32
71081	FARMING	0830	26.7	17.2	58.0	55.0	518.0	64.	0.86	0.00	78.19
71181	FARMING	0830	30.6	16.7	98.0	33.0	602.0	85.	0.86	0.00	79.05
71281	FARMING	0830	27.8	15.0	93.0	41.0	654.0	77.	0.86	0.10	79.91
71381	FARMING	0830	28.3	14.4	99.0	50.0	449.0	19.	0.67	0.51	80.58
71481	FARMING	0830	28.3	15.0	100.0	43.0	591.0	103.	0.83	0.00	81.40
71581	FARMING	0830	29.4	15.6	100.0	40.0	555.0	71.	0.63	0.00	82.04
71681	FARMING	0830	27.8	15.6	100.0	41.0	163.0	60.	0.76	0.30	82.80
71781	FARMING	0830	28.9	14.4	100.0	38.0	554.0	71.	0.97	0.00	83.76
71881	FARMING	0830	30.0	14.4	87.0	37.0	591.0	195.	1.21	0.00	84.97
71981	FARMING	0830	33.3	15.6	62.0	24.0	622.0	101.	1.06	0.00	86.03
72081	FARMING	0830	33.9	15.6	65.0	25.0	677.0	71.	1.08	0.00	87.12
72181	FARMING	0830	34.4	13.3	83.0	29.0	654.0	37.	0.97	0.00	88.08
72281	FARMING	0830	31.7	16.7	84.0	23.0	611.0	166.	1.07	0.00	89.16
72381	FARMING	0830	30.6	18.9	97.0	10.0	482.0	119.	1.13	0.00	90.28
72481	FARMING	0830	31.7	16.7	100.0	40.0	575.0	66.	0.48	0.20	90.76
72581	FARMING	0830	30.6	17.2	100.0	45.0	504.0	227.	0.97	0.08	91.73
72681	FARMING	0830	29.4	16.1	100.0	40.0	542.0	211.	0.97	0.08	92.69
72781	FARMING	0830	30.0	15.6	99.0	31.0	621.0	76.	0.95	0.00	93.64
72881	FARMING	0830	30.6	15.0	84.0	31.0	625.0	58.	0.72	0.00	94.37
72981	FARMING	0830	30.6	15.6	97.0	33.0	610.0	122.	1.00	0.00	95.37
73081	FARMING	0830	30.6	16.7	76.0	40.0	614.0	89.	0.71	0.00	96.08
73181	FARMING	0830	30.0	18.0	100.0	50.0	458.0	174.	0.86	0.00	96.94
	MEAN		29.7	15.4	91.4	38.3	586.1	103.	0.88		
	STANDARD DEV		2.7	1.5	12.0	10.5	67.3	56.	0.20		

(continued)

