9-15-1995

Evaluation of Irrigated and Non-Irrigated Corn Production in Brookings County

Douglas Franklin
South Dakota State University

Eric S. Stebbins

Recommended Citation
Franklin, Douglas and Stebbins, Eric S., "Evaluation of Irrigated and Non-Irrigated Corn Production in Brookings County" (1995). *Department of Economics Research Reports.* Paper 51.
http://openprairie.sdstate.edu/econ_research/51

EVALUATION OF IRRIGATED AND NON-IRRIGATED CORN PRODUCTION IN BROOKINGS COUNTY

by

Douglas R. Franklin & Eric S. Stebbins*

Economics Research Report 95-3
September 1995

Abstract

The evaluation of irrigated corn production requires crop water production functions which are time and location specific. This analysis evaluated irrigated and non-irrigated corn production from 1984 to 1993 in Brookings County. The CERES-Maize crop simulation model generated agronomic data which was representative of Brookings County. Crop budgets were created to establish production costs associated with the study area. Net returns for each of the production methods were compared.

The authors wish to thank South Dakota State University Economics Department faculty members Drs. Dillon Feuz and Bashir Qasmi for their review of an earlier draft of this report and to Drs. Don Taylor and Larry Janssen for their helpful comments.

[*] Franklin is an Associate Professor of Economics and Stebbins is a former Graduate Research Assistant at South Dakota State University.

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS

Page

INTRODUCTION

South Dakota agriculture has undergone many changes in recent years. The increased use of irrigation in South Dakota is an example of one of these many changes. From 1940 to 1987, the total number of irrigated farms and total acres irrigated in South Dakota have increased by 93 and 569 percent, respectively. From 1974 to 1990, the total number of irrigated farms increased by 74 percent and total acres irrigated by 138 percent (Franklin, et. al, 1991). Even though the growth of irrigated farms and land in South Dakota is increasing, in 1992, the number of irrigated farms was 1,674, or 0.5 percent of the total number of farms, and the number of irrigated acres was 371,263, or 0.8 percent of the total acres (U. S. Department of Commerce).

These statistics reflect the trend toward South Dakota's increased use of irrigation. Irrigation is appealing to the producer because it expands income earning potential and reduces risks associated with drought conditions (Shane et. al., 1982).

The potential for irrigation development in South Dakota is large. Ground water is abundant with known physical supplies over 3.97 billion acre feet. The Missouri River also extends through the state providing an excellent source for irrigation water. Approximately 25 percent of the permitted area for irrigation in South Dakota uses the Missouri River as a water supply (De Boer, et. al., 1989). Irrigation represents an opportunity for farmers to increase income earning potential while reducing risk. The effectiveness of this farming practice largely depends on prevailing factors which are location and time specific. Producer level agronomic data is necessary to accurately investigate the economic effects of implementing irrigation into a farming operation.

Numerous irrigation studies (Stone, et. al., 1978; Wilson 1978; James, et. al., 1983; and Moore et. al., 1984) which examine water-yield relationships exist. They examine agronomic relationships which focus on maximizing yields given some existing conditions. Considerable work (Taylor, 1985; Everson, 1979; and Hoyt, 1984) also has been done examining the economic feasibility of irrigation. This research is often directed at state or regional levels. Examination of the long run profitability of regional irrigation projects is often the intended goal.

Crop simulation models are becoming more prevalent in research. Simulation models seem to have found a place in economic studies wherever sufficient data does not exist. The results can provide estimates for missing data, expand data sets, or fit data to better adapt to the framework of a study. Simulated agronomic data, based on a selective soil type, prevailing weather, and accepted management practices, associated with the study area, provide "localized" yield functions. These functions are the basis for economic analysis. Crop simulation models offer the opportunity to generate large numbers of yield distributions which can be converted to net returns for comparison. CERES-Maize is a model that simulates maize growth and development. The results of a simulation model, CERES-Maize, on Brookings County, South Dakota is reported here.

OBJECTIVE

The objective of this research is to determine the profitability of irrigated corn compared to non-irrigated corn in Brookings County, South Dakota. To achieve this objective, irrigated and non-irrigated corn yields using CERES-Maize are simulated and annual crop budgets, with costs and corn prices representative of the area from 1984 to 1993 are developed.

STUDY AREA

Brookings County is in the east central region of South Dakota. The area can normally expect 150 frost free days. The last spring frost typically occurs at the end of April or the first week in May, while the first autumn frost can be expected toward the end of September. Growing season precipitation from April through September averaged 17 to 19 inches annually over the 30 year period from 1961 to 1990 (South Dakota Agricultural Statistics Service, 1992).

The 1992 census reported that there were 959 farms in Brookings County with the average farm size being 463 acres. There were 444,440 total acres of land in farms with 14,666 acres being irrigated on 79 farms within the county (South Dakota Agricultural Statistics Service, 1995). The majority of the irrigation done in Brookings County involves the use of center-pivot irrigation systems. The lack of level land necessary for gated pipe irrigation and the fact that pivots are less labor intensive have contributed to the popularity of center pivots (Everson, 1979).

Brookings County ranked ninth in the state in corn production in 1992; 117,700 acres of non-irrigated corn and 13,100 acres of irrigated corn were planted (South Dakota Agricultural Statistics Service, 1992). Brookings County consistently ranks as one of the top five corn producing counties in the state.

PRINCIPLES OF CORN PRODUCTION

As with all crops, corn yields are influenced by the levels of heat and water available during the growing season.

Plant - Temperature Relationship

Corn requires warmth throughout its active life. It is sensitive to frost at all stages with responses to temperature varying with developmental stages. Frosts can be injurious to the crop anytime after emergence. In the growth stages from emergence to tasseling temperature can be the single most important factor influencing crop development. Agronomists typically measure the general effect of temperatures during the growing season as "degree days" or "heat units". Because corn growth below a certain temperature is curtailed, these units are usually stated over a base temperature, for example 10 degrees C, or 55 degrees

F. Studies have shown that heat units accumulated over a base temperature are a better guide to maize development than days from planting or emergence. Monthly mean temperatures of 22 to 23 degrees Celsius (72 to 74 degrees Fahrenheit) have been found to be optimal for corn development. After the crop has reached physiological maturity, warmer temperatures can be beneficial to help reduce grain moisture (FAO, 1980).

The length of the growing season needed varies with different varieties of the corn. Early fall or late spring frosts are usually the limiting factor on growing seasons.

Plant - Water Relationship

Corn produces one kg of dry matter for every 370 to 400 kg of water used (FAO, 1980). Since corn has a high water requirement, moisture can be the most important factor limiting yield on non-irrigated farms. In many areas rainfall alone seldom meets the requirement to maximize potential yield. The rainfall in the corn belt normally ranges from 22 to 45 cm (8.7 to 17.7 in.) during the 100 to 130 days of corn growth and development. A dry period, even of short duration, may reduce plant growth and yields considerably.

Several factors concerning moisture are important in successful corn production. These factors include the amount, efficiency, and distribution of precipitation. The moisture requirement of the crop depends on the growth stage. During early stages of development the crop requires little water. Corn requires the bulk of its moisture from the tasseling through the flowering stage. Corn is especially sensitive to moisture stress during flowering. Even short periods of stress during this critical stage can reduce yields 30 to 50 percent (FAO, 1980).

The crop can be expected to use 480 to 800 mm (19 to 31 inches) of water throughout the growing season for optimal yield. However, many factors can influence the water requirements of the crop and it must be remembered that distribution of moisture is as important as the total amount of rainfall available.

Evapotranspiration is the combined effect of water loss due to evaporation and the natural process of water passing to the atmosphere through plant leaves called transpiration. Cumulative evapotranspiration (CET) represents the total water used by the crop throughout the growing season. When conditions are not limiting, the maximum value depends upon climatic, atmospheric, and geographical conditions, and is termed potential evapotranspiration (PET) (Finkel, 1983).

Proper scheduling is critical for irrigation to be successful. Several factors influence irrigation scheduling. The crop irrigated, soil conditions, weather related variables, and phenological growth stages in plants will all influence irrigation. The period from tasseling to the dough stage of grain development is the most critical growth period in relation to the availability of water. During this stage allowable depletion levels are lower and proper irrigation scheduling is crucial for optimal yield.

Thus, length of growing season, temperature, precipitation, and other climatic factors tend to be interdependent on crop development and all must be considered together to determine overall environmental effects.

According to the Food and Agriculture Organization of the United Nations (FAO 1980):

> "In drier areas increased intensity of radiation increases water losses and thus yields tend to be negatively correlated with radiation. However, in regions with adequate soil moisture decreased light intensity due to heavy cloud cover tend to limit crop yield by reducing the rates of photosynthesis. With adequate soil moisture, plant nutrients, and proper management, the light intensity in the crop canopy seems to be the most important factor limiting crop yields." (p.146)

CERES-MAIZE SIMULATION MODEL

CERES-Maize is a daily-incrementing simulation model of maize growth, development, and yield. The model has four major components: weather, soil, management, and output. Simulating maize development takes into account the following processes: phenological development, especially as it is affected by genotype and weather; extension growth of leaves, stems, and roots; biomass accumulation and partitioning, especially as phenological development and growth of vegetation and reproductive organs; soil water balance and water use by the crop; and soil nitrogen transformations, uptake by the crop, and partitioning among plants (Ritchie, et. al., 1992).

The CERES-Maize simulation program uses specific weather data in the simulation process. The weather data include weather station name and location (latitude), minimum and maximum temperature, precipitation, and solar radiation. Since the simulation model functions on a daily-incrementing process, these variables must be provided on a daily basis. The minimum weather data set must include at least all the days in the growing season. Ideally this should contain weather data from before planting to after crop maturity. This enables the simulation to start before planting and all soil processes would be considered (IBSNAT, 1990).

The soil profile properties are used in the soil-water, nitrogen, and root growth sections of the crop model. The soil variables are in two forms. First, soil profile variables, which include: bare soil albedo, measures the soil's reflectivity and absorption of sunlight; upper limit of stage 1 soil evaporation; soil water drainage constant; annual average ambient temperature, refers to the average soil temperature throughout the root growth sections of the soil; annual amplitude in mean monthly temperature; and a variable that allows for the identification of soils which are poor mineralizers due to chemical or physical protection of the organic matter.

Second, soil profile descripter variables, which include: thickness of the soil layer; lower limit of plant-extractable soil water for soil layer; drained upper limit soil water content for soil layer; saturated water content for soil layer; default soil water content for soil layer; weighing factor for soil depth to determine new growth distributions; moist bulk density of soil in soil layer; organic carbon concentrate in soil layer; soil ammonium in soil layer; soil nitrate in soil layer; pH in the soil layer; and saturated hydraulic conductivity in soil layer (IBSNAT, 1990).

A third component of the CERES-Maize model is the management component which contain crop management data. This identifies treatment and farm management practices associated with the specific area of crop growth. The management inputs include: soil identification number; cultivar number for the treatment; the Julian day simulation begins; sowing date; plant population; row spacing; sowing depth; irrigation management variable; nitrogen application variable; irrigation system efficiency; irrigation management depth; available water; and number of years of simulation (IBSNAT, 1990).

The output is accumulated by phenological growing stages. These include sowing, germination, emergence, end juvenile, tassel initiation, 75 percent silking, begin grain fill, end grain fill, and physiological maturity, given in respective order of occurrence. The beginning date of each stage is given. Information for all of the above variables are recorded within each growing stage.

The model records the final yield, grain number, and kernel weight. If irrigation is applied, the date and amount of each irrigation application is recorded (IBSNAT 1990).

PROCEDURE

The primary objective is to determine the profitability of irrigated and non-irrigated corn using a crop simulation model. The first procedure was to incorporate weather, soil and management data associated with CERES-Maize and generating agronomic data. The development of crop budgets for a representative farm operation in Brookings County and the economic adjustment over a ten year time horizon was then determined.

CERES-Maize Simulation Model

The first procedure was the simulation of crop yields using CERES-Maize. In order for the simulation process to effectively represent corn growth in Brookings County, weather, soil, and management procedures indicative of the area had to be established.

Weather

Weather information was gathered from the weather station at South Dakota State University. The location specified to the model was 44.19 degrees north latitude and 96.48 degrees west longitude. Daily weather data, temperature highs and lows, precipitation, and solar radiation, was entered for the period from 1984 to 1993.

Frost damage is assumed to be non-existent. However, within the northern region of the U.S. corn belt late spring or early fall frosts can have extreme impacts on corn production. The CERES-Maize program terminates when a daily temperature below freezing is encountered once the crop has emerged. The indetermination of the severity of frost damage on the crop during a given year was the basis for assuming no frost damage.

The model does not take into account problems such as hail damage, pest and insect related problems, weed problems, or diseases. The only potential "disasters" the model considers include those derived from the model inputs, such as, droughts and temperature effects (other than frost) on crop development, and solar radiation as it impacts photosynthesis and crop development.

Soil

The Brookings County Soil Conservation Service (SCS) identified three major soil types which were most representative of irrigated corn production in the area. These were Estelline, Brandt, and Renshaw soil types. Estelline soil, Pachic Udic Haploborolls, was further identified as the dominant of the three associated with irrigated corn in Brookings County.

Estelline soil is a silt loam over a gravelly or sandy substrata. The top 71 cm are defined as a silt loam. From 71 to 97 centimeters in depth the soil is classified as a sandy loam. Below 97 centimeters the soil is sand and gravel. Table 1 illustrates the soil composition and moisture holding capacity of Estelline soil with reference to depth. The soil composition information was used to estimate the lower limit of plant extractable water, and the drained upper limit of soil water content. These refer to estimates of the permanent wilting point and field capacity.

Table 1: Soil composition and moisture holding capacity.

DEPTH (cm)	COMPOSITION (%)			L.LIMIT (cm^3/cm^3)	U.LIMIT (cm^3/cm^3)
	Clay	Silt	Sand		
0- 18	24.4	58.2	17.4	.144	.282
18- 32	26.4	59.5	14.1	.153	.291
32- 46	26.1	62.4	11.5	.152	.291
46- 58	25.4	66.3	8.3	.149	.290
58- 71	19.4	62.1	18.5	.122	.261
71- 84	14.6	33.8	51.6	.101	.226
84- 97	11.4	15.1	73.5	.087	.202
97-124	3.8	7.5	88.7	.039	.124
124-152	2.1	7.4	90.5	.036	.114

Estelline soil has a potentially high crop production level. The soil can sustain very productive crop yields if adequate moisture is available. However, due to the structure of this soil type it can drain quickly and dry out. This is evident in Table 1 by the low water holding capacity at lower depths within the soil profile. This can have very adverse effects on crop production when dry periods persist.

Management

The management variables were chosen to best represent farm management practices in Brookings County. The management variables are given in Table 2.

Table 2: Management variables in CERES-Maize.

	Irrigated	Non-irrigated
Seed Variety:	Pioneer 3475	Pioneer 3475
Row Space:	30 inches	30 inches
Plant Population:	30,000 p/ac.	22,000 p/ac.
Planting Date:	May 5	May 5
Fertilizer Rates:	N=180 lb./ac.	N=120 lb./ac.
	P=45 lb./ac.	P=45 lb./ac.
	K=20 lb./ac.	K=20 lb./ac.

Irrigation

CERES-Maize has an automatic irrigation option which was used to trigger an irrigation event. An irrigation event was triggered when 50 percent of the soil moisture was depleted within the top 18 inches of the soil profile. Irrigation continues until the profile is refilled to the drained upper limit.

The model uses the weather and soil profile files and the automatic irrigation option to establish irrigation schedules. Within these schedules the amount of water applied and the date of application are recorded. These schedules reflect two important assumptions. First, the allowable soil moisture depletion level is constant. Throughout the growing season the allowable depletion level is always at 50 percent. Second, when an irrigation event is triggered irrigation continues until the soil profile is completely full. In most cases irrigators will not apply water to completely refill the soil profile to field capacity.

Crop Budgets

The development of crop budgets involved inputs that were directly and indirectly established, and thus, expenses that were directly and indirectly derived. Directly established inputs included seed, nitrogen fertilizer, and variable irrigation inputs. The expenses associated with these inputs were derived by multiplying input cost per unit by their respective quantities employed.

