EFFECT OF IRRIGATION AND NITROGEN ON CORN YIELD AND PROFIT

Donald R. Christenson
Crop and Soil Sciences Department
Michigan State University

ABSTRACT

An understanding of the interaction of various inputs on corn yield and profit is important in decision making for corn production. This study was conducted to evaluate 1) the effect of irrigation, hybrid, seeding rate and nitrogen rate on yield of corn and 2) the effect of these inputs on marginal return and cost per bushel for corn production. This study was conducted for three years at two locations on a Conover loam and a Zilwaukee clay soil. The three years represented a normal rainfall year, a dry year and a year with above normal rainfall. Corn yield was increased 40 bushels per acre by irrigation and there was a 24 bu/acre difference between two hybrids. Seeding and N rates had no effect on yield. Irrigation reduced marginal return $85/acre compared to non-irrigated, there was a $52/acre difference in return between hybrids and there was a $15/acre loss from the use of an extra 75 lb N/acre. In order for a center pivot irrigation system to be profitable, there would have to be at least a 75 bu/acre advantage from irrigation. It does not appear that this is possible on medium and fine textured soils in Michigan.

* * * * * * *

Meteorological drought occurs sometime during the growing season nearly every year in Michigan. Strommen et al. (1969) reported during a 37 year period that drought occurred in 36 percent of the months. Baten et al. (1959) reported there being less than a 20% probability of receiving in excess of one inch of rain during June, July and August in Michigan. Corn can tolerate some moisture stress during the growing season. For example, Robbins and Domingo (1953) reported that corn can tolerate appreciable soil moisture stress with only limited effect on grain yield except during the period of tassel emergence to pollination. Bruce et al. (1969) found that 16 of 25 double cross hybrids gave a 10% or greater grain yield response to irrigation while the remainder showed little or no yield increase.

Many growers in Michigan have installed irrigation systems for corn production on coarse textured soils and are producing high yields. While there are some indications that it would not be economical to irrigate corn on medium and fine textured soils, there are not sufficient data to evaluate this question over a number of years and sites.

Other inputs such as nitrogen and seeding rate will have an effect on marginal return in corn production. Vitosh et al. (1974) have shown economic rates of nitrogen for corn production without irrigation. Karlen and Camp (1985) showed that a plant density of approximately 28,000 to 36,000 plants per acre would be sufficient optimum for corn production on sandy soils. Without irrigation, the rate should not exceed 28,000. There are little data showing the effect of seeding rate and the interaction of irrigation, seeding rate and nitrogen rate on the economics of corn production.

This study was oriented toward evaluation of some inputs which could result in a reduction of the cost of production per bushel of corn. The objectives of the study were: 1) to evaluate the effect of supplemental irrigation, choice of hybrid, plant population and nitrogen rate on yield of corn grown on medium and fine textured soils and 2) to evaluate the marginal return and cost per bushel after use of these inputs.

METHODS

A series of experiments were conducted on a Conover loam and a Zilwaukee clay soil for three years giving six location-year combinations. Yield, grain moisture, barren stalks at harvest, marginal return and marginal cost per bushel were measured.

The experiments were arranged in a split plot design with four replications. The main plot was irrigation level (plus and minus)
and the sub-plots were factorial combinations of corn hybrid (Pioneer 3901 and 3475), planting time population (28,000 and 37,000) and nitrogen rate (150 and 225 lb/acre).

Irrigation timing was scheduled using a program developed by M. L. Vitosh of the Crop and Soil Sciences Department, Michigan State University. Irrigation was applied so as to keep the available water in the surface three feet above 50% of the available water capacity. The corn hybrids represent a nominal 100 day (3901) and a 115 day (3475) maturity which did not have the same inbred lines in their parentage. Nitrogen application was split with one-half applied pre-plant and one-half sidedressed in June. Phosphorus and K were applied based on soil test values.

