CORN YIELD RESPONSE TO NITROGEN AND IRRIGATION IN SOUTHEAST MISSOURI 1963

Stevens Stauber and Frank Miller

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CONTENTS

SUMMARY

The yield response of corn to supplemental water applications varies from year to year depending on the weather conditions which are encountered during the crop season. Likewise, the optimum plant population and optimum plan of nitrogen fertilization are related to the soil moisture conditions which exist during the growing season. This report contains results of the first of a series of experiments which are being conducted to provide basic information regarding the relationships of soil moisture, nitrogen level, and plant population to corn yield. Application of the results of a single year's observations in making management and investment decisions should be done with extreme caution.

ACKNOWLEDGMENTS

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Wayne L. Decker of the Department of Soils, and Charles Cromwell of the Department of Agricultural Engineering, contributed significantly to this project. Norman Brown, superintendent, Delta Research and Extension Center, Portageville, Mo. directed the experimental work.

CORN YIELD RESPONSE TO NITROGEN FERTILIZATION AND IRRIGATION IN SOUTHEASTERN MISSOURI 1963

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Farmers have increased their use of supplemental irrigation rapidly in Missouri and other subhumid areas of the United States in the last 10 years. This has emphasized the need for critical examination of the economics of this practice.

The amount and distribution of rainfall cannot be predicted accurately on a year-to-year basis. For this reason it is impossible to forecast the need for supplemental irrigation or the response it will give in a specific crop season. During a given period of years, severe drouth seasons with total or near complete crop failure will occur. These years will be balanced by seasons of nearly optimum amounts and distribution of rainfall. Between these two extremes will fall years of widely varying degrees of drouth intensity. Consequently, realized costs and returns from irrigation vary widely from year to year.

Objective economic analysis must consider the effect of these varying intensities of drouth upon net returns from given crops and the associated probabilities of occurrence of these conditions over the useful life of the irrigation equipment. An investor in irrigation equipment cannot expect an equal return each year; he must be prepared to recover the cost over time.

The experiments reported here were designed to determine the response of corn to supplemental water applications and rates of nitrogen fertilization for soil and climatic conditions in southeast Missouri. They were conducted on Dubbs silt loam at the Barnes Ridge Farm, Delta Research Center, Portageville. A soil test was made and plant nutrients were applied in accordance with the recommendations of soil scientists so plant nutrients other than nitrogen would not limit yields. Table 1 gives results of the soil test. Table 2 lists the water-holding characteristics of the soil.

The 1963 growing season can best be described as "slightly better than average." Rainfall in June and July, although slightly less than normal, was ideally distributed for the development of the corn crop. Climatological data from a recording site located approximately one-fourth mile from the experimental site are summarized in Table 3.

TABLE 1 - RESULTS OF A SOIL TEST FROM THE SITE OF IRRIGATED CORN EXPERIMENTS

Barnes Ridge Research Farm, Portageville, 1963

Soil Type	O.M. %	P_2O_5 lbs/A	K lbs/A	Mg lbs/A	Ca lbs/A	H lbs/A	pH	Calculated Exchange Capacity
Dubbs silt loam	1.1	224	290	320	2,000	1.5	5.6	8.0

TABLE 2 - WATER-HOLDING CHARACTERISTICS OF DUBBS SILT LOAM FROM THE SITE OF IRRIGATED CORN EXPERIMENTS

Barnes Ridge Research Farm, Portageville, 1963

Item	Profile Depth (inches) 0-6	6-12	12-18	18-24	24-30	30-36	36-42
Available water per inch of soil depth	.1507	.1205	.1250	.1003	.0852	.1027	.0938
Accumulated available water in the profile at speci- fied depths	.9040	1.6270	2.3770	2.9790	3.4900	4.1060	4.6690

TABLE 3 - RECORDED PRECIPITATION AND TEMPERATURES FOR SPECIFIED PERIODS

Barnes Ridge Research Farm, Portageville, 1963

Period	Precipitation 1963	Normal[1]	Departure	Temperature 1963	Normal[1]	Departure
	(inches)			(degrees fahrenheit)		
May	3.78	4.51	-0.73	70.7	68.1	2.6
June	3.75	3.96	-0.21	77.3	77.1	0.2
July	2.99	3.22	-0.23	79.1	80.3	-1.2
August	1.90	4.98	-3.08	77.4	78.0	-0.6

[1]Bootheel Division averages from U.S. Department of Commerce, Weather Bureau, Climatological Data; Missouri; Annual Summary, 1962, Volume 66, No. 13.