Indirect established inputs included phosphorous and potassium fertilizer, herbicide, insecticide, drying, overhead, fuel and lubrication, machinery repair, interest on operating loan, interest on machinery investment, depreciation on machinery and equipment, machinery housing and insurance, labor, real estate taxes, and land charges. Estimates of accepted farm management practices and associated expenses in the region were estimated from Hoyt, et. al.

Expenses assumed to differ between irrigated and non-irrigated production, included: seed expense, nitrogen fertilizer expense, crop drying expense, labor expense, and expenses related to irrigation operation and ownership.

All other expenses, such as, herbicide, insecticide, overhead, fuel and lubrication, machinery repair, interest on machinery investment, depreciation on machinery, machinery housing and insurance, real estate taxes, and land charges, were assumed to not vary between irrigated and non-irrigated production. It is recognized that some of these expenses, such as non-irrigation machinery depreciation, will vary between irrigated and non-irrigated production. However, it is difficult to estimate the magnitude of this variation because it is based on crop yield differentials and operational-based related differences.

Input Prices

Seed and fertilizer prices per unit were obtained from local dealers. Estimated herbicide cost, overhead, fuel and lubrication, and machinery repair were obtained from Hoyt, et. al., which are reflective of a "typical" operator in Brookings County. Drying costs were calculated as a flat rate estimate of $.15 per bushel.

Annual interest on machinery investment, housing, and insurance is estimated to be approximately 10, 1, and 0.5 percent, respectively, of the average machinery investment.

Depreciation of non-irrigation machinery and equipment is based on a straight line depreciation rate of 8 percent of the purchase price

(10-year life, purchase price was estimated at 167 percent of the average machinery investment, and salvage value equal to 20 percent of purchase cost).

Operator labor is the estimated time to perform the machine operations, time spent preparing machinery, planning business, keeping records, purchasing supplies, and marketing. Operator labor was estimated to be 2.25 hours per acre for non-irrigated production and 2.9 hours per acre for irrigated production (Taylor et. al, 1986).

Real estate taxes was calculated at 1.2 percent of the estimated land value averages.

A cost associated with crop operating loan was estimated to cover 75 percent of the variable costs for 7 months. The interest rates used in the budget were short-term agricultural loan rates for each respective year.

Irrigation costs - system design. A center pivot irrigation system is assumed to irrigate 130 acres which is a standard size system. The tower system is non-towable consisting of 6 towers totaling 1,288 feet in length. The well is assumed to be in the field at the location of the system. The system has an 800 gallon per minute pumping capacity. This converts into the ability to pump 1.77 acre inches per hour. The entire system is 48 horsepower (H.P.). This consists of a 40 H.P. pump, six 1 H.P. drive motors, and a 2 H.P. booster pump. The amount of irrigation water applied is directly simulated by the model. The system was estimated to have an average pull of 30 to 32 H.P. and required 27.5 kilowatt hours per hour of operation. The amount of time needed to apply the water with the irrigation system was calculated by dividing the amount applied by 1.77 acre inches per hour times 130 acres. The system running time was then multiplied by 27.5 kilowatt hours per hour to determine the kilowatts used. The irrigation system that was assumed to be used was a Valley 6000 system with a Nelson low pressure sprinkler package.

Irrigation costs - system cost. Farmers Implement and Irrigation of Brookings, SD provided cost estimates for the system. Information in Table 3 lists the components of the system and prices.

Table 3: Irrigation System Initial Investment.

Irrigation Component	Base Price
Base Beam/Drive Unit	$ 30,000
Sprinkler System	$ 2,800
Pipeline System	$ 800
Well/Casing	$ 5,000
Pump	$ 6,000
Pump Control Panel	$ 2,000
Auto Restart System	$ 400
Total System	$ 47,000

Irrigation systems represent multi-period input use, thus, the irrigation lease/ownership costs is reflected through an amortization process. The purchase of the irrigation system was assumed to be via lease ownership.

The lease/ownership agreement consisted of seven equal fixed annual payments and a 10 percent buy out cost during the eighth year. The present value of these series of payments was determined using a 7.5 percent discount rate. The sum of the present values is converted to an annual basis and adjusted over the twenty year useful life of the system. This represent annualized "financial" ownership costs with attention given to the "economic" value of the system over its useful life.

The depreciation on the irrigation system was calculated by using a straight line method with the system having a useful life of 20 years and no salvage value.

Irrigation costs - electric cost. The electric rate structure faced by irrigators was obtained through Sioux Valley Electric Cooperative located in Colman, S.D. The rate structure includes a facilities charge of $20.00 per maximum kilowatt per year; a full service demand charge of $5.00 per metered kilowatt per month; and a two step declining energy block charge which consisted of a $.050 charge per kilowatt hour for the first 100 kilowatt hours per kilowatt and a $.020 charge per kilowatt hour in excess of 100 kilowatt hours per kilowatt.

The maximum kilowatts used in the calculation of the facilities charge should represent the maximum 30 minute demand measured from the previous irrigation season. In cases where this is the first year of irrigation the maximum kilowatt is calculated by multiplying the nameplate H.P. by .746.

A facilities charge was estimated for each year. The demand charge was paid in only those months when irrigation occurred. If the model did not schedule any irrigation in a given month no demand charge was calculated.

Irrigation costs - miscellaneous cost. Other direct irrigation expenses were obtained from a local irrigation dealer. Maintenance and repairs were estimated at $120 annually for servicing the irrigation system and $100 annually for replacing a drive motor once every two years. Insurance on the irrigation system was estimated to cost $7.50 per $1,000 of system value annually. The initial purchase price was used as a base value when considering insurance.

Summary

The expenses were summed to compile a per acre production cost for both irrigated and non-irrigated corn production. Dividing total production costs by the per acre simulated yield calculated a per bushel production cost.

Land charges, estimated at 8 percent of current land value, which represented cash rent paid, or a share of the total income if share rented, or a percentage of the current land value, were added to the estimated production expenses to calculate total cost. Breakeven corn costs were estimated based on the simulated yield and total costs.

The method for determining the annual adjustments to the input costs are given in Appendix A.

AGRONOMIC RESULTS

CERES-Maize generated simulated corn yield for irrigated and non-irrigated corn for the ten year period from 1984 to 1993. The simulated agronomic output, weather, irrigation data, and crop budgets for the period from 1984 to 1993 are contained in Appendix B.

Output Characteristics

The simulated yields per acre ranged from 6.1 bu. to 163.5 bu. for non-irrigated corn production and 70.2 bu. to 279.9 bu. for irrigated corn production. Figure 1 and Table 4 contain information on simulated yields. The ten year average yield per acre was 67.5 bu. for non-irrigated and 186.3 bu. for irrigated corn production. The variation in non-irrigated yields can be attributed to total precipitation available and the distribution of that precipitation throughout the growing season. Precipitation ranged from 215 mm to 556 mm with a mean value of 364 mm during the growing seasons over the ten year period.

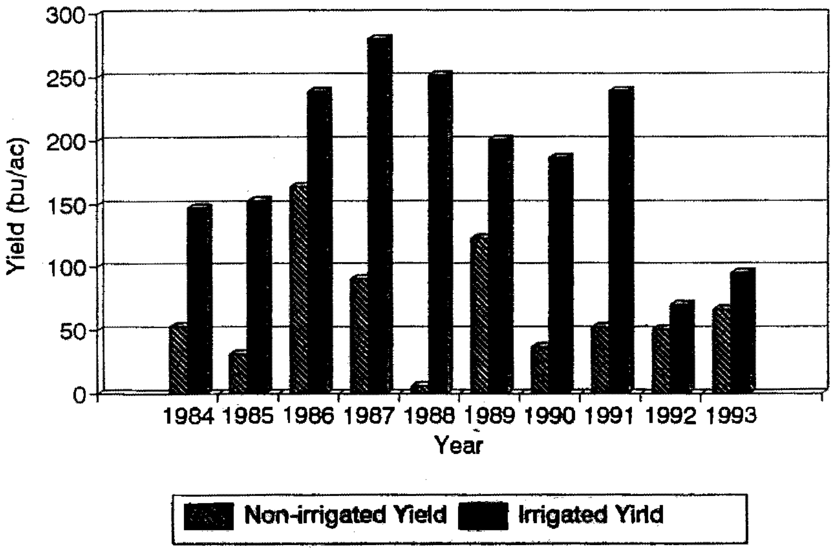


Figure 1. Simulated Yields
1984 to 1993

Table 4: Simulated non-irrigated and irrigated yields.

YEAR	NON-IRRIGATED YIELD bu/ac	IRRIGATED YIELD bu/ac
1984	53.0	147.5
1985	31.1	152.7
1986	163.5	238.4
1987	90.7	279.9
1988	6.1	251.9
1989	123.2	200.8
1990	36.9	186.3
1991	52.6	239.5
1992	50.9	70.2
1993	66.7	95.6

Reference: Appendix B.

Irrigation was primarily a supplemental source of water throughout the ten year period. Only in a drought year, 1988, did irrigation account for the majority of water available to the crop, Figure 2. In this region, unlike more arid regions, the principal function of irrigation is to provide a secondary source of water to maintain a timeliness of water used by the crop throughout the growing season.

Figure 2. Available Water

Precip. & Irrigation from 1984 to 1993

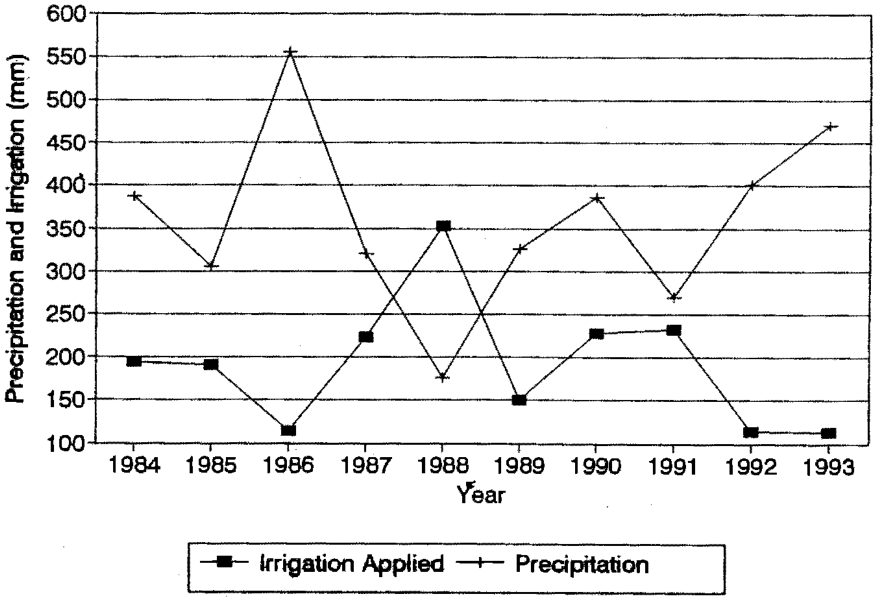


Table 5 illustrates irrigation as a supplemental water source over the ten year period. Less than 10 inches of irrigation water was applied in 9 of 10 years. During four growing seasons less than 5 inches of irrigation was applied. The drought year of 1988 was the only year which relied heavily on irrigation to produce a crop.

Table 5: Irrigation water applied.

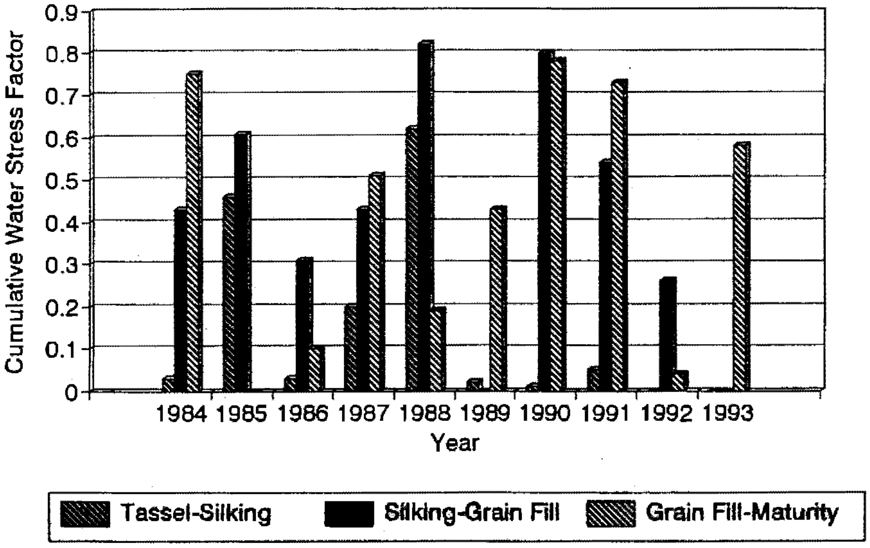
Irrigation Water Applied/Year		
0 to 5 in. (0-127 mm)	5 to 10 in. (127-254 mm)	10 to 15 in. (254-381 mm)
1984	1985	1988
1986	1987	
1992	1989	
1993	1990	
	1991	

Reference: Appendix B.

The distribution of rainfall with reference to phenological growing stage is as important as the total amount received throughout the growing season. Figure 3 illustrates a cumulative water stress factor, with 0.0 representing minimum water stress and 1.0 representing maximum water stress, for there growth stages, in non-irrigated corn, most sensitive to water stress.

Figure 3. Cumulative Water Stress

Non-Irrigated Corn from 1984 to 1993



The three years with the lowest yields 1985, 1988, and 1990 had the highest stress factor, above 0.6, during the silking to begin grain fill stage.

The importance of receiving rainfall in a timely manner is also important. During the 1990 growing season 386 mm of rainfall was received and the CDTT, cumulative heat unit factor, was 1511. During the 1989 growing season 326 mm of rainfall was received and the CDTT was 1440. The 1990 growing season had more rain and solar radiation compared to the 1989 season, yet the yield was smaller, 36.9 bu. per acre compared to 123.2 bu. per acre. The main difference was the distribution of rainfall received. The 1990 growing season received the majority of its rainfall early in the growing season (May and June) while the 1989 growing season rainfall was more evenly distributed. Adequate precipitation was received during the critical growth stages of the crop. Therefore, a lower moisture stress level was established during these critical stages which resulted in a much higher yield.

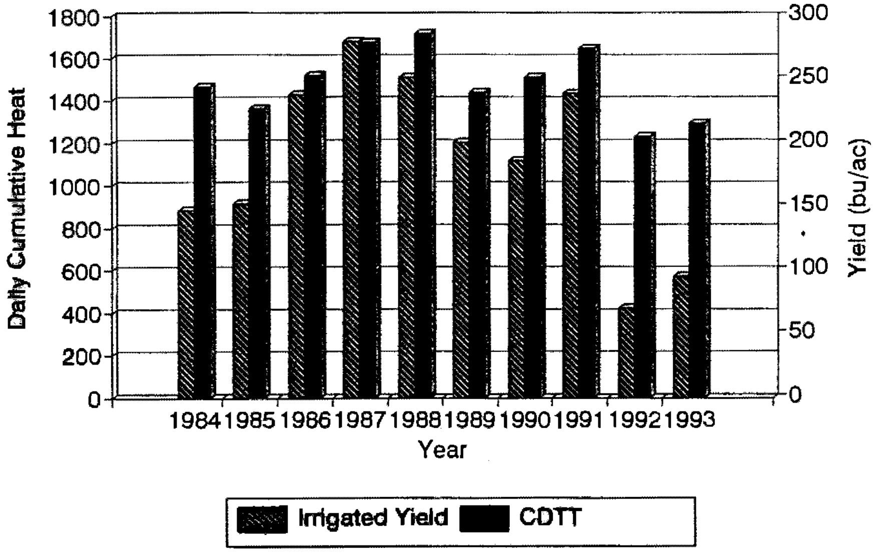
With respect to the irrigated corn production, the simulation process limited moisture stress throughout the growing season. Rainfall and irrigation ranged from 476 mm to 670 mm with a mean value of 559 mm during the ten year period. Thus, factors other than moisture stress influenced yield and yield variability. One factor which influenced the variability of yields considerably was the cumulative heat factor, CDTT. It is associated with temperature and solar radiation. The CDTT values ranged from 1233 to 1718 with a mean value of 1487 over the ten years.