Marginal costs and returns were calculated using the following prices and costs:

Income:	$2.50/bushel		
Costs:	a.	Seed	- $70/unit of 80,000 seeds
	b.	Irrigation	- equipment $150/acre/year - pumping $3.50/acre inch
	c.	Nitrogen	- $0.19/lb N
	d.	Trucking	- $0.10/bushel
	e.	Drying	- $0.015/ bushed for each percent moisture above 15.5%

Planting dates were between the 20th of April and the 1st of May

with harvest dates between the 10th and 25th of October. A weed control program of Bladex and Lasso was followed, supplemented by cultivation and hand weeding.

RESULTS

Rainfall, applied irrigation and "normal" rainfall are given in Table 1 for both sites. This study was conducted in a range of moisture conditions ranging from a "normal" year (1987), a dry year (1988) and a "wet" year (1989). The differences in total water supplied between years is due to seasonal distribution of rainfall.

The average values (six-location/years) for the various parameters measured as affected by irrigation, hybrid, seeding rate and nitrogen rate are given in Table 2. The interaction of irrigation x hybrid x seeding rate x nitrogen rate was not significant for any of the parameters measured. Most of the other interactions were not significant leaving the simple effects to be examined.

Yield of corn was increased by 40 bushels per acre from the application of supplemental water (Table 3). Hybrid 3475 yielded 24 bushels more than 3901, with there being no difference in yield for the two seeding rates and two nitrogen rates. Grain moisture was reduced by 1.9% with irrigation, was 1.2% lower for hybrid 3901 and was 0.5% higher at the higher seeding rate. Nitrogen rate had no effect on grain moisture. The coefficient of variation for the barren stalk measurement was extremely high, consequently there were no detectable differences between the various inputs.

Marginal return was $85/acre greater without irrigation than with irrigation. Hybrid 3475 produced $52/acre more the 3901 when averaged across all other inputs. The higher N rate reduced marginal return by $15/acre. The unit cost for prod- ucing corn was lowest for the non-irrigated treatment and for the best yielding hybrid.

DISCUSSION

The effect of the extra nitrogen on marginal return in the "best case" (non-irrigated, hybrid 3475, 28,000 seeds/acre) was $20/acre (Table 2). There was a $12/acre reduction in marginal return due to the higher seeding rate. These differences may be greater than the cost of the input because of small variations in other costs such as drying etc.

These results clearly show that irrigation on these medium and fine textured soils in not economically viable for corn production in Michigan. Even in the driest year (1988), the marginal return was $56/acre greater for the non-irrigated than for the irrigated treatments. The yield advantage from irrigation would have to be at least 75 bushels per acre in order to break even. For those farmers who could reduce the installation cost of $1,000/acre, the economic viability of sprinkler irrigation of corn may be much better.

REFERENCES

Baten, W. D., A. H. Eichmeier and E. H. Kidder. 1959. Rainfall probabilities in Michigan. Mich. Agric. Exp. Sta. Quar. Bull. 42: 142-145

Bruce, R. R., J. O. Sanford, C. O. Grogan and D. L. Myhre. 1969. Soil water supply and depletion pattern differentiate among Zea mays L. in single and double cross hybrids. Agron. J. 61:416-442.

Karlen, D. L. and C. R. Camp. 1985. Row spacing, plant population and water management effects on corn in the Atlantic Coastal Plain. Agron J. 77:393-398.

Robbins, J. S. and C. E. Domingo. 1953. Some effects of severe soil moisture deficits at specific growth stages in corn. Agron. J. 45: 618-621.

Strommen, N. D., C. Van Den Brink and E. H. Kidder. 1969. Meteorological drought in Michigan. Mich. Agric. Exp. Sta. Res. Rep. 78.

Vitosh, M. L.,. R. E. Lucas and R. J. Black. 1979. Effect of nitrogen fertilizer on Corn yield. Mich. State Univ, Coop. Ext. Bull. E-802.