PROCEDURE

Field Design

A complete factorial was imposed on a randomized block split-plot design. Irrigation was the main plot treatment. Five levels of nitrogen were applied to sub-plots within each irrigation plot. A controlled stand of 18,000 plants per acre was used in the irrigation plots. For comparison, plots with a stand of 14,000 plants per acre were included. These plots were not irrigated.

Treatments

Irrigation treatments. Irrigation applications were scheduled by computation of available soil-moisture balances using an evapo-transpiration formula. Three irrigation treatments were planned. One set of plots was to be irrigated whenever 2 inches of water were depleted from the root zone of the crop. Another set of plots was to be irrigated whenever 3 inches of water were depleted from the root zone. The last set of plots was not to be irrigated regardless of the severity of the drouth conditions. Drouth conditions demanding the application of water at the 3-inch level of depletion were not encountered during the course of the experiment.

Irrigation water was applied in the furrow with plastic gated pipe. The amount of water pumped was measured by a flow meter. The water received by the plots, either through rainfall or irrigation, is indicated in Table 4. Note that rainfall occurring after the first and third irrigations largely nullified the potential effect of these water applications. Therefore, most of any yield increase due to irrigation must be attributed to the second irrigation treatment. The second application was made July 4, which was 2 days following tasseling.[1]

Nitrogen applications. The five rates of nitrogen applied were 60, 100, 140, 180, and 220 pounds per acre. A starter application of 36 pounds was applied to all plots and the remainder was top dressed in the form of ammonium nitrate when the corn was approximately knee high.

Plant population. Plant populations were obtained by thinning to the desired levels after emergence.

Cultural practices. Cultural practices consistent with advanced technology were used. The ground was plowed, disked, and prepared for seeding in a conventional manner. Corn variety 523W was planted in beds on April 25 with 4-row equipment. Atrazine, applied as a pre-emergence herbicide at a rate of 2 pounds per acre, was very effective in controlling weeds and grass. The corn was cultivated one time, primarily to open the furrows for the application of irrigation water.

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[1]Tasseling is defined as the date pollen is shed from at least one spike on approximately one-half of the corn plants.

TABLE 4 - RECORD OF DAILY PRECIPITATION AND IRRIGATION APPLICATIONS TO IRRIGATED CORN PLOTS

Barnes Ridge Research Farm, Portageville, Mo., June and July, 1963

Date	Rainfall	Irrigation	Date	Rainfall	Irrigation
6/1			7/1		
6/2			7/2	0.01	
6/3			7/3		
6/4			7/4		0.93
6/5			7/5		
6/6			7/6		
6/7			7/7	.32	
6/8			7/8		
6/9			7/9		
6/10			7/10		1.35
6/11	0.04		7/11		
6/12			7/12		
6/13			7/13	1.50	
6/14	.46		7/14		
6/15		1.60	7/15	.20	
6/16	1.80		7/16		
6/17	.05		7/17		
6/18			7/18	.60	
6/19			7/19		
6/20			7/20		
6/21	.90		7/21		
6/22			7/22		
6/23			7/23		
6/24	.03		7/24		
6/25			7/25		
6/26			7/26		
6/27			7/27	.03	
6/28	.36		7/28		
6/29	.11		7/29	.22	
6/30			7/30	.11	
			7/31		
Total	3.75	1.60		2.99	2.28

Aldrin was applied at a rate of 1 1/2 pounds per acre to control soil insects. The chemical was broadcast before planting and worked into the soil immediately.

Harvesting method. The corn was harvested with a combine equipped with a picker attachment. The entire plots were harvested. Dropped ears were not included in yield calculations. Two samples were taken from each plot for moisture determinations. Yields reported are on the basis of shelled corn adjusted to a 15.5 percent moisture content.

RESULTS

Yields

Table 5 gives yields obtained with the various treatments. Regression analysis was used to determine the relationship between nitrogen rate and corn yield per acre for the treatment combinations of (1) 18,000 plants--irrigated; (2) 18,000 plants--nonirrigated; and (3) 14,000 plants--nonirrigated. These relationships are presented in Figure 1.