Table N2. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
80181	FARMING	0830	28.5	15.0	100.0	44.0	508.0	31.	0.66	0.00	97.60
80281	FARMING	0830	29.4	14.4	97.0	36.0	625.0	150.	0.74	0.00	98.33
80381	FARMING	0830	31.1	16.7	82.0	38.0	603.0	80.	0.71	0.00	99.04
80481	FARMING	0830	31.7	15.6	64.0	34.0	599.0	87.	0.87	0.00	99.91
80581	FARMING	0830	31.7	13.9	70.0	32.0	623.0	114.	0.87	0.00	100.78
80681	FARMING	0830	33.3	16.7	62.0	28.0	629.0	227.	0.95	0.00	101.73
80781	FARMING	0830	31.7	15.6	88.0	40.0	582.0	167.	0.82	0.00	102.55
80881	FARMING	0830	30.6	15.6	100.0	40.0	640.0	172.	1.02	0.00	103.57
80981	FARMING	0830	25.9	15.6	100.0	45.0	508.0	217.	0.69	0.00	104.26
81081	FARMING	0830	25.6	13.9	100.0	34.0	347.0	148.	0.68	0.18	104.94
81181	FARMING	0830	23.9	13.3	100.0	54.0	367.0	122.	0.30	0.36	105.24
81281	FARMING	0830	25.0	11.1	100.0	40.0	479.0	84.	0.71	0.00	105.95
81381	FARMING	0830	23.9	10.6	100.0	50.0	424.0	39.	0.25	0.00	106.20
81481	FARMING	0830	24.1	10.0	100.0	44.0	501.0	26.	0.73	0.00	106.93
81581	FARMING	0830	27.8	13.3	100.0	40.0	497.0	29.	0.51	0.00	107.44
81681	FARMING	0830	26.5	11.1	100.0	40.0	545.0	108.	1.01	0.00	108.46
81781	FARMING	0830	29.4	13.3	93.0	40.0	559.0	216.	1.01	0.00	109.47
81881	FARMING	0830	29.4	15.0	100.0	40.0	503.0	85.	0.71	0.00	110.18
81981	FARMING	0830	30.6	12.2	100.0	38.0	567.0	113.	0.65	0.00	110.83
82081	FARMING	0830	32.2	16.1	80.0	32.0	581.0	153.	0.96	0.00	111.79
82181	FARMING	0830	31.1	17.8	83.0	40.0	394.0	137.	0.62	0.18	112.40
82281	FARMING	0830	25.6	14.4	100.0	42.0	565.0	172.	0.72	0.00	113.12
82381	FARMING	0830	30.0	12.2	93.0	29.0	526.0	64.	0.57	0.00	113.69
82481	FARMING	0830	30.0	16.7	65.0	36.0	474.0	393.	0.66	0.00	114.35
82581	FARMING	0830	31.7	15.0	80.0	34.0	565.0	166.	0.86	0.00	115.21
82681	FARMING	0830	32.2	14.4	76.0	30.0	507.0	150.	1.17	0.00	116.37
82781	FARMING	0830	32.8	15.0	80.0	12.0	521.0	127.	0.63	0.00	117.01
82881	FARMING	0830	30.0	14.4	100.0	12.0	535.0	167.	0.71	0.00	117.72
82981	FARMING	0830	23.9	14.4	100.0	41.0	489.0	169.	0.61	0.00	118.33
83081	FARMING	0830	29.4	15.6	86.0	40.0	408.0	278.	0.66	0.00	118.99
83181	FARMING	0830	22.3	10.0	100.0	30.0	221.0	48.	0.26	0.00	119.24
	MEAN		29.1	14.2	90.3	39.9	512.7	137.	0.72		
	STANDARD DEV		2.5	2.0	12.6	6.5	93.2	78.	0.21		

(continued)

Table N2. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
90181	FARMING	0830	27.2	11.1	100.0	28.0	546.0	124.	0.74	0.00	119.99
90281	FARMING	0830	28.9	12.2	84.0	42.0	435.0	98.	0.86	0.00	120.85
90381	FARMING	0830	28.3	15.0	96.0	34.0	535.0	171.	1.02	0.00	121.87
90481	FARMING	0830	26.7	16.1	100.0	38.0	190.0	158.	0.71	1.12	122.58
90581	FARMING	0830	22.2	13.9	100.0	64.0	360.0	87.	1.04	0.51	123.62
90681	FARMING	0830	20.6	11.1	100.0	72.0	325.0	50.	0.09	0.10	123.71
90781	FARMING	0830	26.1	11.7	100.0	40.0	509.0	185.	1.62	0.00	125.33
90881	FARMING	0830	25.0	15.6	100.0	41.0	496.0	63.	0.71	0.00	126.04
90981	FARMING	0830	26.1	11.7	100.0	40.0	462.0	151.	0.15	0.00	126.19
91081	FARMING	0830	22.8	12.2	100.0	40.0	419.0	89.	0.66	0.00	126.85
91181	FARMING	0830	23.9	10.6	100.0	38.0	450.0	163.	0.26	0.00	127.10
91281	FARMING	0830	23.9	10.0	80.0	40.0	428.0	98.	0.53	0.00	127.63
91381	FARMING	0830	24.4	10.0	96.0	36.0	493.0	188.	0.51	0.00	128.14
91481	FARMING	0830	26.7	11.1	90.0	31.0	494.0	169.	0.57	0.00	128.71
91581	FARMING	0830	27.8	13.3	70.0	32.0	368.0	103.	0.42	0.00	129.13
91681	FARMING	0830	26.7	10.6	88.0	34.0	474.0	130.	1.01	0.00	130.14
91781	FARMING	0830	26.1	12.8	89.0	36.0	482.0	100.	0.29	0.00	130.43
91881	FARMING	0830	25.6	11.1	58.0	33.0	483.0	77.	0.54	0.00	130.97
91981	FARMING	0830	24.4	9.4	70.0	30.0	483.0	114.	0.34	0.00	131.32
92081	FARMING	0830	26.1	10.0	62.0	30.0	488.0	84.	0.55	0.00	131.87
92181	FARMING	0830	28.9	11.1	68.0	32.0	461.0	89.	0.94	0.00	132.81
92281	FARMING	0830	27.2	11.7	84.0	33.0	377.0	106.	0.30	0.00	133.11
92381	FARMING	0830	21.7	15.0	100.0	44.0	155.0	135.	0.04	0.03	133.15
92481	FARMING	0830	23.9	10.6	100.0	34.0	440.0	79.	0.66	0.00	133.81
92581	FARMING	0830	22.8	11.1	85.0	30.0	418.0	109.	0.26	0.00	134.07
92681	FARMING	0830	21.1	7.2	60.0	24.0	428.0	116.	0.52	0.00	134.58
92781	FARMING	0830	25.6	7.2	42.0	22.0	497.0	116.	0.66	0.00	135.24
92881	FARMING	0830	28.9	10.0	50.0	30.0	394.0	122.	0.36	0.00	135.60
92981	FARMING	0830	28.9	13.3	59.0	26.0	339.0	127.	0.46	0.00	136.05
93081	FARMING	0830	25.0	12.2	51.0	29.0	317.0	164.	0.99	0.00	137.04
	MEAN		25.4	11.6	84.1	36.1	424.9	119.	0.59		
	STANDARD DEV		2.4	2.1	18.3	10.3	91.2	36.	0.34		