Table 1. Rainfall plus irrigation for May-September for the irrigation study on the Conover loam and the Zilwaukee clay, 1987-1989.

Year	Conover loam			Zilwaukee clay		
	Rainfall	Irrigation	Total	Rainfall	Irrigation	Total
1987	13.58	8.00	21.58	15.08	6.75	21.83
1988	9.91	8.58	18.49	9.81	7.00	16.81
1989	22.57	4.75	27.32	18.99	5.50	24.49
40 year average rainfall		15.45			14.40	

Table 2. Effect of irrigation, hybrid, seeding rate and nitrogen rate on yield, grain moisture, barren stalks, marginal return and marginal unit cost for corn grown on a Conover loam and a Zilwaukee clay, 1987-1989.

Irrigation	Pioneer Hybrid	Seeding Rate+	Nitrogen Rate	Yield	Grain Moisture	Barren Stalks	Marginal Return	Marginal Cost
		seeds/acre	lb/acre	bu/acre	- - - - - %	- - - - - -	$/acre	$/bu
No	3901	28,000	150	113	24.5	6.8	203	0.75
No	3901	28,000	225	117	24.2	4.7	197	0.86
No	3901	37,000	150	116	24.9	5.7	201	0.83
No	3901	37,000	225	112	25.3	4.7	177	1.01
No	3475	28,000	150	137	25.6	3.9	257	0.66
No	3475	28,000	225	135	25.5	8.6	237	0.80
No	3475	37,000	150	136	24.8	10.8	245	0.74
No	3475	37,000	225	134	26.1	11.5	227	0.88
Yes	3901	28,000	150	149	24.8	5.6	109	1.82
Yes	3901	28,000	225	147	25.0	6.4	91	1.93
Yes	3901	37,000	150	157	25.6	3.9	120	1.76
Yes	3901	37,000	225	154	25.6	6.8	98	1.90
Yes	3475	28,000	150	172	25.5	3.8	159	1.60
Yes	3475	28,000	225	176	25.7	3.7	155	1.65
Yes	3475	37,000	150	180	26.2	5.4	170	1.57
Yes	3475	37,000	225	184	26.3	6.4	163	1.64
LSD (5%) Irrigation x Hybrid x Seeding Rate x N Rate				NS	NS	NS	NS	NS

+ Population at harvest: 26,400 and 33,000 plants per acre for 28,000 and 37,000 seeds/acre respectively

Table 3. Simple effect of irrigation, hybrid, seeding rate and nitrogen rate on yield, grain moisture, barren stalks, marginal return and marginal unit cost for corn grown on a Conover loam and a Zilwaukee clay, 1987-1989.

Simple Effect	Yield	Grain Moisture	Barren Stalks	Marginal Return	Marginal Cost
	bu/acre	- - - - % - - - - - -		$/acre	$/bu
Irrigation					
No	125	25.1	7.1	218	0.82
Yes	165	25.6	5.2	133	1.73
Probability	*	*	NS	*	*
Hybrid					
3901	133	25.0	5.6	150	1.36
3475	157	25.7	6.8	202	1.19
Probability	*	*	NS	*	*
Seeding Rate					
28,000	143	25.1	5.4	176	1.26
37,000	146	25.6	6.9	175	1.29
Probability	NS	*	NS	NS	NS
Nitrogen Rate					
150	145	25.2	5.7	183	1.22
225	145	25.5	6.6	168	1.33
Probability	NS	NS	NS	*	*

* = 5%

PROCEEDINGS OF THE TWENTIETH

NORTH CENTRAL EXTENSION - INDUSTRY SOIL FERTILITY CONFERENCE

November 14-15, 1990, Holiday Inn St. Louis Airport

Bridgeton, Missouri

Volume 6

Program Chairman:

David B. Mengel

Department of Agronomy
Purdue University
Lilly Hall of Life Sciences
West Lafayette, IN 47907-7899