It is evident that, for the weather conditions encountered during this experiment, 14,000 plants with no irrigation was superior to 18,000 plants with no irrigation at all levels of nitrogen. The treatment of 14,000 plants with no irrigation produced larger yields than 18,000 plants with irrigation up to approximately 80 pounds of nitrogen. However, at nitrogen rates higher than 80 pounds, production was appreciably greater on the irrigated than on the nonirrigated plots. At optimum nitrogen rates, the irrigated corn produced 130 bushels per acre compared to 112 bushels for the nonirrigated corn.

Costs and Returns

Budgeting methods were used to determine the expected costs and returns of alternative methods of production. The treatment of 18,000 plants with no irrigation was not considered because the less costly rate of 14,000 plants produced larger yields over the entire range of nitrogen treatments. This does not imply that 18,000 stalks are to be considered inferior to 14,000 stalks under conditions of no irrigation in all years. This was the outcome for this particular year. Conceivably, climatological conditions in another year could be such that the response from nonirrigated plots would be widely different from this year. This will only be established upon further investigation.

TABLE 5 - AVERAGE TREATMENT YIELDS FOR IRRIGATED CORN EXPERIMENT CONDUCTED ON DUBBS SILT LOAM SOIL
Barnes Ridge Farm, Portageville, 1963

Treatment	Pounds of Nitrogen Applied Per Acre				
	60	100	140	180	220
			(Bushels per acre)		
14,000 plants - nonirrigated	96.7	112.5	112.7	111.8	115.4
18,000 plants - nonirrigated	83.3	104.2	105.3	111.0	107.9
18,000 plants - irrigated	90.8	116.2	129.3	127.2	130.6

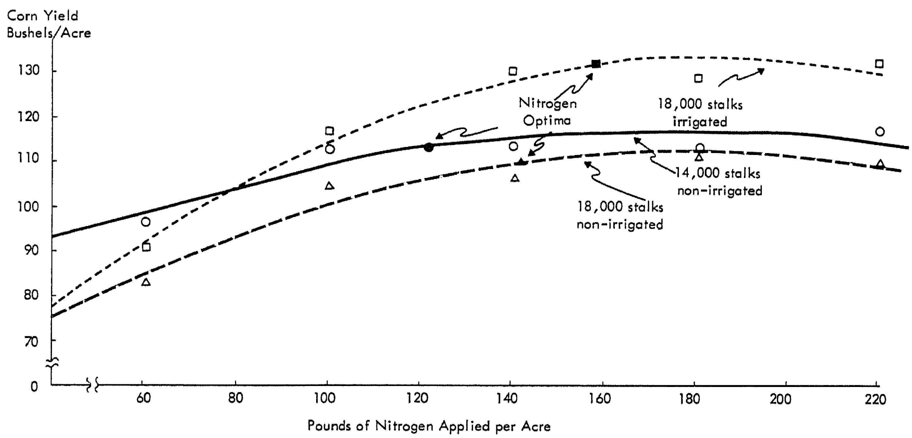

Figure 1. Corn yield response to nitrogen fertilizer for specified irrigation treatments and plant populations on a silt loam soil. (Barnes Ridge Experimental Farm, Portageville, 1963)

The budgets are presented for two levels of nitrogen fertilization: the first is for the optimum rate as determined by equating the marginal cost of applying nitrogen to the expected marginal returns from the use of nitrogen. The second set was prepared for a rate of nitrogen 20 pounds less than the optimum. This rate was used because of the tendency of many farmers to be conservative and to apply less than the optimum amount. The two rates of nitrogen application budgeted for 14,000-plant-nonirrigated treatments were 100 and 120 pounds. For the 18,000-plant-irrigated treatments, 135 and 155 pounds of nitrogen were budgeted.

Input-output relationships and costs used in the budgets reflect an advanced technology. The cost and input requirements used for irrigation are for the gated pipe method of water application.

The budgets reveal that the profitability of irrigation during the past year was dependent upon the specific resource situation in which it was used. If an irrigation system was available and an optimum nitrogen rate was used, returns to land, labor, management, and irrigation equipment would have amounted to $52.25 per acre (Table 6). Unirrigated corn brought a return of $45.93 per acre. This is a difference of $6.32 in favor of irrigated production.