(continued)

Table N2. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
100181	FARMING	0830	22.8	13.9	84.0	36.0	284.0	190.	0.28	0.03	137.32
100281	FARMING	0830	15.6	12.2	100.0	22.0	0.0	150.	0.41	2.11	137.73
100381	FARMING	0830	17.2	7.2	100.0	42.0	309.0	76.	0.30	0.00	138.03
100481	FARMING	0830	20.0	7.8	95.0	42.0	379.0	39.	0.28	0.00	138.31
100581	FARMING	0830	21.1	6.7	100.0	33.0	419.0	55.	0.48	0.00	138.79
100681	FARMING	0830	23.3	7.2	92.0	19.0	425.0	179.	0.56	0.00	139.35
100781	FARMING	0830	21.7	9.4	93.0	39.0	358.0	129.	0.51	0.00	139.86
100881	FARMING	0830	22.8	10.6	91.0	25.0	326.0	174.	0.55	0.00	140.42
100981	FARMING	0830	13.9	5.6	95.0	35.0	406.0	111.	0.51	0.00	140.92
101081	FARMING	0830	19.4	7.8	79.0	28.0	403.0	143.	0.27	0.00	141.19
101181	FARMING	0830	16.1	3.9	91.0	30.0	182.0	240.	0.63	0.00	141.83
101281	FARMING	0830	16.1	4.4	100.0	54.0	196.0	114.	0.22	0.13	142.05
101381	FARMING	0830	20.6	7.8	100.0	29.0	272.0	101.	0.36	0.00	142.41
	MEAN		19.7	8.0	93.8	34.9	304.5	131.	0.41		
	STANDARD DEV		2.7	2.9	6.6	8.5	121.6	57.	0.14		

Table N3. Climate data for Farmington, New Mexico, 1982.