CDTT had two noticeable effects on irrigated production. First, as CDTT increased, total crop-water needs (rainfall and irrigation) increases to compensate for higher evapotranspiration (CET) rates. Without additional recorded rainfall, the simulation model increased irrigation to compensate for the higher CET rates. This was an effect of a higher CDTT, but not an effect which influenced yield variability.

Second, lower than normal CDTT levels influenced yield variability in irrigated production. Figure 4 shows the relationship between CDTT and irrigated yields. Once moisture stress was removed, with irrigation, the major limiting factor was associated with cool temperatures and low levels of solar radiation. The 1992 and 1993 growing seasons were cooler than normal. These two years produced the lowest irrigated yields in the ten year period. Even though crop moisture was available, the cool temperatures and low levels of solar radiation slowed crop development and in turn limited yield.

Figure 4. Cumulative Heat and Yield

Irrigated Corn from 1984 to 1993



Figures 5 and 6 illustrates cumulative evapotranspiration, CET, by growth stages for non-irrigated and irrigated corn. There are two important characteristics associated with Figures 5 and 6. First, the majority of CET occurs during the final three growth stages (tasseling through maturity). Second, the total water usage, represented by CET, is higher and more stable in irrigated production over the ten year period. The CET associated with non-irrigated corn varies considerably in the critical growth stages. This is a reason for the wide variability of non-irrigated yields from one year to another.

Figure 5. CET through Growth Stages
Non-Irrigated Corn from 1984 to 1993

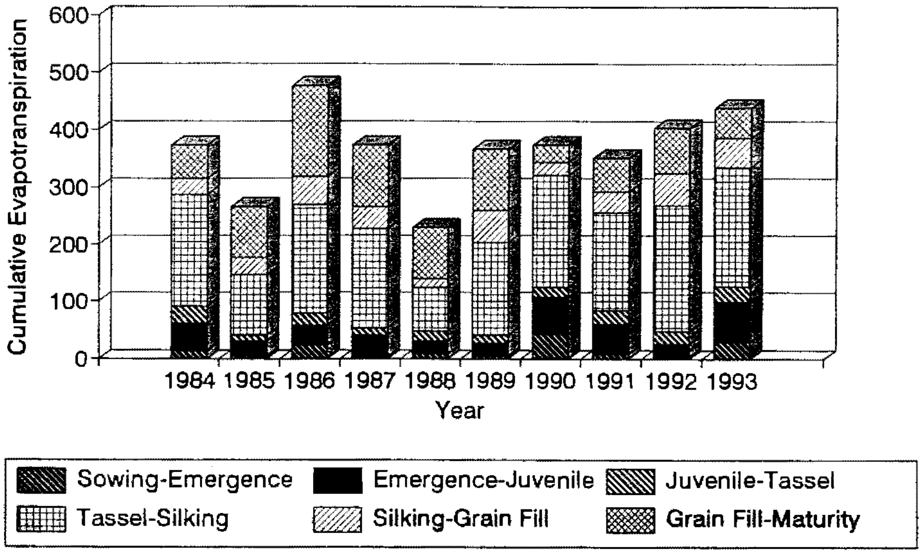
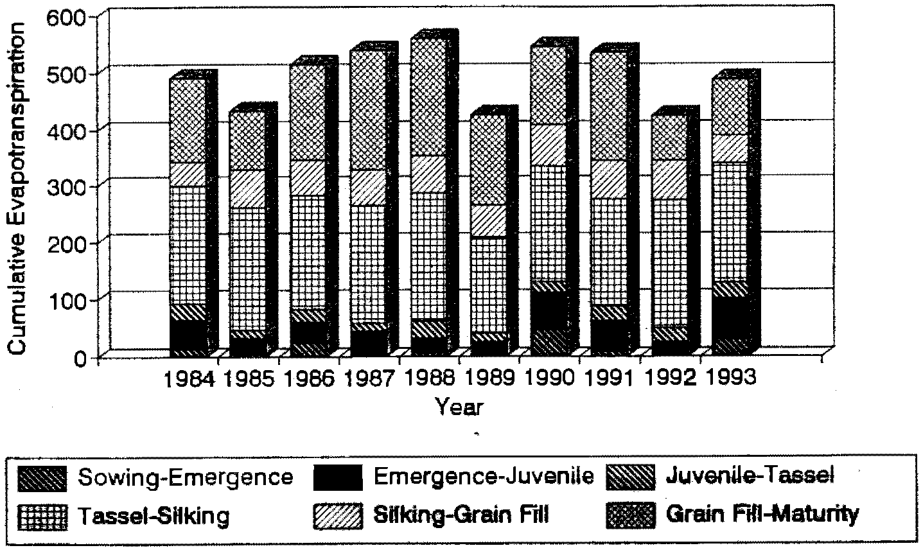


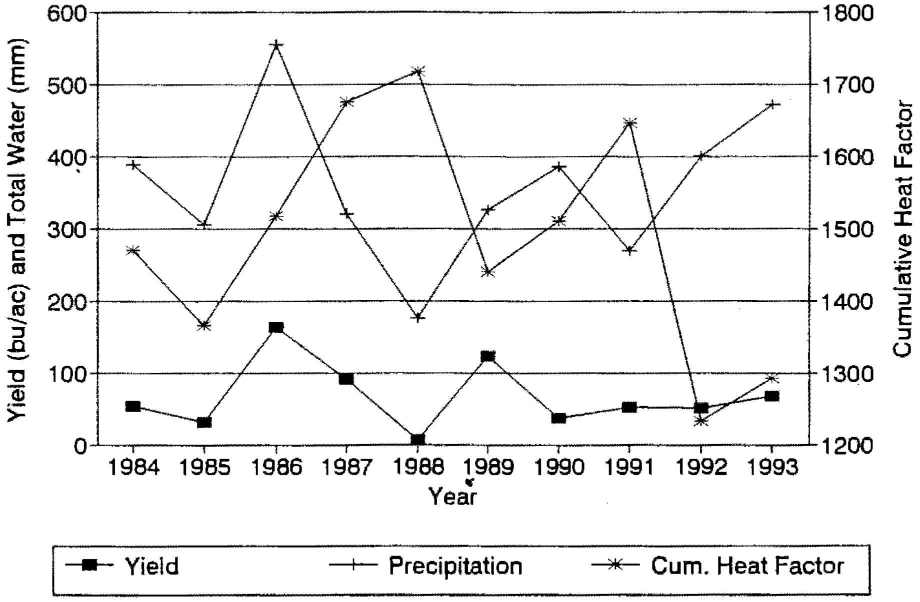
Figure 6. CET through Growth Stages
Irrigated Corn from 1984 to 1993



Figures 7 and 8, illustrates the relationship between yield, precipitation, and CDTT (the cumulative heat factor). Precipitation for non-irrigated corn is rainfall received. Non-irrigated corn yield mirrors precipitation each time period (Figure 7).

Figure 7. Yield, Total Water & Heat

Non-Irrigated Corn from 1984 to 1993



Precipitation for irrigated production represents rainfall and irrigation water applied. Irrigated corn yield mirrors CDTT (Figure 8).

Figure 8. Yield, Total Water & Heat

Irrigated Corn from 1984 to 1993

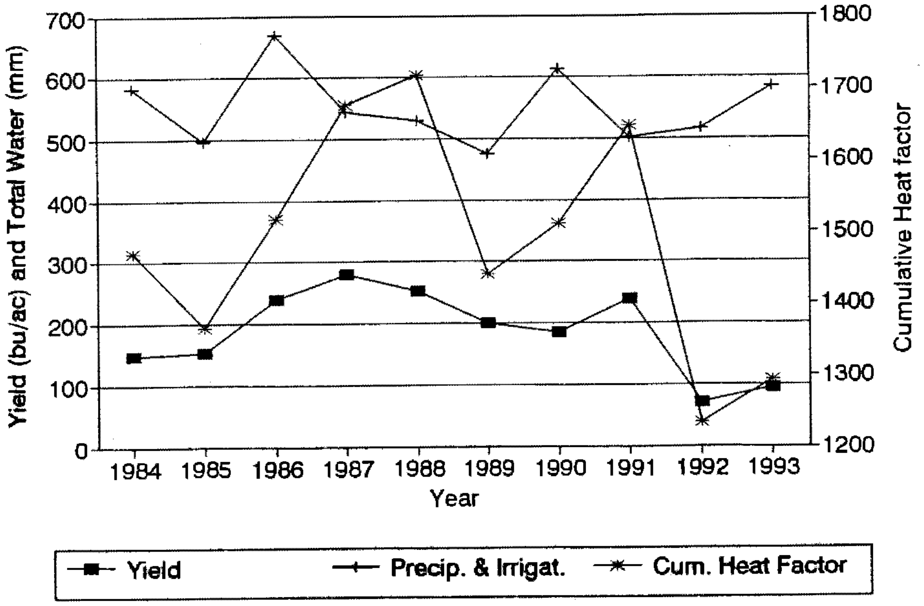


Table 6 presents measures of correlation between yield, precipitation, and CDTT for non-irrigated and irrigated corn production. The cumulative heat factor, CDTT, has the highest correlation to irrigated yield and precipitation has the highest correlation to non-irrigated yield.

Table 6: Pearson correlation coefficients.

Item	Pearson Coefficient	Prob. Rho=0
CDTT*Irr. Yield	.93417#	.0001
CDTT*Irr. Precip.	.20755	.5650
Irr. Yield*Irr. Precip.	.17193	.6348
CDTT*NonIrr. Yield	-.05093	.8889
CDTT*NonIrr. Precip.	-.50747	.1343
NonIrr. Yield*NonIrr. Precip.	.62738#	.0522

Significant @ .05 level.

ECONOMIC RESULTS

The output price of corn represent marketing year averages. The marketing year average corn prices are based on monthly prices weighted by monthly marketings for the period from September through August of each year (South Dakota Agricultural Statistics Service, 1992). The output price of corn, used in the analysis, do not reflect any involvement in government programs. Additionally, crops are assumed to be not insured. The budgets do not reflect any crop insurance expense or revenue from crop insurance or disaster payments during poor years. Insuring crops is strictly an individual producer choice, thus, purchasing crop insurance can reduce income variability and may distort the profitability comparison between non-irrigated and irrigated production. Depending on a given year, yield, and individual producer, government support programs and crop insurance may have a considerable impact on the profitability conclusions.

Economic Analysis

The crop budgets were generated and breakeven costs of producing irrigated and non-irrigated corn for each year were simulated. The simulated breakeven corn costs include all variable and fixed costs, including land charges, for producing corn. The simulated breakeven corn costs were calculated by dividing the per acre production cost by yield for each respective year. The simulated breakeven corn costs were compared to marketing average corn prices (South Dakota Statistics Service 1990, 1994) in the analysis. Table 7 lists breakeven costs for non-irrigated and irrigated corn production, and marketing year average corn prices. The ten year average cost is calculated as a weighted average cost based on simulated annual yields and production cost. The severe drought year of 1988 which resulted in non-irrigated production of 6.1 bu. per acre distorts the ten-year breakeven analysis. Therefore, average cost excluding the drought year, 1988, is also reported in the table as a second average cost.

Table 7: Breakeven cost and marketing year average price from 1984 to 1993. ($ per bu.)

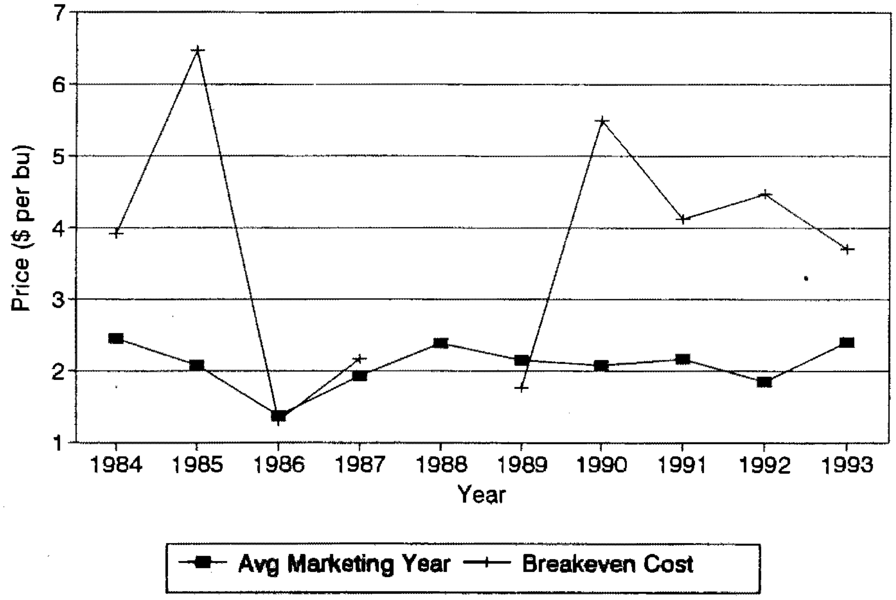
	Breakeven Cost		Marketing Year
Year	Non-irrigated	Irrigated	Ave. Corn Price
1984	$ 3.90	$2.17	$2.45
1985	$ 6.46	$2.07	$2.07
1986	$ 1.30	$1.32	$1.37
1987	$ 2.16	$1.14	$1.92
1988	$30.93	$1.29	$2.38
1989	$ 1.76	$1.63	$2.14
1990	$ 5.49	$1.73	$2.08
1991	$ 4.12	$1.44	$2.16
1992	$ 4.46	$4.64	$1.84
1993	$ 3.70	$3.65	$2.40
Weighted Average Cost per Bushel			
	1. $ 3.13	$1.75	$2.08
	2. $ 2.88		

Note: (1.) includes 1988, (2.) excludes 1988
Reference: Appendix B.

A high and low prices for each year was constructed by adding and subtracting one standard deviation to the marketing average corn price for each respective year. Figure 9 and 10 shows non-irrigated and irrigated corn production breakeven costs, respectively, with the high and low corn prices over the ten year period. With non-irrigated corn production, Figure 9, only 1989 was profitable using the low corn price range. Three years, 1986, 1987, and 1989, were profitable using the high corn price range. Seven of the ten years were not profitable even using the high corn price range. The weighted average breakeven cost, excluding the drought year of 1988, was $2.88, which is considerably higher than the average corn price of $2.08 received during the ten year period.

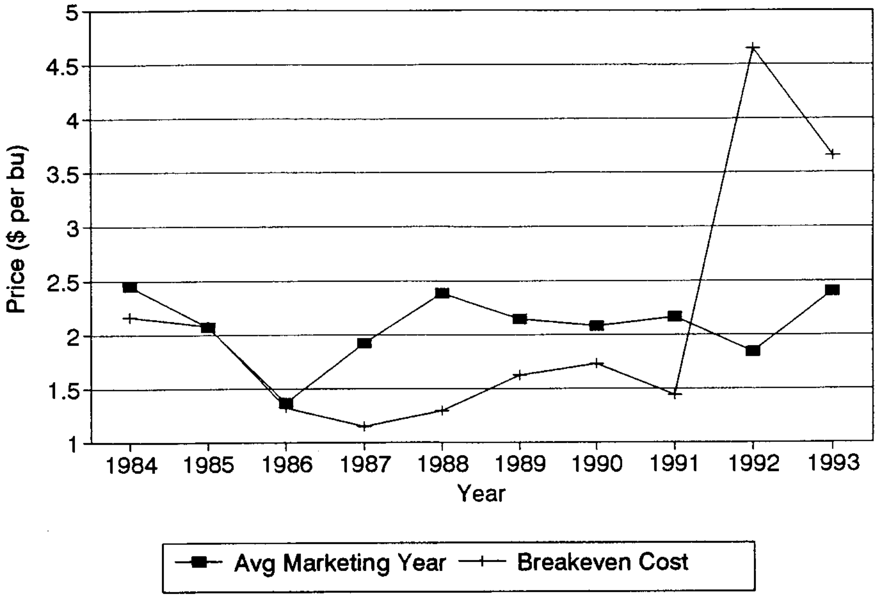
Figure 9. Corn Price & Breakeven Cost

Non-Irrigated Corn from 1984 to 1993



With irrigated corn production breakeven cost, Figure 10, five of the ten years had breakeven costs below the low corn price. Eight of the ten years were profitable using the high corn price. Two years 1992 and 1993 had breakeven cost above the high corn prices. The weighted average breakeven cost for irrigated corn was $1.75 which is considerably lower than the average corn price of $2.08 received during the ten year period.

