Optimum N Rates for Corn Production as Influenced by Crop Rotation

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Fertilizer N efficiency in corn production has become a "hot" research topic in the 1980's. Increased concerns of nitrate-N entering the groundwater and the potential for improving the profitability of corn producers are the impetus for fine-tuning fertilizer N recommendations. Crop production factors such as improved diagnostic techniques, full utilization of symbiotic N fixation, and crop rotation have been gaining widespread research support throughout the United States. The adoption of crop rotations or sequences may play a vital role in the conservation of N. This paper will address a long term crop rotation experiment conducted at Waseca, Minnesota. The study covers a 12 year period and was initiated to determine the N needs of corn grown in rotations that are representative of southern Minnesota crop production systems.

Experimental Procedures

The experiment was established in 1974 on a Webster clay loam with three crop sequences. The treatments were continuous corn, corn-soybeans, and corn-wheat. All plots were replicated five times in a split plot design with crop sequences as the main plot. Each main plot was split into six N rates of 0, 40, 80, 120, 160 and 200 lb N/A which have been applied annually to corn.

In the fall of 1974 and 1975, the N treatments (each N plot 15' x 60') were applied broadcast as urea and plowed down immediately. All other years, the N was applied as anhydrous ammonia preplant. The wheat crop annually received 50 lb N/A as urea before planting. Phosphorus and potassium were applied as needed so as to not be a limiting factor.

Corn was planted consistently in early May throughout the study in 30" rows. A soil insecticide was used at recommended rates on all corn plots to control rootworms. Wheat and soybeans were also consistently planted in late April and mid May, respectively. Each year weeds were controlled with recommended chemical and/or cultural practices on all plots. Corn yields were determined by mechanical harvesting.

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After each harvest soil samples were taken to a depth of 5' in one foot increments from the 0 and 160 lb N treatments within the continuous corn system. Soil samples were also taken from the 0-lb N treatments in the plots where soybeans and wheat were the preceding crops grown in the respective rotation. Between the 1984-1985 and the 1985-1986 crop years, soil samples were taken in the fall and in the spring. Two cores/plot were extracted, composited, and analyzed for nitrate-N.

Results

Total nitrate-N levels remaining in the soil profile between the 1984-1985 and the 1985-1986 crop years are shown in Table 1. These data indicate that where no fertilizer N was applied (except the blanket 50 lb N rate to wheat), very little difference in residual nitrate-N was found in the fall sampling among the crop sequences and within the same crop year. This was consistent with past years of the study.

However, nitrate-N levels fluctuated from the fall sampling period to spring sampling at the 0-lb N rate. Between 1984-1985 crop years, a slight increase in nitrate-N was found in the spring compared to the previous fall sampling. In contrast, between the 1985-1986 crop years residual nitrate-N levels decreased from the fall to the spring sampling period. At the 160 lb N rate, nitrate-N in the soil profile decreased from the fall to the spring sampling in both years. Reasons for these decreases are probably due to either denitrification or leaching.

The effect of previous crop on corn response to N from 1975-1986 is summarized in Table 2. This long term study shows that crop rotation has a substantial effect on corn yield. When averaged over the 12 year period, corn yields have been optimized with 175, 140, and 140 lb N/A for the continuous corn, corn-soybean, and corn-wheat rotations, respectively. The highest corn yields obtained with minimum N input were found when corn followed either soybeans or wheat. At the optimized N rates, yields for corn following soybeans and wheat were 15 and 13% higher than for continuous corn. In most years the sequence X N rate interaction was highly significant. There did not appear to be any consistent relationship between the residual soil nitrate-N levels (Table 1) and corn yield response to N in each of the crop sequences. This was consistent with past years.

In Table 3, a closer examination of the data show that the University of Minnesota N recommendations lie favorably between the N rates that gave maximum yield and the N rates that give 95% maximum yield for each crop rotation. When plotted on a curve (Figure 1), it is evident that the N recommendations developed by the University of Minnesota are neither too conservative or excessive.

Summary

1. Residual soil nitrate-N levels determined in the fall after harvest and within the same crop year, result in very little difference irrespective of the crop sequence. Diagnostic techniques for predicting N needs in corn production will require further study. If soil testing for residual nitrate-N can be correlated with yield

response, the sampling period will probably be in the spring before planting in south central Minnesota.