If the additional labor needed to operate the system was hired at a rate of $1.00 per hour, the difference between the two methods of production is slight-- $43.55 per acre compared to $41.23 per acre in favor of irrigated production. However, if the annual fixed costs of the irrigation system are charged, returns to land and management are $36.55 for irrigated production compared to $41.23 for unirrigated production. This is a difference of $4.68 in favor of production without irrigation.

In summary, in 1963 under the described conditions, it would have been profitable to incur all variable costs of applying irrigation water including hired labor. However, the returns would not have covered the annual ownership cost of the irrigation system.

It must be emphasized that because of the variability of weather conditions these findings should not be interpreted as an average or normal expectation. However, an analysis of historical climatological records indicates that rainfall patterns more favorable to corn production than in 1963 can be expected about five years out of ten. Therefore, over a period of 10 years, 5 years can be expected with the same or less response to irrigation and 5 years with greater response. Information concerning the magnitude of these responses and the proportion of time where both fixed and variable costs can be met is not presently available. Only when additional information on the relationship of yield to varying moisture conditions is available can a complete evaluation of the economic feasibility of supplemental irrigation of this crop be made.

TABLE 6 - COSTS AND RETURNS PER ACRE, FOR IRRIGATED AND NONIRRIGATED METHODS OF CORN PRODUCTION, SILT LOAM SOIL, 1963[a]

			14,000 plants non-irrigated				18,000 plants irrigated			
			100 lbs. Nitrogen		120 lbs. Nitrogen		135 lbs. Nitrogen		155 lbs. Nitrogen	
Item	Unit	Price	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
Income:										
Corn	Bu.	$ 1.10	109	$119.90	112	$123.20	125	$137.50	130	$143.00
Expenses:										
Seed	Bu.	12.00	.20	2.40	.20	2.40	.24	2.88	.24	2.88
Fertilizer										
Phosphate	Ton	25.00	.15	3.75	.15	3.75	.15	3.75	.15	3.75
Lime	Ton	5.00	.50	2.50	.50	2.50	.50	2.50	.50	2.50
Starter (18-18-18)	Cwt.	4.50	2	9.00	2	9.00	2	9.00	2	9.00
Nitrogen	Lb.	.12	100	12.00	120	14.40	135	16.20	155	18.60
Aldrin	Lb.	2.75	1.5	4.12	1.5	4.12	1.5	4.12	1.5	4.12
Atrazine	Lb.	2.50	2	5.00	2	5.00	2	5.00	2	5.00
Tractor operation	Hr.	1.80	2.75	4.95	2.75	4.95	2.75	4.95	2.75	4.95
Equipment operation	Acre	2.85	1	2.85	1	2.85	1	2.85	1	2.85
Custom harvest	Bu.	.12	109	13.08	112	13.44	125	15.00	130	15.60
Truck operation	Mi.	.24	20	4.80	20	4.80	20	4.80	20	4.80
Storage	Bu.	.08	109	8.72	112	8.96	125	10.00	130	10.40
Interest on Operating Capital	Acre	1.10	1	1.10	1	1.10	1	1.10	1	1.10
Irrigation Operating Costs	Acre-inch	1.30					4	5.20	4	5.20
Total Costs				74.27		77.27		87.35		90.75
Return to Land, Labor, Management and Irrigation Equipment				45.63		45.93		50.15		52.25

TABLE 6 (CONTINUED)

Item	Unit	Price	14,000 plants non-irrigated				18,000 plants irrigated			
			100 lbs. Nitrogen		120 lbs. Nitrogen		135 lbs. Nitrogen		155 lbs. Nitrogen	
			Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
Labor										
Tractor operation	Hr.	1.00	3.1	3.10	3.1	3.10	3.1	3.10	3.1	3.10
Truck operation	Hr.	1.00	1.6	1.60	1.6	1.60	1.6	1.60	1.6	1.60
Irrigation	Hr.	1.00					4	4.00	4	4.00
Total Labor	Hr.	1.00	4.7	4.70	4.7	4.70	8.7	8.70	8.7	8.70
Return to Land, Management, and Irrigation Equipment				40.93		41.23		41.45		43.55
Fixed Cost of Irrigation Equipment	Acre	1.00						7.00		7.00
Return to Land and Management				40.93		41.23		34.45		36.55

[a]Costs used reflect advanced technology and the gated pipe and furrow method of applying irrigation water.