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
40582	FARMING		14.4	3.9	51.0	42.0	504.0	106.	1.24	0.00	1.24
40682	FARMING		18.3	3.9	71.0	46.0	403.0	455.	0.92	0.00	2.16
40782	FARMING		13.3	-3.3	70.0	44.0	556.0	282.	1.09	0.00	3.25
40882	FARMING		8.9	-5.0	70.0	40.0	630.0	143.	0.52	0.00	3.77
40982	FARMING		11.7	-2.2	73.0	44.0	647.0	180.	0.52	0.00	4.30
41082	FARMING		12.8	-6.1	80.0	34.0	566.0	114.	0.52	0.00	4.82
41182	FARMING		21.1	0.6	64.0	40.0	444.0	288.	0.52	0.00	5.34
41282	FARMING		23.3	4.4	84.0	36.0	587.0	319.	1.25	0.00	6.59
41382	FARMING		22.2	3.3	86.0	36.0	623.0	55.	0.84	0.00	7.43
41482	FARMING		22.8	3.9	56.0	11.0	637.0	89.	0.42	0.00	7.85
41582	FARMING		20.6	3.9	56.0	12.0	632.0	192.	0.89	0.00	8.75
41682	FARMING		15.0	2.8	60.0	20.0	613.0	267.	0.80	0.00	9.55
41782	FARMING		18.9	-1.7	68.0	23.0	622.0	47.	0.97	0.00	10.52
41882	FARMING		18.9	0.6	80.0	19.0	608.0	161.	0.63	0.00	11.15
41982	FARMING		15.0	-1.1	58.0	11.0	657.0	243.	1.04	0.00	12.19
42082	FARMING		7.8	-4.4	46.0	22.0	542.0	200.	0.21	0.03	12.41
42182	FARMING		5.0	-1.7	100.0	41.0	229.0	254.	0.19	0.00	12.60
42282	FARMING		7.2	-1.1	100.0	50.0	187.0	269.	0.19	0.33	12.79
42382	FARMING		12.2	1.7	100.0	29.0	343.0	74.	0.20	1.30	12.99
42482	FARMING		18.9	2.2	81.0	29.0	544.0	171.	0.38	0.00	13.37
42582	FARMING		21.1	3.9	93.0	21.0	362.0	150.	0.83	0.00	14.20
42682	FARMING		22.2	1.1	69.0	24.0	572.0	158.	0.97	0.00	15.17
42782	FARMING		22.2	7.2	74.0	25.0	584.0	109.	0.72	0.00	15.90
42882	FARMING		22.2	5.6	92.0	22.0	664.0	138.	0.76	0.00	16.65
42982	FARMING		23.9	7.2	61.0	20.0	619.0	151.	0.82	0.00	17.47
43082	FARMING		23.9	7.8	76.0	29.0	601.0	172.	1.12	0.00	18.59
	MEAN		17.1	1.4	73.8	30.0	537.5	185.	0.71		
	STANDARD DEV		5.7	3.9	15.3	11.2	130.7	93.	0.32		

(continued)

Table N3. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
50182	FARMING		23.3	10.0	94.0	30.0	611.0	132.	0.67	0.00	19.26
50282	FARMING		22.8	10.6	83.0	32.0	488.0	103.	0.45	0.00	19.71
50382	FARMING		23.3	8.9	99.0	32.0	604.0	79.	0.40	0.00	20.11
50482	FARMING		18.9	6.7	100.0	48.0	346.0	154.	0.45	0.97	20.56
50582	FARMING		15.0	6.7	100.0	30.0	466.0	183.	0.54	0.56	21.10
50682	FARMING		15.0	-0.6	86.0	22.0	689.0	182.	0.75	0.00	21.86
50782	FARMING		20.0	1.1	80.0	30.0	688.0	121.	0.69	0.00	22.54
50882	FARMING		24.4	8.3	93.0	30.0	563.0	140.	0.72	0.00	23.26
50982	FARMING		23.9	8.9	60.0	20.0	575.0	268.	1.36	0.00	24.62
51082	FARMING		20.6	6.7	84.0	20.0	676.0	188.	0.68	0.00	25.30
51182	FARMING		18.9	5.6	94.0	32.0	470.0	143.	0.51	0.05	25.81
51282	FARMING		7.8	5.6	99.0	60.0	191.0	209.	0.37	0.51	26.19
51382	FARMING		16.7	2.2	98.0	32.0	579.0	275.	0.59	0.00	26.78
51482	FARMING		18.3	2.2	92.0	30.0	663.0	290.	0.49	0.00	27.26
51582	FARMING		20.6	4.4	84.0	30.0	490.0	103.	0.34	0.00	27.60
51682	FARMING		21.7	4.4	97.0	32.0	687.0	180.	0.47	0.00	28.08
51782	FARMING		22.2	8.3	77.0	29.0	682.0	140.	0.60	0.00	28.67
51882	FARMING		25.6	8.9	70.0	20.0	558.0	134.	0.94	0.00	28.62
51982	FARMING		23.9	7.8	55.0	28.0	576.0	195.	0.77	0.00	30.38
52082	FARMING		20.6	6.1	68.0	26.0	736.0	161.	0.93	0.00	31.32
52182	FARMING		24.4	3.3	69.0	24.0	801.0	142.	1.38	0.00	32.70
52282	FARMING		25.6	10.0	80.0	30.0	480.0	220.	0.75	0.00	33.46
52382	FARMING		25.6	10.6	91.0	34.0	624.0	92.	0.65	0.00	34.11
52482	FARMING		25.0	7.2	98.0	24.0	648.0	93.	0.58	0.00	34.69
52582	FARMING		23.9	10.6	90.0	21.0	723.0	89.	0.42	0.00	35.10
52682	FARMING		26.7	9.4	54.0	19.0	702.0	129.	1.15	0.00	36.25
52782	FARMING		22.2	12.2	60.0	20.0	384.0	127.	0.44	0.00	36.69
52882	FARMING		23.3	7.8	96.0	20.0	734.0	179.	1.26	0.00	37.95
52982	FARMING		25.6	7.8	67.0	11.0	712.0	167.	0.84	0.00	38.79
53082	FARMING		23.3	7.8	50.0	18.0	717.0	153.	0.93	0.00	39.72
53182	FARMING		23.9	4.4	75.0	18.0	730.0	151.	1.20	0.00	40.92
	MEAN		21.7	6.9	82.0	27.2	599.8	160.	0.72		
	STANDARD DEV		4.0	3.1	15.4	9.3	134.8	96.	0.30		