Figure 10. Corn Price & Breakeven Cost
Irrigated Corn from 1984 to 1993



Tables 8 and 9 contain information on non-irrigated and irrigated corn net returns estimated for each year based on the simulated yields. Net returns were calculated by subtracting total costs from the total revenues for each year. Revenues were calculated by multiplying simulated yield by the marketing average corn price for each respective year. Total costs were estimated in the budgets. Total costs per acre ranged from $188.67 to $247.05 for non-irrigated corn production and $314.22 to $348.92 for irrigated corn production. Total revenues per acre ranged from $14.52 to $263.65 for non-irrigated corn production and from $128.98 to $599.52 per acre for irrigated corn production . The combined effect of variability in annual yield and corn prices, during 1984 to 1993, created wide fluctuations in per acre revenues. The variation in net returns were more attributed to revenue variation than to variations in production costs.

Table 8. Non-irrigated corn total revenue, total cost, and net returns per acre from 1984 to 1993.

Year	Yield	Corn Price	Total Revenue	Total Cost	Net Return
1984	53.0	$2.45	$129.85	$206.87	($77.02)
1985	31.1	$2.07	$ 64.38	$200.89	($136.51)
1986	163.5	$1.37	$224.00	$211.96	$12.03
1987	90.7	$1.92	$174.14	$196.06	($21.92)
1988	6.1	$2.38	$ 14.52	$188.67	($174.15)
1989	123.2	$2.14	$263.65	$216.94	$46.71
1990	36.9	$2.08	$ 76.75	$202.59	($125.84)
1991	52.6	$2.16	$113.62	$216.47	($105.85)
1992	50.9	$1.84	$ 93.66	$227.21	($133.55)
1993	66.7	$2.40	$160.08	$247.05	($86.97)

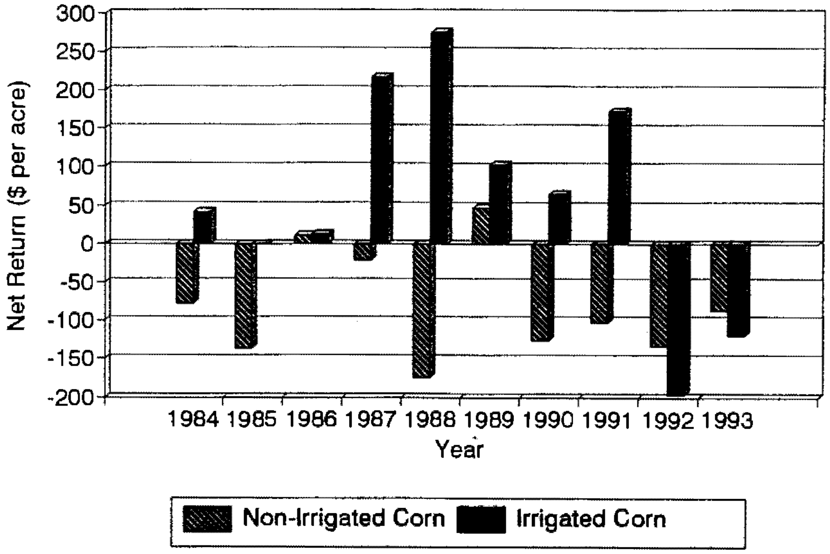
Table 9. Irrigated corn total revenue, total cost, and net returns per acre from 1984 to 1993.

Year	Yield	Corn Price	Total Revenue	Total Cost	Net Return
1984	147.5	$2.45	$361.41	$319.41	$41.96
1985	152.7	$2.07	$316.72	$316.73	($0.64)
1986	238.4	$1.37	$326.22	$314.22	$12.39
1987	279.9	$1.92	$537.96	$319.96	$217.45
1988	251.9	$2.38	$599.56	$324.56	$274.96
1989	200.8	$2.14	$429.04	$327.04	$102.67
1990	186.3	$2.08	$387.25	$322.25	$65.25
1991	239.5	$2.16	$517.32	$345.32	$172.00
1992	70.1	$1.84	$128.82	$325.84	($196.86)
1993	95.6	$2.40	$229.92	$348.92	($119.48)

Figure 11 illustrates the net returns associated with non-irrigated and irrigated corn production over the ten year period. The average return over total cost, during the ten year period, for non-irrigated corn was ($80.00) per acre compared to $56.97 per acre for irrigated corn.

Figure 11. Return over Total Cost

Non-Irrigated & Irrigated: 1984-1993



CONCLUSIONS

Evaluating the economics of implementing an irrigation system into a farming operation is multifarious. The effectiveness of irrigation, from an agronomic viewpoint, depends largely on geographical conditions and prevailing weather. Profitability relies not only on geographical and agronomic conditions but also on market driven factors such as corn prices and input costs.

The overall objective was to compare the profitability of non-irrigated and irrigated corn production in Brookings County. A crop simulation model CERES-Maize was used to generate agronomic data using specific geographic and weather conditions. Representative management practices associated with corn production in Brookings County were used. Time and location specific yield functions were generated.

The use of a simulation model, CERES-Maize, proved to be quite valuable in studying the impacts of water availability, temperature, and other weather variables on yield variability and the resulting influence on economic performance.

The economic analysis strongly supported the use of irrigation. Given the characteristics of the Estelline soil type and prevailing weather conditions from 1984 to 1993 irrigated corn production was more profitable than non-irrigated corn production. In nine out of the ten years studied per acre net returns were higher for irrigated corn than non-irrigated corn. The breakeven cost comparison between the irrigated and non-irrigated corn production indicated that irrigated corn produced a lower ten year average breakeven cost and less variability in the breakeven cost than non-irrigated corn. The ten year average breakeven corn cost for irrigated production was $1.75, while for non-irrigated production it was $2.88 ($3.75 including the drought year of 1988).

REFERENCES

Aldrich, Samuel; and Leng, Earl. Modern Corn Production. F&W Publishing Corp., Cincinnati, Ohio, 1965.

De Boer, Darrell; Ketelhut, Brian; and Beck, Dwayne. "Corn Water Use in Central South Dakota." American Society of Agricultural Engineers. September, 1989: 392-396.

Everson, Curtis. An Estimation of the Economic Value of Water used for Irrigation in Eastern South Dakota. Unpublished M.S. Thesis, South Dakota State University, 1979.

Economic Research Service. Agricultural Income and Finance. AFO-32. U.S. Department of Agriculture. February, 1989.

Economic Research Service. Agricultural Income and Finance. AIS-52. U.S. Department of Agriculture. February, 1994.

Finkel, Herman. Handbook of Irrigation Technology. Vol. I., CRC Press, Inc., Boca Raton, Florida, 1983.

Food and Agricultural Organization of the United Nations. Improvement and Production of Maize, sorghum, and Millet Vol. 2.- Breeding,Agronomy and Seed Production. FAO, Rome, Italy, 1980.

Franklin, Douglas; Powers, John; and Lundeen, Ardelle. Water Use Trends in South Dakota. Research Report 91-6, Economics Department, South Dakota State University, Brookings, South Dakota, August 1991.

Hoyt, Curtis; Madsen, Lawrence; Matz, Ralph; and Lamp, Leroy. Comparative Crop Budgets For planning a Cropping Program in South Dakota. EMC 864, Cooperative Extension Service, South Dakota State University, U.S. Department of Agriculture, April 1989.

Hoyt, Curtis; Madsen, Lawrence; Matz, Ralph; and Lamp, Leroy. Comparative Crop Budgets For planning a Cropping Program in South Dakota. EMC 864 (Revised), Cooperative Extension Service, South Dakota State University, U.S. Department of Agriculture, 1993.

IBSNAT. Technical Report 5-Documentation for IBSNAT Crop Model Input and Output Files, Version 1.1. Department of Agronomy and Soil Sciences, University of Hawaii, Honolulu, Hawaii, 1990.

James, L.G.; Erpenbeck, J.M.; and Bassett, D.L. "Estimating Seasonal Irrigation Requirements for Washington." American Society of Agricultural Engineers. February, 1983: 1380-1385.

Moore, Michael R.; Gollehon, Noel R.; and Negri, Donald H. "Alternative Forms for Production Functions of Irrigated Crops." The Journal of Agricultural Economics Research. Vol. 44, No. 3: 16-32.

National Agricultural Statistics Service. Agricultural Prices-1992 Summary. U.S. Department of Agriculture, 1992.

Ritchie, J.; Singh, U.; Godwin, D.; and Hunt, L. A User's Guild to CERES-Maize-V2.10. International Fertilizer Development Center, Muscle Shoals, Alabama, 1992.

Shane, Richard; and Brown, Ralph. Irrigation Development It's Potential Impact on South Dakota's Economy. Research Report 82-1, Economics Department, South Dakota State University, Brookings, South Dakota, 1982.

South Dakota Agricultural Statistics Service. South Dakota Agricultural Statistics 1984-1990. S.D. Department of Agriculture, Sioux Falls, South Dakota, 1990.

South Dakota Agricultural Statistics Service. South Dakota Agricultural Statistics 1991-1992. S.D. Department of Agriculture, Sioux Falls, South Dakota, 1992.

South Dakota Agricultural Statistics Service. South Dakota Agricultural Statistics 1993-1994. S.D. Department of Agriculture, Sioux Falls, South Dakota, 1994.

Stone, L.R.; Gwin, R.E.; and Dillon, M.A. "Corn and grain sorghum yield response to limited irrigation." Journal of Soil and Water Conservation. September - October 1978: 235-238.

Taylor, Don. Irrigation in Brookings County: An economic study of irrigated corn. Technical Bulletin 81, Agricultural Experiment Station, South Dakota State University, Brookings, South Dakota, January, 1985.

Taylor, D.; Lone, T.; and Lundeen, Ardelle. Enterprise Budgets and Other Basic Data-Sets Electric Rate Structure-Irrigation Study Clay-Union, Union, Cherry-Todd And Cam-Wal REC's. Research Report 86-1, Economics Department, South Dakota State University, Brookings South Dakota, October, 1986.

U. S. Department of Commerce. Bureau of the Census. Census of Agriculture. Washington, D. C. 1992.

Wilson, Dennis G.; Watts, D. G.; and Fischbach, P. E. "Response of Corn to Limited Irrigation on Sandy Soils." American Society of Agricultural Engineers. Presentation at the 1978 Winter Meeting. December 18-20, 1978.

APPENDIX A

PRICE ADJUSTMENTS

This appendix contains information on adjustment to input costs were made from year to year. The examination covers a ten year production period from 1984 to 1993. Budgets were adjusted to reflect changes over time. Cost estimates for seed, fertilizers, and irrigation expenses were directly obtained from local dealers and representatives.

The publications by Hoyt, et. al. on crop budget are updated every several years. The budget were updated in 1985, 1989, and 1993. These years were considered "base" years. Budget estimates during these years were directly used with no further adjustment. During the years between publication dates, those expenses which were not directly obtained from local dealers were derived by an averaging/indexing method to adjust in the model. Expenses were assumed to change for two basic reasons: (1) relative price changes in the cost of expense items, and (2) changes in farming practices. Depending on the type of input one of three indexing methods was used.

Several input expense items used a 50/50 weighted average/index method to adjust prices. The differences between crop budgets, in different base years, and an index adjustment factor obtained from the Prices Paid by Farmers Index, published by the USDA, was used. This method involved: (1) averaging the difference between base year publications for each year and assigning a 50 percent weight to this adjustment factor, and (2) adjusting the base year price by the USDA index and assigning a 50 percent weight to this factor. The expenses which were adjusted using this method, due to their homogeneous nature, included herbicide, insecticide, and fuel expenses.

Other budget expense items were adjusted through the time period by "averaging" the differences between base year budgets and assigning a 100 percent weight to only this factor. These expense items included machine repair, interest on machine investment, machine housing and insurance, depreciation on machinery, real estate taxes, and land charges.

The wage rate was not assumed to change every year. Average farm wages typically do not adjust annually. The Hoyt, et. al. publications reflected this by only adjusting the hourly wage rate once during the ten year period. From 1983 to 1988 a $5.00/hr. wage was assumed. From 1989 to 1993 a wage rate of $6.50/hr. was used (Hoyt, et. al., 1985, 1989, 1993). The interest charged on the operating loan was adjusted annually using a short-term non-real estate agricultural loan rate averaged for all banks (Economic Research Service, 1989, 1994).

APPENDIX B

SIMULATION RESULTS, WEATHER, IRRIGATION, CROP BUDGETS

This appendix contains crop simulation results, weather, irrigation schedules and crop budgets used.

1984 IRRIGATED SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE          BIOM     LAI NUPTK    N%    CET  RAIN   PESW
 4 May    0. SOWING                     g/m^2        kg/ha          ---mm----    cm
 5 May    1. GERMINATION                                             8.   10.     8.
18 May   44. EMERGENCE                                              13.   22.     8.
13 Jun  239. END JUVENILE                 13.    .26   4.7  3.54    64.  161.    16.
20 Jun  322. TASSEL INITIATION            33.    .62  12.5  3.73    95.  219.    18.
 1 Aug  878. 75% SILKING                 885.   4.87 178.0  2.01   302.  408.     9.
12 Aug 1043. BEGIN GRAIN FILL           1109.   4.57 180.7  2.19   345.  415.     6.
 CROP MATURE ON JD 268BECAUSE OF SLOWED GRAIN FILLING
24 Sep 1470. END GRAIN FILL             1871.   2.57  69.4   .86   494.  582.     7.
25 Sep 1470. PHYSIOLOGICAL MATURITY     1871.   2.57  69.4   .86   495.  585.     8.

YIELD (KG/HA)=  9264. (BU/ACRE)=147.5 FINAL GPSM= 2996. KERNEL WT.(mg)=261.3

ISTAGE       CSD1        CSD2      CNSD1        CNSD2   S T A G E  OF  G R O W T H
     1        .00         .00        .00          .06   EMERG to END JUVENILE PHASE
     2        .00         .00        .01          .07   END JUV to TASSEL INITIATION
     3        .00         .00        .03          .12   TASSEL INITIATION to SILKING
     4        .00         .00        .02          .10   SILKING to BEGIN GRAIN FILL
     5        .00         .00        .05          .18   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1984 DRYLAND SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE          BIOM     LAI NUPTK    N%    CET  RAIN   PESW
 4 May    0. SOWING                     g/m^2        kg/ha          ---mm----    cm
 5 May    1. GERMINATION                                             8.   10.     8.
18 May   44. EMERGENCE                                              13.   22.     8.
13 Jun  239. END JUVENILE                 10.    .19   3.4  3.45    63.  161.    16.
20 Jun  322. TASSEL INITIATION            24.    .45   8.6  3.53    94.  219.    18.
 1 Aug  878. 75% SILKING                 636.   3.70  96.9  1.52   291.  330.     3.
12 Aug 1043. BEGIN GRAIN FILL            714.   2.96 101.4  1.78   320.  339.     1.
 CROP MATURE ON JD 268BECAUSE OF SLOWED GRAIN FILLING
24 Sep 1470. END GRAIN FILL              920.    .48  53.9  1.09   378.  388.     0.
25 Sep 1470. PHYSIOLOGICAL MATURITY      920.    .48  53.9  1.09   379.  391.     0.