2. Corn yields were substantially greater when corn followed soybeans and wheat compared to continuous corn. When corn is rotated with either of these two crops, yield increases of approximately 14% can be obtained over the continuous corn system at the recommended N rates.

3. N recommendations developed by the University of Minnesota under high yielding corn production, are neither too conservative or excessive and can result in the most favorable return for corn producers.

Reference

G. W. Randall, P. L. Kelly, and M. P. Russelle. Rotation Nitrogen Study, Waseca, 1986. Soil Series 117, A Report on Field Research in Soils. Agricultural Experiment Station, Miscellaneous Publication 2 (revised). University of Minnesota, St. Paul, MN. 1987.

Table 1. Effect of N rate applied to corn and crop sequence on total NO_3-N remaining in the 0-5 ft. profile, 1985 + 1986

Crop	Oct., 1984	April, 1985	Oct., 1985	April, 1986
	Total (lb NO_3-N/5 ft.)			
	0 lb N/A Rate			
Corn	77	96	53	30
Soybeans	95	119	68	53
Wheat	95	107	55	37
	160 lb N/A Rate			
Corn	297	125	119	88

Table 2. Effect of previous crop on corn response to N from 1975-86 at Waseca

N rate	Corn	Soybeans	Wheat
lb N/A	---------- bu/A ----------		
0	75	109	104
40	100	134	130
80	115	146	147
120	125	153	151
160	133	158	154
200	136	158	156

Table 3. Regression analyses of these data indicate:

		Crop Sequence	
	Continuous Corn	Corn-Soybeans	Corn-Wheat
Maximum yield (bu/A)	135.2	159.1	156.7
N rate that gave maximum yield (lb/A)	196	169	161
95% max. yield (bu/A)	128.4	151.1	148.9
N rate that gave 95% max. yield (lb/A)	130	100	98
Yield difference (max - 95%)	6.8	8.0	7.8
N difference (max - 95%)	66	69	63
U of M N recommendations (lb/A)	170	130	130