(continued)

Table N3. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
60182	FARMING		25.6	10.0	37.0	12.0	736.0	217.	0.87	0.00	41.78
60282	FARMING		25.0	6.7	56.0	20.0	725.0	138.	0.57	0.00	42.36
60382	FARMING		22.8	7.2	69.0	24.0	729.0	132.	1.33	0.00	43.69
60482	FARMING		26.7	6.7	58.0	14.0	728.0	180.	1.12	0.00	44.81
60582	FARMING		26.7	8.9	35.0	12.0	648.0	383.	1.25	0.00	46.07
60682	FARMING		23.9	3.9	63.0	20.0	714.0	155.	0.88	0.00	47.04
60782	FARMING		27.8	7.8	45.0	20.0	746.0	227.	0.78	0.00	47.83
60882	FARMING		25.6	7.8	50.0	25.0	687.0	166.	0.96	0.00	48.79
60982	FARMING		27.8	6.7	50.0	20.0	740.0	156.	0.76	0.00	49.55
61082	FARMING		27.8	11.7	50.0	20.0	528.0	140.	0.59	0.00	50.14
61182	FARMING		28.9	11.7	45.0	22.0	747.0	188.	0.98	0.00	51.12
61282	FARMING		30.6	13.3	64.0	16.0	748.0	214.	1.30	0.00	52.42
61382	FARMING		30.0	13.3	39.0	18.0	656.0	192.	1.23	0.00	53.64
61482	FARMING		26.7	11.1	52.0	17.0	664.0	196.	0.62	0.00	54.26
61582	FARMING		26.1	7.8	54.0	17.0	682.0	208.	1.12	0.00	55.38
61682	FARMING		28.3	11.7	48.0	18.0	750.0	200.	1.00	0.00	56.38
61782	FARMING		29.4	13.3	40.0	18.0	591.0	185.	0.63	0.00	57.01
61882	FARMING		28.9	11.7	50.0	20.0	806.0	217.	1.18	0.00	58.20
61982	FARMING		26.7	12.2	68.0	14.0	618.0	274.	1.19	0.00	59.39
62082	FARMING		26.7	12.2	63.0	25.6	611.0	278.	1.10	0.00	60.49
62182	FARMING		29.4	12.8	69.0	26.0	700.0	320.	0.88	0.00	61.36
62282	FARMING		30.6	15.0	54.0	22.0	746.0	272.	1.07	0.00	62.44
62382	FARMING		31.1	14.4	52.0	18.0	754.0	188.	1.09	0.00	63.53
62482	FARMING		31.1	10.6	54.0	20.0	759.0	145.	1.00	0.00	64.54
62582	FARMING		30.0	13.3	36.0	24.0	785.0	179.	1.24	0.00	65.78
62682	FARMING		29.4	12.8	53.0	25.0	760.0	258.	1.34	0.00	67.12
62782	FARMING		32.2	13.3	59.0	26.0	695.0	154.	0.83	0.00	67.94
62882	FARMING		33.3	16.7	54.0	20.0	753.0	158.	1.21	0.00	69.16
62982	FARMING		31.7	16.1	40.0	24.0	665.0	159.	1.62	0.00	70.77
63082	FARMING		31.7	17.8	90.0	26.0	552.0	320.	0.67	0.00	71.44
	MEAN		28.4	11.3	53.2	20.2	700.8	208.	1.02		
	STANDARD DEV		2.6	3.4	11.9	4.3	67.8	61.	0.26		