YIELD (KG/HA)=  3330. (BU/ACRE)= 53.0 FINAL GPSM= 1746. KERNEL WT.(mg)=161.1

ISTAGE       CSD1        CSD2      CNSD1        CNSD2   S T A G E  OF  G R O W T H
     1        .00         .00        .00          .06   EMERG to END JUVENILE PHASE
     2        .00         .00        .02          .09   END JUV to TASSEL INITIATION
     3        .01         .03        .04          .15   TASSEL INITIATION to SILKING
     4        .33         .43        .04          .16   SILKING to BEGIN GRAIN FILL
     5        .70         .75        .03          .13   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1984 WEATHER

MONTH	MAX TEMP (C)	MIN TEMP (C)	SOLAR RADIATION (MJ/M^2)	RAIN (mm)
Jan	-4.39	-14.45	6.24	0.00
Feb	0.45	-6.66	7.41	0.00
Mar	-0.65	-9.35	11.41	0.00
Apr	11.57	1.87	14.06	21.00
May	17.94	6.26	19.91	57.00
Jun	23.83	13.93	20.11	207.00
Jul	27.39	15.90	22.79	70.00
Aug	27.97	15.77	18.96	39.00
Sep	18.70	5.90	14.16	23.00
Oct	13.03	4.23	8.07	102.00
Nov	5.80	-4.57	7.18	0.00
Dec	-4.00	-13.94	4.97	0.00
AVG/TOTAL	11.47	1.24	12.94	519.00

1984 IRRIGATION

	Jun	Jul	Aug	Sep	Year Total
Inches per acre	0.00	2.99	3.15	1.46	7.60
Total Water (in.)	0.00	388.70	409.50	189.80	578.50
System Time (hrs.)	0.00	218.65	230.35	106.77	325.42
KW Used	0.00	6012.97	6334.73	2936.10	8949.06
Total Energy Cost	$0.00	$340.26	$346.69	$278.72	$965.68
Cost per acre	$0.00	$2.62	$2.76	$2.14	$7.43

	1984	
RECEIPTS:	IRRIGATED	DRYLAND
Simulated grain yield (units/ac.)	147.5	53.0
DIRECT COSTS:		
Seed ($/ac.)	$26.40	$19.36
Fertilizer ($/ac.)	$48.59	$36.20
Herbicide ($/ac.)	$11.24	$11.24
Insecticide ($/ac.)	$12.45	$12.45
Drying ($/unit)	$0.15	$0.15
Drying ($/ac.)	$22.13	$7.95
Overhead	$4.50	$4.50
Fuel and Lubrication	$9.05	$9.05
Machinery repair	$13.35	$13.35
Crop operating loan borrowed (months)	7	7
Interest APR (%)	14.50	14.50
Crop direct costs borrowed (%)	75	75
Interest on direct costs ($/ac.)	$8.05	$5.62
Subtotal direct operating costs:	$155.76	$119.67
Irrigation:		
Facilities charge	$5.50	-
Power	$7.43	-
System repair/maintainance	$1.70	-
Insurance	$2.71	-
Subtotal irrigation direct cost:	$17.34	-
Total direct operating cost:	$173.10	$119.67
FIXED COSTS:		
Interest on machine investment ($/ac.)	$13.70	$13.70
Deprec. on machinery and equipment ($/ac.)	$17.00	$17.00
Machinery housing and insurance ($/ac.)	$2.00	$2.00
Irrigation lease/ownership cost ($/ac.)	$37.78	-
Deprec. on irrigation system ($/ac.)	$18.08	-
Operator Labor (hr./ac.)	2.90	2.25
Operator Labor cost ($/hr.)	$5.00	$5.00
Operator Labor cost ($/ac.)	$14.50	$11.25
Real estate taxes ($/ac.)	$6.75	$6.75
Total fixed costs	$109.81	$50.70
RESULTS:		
Production costs ($/ac., excluding land)	$282.91	$170.37
Production costs ($/unit)	$1.92	$3.21
Land charges ($/ac.)	$36.50	$36.50
Total cost ($/ac.)	$319.41	$206.87
Breakeven price ($/unit)	$2.17	$3.90

1985 IRRIGATED SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE         BIOM    LAI NUPTK   N%   CET  RAIN  PESW
 5 May    0. SOWING                    g/m^2       kg/ha        ---mm----    cm
 6 May    4. GERMINATION                                         14.   37.   10.
11 May   44. EMERGENCE                                            4.    5.   10.
 9 Jun  246. END JUVENILE                15.   .29   5.7  3.91   33.   40.   10.
15 Jun  307. TASSEL INITIATION           27.   .53  11.8  4.25   47.   46.   10.
30 Jul  942. 75% SILKING                913.  4.59 141.7  1.74  263.  247.    9.
15 Aug 1012. BEGIN GRAIN FILL          1044.  4.31 160.3  2.15  330.  363.   12.
 CROP MATURE ON JD 269BECAUSE OF SLOWED GRAIN FILLING
26 Sep 1366. END GRAIN FILL            1797.   .00  68.4  1.00  436.  496.   12.
27 Sep 1366. PHYSIOLOGICAL MATURITY    1797.   .00  68.4  1.00  439.  496.   12.

YIELD (KG/HA)=  9587. (BU/ACRE)=152.7 FINAL GPSM= 3282. KERNEL WT.(mg)=246.9

ISTAGE       CSD1       CSD2      CNSD1      CNSD2   S T A G E  OF  G R O W T H
     1        .00        .00        .00        .06   EMERG to END JUVENILE PHASE
     2        .00        .00        .00        .06   END JUV to TASSEL INITIATION
     3        .00        .00        .03        .11   TASSEL INITIATION to SILKING
     4        .00        .00        .03        .11   SILKING to BEGIN GRAIN FILL
     5        .00        .00        .04        .14   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum -
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1985 DRYLAND SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE         BIOM    LAI NUPTK   N%   CET  RAIN  PESW
 5 May    0. SOWING                    g/m^2       kg/ha        ---mm----    cm
 6 May    4. GERMINATION                                          3.    0.    7.
11 May   44. EMERGENCE                                            5.    5.    7.
 9 Jun  246. END JUVENILE                11.   .21   4.2  3.91   32.   40.    8.
15 Jun  307. TASSEL INITIATION           20.   .39   8.0  3.96   44.   46.    7.
30 Jul  942. 75% SILKING                209.   .84  24.4  1.17  151.   93.    1.
15 Aug 1012. BEGIN GRAIN FILL           246.   .53  38.2  2.00  181.  172.    6.
 CROP MATURE ON JD 269BECAUSE OF SLOWED GRAIN FILLING
26 Sep 1366. END GRAIN FILL             407.   .00  22.9  1.30  271.  305.    9.
27 Sep 1366. PHYSIOLOGICAL MATURITY     407.   .00  22.9  1.30  271.  305.    9.

YIELD (KG/HA)=  1954. (BU/ACRE)= 31.1 FINAL GPSM=  689. KERNEL WT.(mg)=246.9

ISTAGE       CSD1       CSD2      CNSD1      CNSD2   S T A G E  OF  G R O W T H
     1        .00        .00        .00        .06   EMERG to END JUVENILE PHASE
     2        .00        .00        .00        .06   END JUV to TASSEL INITIATION
     3        .38        .46        .18        .42   TASSEL INITIATION to SILKING
     4        .57        .61        .09        .27   SILKING to BEGIN GRAIN FILL
     5        .00        .00        .00        .05   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1985 WEATHER

MONTH	MAX TEMP (C)	MIN TEMP (C)	SOLAR RADIATION (MJ/M^2)	RAIN (mm)
Jan	-7.26	-18.68	7.26	0.00
Feb	-3.71	-14.21	10.66	0.00
Mar	5.81	-3.06	13.90	0.00
Apr	16.07	3.17	16.25	40.00
May	22.06	9.45	21.05	38.00
Jun	22.87	10.63	22.31	19.00
Jul	27.29	14.16	22.94	36.00
Aug	23.42	12.65	17.17	89.00
Sep	17.87	9.30	11.56	127.00
Oct	13.32	0.61	9.58	30.00
Nov	-2.97	-11.87	6.08	3.00
Dec	-8.16	-19.10	5.67	0.00
AVG/TOTAL	10.55	-0.58	13.70	382.00

1985 IRRIGATION

	Jun	Jul	Aug	Sep	Year Total
Inches per acre	1.46	4.61	1.46	0.00	7.53
Total Water (in.)	189.80	599.30	189.80	0.00	978.90
System Time (hrs.)	106.77	337.12	106.77	0.00	550.66
KW Used	2936.10	9270.83	2936.10	0.00	15143.03
Total Energy Cost	$278.72	$405.42	$278.72	$0.00	$962.86
Cost per acre	$2.14	$3.12	$2.14	$0.00	$7.41

	1985	
RECEIPTS:	IRRIGATED	DRYLAND
Simulated grain yield (units/ac.)	152.7	31.1
DIRECT COSTS:		
Seed ($/ac.)	$26.70	$19.58
Fertilizer ($/ac.)	$46.04	$34.30
Herbicide ($/ac.)	$11.20	$11.20
Insecticide ($/ac.)	$12.40	$12.40
Drying ($/unit)	$0.15	$0.15
Drying ($/ac.)	$22.91	$4.67
Overhead	$4.50	$4.50
Fuel and Lubrication	$9.05	$9.05
Machinery repair	$13.35	$13.35
Crop operating loan borrowed (months)	7	7
Interest APR (%)	12.65	12.65
Crop direct costs borrowed (%)	75	75
Interest on direct costs ($/ac.)	$6.96	$4.68
Subtotal direct operating costs:	$153.10	$113.69
Irrigation:		
Facilities charge	$5.50	-
Power	$7.41	-
System repair/maintainance	$1.70	-
Insurance	$2.71	-
Subtotal irrigation direct cost:	$17.32	-
Total direct operating cost:	$170.42	$113.69
FIXED COSTS:		
Interest on machine investment ($/ac.)	$13.70	$13.70
Deprec. on machinery and equipment ($/ac.)	$17.00	$17.00
Machinery housing and insurance ($/ac.)	$2.00	$2.00
Irrigation lease/ownership cost ($/ac.)	$37.78	-
Deprec. on irrigation system ($/ac.)	$18.08	-
Operator Labor (hr./ac.)	2.90	2.25
Operator Labor cost ($/hr.)	$5.00	$5.00
Operator Labor cost ($/ac.)	$14.50	$11.25
Real estate taxes ($/ac.)	$6.75	$6.75
Total fixed costs	$109.81	$50.70
RESULTS:		
Production costs ($/ac., excluding land)	$280.23	$164.39
Production costs ($/unit)	$1.84	$5.29
Land charges ($/ac.)	$36.50	$36.50
Total cost ($/ac.)	$316.73	$200.89
Breakeven price ($/unit)	$2.07	$6.46

1986 IRRIGATED SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE          BIOM    LAI NUPTK   N%   CET  RAIN  PESW
 5 May    0. SOWING                    g/m^2        kg/ha        ---mm----   cm
 6 May    7. GERMINATION                                         14.   37.   10.
15 May   46. EMERGENCE                                           23.   76.   14.
10 Jun  248. END JUVENILE                14.   .28    5.4  3.90   60.  140.   15.
17 Jun  318. TASSEL INITIATION           31.   .59   12.7  4.05   93.  142.   12.
28 Jul  982. 75% SILKING                999.  4.84  148.9  1.66  293.  338.   11.
 9 Aug 1041. BEGIN GRAIN FILL          1134.  4.51  168.9  2.01  346.  353.    6.
 CROP MATURE ON JD 284BECAUSE OF SLOWED GRAIN FILLING
11 Oct 1518. END GRAIN FILL            2229.   .00   42.3   .64  515.  670.   12.
12 Oct 1518. PHYSIOLOGICAL MATURITY    2229.   .00   42.3   .64  516.  670.   12.

YIELD (KG/HA)= 14971. (BU/ACRE)=238.4 FINAL GPSM= 3795. KERNEL WT.(mg)=333.4

ISTAGE       CSD1       CSD2      CNSD1       CNSD2   S T A G E  OF  G R O W T H
     1        .00        .00        .00         .08   EMERG to END JUVENILE PHASE
     2        .00        .00        .00         .05   END JUV to TASSEL INITIATION
     3        .00        .00        .03         .12   TASSEL INITIATION to SILKING
     4        .00        .00        .03         .12   SILKING to BEGIN GRAIN FILL
     5        .00        .00        .17         .37   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1986 DRYLAND SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE          BIOM    LAI NUPTK   N%   CET  RAIN  PESW
 5 May    0. SOWING                    g/m^2        kg/ha        ---mm----   cm
 6 May    7. GERMINATION                                          3.    0.    7.
15 May   46. EMERGENCE                                           23.   76.   12.
10 Jun  248. END JUVENILE                10.   .20    4.0  3.90   59.  140.   15.
17 Jun  318. TASSEL INITIATION           23.   .43    9.3  4.05   80.  142.   12.
28 Jul  982. 75% SILKING                655.  3.65  102.4  1.58  271.  262.    4.
 8 Aug 1041. BEGIN GRAIN FILL           762.  3.00  108.6  1.82  320.  277.    1.
 CROP MATURE ON JD 283BECAUSE OF SLOWED GRAIN FILLING
10 Oct 1517. END GRAIN FILL            1529.   .00   27.5   .57  479.  555.    9.
11 Oct 1518. PHYSIOLOGICAL MATURITY    1529.   .00   27.5   .57  479.  558.    8.

YIELD (KG/HA)= 10268. (BU/ACRE)=163.5 FINAL GPSM= 2707. KERNEL WT.(mg)=320.4

ISTAGE       CSD1       CSD2      CNSD1       CNSD2   S T A G E  OF  G R O W T H
     1        .00        .00        .00         .08   EMERG to END JUVENILE PHASE
     2        .00        .00        .00         .05   END JUV to TASSEL INITIATION
     3        .02        .03        .03         .13   TASSEL INITIATION to SILKING
     4        .23        .31        .04         .15   SILKING to BEGIN GRAIN FILL
     5        .07        .10        .22         .44   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1986 WEATHER

MONTH	MAX TEMP (C)	MIN TEMP (C)	SOLAR RADIATION (MJ/M ^ 2)	RAIN (mm)
Jan	-2.55	-12.77	6.43	0.00
Feb	-5.18	-15.21	9.18	5.00
Mar	6.52	-4.58	13.10	28.00
Apr	13.13	1.67	14.65	108.00
May	20.32	7.35	19.89	93.00
Jun	26.17	13.67	21.89	110.00
Jul	29.03	16.06	23.29	74.00
Aug	24.90	11.42	19.47	77.00
Sep	19.73	9.40	11.32	195.00
Oct	14.48	2.35	8.88	9.00
Nov	2.03	-8.13	6.67	8.00
Dec	2.26	-9.97	5.95	0.00
AVG/TOTAL	12.57	0.94	13.39	707.00

1986 IRRIGATION

	Jun	Jul	Aug	Sep	Year Total
Inches per acre	0.00	2.99	1.46	0.00	4.45
Total Water (in.)	0.00	388.70	189.80	0.00	578.50
System Time (hrs.)	0.00	218.65	106.77	0.00	325.42
KW Used	0.00	6012.97	2936.10	0.00	8949.07
Total Energy Cost	$0.00	$340.26	$278.72	$0.00	$618.98
Cost per acre	$0.00	$2.62	$2.14	$0.00	$4.76

	1986	
RECEIPTS:	IRRIGATED	DRYLAND
Simulated grain yield (units/ac.)	238.4	163.5
DIRECT COSTS:		
Seed ($/ac.)	$26.10	$19.14
Fertilizer ($/ac.)	$36.57	$27.89
Herbicide ($/ac.)	$11.20	$11.20
Insecticide ($/ac.)	$12.03	$12.03
Drying ($/unit)	$0.15	$0.15
Drying ($/ac.)	$35.76	$24.53
Overhead	$4.50	$4.50
Fuel and Lubrication	$7.97	$7.97
Machinery repair	$13.35	$13.35
Crop operating loan borrowed (months)	7	7
Interest APR (%)	11.45	11.45
Crop direct costs borrowed (%)	75	75
Interest on direct costs ($/ac.)	$6.25	$4.69
Subtotal direct operating costs:	$153.73	$125.25
Irrigation:		
Facilities charge	$5.50	-
Power	$4.76	-
System repair/maintainance	$1.70	-
Insurance	$2.71	-
Subtotal irrigation direct cost:	$14.67	-
Total direct operating cost:	$168.40	$125.25
FIXED COSTS:		
Interest on machine investment ($/ac.)	$13.69	$13.69
Deprec. on machinery and equipment ($/ac.)	$17.32	$17.32
Machinery housing and insurance ($/ac.)	$2.00	$2.00
Irrigation lease/ownership cost ($/ac.)	$37.78	-
Deprec. on irrigation system ($/ac.)	$18.08	-
Operator Labor (hr./ac.)	2.90	2.25
Operator Labor cost ($/hr.)	$5.00	$5.00
Operator Labor cost ($/ac.)	$14.50	$11.25
Real estate taxes ($/ac.)	$6.32	$6.32
Total fixed costs	$109.69	$50.58
RESULTS:		
Production costs ($/ac., excluding land)	$278.09	$175.83
Production costs ($/unit)	$1.17	$1.08
Land charges ($/ac.)	$36.13	$36.13
Total cost ($/ac.)	$314.22	$211.96
Breakeven price ($/unit)	$1.32	$1.30