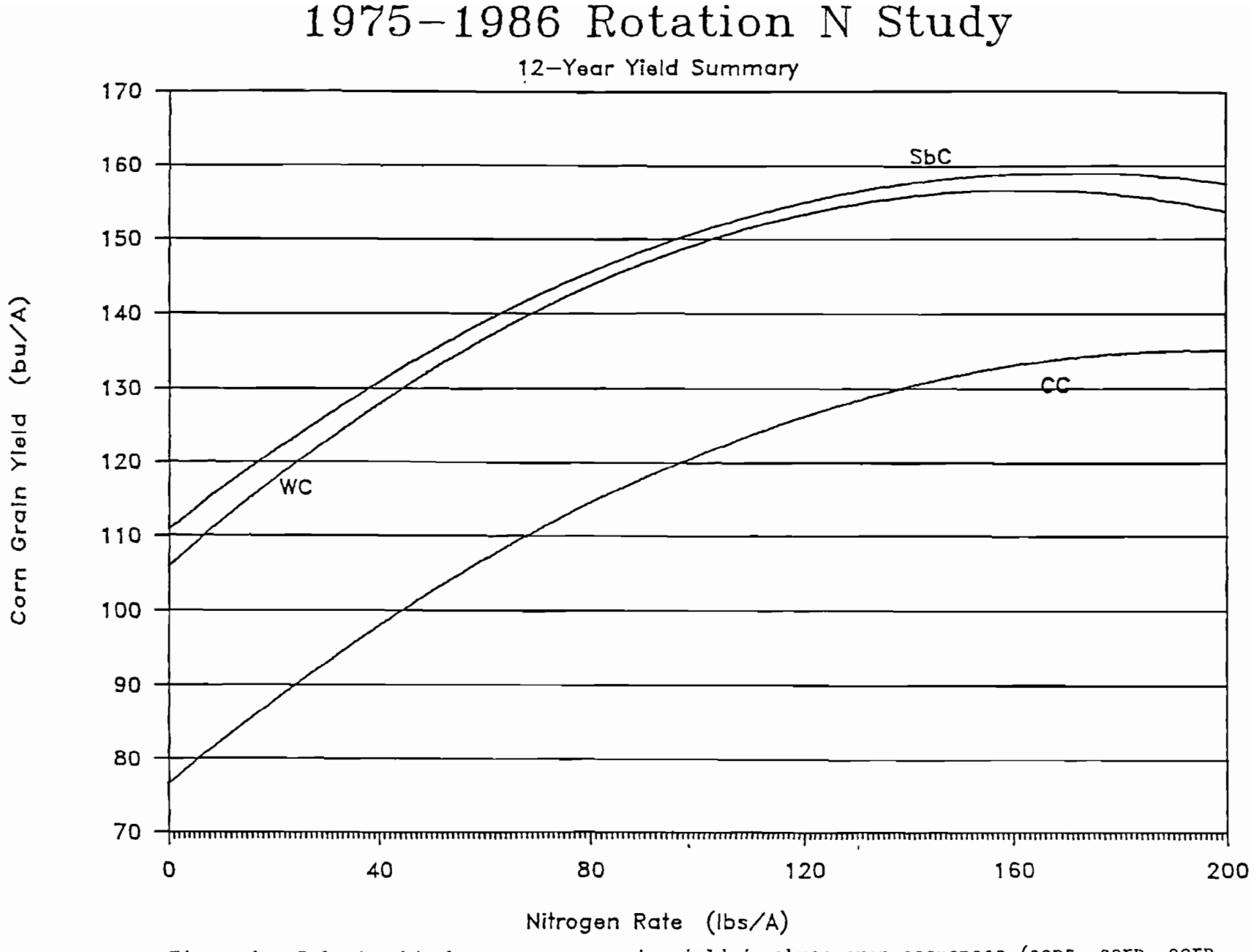

Figure 1. Relationship between corn grain yield in three crop sequences (cont. corn, corn after soybeans, and corn after wheat) and applied rate of N at Waseca.

Vol. 3

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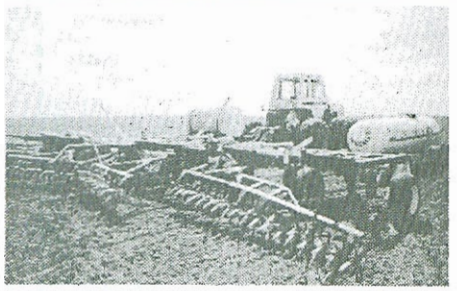

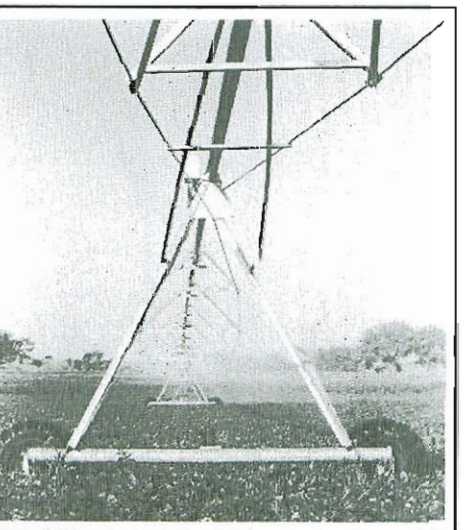
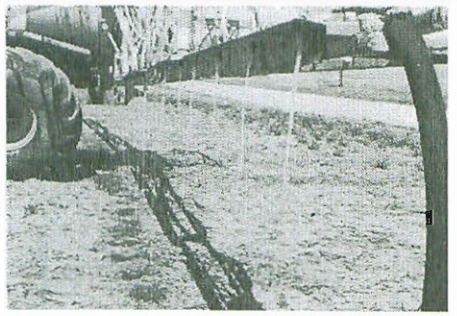
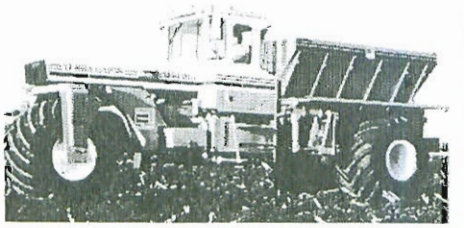
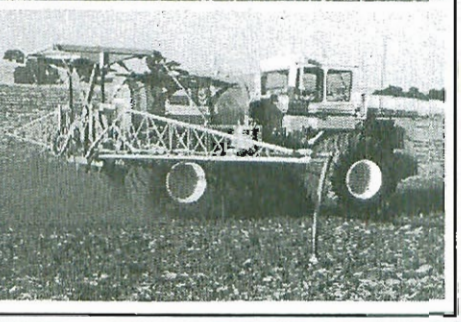

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