Table N3. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
70182	FARMING		28.3	14.4	92.0	23.0	708.0	214.	0.94	0.00	72.38
70282	FARMING		29.4	9.4	70.0	30.0	820.0	135.	0.92	0.00	73.30
70382	FARMING		28.9	11.7	40.0	24.0	716.0	63.	0.83	0.00	74.13
70482	FARMING		30.6	13.3	52.0	30.0	566.0	193.	0.68	0.00	74.81
70582	FARMING		29.4	11.1	49.0	26.0	595.0	249.	0.77	0.00	75.58
70682	FARMING		23.3	11.7	60.0	31.0	657.0	200.	0.75	0.00	76.33
70782	FARMING		27.2	12.8	74.0	31.0	575.0	106.	0.65	0.00	76.99
70882	FARMING		28.9	14.4	80.0	24.0	703.0	114.	0.65	0.00	77.63
70982	FARMING		26.7	11.7	62.0	20.0	736.0	208.	1.10	0.00	78.74
71082	FARMING		29.4	12.2	50.0	20.0	725.0	174.	1.10	0.00	79.84
71182	FARMING		32.8	16.7	38.0	20.0	708.0	182.	1.10	0.00	80.94
71282	FARMING		33.9	17.8	46.0	16.0	751.0	211.	1.36	0.00	82.30
71382	FARMING		32.8	18.9	40.0	18.0	733.0	201.	0.67	0.00	82.97
71482	FARMING		33.3	16.7	36.0	17.0	733.0	143.	1.39	0.00	84.36
71582	FARMING		32.2	16.1	36.0	16.0	740.0	238.	0.15	0.00	84.51
71682	FARMING		30.6	17.2	77.0	26.0	533.0	164.	0.94	0.00	85.44
71782	FARMING		28.9	14.4	80.0	22.0	502.0	90.	0.48	0.53	85.92
71882	FARMING		28.9	15.6	70.0	24.0	610.0	169.	0.76	0.00	86.68
71982	FARMING		31.7	17.8	70.0	18.0	689.0	200.	0.93	0.00	87.61
72082	FARMING		33.9	15.6	54.0	17.0	711.0	180.	1.05	0.00	88.67
72182	FARMING		35.0	18.9	49.0	16.0	640.0	135.	1.12	0.00	89.78
72282	FARMING		35.0	16.7	54.0	18.0	651.0	111.	0.75	0.00	90.54
72382	FARMING		33.3	16.7	67.0	20.0	679.0	138.	0.62	0.00	91.16
72482	FARMING		32.2	16.7	48.0	24.0	636.0	121.	0.87	0.00	92.04
72582	FARMING		33.3	20.0	54.0	28.0	652.0	130.	1.25	0.30	93.29
72682	FARMING		31.7	17.8	80.0	22.0	610.0	124.	0.96	0.28	94.25
72782	FARMING		30.6	15.6	82.0	28.0	627.0	164.	0.90	0.08	95.15
72882	FARMING		28.3	16.7	84.0	28.0	490.0	106.	0.37	0.91	95.52
72982	FARMING		28.3	15.6	83.0	24.0	543.0	171.	0.87	0.00	96.38
73082	FARMING		29.4	15.6	85.0	34.0	576.0	206.	-0.00	1.02	96.38
73182	FARMING		29.4	13.3	58.0	24.0	641.0	98.	0.50	1.02	96.88
	MEAN		30.6	15.3	63.2	23.2	653.4	159.	0.82		
	STANDARD DEV		2.7	2.6	18.0	5.3	79.9	47.	0.31		

(continued)