1987 IRRIGATED SIMULATION

```
                                                 BIOM    LAI NUPTK    N%    CET  RAIN  PESW
DATE  CDTT PHENOLOGICAL STAGE                   g/m^2        kg/ha          ---mm----    cm
 5 May    0. SOWING                                                          15.   38.   10.
 6 May    6. GERMINATION                                                      1.    1.   10.
11 May   47. EMERGENCE                            15.    .30   5.9  3.90     45.   40.    9.
 3 Jun  250. END JUVENILE                         37.    .68  15.0  4.01     60.  100.   13.
10 Jun  333. TASSEL INITIATION                   970.   4.86 147.5  1.69    288.  280.    9.
20 Jul  870. 75% SILKING                        1168.   4.58 150.2  1.79    331.  317.    7.
30 Jul 1053. BEGIN GRAIN FILL                   2475.   2.07  36.3   .55    542.  543.    8.
27 Sep 1639. END GRAIN FILL                     2475.   2.07  36.3   .55    544.  543.    8.
 2 Oct 1676. PHYSIOLOGICAL MATURITY

YIELD (KG/HA)= 17575. (BU/ACRE)=279.9 FINAL GPSM= 4195. KERNEL WT.(mg)=354.0

                                                      S T A G E   OF   G R O W T H
ISTAGE        CSD1        CSD2       CNSD1       CNSD2  EMERG to END JUVENILE PHASE
   1           .00         .00         .00         .06  END JUV to TASSEL INITIATION
   2           .00         .00         .00         .05  TASSEL INITIATION to SILKING
   3           .00         .00         .03         .12  SILKING to BEGIN GRAIN FILL
   4           .00         .00         .04         .14  GRAIN FILLING PHASE
   5           .00         .00         .27         .47
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1987 DRYLAND SIMULATION

```
                                                 BIOM    LAI NUPTK    N%    CET  RAIN  PESW
DATE  CDTT PHENOLOGICAL STAGE                   g/m^2        kg/ha          ---mm----    cm
 5 May    0. SOWING                                                           4.    1.    7.
 6 May    6. GERMINATION                                                      2.    1.    7.
11 May   47. EMERGENCE                            11.    .22   3.9  3.53     41.   40.    7.
 3 Jun  250. END JUVENILE                         23.    .44   9.2  3.95     54.   62.    8.
10 Jun  333. TASSEL INITIATION                   451.   2.33  86.2  1.91    229.  206.    5.
20 Jul  970. 75% SILKING                         573.   1.98  86.1  2.03    268.  206.    1.
30 Jul 1053. BEGIN GRAIN FILL                    970.    .48  34.1  1.00    375.  320.    2.
27 Sep 1639. END GRAIN FILL                      970.    .48  34.1  1.00    375.  320.    2.
 2 Oct 1676. PHYSIOLOGICAL MATURITY

YIELD (KG/HA)=  5698. (BU/ACRE)= 90.7 FINAL GPSM= 2390. KERNEL WT.(mg)=201.5

                                                      S T A G E   OF   G R O W T H
ISTAGE        CSD1        CSD2       CNSD1       CNSD2  EMERG to END JUVENILE PHASE
   1           .00         .00         .01         .07  END JUV to TASSEL INITIATION
   2           .00         .00         .09         .26  TASSEL INITIATION to SILKING
   3           .13         .20         .12         .31  SILKING to BEGIN GRAIN FILL
   4           .35         .43         .03         .11  GRAIN FILLING PHASE
   5           .46         .51         .04         .16
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1987 WEATHER

MONTH	MAX TEMP (C)	MIN TEMP (C)	SOLAR RADIATION (MJ/M^2)	RAIN (mm)
Jan	0.13	-11.29	6.24	0.00
Feb	5.54	-6.11	8.77	5.00
Mar	6.39	-3.45	10.02	70.00
Apr	18.90	2.20	19.32	8.00
May	23.71	9.90	18.58	41.00
Jun	28.13	13.57	24.54	55.00
Jul	29.81	17.00	23.74	111.00
Aug	25.42	12.26	18.55	42.00
Sep	22.40	9.00	15.18	72.00
Oct	12.58	-1.35	10.21	15.00
Nov	7.87	-3.00	5.82	3.00
Dec	-1.16	-9.23	4.10	10.00
AVG/TOTAL	14.98	2.46	13.76	432.00

1987 IRRIGATION

	Jun	Jul	Aug	Sep	Year Total
Inches per acre	2.95	1.42	2.95	1.46	8.78
Total Water (in.)	383.50	184.60	383.50	189.80	1141.40
System Time (hrs.)	215.73	103.84	215.73	106.77	642.07
KW Used	5932.53	2855.66	5932.53	2936.10	17656.82
Total Energy Cost	$338.65	$277.11	$338.65	$278.72	$1,233.14
Cost per acre	$2.61	$2.13	$2.61	$2.14	$9.49

	1987	
RECEIPTS:	IRRIGATED	DRYLAND
Simulated grain yield (units/ac.)	279.9	90.7
DIRECT COSTS:		
Seed ($/ac.)	$26.10	$19.14
Fertilizer ($/ac.)	$32.59	$24.76
Herbicide ($/ac.)	$11.38	$11.38
Insecticide ($/ac.)	$11.11	$11.11
Drying ($/unit)	$0.15	$0.15
Drying ($/ac.)	$41.98	$13.61
Overhead	$4.50	$4.50
Fuel and Lubrication	$8.24	$8.24
Machinery repair	$13.35	$13.35
Crop operating loan borrowed (months)	7	7
Interest APR (%)	10.55	10.55
Crop direct costs borrowed (%)	75	75
Interest on direct costs ($/ac.)	$5.99	$3.80
Subtotal direct operating costs:	$155.24	$109.85
Irrigation:		
Facilities charge	$5.50	-
Power	$9.49	-
System repair/maintainance	$1.70	-
Insurance	$2.71	-
Subtotal irrigation direct cost:	$19.40	-
Total direct operating cost:	$174.64	$109.85
FIXED COSTS:		
Interest on machine investment ($/ac.)	$13.69	$13.69
Deprec. on machinery and equipment ($/ac.)	$17.64	$17.64
Machinery housing and insurance ($/ac.)	$2.00	$2.00
Irrigation lease/ownership cost ($/ac.)	$37.78	-
Deprec. on irrigation system ($/ac.)	$18.08	-
Operator Labor (hr./ac.)	2.90	2.25
Operator Labor cost ($/hr.)	$5.00	$5.00
Operator Labor cost ($/ac.)	$14.50	$11.25
Real estate taxes ($/ac.)	$5.88	$5.88
Total fixed costs	$109.57	$50.46
RESULTS:		
Production costs ($/ac., excluding land)	$284.21	$160.31
Production costs ($/unit)	$1.02	$1.77
Land charges ($/ac.)	$35.75	$35.75
Total cost ($/ac.)	$319.96	$196.06
Breakeven price ($/unit)	$1.14	$2.16

1988 IRRIGATED SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE          BIOM    LAI NUPTK   N%   CET  RAIN  PESW
 4 May    0. SOWING                     g/m^2        kg/ha        ---mm----   cm
 5 May    5. GERMINATION                                          14.   37.   10.
14 May   51. EMERGENCE                                             6.    6.   10.
 1 Jun  249. END JUVENILE                 14.   .28   5.5  3.90   33.   31.    9.
 8 Jun  350. TASSEL INITIATION            41.   .74  17.4  4.23   63.   71.   10.
17 Jul  919. 75% SILKING                 910.  4.95 148.3  1.83  287.  265.    7.
29 Jul 1090. BEGIN GRAIN FILL           1165.  4.80 151.0  1.77  355.  328.    7.
14 Sep 1683. END GRAIN FILL             2370.  2.08  37.5   .52  562.  529.    6.
18 Sep 1719. PHYSIOLOGICAL MATURITY     2370.  2.08  37.5   .52  587.  568.    9.

YIELD (KG/HA)= 15818. (BU/ACRE)=251.9 FINAL GPSM= 4180. KERNEL WT.(mg)=319.8

ISTAGE       CSD1       CSD2      CNSD1       CNSD2   S T A G E  OF  G R O W T H
     1        .00        .00        .00         .08   EMERG to END JUVENILE PHASE
     2        .00        .00        .02         .09   END JUV to TASSEL INITIATION
     3        .00        .00        .04         .13   TASSEL INITIATION to SILKING
     4        .00        .00        .04         .14   SILKING to BEGIN GRAIN FILL
     5        .00        .00        .23         .42   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1988 DRYLAND SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE          BIOM    LAI NUPTK   N%   CET  RAIN  PESW
 4 May    0. SOWING                     g/m^2        kg/ha        ---mm----   cm
 5 May    5. GERMINATION                                           3.    0.    7.
14 May   51. EMERGENCE                                             8.    6.    7.
 1 Jun  249. END JUVENILE                 10.   .21   2.8  2.53   31.   31.    7.
 8 Jun  350. TASSEL INITIATION            20.   .39   4.0  2.02   49.   34.    6.
17 Jul  919. 75% SILKING                 100.   .43   7.9   .79  126.   70.    1.
29 Jul 1090. BEGIN GRAIN FILL            113.   .27  10.1  1.17  143.   93.    2.
14 Sep 1683. END GRAIN FILL              201.   .19   8.5  1.00  233.  178.    1.
18 Sep 1718. PHYSIOLOGICAL MATURITY      201.   .19   8.5  1.00  244.  215.    4.

YIELD (KG/HA)=   384. (BU/ACRE)=  6.1 FINAL GPSM=  108. KERNEL WT.(mg)=301.6

ISTAGE       CSD1       CSD2      CNSD1       CNSD2   S T A G E  OF  G R O W T H
     1        .00        .00        .03         .12   EMERG to END JUVENILE PHASE
     2        .01        .22        .21         .51   END JUV to TASSEL INITIATION
     3        .50        .82        .59         .83   TASSEL INITIATION to SILKING
     4        .77        .82        .44         .72   SILKING to BEGIN GRAIN FILL
     5        .14        .19        .02         .10   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1988 WEATHER

MONTH	MAX TEMP (C)	MIN TEMP (C)	SOLAR RADIATION (MJ/M^2)	RAIN (mm)
Jan	-6.23	-19.03	8.82	1.00
Feb	-4.28	-17.07	11.98	0.00
Mar	6.74	-4.55	12.03	5.00
Apr	14.73	-1.17	18.62	27.00
May	24.26	10.13	22.11	27.00
Jun	30.57	15.07	26.34	26.00
Jul	30.90	15.65	24.48	40.00
Aug	28.84	14.74	20.52	68.00
Sep	22.63	8.20	14.67	103.00
Oct	13.58	-1.61	11.67	1.00
Nov	5.23	-5.27	6.30	25.00
Dec	-0.29	-11.77	5.55	1.00
AVG/TOTAL	13.89	0.28	15.26	324.00

1988 IRRIGATION

	Jun	Jul	Aug	Sep	Year Total
Inches per acre	4.45	4.76	3.11	1.54	13.86
Total Water (in.)	578.50	618.80	404.30	200.20	1801.80
System Time (hrs.)	325.42	348.09	227.43	112.62	1013.56
KW Used	8949.06	9572.48	6254.29	3096.98	27872.81
Total Energy Cost	$398.98	$411.45	$345.09	$281.94	$1,437.46
Cost per acre	$3.07	$3.17	$2.65	$2.17	$11.06

	1988	
RECEIPTS:	IRRIGATED	DRYLAND
Simulated grain yield (units/ac.)	251.9	6.1
DIRECT COSTS:		
Seed ($/ac.)	$26.40	$19.36
Fertilizer ($/ac.)	$39.44	$30.31
Herbicide ($/ac.)	$11.82	$11.82
Insecticide ($/ac.)	$10.47	$10.47
Drying ($/unit)	$0.15	$0.15
Drying ($/ac.)	$37.79	$0.92
Overhead	$4.50	$4.50
Fuel and Lubrication	$8.52	$8.52
Machinery repair	$13.35	$13.35
Crop operating loan borrowed (months)	7	7
Interest APR (%)	11.10	11.10
Crop direct costs borrowed (%)	75	75
Interest on direct costs ($/ac.)	$6.47	$3.74
Subtotal direct operating costs:	$158.76	$102.95
Irrigation:		
Facilities charge	$5.50	-
Power	$11.06	-
System repair/maintainance	$1.70	-
Insurance	$2.71	-
Subtotal irrigation direct cost:	$20.97	-
Total direct operating cost:	$179.73	$102.95
FIXED COSTS:		
Interest on machine investment ($/ac.)	$13.69	$13.69
Deprec. on machinery and equipment ($/ac.)	$17.96	$17.96
Machinery housing and insurance ($/ac.)	$2.00	$2.00
Irrigation lease/ownership cost ($/ac.)	$37.78	-
Deprec. on irrigation system ($/ac.)	$18.08	-
Operator Labor (hr./ac.)	2.90	2.25
Operator Labor cost ($/hr.)	$5.00	$5.00
Operator Labor cost ($/ac.)	$14.50	$11.25
Real estate taxes ($/ac.)	$5.44	$5.44
Total fixed costs	$109.45	$50.34
RESULTS:		
Production costs ($/ac., excluding land)	$289.18	$153.29
Production costs ($/unit)	$1.15	$25.13
Land charges ($/ac.)	$35.38	$35.38
Total cost ($/ac.)	$324.56	$188.67
Breakeven price ($/unit)	$1.29	$30.93

1989 IRRIGATED SIMULATION

```
 DATE   CDTT PHENOLOGICAL STAGE          BIOM     LAI NUPTK    N%    CET   RAIN   PESW
 5 May     0. SOWING                     g/m^2        kg/ha          ---mm----      cm
 6 May     0. GERMINATION                                            15.    38.    10.
16 May    45. EMERGENCE                                               1.     1.    10.
10 Jun   240. END JUVENILE                 13.    .28    5.2  3.91   28.    21.     9.
17 Jun   293. TASSEL INITIATION            24.    .48    8.8  3.84   42.    57.    11.
22 Jul   793. 75% SILKING                 743.   4.34  153.3  2.08  211.   297.    14.
 2 Aug   983. BEGIN GRAIN FILL           1029.   4.00  144.5  2.01  268.   335.    11.
 CROP MATURE ON JD 257BECAUSE OF SLOWED GRAIN FILLING
14 Sep  1435. END GRAIN FILL             2048.    .00   50.2   .75  430.   478.     9.
15 Sep  1440. PHYSIOLOGICAL MATURITY     2048.    .00   50.2   .75  433.   478.     9.

YIELD (KG/HA)= 12807. (BU/ACRE)=200.8 FINAL GPSM= 3772. KERNEL WT.(mg)=282.4

ISTAGE       CSD1       CSD2       CNSD1       CNSD2    S T A G E  OF  G R O W T H
    1         .00        .00         .00         .05    EMERG to END JUVENILE PHASE
    2         .00        .00         .00         .05    END JUV to TASSEL INITIATION
    3         .00        .00         .02         .10    TASSEL INITIATION to SILKING
    4         .00        .00         .02         .10    SILKING to BEGIN GRAIN FILL
    5         .00        .00         .07         .20    GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1989 DRYLAND SIMULATION

```
 DATE   CDTT PHENOLOGICAL STAGE          BIOM     LAI NUPTK    N%    CET   RAIN   PESW
 5 May     0. SOWING                     g/m^2        kg/ha          ---mm----      cm
 6 May     0. GERMINATION                                             4.     1.     7.
16 May    45. EMERGENCE                                               4.     1.     7.
10 Jun   240. END JUVENILE                 10.    .19    3.8  3.73   27.    21.     8.
17 Jun   293. TASSEL INITIATION            17.    .34    7.2  4.10   41.    57.     9.
22 Jul   793. 75% SILKING                 539.   3.18  105.0  1.98  204.   280.    11.
 2 Aug   983. BEGIN GRAIN FILL            751.   2.92  104.0  1.99  280.   281.     8.
 CROP MATURE ON JD 257BECAUSE OF SLOWED GRAIN FILLING
14 Sep  1435. END GRAIN FILL             1289.    .00   40.1   .98  367.   328.     1.
15 Sep  1440. PHYSIOLOGICAL MATURITY     1289.    .00   40.1   .98  370.   328.     1.