Table N3. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
80182	FARMING		30.0	14.4	90.0	20.0	451.0	122.	1.16	0.00	98.04
80282	FARMING		27.8	17.8	82.0	28.0	488.0	132.	0.45	0.91	98.49
80382	FARMING		25.6	15.0	88.0	25.0	403.0	135.	0.75	0.00	99.24
80482	FARMING		28.3	13.9	80.0	19.0	672.0	134.	0.81	0.00	100.04
80582	FARMING		27.8	13.9	52.0	20.0	688.0	151.	1.17	0.00	101.22
80682	FARMING		32.2	17.8	70.0	26.0	647.0	183.	0.68	0.00	101.89
80782	FARMING		30.0	16.7	55.0	30.0	486.0	187.	0.64	0.33	102.54
80882	FARMING		30.0	16.7	82.0	22.0	603.0	193.	0.72	0.00	103.26
80982	FARMING		30.0	17.8	60.0	24.0	693.0	196.	0.88	0.00	104.13
81082	FARMING		32.2	17.8	59.0	24.0	604.0	303.	0.44	0.00	104.57
81182	FARMING		30.6	17.2	87.0	28.0	663.0	153.	0.84	0.00	105.41
81282	FARMING		27.8	15.0	90.0	33.0	595.0	169.	0.48	0.15	105.80
81382	FARMING		27.8	15.6	84.0	34.0	530.0	166.	0.61	0.00	106.51
81482	FARMING		26.7	16.1	89.0	28.0	646.0	150.	0.68	0.00	107.19
81582	FARMING		30.0	16.7	67.0	26.0	634.0	187.	0.80	0.00	107.98
81682	FARMING		31.7	15.0	84.0	27.0	611.0	156.	0.42	0.28	108.40
81782	FARMING		31.1	15.0	76.0	28.0	602.0	101.	0.35	0.20	108.75
81882	FARMING		30.0	17.2	24.0	25.0	645.0	119.	0.43	0.00	109.19
81982	FARMING		33.3	15.0	79.0	29.0	684.0	219.	1.46	0.00	110.65
82082	FARMING		32.2	16.1	83.0	30.0	609.0	119.	0.80	0.38	111.45
82182	FARMING		29.4	14.4	98.0	35.0	520.0	167.	0.64	1.30	112.09
82282	FARMING		26.7	15.0	96.0	43.0	424.0	69.	0.41	0.05	112.50
82382	FARMING		23.9	16.1	86.0	49.0	367.0	76.	0.12	0.23	112.61
82482	FARMING		26.1	15.0	95.0	40.0	517.0	167.	0.44	0.30	113.06
82582	FARMING		23.9	16.1	86.0	54.0	313.0	64.	0.38	2.79	113.44
82682	FARMING		25.0	12.8	89.0	48.0	420.0	56.	0.39	0.00	113.83
82782	FARMING		26.7	15.0	80.0	35.0	570.0	145.	0.82	0.00	114.65
82882	FARMING		28.9	16.1	70.0	29.0	535.0	130.	0.27	0.00	114.92
82982	FARMING		28.9	16.1	73.0	28.0	598.0	69.	0.50	0.00	115.42
83082	FARMING		29.4	16.1	70.0	29.0	638.0	219.	0.70	0.00	116.12
83182	FARMING		29.4	16.1	84.0	28.0	678.0	109.	0.84	0.00	116.96
	MEAN		28.8	15.8	78.0	31.1	565.9	147.	0.65		
	STANDARD DEV		2.5	1.3	15.7	8.6	102.2	53.	0.28		

(continued)

Table N3. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
90182	FARMING		28.9	15.0	72.0	29.0	678.0	113.	1.15	0.00	118.10
90282	FARMING		29.4	11.1	75.0	18.0	640.0	164.	0.66	0.00	118.76
90382	FARMING		29.4	17.8	56.0	26.0	719.0	142.	0.87	0.00	119.63
90482	FARMING		31.1	16.7	70.0	28.0	523.0	161.	0.71	0.00	120.33
90582	FARMING		28.9	10.0	100.0	23.0	586.0	129.	0.70	0.00	121.03
90682	FARMING		29.4	8.9	99.0	18.0	608.0	127.	0.78	0.00	121.82
90782	FARMING		27.8	14.4	60.0	27.0	535.0	246.	0.75	0.00	122.57
90882	FARMING		27.2	15.0	73.0	29.0	449.0	164.	0.55	0.00	123.12
90982	FARMING		28.3	15.6	77.0	26.0	488.0	132.	0.84	0.00	123.96
91082	FARMING		25.0	14.4	68.0	38.0	369.0	84.	0.33	0.00	124.28
91182	FARMING		16.1	12.2	100.0	70.0	144.0	69.	0.13	1.47	124.41
91282	FARMING		17.8	10.0	100.0	53.0	239.0	127.	0.03	0.53	124.43
91382	FARMING		14.4	4.4	100.0	60.0	144.0	169.	0.73	1.63	125.16
91482	FARMING		19.4	7.2	100.0	36.0	405.0	274.	0.51	0.00	125.68
91582	FARMING		26.1	8.3	75.0	26.0	489.0	212.	0.82	0.00	126.50
91682	FARMING		27.2	12.8	89.0	24.0	529.0	163.	0.41	0.00	126.91
91782	FARMING		24.4	12.8	89.0	31.0	452.0	45.	0.54	0.00	127.45
91882	FARMING		22.8	13.9	92.0	38.0	392.0	190.	0.28	0.00	127.73
91982	FARMING		26.7	12.8	91.0	24.0	446.0	185.	0.57	0.00	128.30
92082	FARMING		23.3	12.2	84.0	46.0	344.0	256.	0.10	0.13	128.40
92182	FARMING		25.0	11.1	91.0	30.0	535.0	179.	0.47	0.00	128.87
92282	FARMING		27.2	12.8	84.0	32.0	543.0	108.	0.49	0.00	129.36
92382	FARMING		26.7	12.2	90.0	33.0	569.0	148.	0.94	0.00	130.30
92482	FARMING		26.7	12.2	62.0	30.0	443.0	130.	0.46	0.00	130.76
92582	FARMING		28.3	16.1	72.0	32.0	567.0	76.	0.66	0.00	131.42
92682	FARMING		27.8	12.2	84.0	26.0	463.0	208.	0.85	0.00	132.26
92782	FARMING		20.6	11.1	84.0	30.0	277.0	286.	0.40	0.00	132.67
92882	FARMING		16.7	4.4	85.0	32.0	336.0	111.	0.30	0.05	132.97
92982	FARMING		23.3	3.9	70.0	16.0	493.0	267.	1.09	0.00	134.06
93082	FARMING		25.0	7.8	72.0	28.0	461.0	164.	1.06	0.00	135.12
	MEAN		25.0	11.6	82.5	31.7	462.6	161.	0.61		
	STANDARD DEV		4.4	3.6	13.2	11.9	139.7	63.	0.29		

(continued)

Table N3. (continued)

DATE	SITE	TIME	T(MAX) DEG.C	T(MIN) DEG.C	H(MAX) PERCENT	H(MIN) PERCENT	SOLAR LY	WIND 24-HRS KM	PAN EVAP CM	PRECIP CM	TOTAL EVAP CM
100182	FARMING		18.9	3.9	64.0	23.0	532.0	60.	0.51	0.00	135.63
100282	FARMING		17.2	1.7	80.0	34.0	399.0	169.	0.52	0.00	136.15
100382	FARMING		24.4	5.6	75.0	23.0	448.0	169.	0.60	0.00	136.75
100482	FARMING		26.1	8.9	53.0	19.0	478.0	116.	0.50	0.00	137.25
100582	FARMING		20.0	5.0	46.0	27.0	459.0	171.	0.78	0.00	138.03
100682	FARMING		18.9	-1.7	80.0	23.0	462.0	219.	0.36	0.00	138.40
100782	FARMING		25.0	5.6	48.0	16.0	468.0	396.	1.04	0.00	139.44
100882	FARMING		11.7	3.3	58.0	22.0	460.0	346.	0.63	0.00	140.07
100982	FARMING		12.2	-0.0	70.0	32.0	511.0	171.	0.55	0.00	140.62
101082	FARMING		16.1	-1.7	79.0	26.0	381.0	24.	0.51	0.00	141.13
101182	FARMING		14.4	1.1	64.0	44.0	302.0	80.	0.59	0.00	141.72
101282	FARMING		15.0	-1.7	100.0	28.0	394.0	63.	0.63	0.00	142.35
101382	FARMING		16.1	0.6	89.0	27.0	414.0	89.	0.63	0.00	142.99
101482	FARMING		17.8	1.7	69.0	19.0	483.0	161.	0.62	0.00	143.61
	MEAN		18.1	2.5	69.6	26.6	442.2	159.	0.61		
	STANDARD DEV		4.5	3.3	15.5	7.3	59.4	106.	0.16		