YIELD (KG/HA)=  7737. (BU/ACRE)=123.2 FINAL GPSM= 3420. KERNEL WT.(mg)=191.2

ISTAGE       CSD1       CSD2       CNSD1       CNSD2    S T A G E  OF  G R O W T H
    1         .00        .00         .01         .08    EMERG to END JUVENILE PHASE
    2         .00        .00         .01         .07    END JUV to TASSEL INITIATION
    3         .00        .02         .03         .12    TASSEL INITIATION to SILKING
    4         .00        .00         .02         .11    SILKING to BEGIN GRAIN FILL
    5         .37        .43         .14         .37    GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1989 WEATHER

MONTH	MAX TEMP (C)	MIN TEMP (C)	SOLAR RADIATION (MJ/M^2)	RAIN (mm)
Jan	0.97	-12.21	6.28	0.00
Feb	-7.57	-20.53	9.94	2.03
Mar	2.27	-8.63	12.97	9.14
Apr	13.99	0.37	17.95	36.07
May	21.14	5.34	19.51	21.08
Jun	25.64	10.75	21.15	96.01
Jul	29.59	16.78	22.54	145.29
Aug	27.21	14.00	19.36	32.26
Sep	21.96	7.83	15.15	41.91
Oct	17.19	-0.25	11.53	44.96
Nov	3.46	-7.92	6.04	17.02
Dec	-6.57	-17.96	5.00	2.03
AVG/TOTAL	12.44	-1.04	13.95	447.80

1989 IRRIGATION

	Jun	Jul	Aug	Sep	Year Total
Inches per acre	0.00	1.46	2.95	1.50	5.91
Total Water (in.)	0.00	189.80	383.50	195.00	768.30
System Time (hrs.)	0.00	106.77	215.73	109.69	432.19
KW Used	0.00	2936.10	5932.53	3016.54	11885.17
Total Energy Cost	$0.00	$278.72	$338.65	$280.33	$897.70
Cost per acre	$0.00	$2.14	$2.61	$2.16	$6.91

	1989	
RECEIPTS:	IRRIGATED	DRYLAND
Simulated grain yield (units/ac.)	200.8	123.2
DIRECT COSTS:		
Seed ($/ac.)	$29.10	$21.34
Fertilizer ($/ac.)	$47.47	$35.73
Herbicide ($/ac.)	$12.60	$12.60
Insecticide ($/ac.)	$8.00	$8.00
Drying ($/unit)	$0.15	$0.15
Drying ($/ac.)	$30.12	$18.48
Overhead	$4.50	$4.50
Fuel and Lubrication	$9.05	$9.05
Machinery repair	$13.35	$13.35
Crop operating loan borrowed (months)	7	7
Interest APR (%)	12.70	12.70
Crop direct costs borrowed (%)	75	75
Interest on direct costs ($/ac.)	$7.29	$5.20
Subtotal direct operating costs:	$161.50	$128.31
Irrigation:		
Facilities charge	$5.50	-
Power	$6.91	-
System repair/maintainance	$1.70	-
Insurance	$2.71	-
Subtotal irrigation direct cost:	$16.82	-
Total direct operating cost:	$178.32	$128.31
FIXED COSTS:		
Interest on machine investment ($/ac.)	$13.68	$13.68
Deprec. on machinery and equipment ($/ac.)	$18.28	$18.28
Machinery housing and insurance ($/ac.)	$2.05	$2.05
Irrigation lease/ownership cost ($/ac.)	$37.78	-
Deprec. on irrigation system ($/ac.)	$18.08	-
Operator Labor (hr./ac.)	2.90	2.25
Operator Labor cost ($/hr.)	$6.50	$6.50
Operator Labor cost ($/ac.)	$18.85	$14.63
Real estate taxes ($/ac.)	$5.00	$5.00
Total fixed costs	$113.72	$53.64
RESULTS:		
Production costs ($/ac., excluding land)	$292.04	$181.94
Production costs ($/unit)	$1.45	$1.48
Land charges ($/ac.)	$35.00	$35.38
Total cost ($/ac.)	$327.04	$216.94
Breakeven price ($/unit)	$1.63	$1.76

1990 IRRIGATED SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE           BIOM     LAI NUPTK    N%    CET  RAIN   PESW
 5 May    0. SOWING                      g/m^2         kg/ha          ---mm----    cm
 6 May    3. GERMINATION                                               14.   38.   10.
23 May   50. EMERGENCE                                                 46.  100.   15.
13 Jun  244. END JUVENILE                  13.   .27    5.2  3.92    112.  217.   14.
20 Jun  328. TASSEL INITIATION             34.   .63   12.5  3.67    132.  278.   17.
 2 Aug  980. 75% SILKING                  952.  4.70  180.1  1.98    335.  438.   10.
17 Aug 1055. BEGIN GRAIN FILL            1119.  4.40  168.0  2.10    411.  476.    6.
 CROP MATURE ON JD 267BECAUSE OF SLOWED GRAIN FILLING
24 Sep 1501. END GRAIN FILL              2084.   .00   49.2   .68    548.  614.    6.
25 Sep 1511. PHYSIOLOGICAL MATURITY      2084.   .00   49.2   .68    548.  614.    6.

YIELD (KG/HA)= 11701. (BU/ACRE)=186.3 FINAL GPSM= 3941. KERNEL WT.(mg)=250.9

ISTAGE      CSD1      CSD2      CNSD1      CNSD2   S T A G E  OF  G R O W T H
    1        .00       .00        .00        .08   EMERG to END JUVENILE PHASE
    2        .00       .00        .00        .05   END JUV to TASSEL INITIATION
    3        .00       .00        .03        .12   TASSEL INITIATION to SILKING
    4        .00       .00        .02        .10   SILKING to BEGIN GRAIN FILL
    5        .00       .00        .16        .34   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1990 DRYLAND SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE           BIOM     LAI NUPTK    N%    CET  RAIN   PESW
 5 May    0. SOWING                      g/m^2         kg/ha          ---mm----    cm
 6 May    3. GERMINATION                                                4.    1.    7.
23 May   50. EMERGENCE                                                 42.  100.   13.
13 Jun  244. END JUVENILE                  10.   .20    3.8  3.92    107.  217.   14.
20 Jun  328. TASSEL INITIATION             25.   .47    9.1  3.82    128.  278.   17.
 2 Aug  980. 75% SILKING                  628.  3.65   95.9  1.53    322.  362.    3.
17 Aug 1055. BEGIN GRAIN FILL             621.  2.07   98.0  1.83    345.  362.    0.
 CROP MATURE ON JD 267BECAUSE OF SLOWED GRAIN FILLING
24 Sep 1501. END GRAIN FILL               751.   .00   59.7  1.30    375.  386.    0.
25 Sep 1511. PHYSIOLOGICAL MATURITY       751.   .00   59.7  1.30    375.  386.    0.

YIELD (KG/HA)=  2319. (BU/ACRE)= 36.9 FINAL GPSM= 1333. KERNEL WT.(mg)=147.0

ISTAGE      CSD1      CSD2      CNSD1      CNSD2   S T A G E  OF  G R O W T H
    1        .00       .00        .00        .08   EMERG to END JUVENILE PHASE
    2        .00       .00        .00        .05   END JUV to TASSEL INITIATION
    3        .00       .01        .04        .14   TASSEL INITIATION to SILKING
    4        .70       .80        .04        .15   SILKING to BEGIN GRAIN FILL
    5        .75       .78        .00        .05   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1990 WEATHER

MONTH	MAX TEMP (C)	MIN TEMP (C)	SOLAR RADIATION (MJ/M^2)	RAIN (mm)
Jan	3.11	-9.20	6.06	0.00
Feb	1.58	-12.78	9.68	0.00
Mar	7.15	-4.13	11.93	23.11
Apr	14.69	-1.33	18.16	22.35
May	19.04	6.15	18.94	167.64
Jun	26.41	13.39	23.35	135.13
Jul	26.77	13.84	20.62	57.40
Aug	27.00	14.62	19.98	22.10
Sep	24.38	9.65	16.92	4.06
Oct	14.91	-0.36	11.66	13.46
Nov	6.78	-5.28	6.95	0.51
Dec	-4.56	-16.50	5.93	0.00
AVG/TOTAL	13.94	0.67	14.18	445.76

1990 IRRIGATION

	Jun	Jul	Aug	Sep	Year Total
Inches per acre	0.00	1.57	4.41	2.99	8.97
Total Water (in.)	0.00	204.10	573.30	388.70	1166.10
System Time (hrs.)	0.00	114.81	322.50	218.65	655.96
KW Used	0.00	3157.31	8868.62	6012.97	18038.90
Total Energy Cost	$0.00	$283.15	$397.37	$340.26	$1,020.78
Cost per acre	$0.00	$2.18	$3.06	$2.62	$7.85

	1990	
RECEIPTS:	IRRIGATED	DRYLAND
Simulated grain yield (units/ac.)	186.3	36.9
DIRECT COSTS:		
Seed ($/ac.)	$29.10	$21.34
Fertilizer ($/ac.)	$38.58	$29.13
Herbicide ($/ac.)	$14.13	$14.13
Insecticide ($/ac.)	$8.08	$8.08
Drying ($/unit)	$0.15	$0.15
Drying ($/ac.)	$27.95	$5.54
Overhead	$4.50	$4.50
Fuel and Lubrication	$10.21	$10.21
Machinery repair	$12.91	$12.91
Crop operating loan borrowed (months)	7	7
Interest APR (%)	11.35	11.35
Crop direct costs borrowed (%)	75	75
Interest on direct costs ($/ac.)	$6.23	$4.07
Subtotal direct operating costs:	$151.69	$109.88
Irrigation:		
Facilities charge	$5.50	-
Power	$7.85	-
System repair/maintainance	$1.70	-
Insurance	$2.71	-
Subtotal irrigation direct cost:	$17.76	-
Total direct operating cost:	$169.45	$109.88
FIXED COSTS:		
Interest on machine investment ($/ac.)	$13.37	$13.37
Deprec. on machinery and equipment ($/ac.)	$19.64	$19.64
Machinery housing and insurance ($/ac.)	$2.21	$2.21
Irrigation lease/ownership cost ($/ac.)	$37.78	-
Deprec. on irrigation system ($/ac.)	$18.08	-
Operator Labor (hr./ac.)	2.90	2.25
Operator Labor cost ($/hr.)	$6.50	$6.50
Operator Labor cost ($/ac.)	$18.85	$14.63
Real estate taxes ($/ac.)	$5.14	$5.14
Total fixed costs	$115.07	$54.99
RESULTS:		
Production costs ($/ac., excluding land)	$284.52	$164.86
Production costs ($/unit)	$1.53	$4.47
Land charges ($/ac.)	$37.73	$37.73
Total cost ($/ac.)	$322.25	$202.59
Breakeven price ($/unit)	$1.73	$5.49

1991 IRRIGATED SIMULATION

```
 DATE   CDTT PHENOLOGICAL STAGE           BIOM     LAI NUPTK    N%    CET  RAIN   PESW
 5 May    0.  SOWING                      g/m^2        kg/ha          ---mm----    cm
 6 May    0.  GERMINATION                                              13.   60.   12.
13 May   45.  EMERGENCE                                                 8.    3.   11.
 1 Jun  243.  END JUVENILE                  14.    .28   5.5  3.90    63.   84.   14.
 8 Jun  328.  TASSEL INITIATION             35.    .65  14.7  4.17    90.  117.   14.
17 Jul  865.  75% SILKING                  862.   4.78 147.7  1.71   278.  271.    8.
31 Jul 1047.  BEGIN GRAIN FILL            1126.   4.46 150.3  1.87   347.  330.    7.
16 Sep 1635.  END GRAIN FILL              2237.   1.98  34.8   .54   538.  502.    5.
18 Sep 1646.  PHYSIOLOGICAL MATURITY      2237.   1.98  34.8   .54   539.  541.    9.

YIELD (KG/HA)= 15041. (BU/ACRE)=239.5 FINAL GPSM= 3722. KERNEL WT.(mg)=341.5

ISTAGE       CSD1       CSD2       CNSD1       CNSD2   S T A G E  OF  G R O W T H
    1         .00        .00         .00         .05   EMERG to END JUVENILE PHASE
    2         .00        .00         .00         .05   END JUV to TASSEL INITIATION
    3         .00        .00         .03         .12   TASSEL INITIATION to SILKING
    4         .00        .00         .03         .13   SILKING to BEGIN GRAIN FILL
    5         .00        .00         .18         .34   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1991 DRYLAND SIMULATION

```
 DATE   CDTT PHENOLOGICAL STAGE           BIOM     LAI NUPTK    N%    CET  RAIN   PESW
 5 May    0.  SOWING                      g/m^2        kg/ha          ---mm----    cm
 6 May    0.  GERMINATION                                               9.   23.    9.
13 May   45.  EMERGENCE                                                 8.    3.    8.
 1 Jun  243.  END JUVENILE                  10.    .20   4.0  3.90    62.   84.   11.
 8 Jun  328.  TASSEL INITIATION             26.    .48  10.8  4.17    87.  117.   12.
17 Jul  865.  75% SILKING                  600.   3.38 101.1  1.69   280.  193.    2.
31 Jul 1047.  BEGIN GRAIN FILL             659.   2.45 101.9  1.95   298.  218.    0.
16 Sep 1635.  END GRAIN FILL               856.    .46  52.2  1.19   357.  269.    0.
18 Sep 1646.  PHYSIOLOGICAL MATURITY       856.    .46  52.2  1.19   358.  269.    0.

YIELD (KG/HA)=  3303. (BU/ACRE)= 52.6 FINAL GPSM= 1721. KERNEL WT.(mg)=162.2

ISTAGE       CSD1       CSD2       CNSD1       CNSD2   S T A G E  OF  G R O W T H
    1         .00        .00         .00         .05   EMERG to END JUVENILE PHASE
    2         .00        .00         .00         .05   END JUV to TASSEL INITIATION
    3         .03        .05         .03         .13   TASSEL INITIATION to SILKING
    4         .45        .54         .03         .12   SILKING to BEGIN GRAIN FILL
    5         .70        .73         .00         .05   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1991 WEATHER

MONTH	MAX TEMP (C)	MIN TEMP (C)	SOLAR RADIATION (MJ/M^2)	RAIN (mm)
Jan	-5.59	-16.79	6.59	0.00
Feb	3.01	-9.09	9.68	35.56
Mar	7.28	-5.08	12.41	0.00
Apr	14.94	1.76	16.21	81.28
May	20.88	9.76	18.26	98.00
Jun	27.03	16.46	21.78	112.00
Jul	27.01	15.02	23.40	25.40
Aug	27.36	14.58	20.55	45.72
Sep	21.00	8.29	15.21	10.16
Oct	13.67	-0.73	10.48	38.10
Nov	-0.18	-9.46	6.39	91.44
Dec	0.59	-10.09	5.30	15.24
AVG/TOTAL	13.08	1.22	13.86	552.90

1991 IRRIGATION

	Jun	Jul	Aug	Sep	Year Total
Inches per acre	1.54	2.91	3.03	1.61	9.09
Total Water (in.)	200.20	378.30	393.90	209.30	1181.70
System Time (hrs.)	112.62	212.80	221.58	117.74	664.74
KW Used	3096.98	5852.08	6093.41	3237.75	18280.22
Total Energy Cost	$281.94	$337.04	$341.87	$284.76	$1,245.60
Cost per acre	$2.17	$2.59	$2.63	$2.19	$9.58

	1991	
RECEIPTS:	IRRIGATED	DRYLAND
Simulated grain yield (units/ac.)	239.5	52.6
DIRECT COSTS:		
Seed ($/ac.)	$28.50	$20.90
Fertilizer ($/ac.)	$45.58	$34.17
Herbicide ($/ac.)	$17.35	$17.35
Insecticide ($/ac.)	$8.17	$8.17
Drying ($/unit)	$0.15	$0.15
Drying ($/ac.)	$35.93	$7.89
Overhead	$4.50	$4.50
Fuel and Lubrication	$10.41	$10.41
Machinery repair	$12.46	$12.46
Crop operating loan borrowed (months)	7	7
Interest APR (%)	9.95	9.95
Crop direct costs borrowed (%)	75	75
Interest on direct costs ($/ac.)	$6.11	$3.86
Subtotal direct operating costs:	$169.00	$119.73
Irrigation:		
Facilities charge	$5.50	-
Power	$9.58	-
System repair/maintainance	$1.70	-
Insurance	$2.71	-
Subtotal irrigation direct cost:	$19.49	-
Total direct operating cost:	$188.49	$119.73
FIXED COSTS:		
Interest on machine investment ($/ac.)	$13.05	$13.05
Deprec. on machinery and equipment ($/ac.)	$20.99	$20.99
Machinery housing and insurance ($/ac.)	$2.36	$2.36
Irrigation lease/ownership cost ($/ac.)	$37.78	-
Deprec. on irrigation system ($/ac.)	$18.08	-
Operator Labor (hr./ac.)	2.90	2.25
Operator Labor cost ($/hr.)	$6.50	$6.50
Operator Labor cost ($/ac.)	$18.85	$14.63
Real estate taxes ($/ac.)	$5.27	$5.27
Total fixed costs	$116.38	$56.30
RESULTS:		
Production costs ($/ac., excluding land)	$304.87	$176.02
Production costs ($/unit)	$1.27	$3.35
Land charges ($/ac.)	$40.45	$40.45
Total cost ($/ac.)	$345.32	$216.47
Breakeven price ($/unit)	$1.44	$4.12

1992 IRRIGATED SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE         BIOM     LAI NUPTK   N%    CET  RAIN   PESW
 4 May    0. SOWING                    g/m^2        kg/ha         ---mm----    cm
 5 May    3. GERMINATION                                           14.   37.   10.
11 May   44. EMERGENCE                                              0.    0.   10.
10 Jun  244. END JUVENILE                14.    .27   5.5  3.91    26.   25.   10.
17 Jun  335. TASSEL INITIATION           39.    .71  16.4  4.20    51.  160.   17.
13 Aug  880. 75% SILKING                905.   4.82 187.6  2.07   276.  326.    7.
 2 Sep 1047. BEGIN GRAIN FILL          1071.   4.39 177.4  2.26   347.  453.   12.
 CROP MATURE ON JD 273BECAUSE OF SLOWED GRAIN FILLING
29 Sep 1229. END GRAIN FILL            1430.    .00 112.5  1.46   429.  516.   10.
30 Sep 1233. PHYSIOLOGICAL MATURITY    1430.    .00 112.5  1.46   433.  516.    9.

YIELD (KG/HA)=  4405. (BU/ACRE)= 70.2 FINAL GPSM= 2814. KERNEL WT.(mg)=132.3

ISTAGE       CSD1       CSD2       CNSD1       CNSD2   S T A G E  OF  G R O W T H
     1        .00        .00         .01         .06   EMERG to END JUVENILE PHASE
     2        .00        .00         .00         .05   END JUV to TASSEL INITIATION
     3        .00        .00         .02         .10   TASSEL INITIATION to SILKING
     4        .00        .00         .02         .10   SILKING to BEGIN GRAIN FILL
     5        .00        .00         .00         .06   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1992 DRYLAND SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE         BIOM     LAI NUPTK   N%    CET  RAIN   PESW
 4 May    0. SOWING                    g/m^2        kg/ha         ---mm----    cm
 5 May    3. GERMINATION                                            3.    0.    7.
11 May   44. EMERGENCE                                              2.    0.    7.
10 Jun  244. END JUVENILE                10.    .20   4.0  3.84    26.   25.    7.
17 Jun  335. TASSEL INITIATION           27.    .50  11.2  4.09    49.  160.   15.
13 Aug  880. 75% SILKING                667.   3.82 117.8  1.77   270.  287.    3.
 2 Sep 1047. BEGIN GRAIN FILL           729.   3.07 106.9  1.90   326.  376.    6.
 CROP MATURE ON JD 273BECAUSE OF SLOWED GRAIN FILLING
29 Sep 1229. END GRAIN FILL             990.    .00  66.8  1.21   405.  401.    1.
30 Sep 1233. PHYSIOLOGICAL MATURITY     990.    .00  66.8  1.21   405.  401.    1.

YIELD (KG/HA)=  3195. (BU/ACRE)= 50.9 FINAL GPSM= 2045. KERNEL WT.(mg)=132.0

ISTAGE       CSD1       CSD2       CNSD1       CNSD2   S T A G E  OF  G R O W T H
     1        .00        .00         .01         .08   EMERG to END JUVENILE PHASE
     2        .00        .00         .02         .10   END JUV to TASSEL INITIATION
     3        .00        .00         .03         .12   TASSEL INITIATION to SILKING
     4        .17        .26         .03         .11   SILKING to BEGIN GRAIN FILL
     5        .01        .04         .05         .17   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1992 WEATHER

MONTH	MAX TEMP (C)	MIN TEMP (C)	SOLAR RADIATION (MJ/M^2)	RAIN (mm)
Jan	0.07	-10.50	5.88	10.16
Feb	1.51	-6.97	8.36	15.24
Mar	7.01	-4.20	13.00	22.86
Apr	10.59	-0.59	13.33	2.54
May	21.90	6.22	22.89	10.16
Jun	23.47	11.32	22.06	182.88
Jul	22.32	11.87	17.58	55.88
Aug	23.42	11.68	19.68	111.76
Sep	21.14	6.91	15.85	40.64
Oct	14.46	0.86	10.63	22.86
Nov	0.31	-5.50	4.82	5.08
Dec	-4.47	-14.36	5.53	2.54
AVG/TOTAL	11.81	0.56	13.30	482.60

1992 IRRIGATION

	Jun	Jul	Aug	Sep	Year Total
Inches per acre	0.00	1.54	1.50	0.00	3.04
Total Water (in.)	0.00	200.20	195.00	0.00	395.20
System Time (hrs.)	0.00	112.62	109.69	0.00	222.31
KW Used	0.00	3096.98	3016.54	0.00	6113.52
Total Energy Cost	$0.00	$281.94	$280.33	$0.00	$562.27
Cost per acre	$0.00	$2.17	$2.16	$0.00	$4.33

	1992	
RECEIPTS:	IRRIGATED	DRYLAND
Simulated grain yield (units/ac.)	70.2	50.9
DIRECT COSTS:		
Seed ($/ac.)	$28.50	$20.90
Fertilizer ($/ac.)	$51.19	$38.40
Herbicide ($/ac.)	$20.48	$20.48
Insecticide ($/ac.)	$8.25	$8.25
Drying ($/unit)	$0.15	$0.15
Drying ($/ac.)	$10.53	$7.64
Overhead	$4.50	$4.50
Fuel and Lubrication	$10.90	$10.90
Machinery repair	$12.02	$12.02
Crop operating loan borrowed (months)	7	7
Interest APR (%)	8.05	8.05
Crop direct costs borrowed (%)	75	75
Interest on direct costs ($/ac.)	$4.35	$3.34
Subtotal direct operating costs:	$150.72	$126.42
Irrigation:		
Facilities charge	$5.50	-
Power	$4.33	-
System repair/maintainance	$1.70	-
Insurance	$2.71	-
Subtotal irrigation direct cost:	$14.24	-
Total direct operating cost:	$164.96	$126.42
FIXED COSTS:		
Interest on machine investment ($/ac.)	$12.73	$12.73
Deprec. on machinery and equipment ($/ac.)	$22.34	$22.34
Machinery housing and insurance ($/ac.)	$2.51	$2.51
Irrigation lease/ownership cost ($/ac.)	$37.78	-
Deprec. on irrigation system ($/ac.)	$18.08	-
Operator Labor (hr./ac.)	2.90	2.25
Operator Labor cost ($/hr.)	$6.50	$6.50
Operator Labor cost ($/ac.)	$18.85	$14.63
Real estate taxes ($/ac.)	$5.41	$5.41
Total fixed costs	$117.70	$57.62
RESULTS:		
Production costs ($/ac., excluding land)	$282.66	$184.03
Production costs ($/unit)	$4.03	$3.62
Land charges ($/ac.)	$43.18	$43.18
Total cost ($/ac.)	$325.84	$227.21
Breakeven price ($/unit)	$4.64	$4.46

1993 IRRIGATED SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE            BIOM    LAI NUPTK    N%    CET  RAIN   PESW
 5 May    0. SOWING                       g/m^2        kg/ha          ---mm----    cm
 6 May    5. GERMINATION                                               16.    41.   10.
15 May   53. EMERGENCE                                                 28.    60.   13.
16 Jun  249. END JUVENILE                   13.    .27    5.2  3.91   100.   210.   19.
23 Jun  321. TASSEL INITIATION              28.    .54   10.1  3.58   129.   278.   19.
10 Aug  979. 75% SILKING                   896.   4.79  196.6  2.08   340.   449.    9.
22 Aug 1048. BEGIN GRAIN FILL             1146.   4.50  180.5  2.15   391.   490.    7.
 CROP MATURE ON JD 260BECAUSE OF SLOWED GRAIN FILLING
17 Sep 1283. END GRAIN FILL               1836.    .00  100.5  1.23   490.   584.    7.
18 Sep 1292. PHYSIOLOGICAL MATURITY       1836.    .00  100.5  1.23   493.   587.    7.

YIELD (KG/HA)=  6001. (BU/ACRE)= 95.6 FINAL GPSM= 3353. KERNEL WT.(mg)=151.2

ISTAGE       CSD1        CSD2       CNSD1        CNSD2    S T A G E  OF  G R O W T H
     1        .00         .00         .00          .06    EMERG to END JUVENILE PHASE
     2        .00         .00         .01          .08    END JUV to TASSEL INITIATION
     3        .00         .00         .02          .11    TASSEL INITIATION to SILKING
     4        .00         .00         .02          .10    SILKING to BEGIN GRAIN FILL
     5        .00         .00         .03          .12    GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1993 DRYLAND SIMULATION

```
 DATE  CDTT PHENOLOGICAL STAGE            BIOM    LAI NUPTK    N%    CET  RAIN   PESW
 5 May    0. SOWING                       g/m^2        kg/ha          ---mm----    cm
 6 May    5. GERMINATION                                               16.    41.   10.
15 May   53. EMERGENCE                                                 28.    60.   13.
16 Jun  249. END JUVENILE                   10.    .19    3.8  3.91    99.   210.   18.
23 Jun  321. TASSEL INITIATION              20.    .39    6.9  3.38   127.   276.   20.
10 Aug  979. 75% SILKING                   682.   3.90  125.1  1.89   336.   411.    5.
22 Aug 1048. BEGIN GRAIN FILL              858.   3.47  125.3  2.01   387.   452.    4.
 CROP MATURE ON JD 260BECAUSE OF SLOWED GRAIN FILLING
17 Sep 1283. END GRAIN FILL               1160.    .00   68.7  1.17   440.   471.    0.
18 Sep 1292. PHYSIOLOGICAL MATURITY       1160.    .00   68.7  1.17   443.   474.    0.

YIELD (KG/HA)=  4191. (BU/ACRE)= 66.7 FINAL GPSM= 3089. KERNEL WT.(mg)=114.6

ISTAGE       CSD1        CSD2       CNSD1        CNSD2    S T A G E  OF  G R O W T H
     1        .00         .00         .00          .06    EMERG to END JUVENILE PHASE
     2        .00         .00         .02          .10    END JUV to TASSEL INITIATION
     3        .00         .00         .03          .12    TASSEL INITIATION to SILKING
     4        .00         .00         .02          .11    SILKING to BEGIN GRAIN FILL
     5        .49         .58         .06          .19    GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.
```

1993 WEATHER

MONTH	MAX TEMP (C)	MIN TEMP (C)	SOLAR RADIATION (MJ/M^2)	RAIN (mm)
Jan	-5.48	-16.58	7.00	4.06
Feb	-6.70	-16.37	9.72	5.08
Mar	1.88	-9.11	14.71	14.99
Apr	10.79	-0.26	16.02	52.07
May	18.71	6.64	19.37	122.94
Jun	22.18	11.75	19.94	201.93
Jul	25.30	15.61	20.00	105.16
Aug	26.32	14.84	19.62	66.29
Sep	19.24	7.97	17.58	49.02
Oct	15.24	0.93	11.86	8.13
Nov	0.37	-9.62	8.78	0.00
Dec				
AVG/TOTAL	11.62	0.53	14.96	629.67

1993 IRRIGATION

	Jun	Jul	Aug	Sep	Year Total
Inches per acre	0.00	0.00	2.99	1.46	4.45
Total Water (in.)	0.00	0.00	388.70	189.80	578.50
System Time (hrs.)	0.00	0.00	218.65	106.77	325.42
KW Used	0.00	0.00	6012.97	2936.10	8949.07
Total Energy Cost	$0.00	$0.00	$340.26	$278.72	$618.98
Cost per acre	$0.00	$0.00	$2.62	$2.14	$4.76

	1993	
RECEIPTS:	IRRIGATED	DRYLAND
Simulated grain yield (units/ac.)	95.6	66.7
DIRECT COSTS:		
Seed ($/ac.)	$28.50	$20.90
Fertilizer ($/ac.)	$56.79	$42.64
Herbicide ($/ac.)	$28.01	$28.01
Insecticide ($/ac.)	$8.34	$8.34
Drying ($/unit)	$0.15	$0.15
Drying ($/ac.)	$14.34	$10.01
Overhead	$4.50	$4.50
Fuel and Lubrication	$12.76	$12.76
Machinery repair	$11.57	$11.57
Crop operating loan borrowed (months)	7	7
Interest APR (%)	7.50	7.50
Crop direct costs borrowed (%)	75	75
Interest on direct costs ($/ac.)	$4.53	$3.50
Subtotal direct operating costs:	$169.34	$142.23
Irrigation:		
Facilities charge	$5.50	-
Power	$4.76	-
System repair/maintainance	$1.70	-
Insurance	$2.71	-
Subtotal irrigation direct cost:	$14.67	-
Total direct operating cost:	$184.01	$142.23
FIXED COSTS:		
Interest on machine investment ($/ac.)	$12.41	$12.41
Deprec. on machinery and equipment ($/ac.)	$23.69	$23.69
Machinery housing and insurance ($/ac.)	$2.66	$2.66
Irrigation lease/ownership cost ($/ac.)	$37.78	-
Deprec. on irrigation system ($/ac.)	$18.08	-
Operator Labor (hr./ac.)	2.90	2.25
Operator Labor cost ($/hr.)	$6.50	$6.50
Operator Labor cost ($/ac.)	$18.85	$14.63
Real estate taxes ($/ac.)	$5.54	$5.54
Total fixed costs	$119.01	$58.93
RESULTS:		
Production costs ($/ac., excluding land)	$303.02	$201.15
Production costs ($/unit)	$3.17	$3.02
Land charges ($/ac.)	$45.90	$45.90
Total cost ($/ac.)	$348.92	$247.05
Breakeven price ($/unit)	$3.65	$3.70