ECONOMICS OF NITROGEN FERTILIZER USE WITH LOW CROP PRICES

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The low corn price for Y2K combined with the recent increases in fertilizer nitrogen prices have caused agronomists, suppliers, and farmers to closely examine the amount of N they will apply this spring. Corn yield variations and differences in yield response to nitrogen fertilizer are primarily a function of the soil characteristics (depth, drainage, organic matter content, and yield potential) of the environment in which the corn is grown. The response to fertilizer N is also influenced by the amount of available nitrogen from other sources such as residual nitrate-N in the root zone or nitrogen from legumes or manure. These factors are accounted for by the UW soil test recommendations for nitrogen and the recommended adjustments. The combination of these components allows for the estimation of the economically optimum N rate. The very best rate of N to apply is the economic optimum rate because the last unit of N added just pays for itself with additional yield. This rate maximizes the dollar return per acre to the farmer.

The other needed components to calculate the optimum N rate is the fertilizer price, the commodity value, and the handling cost of the extra crop yield. These factors are summarized in Table 1 where the quantity of fertilizer N that can be purchased by the net value of a bushel of corn can be derived. This value is called the net corn:N price ratio. Net corn price refers to the market price of corn minus the cost of drying, marketing, handling, etc. If a $2.00 net corn price and $0.20 nitrogen cost is assumed, the resulting corn:N ratio is 10:1, indicating that a bushel of corn will purchase 10 pounds of N. If anhydrous sells for $360/ton and the net corn price was $1.60/bushel, the corn:N price ratio is 7.3. A quick survey of a couple of dealers suggests N costs may be 50 to 70% higher this coming spring compared to last year. Table 1 shows some example ratios for various fertilizer materials at today's market and several corn prices. Based on these data, it appears that ratios of 5 to 10 may be the norm this spring.

Price Ratio Impact on the Economic Optimum Nitrogen Rate (EONR)

Figure 1 shows the long-term nitrogen response for a Fayette soil in southwest Wisconsin and the economic optimum based on a more typical corn to N price ratio of 13.3 ($2.00 corn and $0.15 nitrogen). Based on these data, it is clear that at the 180 lb N/acre rate little additional return was generated, and if this were the current corn:N ratio and capital was

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Table 1. Corn to nitrogen price ratios for several N fertilizer materials.

Fertilizer	Cost	Unit N price	Corn:N ratio 1.50 corn	1.75 corn	2.00 corn
	$/ton	$/lb N			
Anhydrous NH_3, 82-0-0	360	0.22	6.8	8.0	9.1
Ammonium nitrate, 34-0-0	190	0.28	5.4	6.2	7.1
Ammonium sulfate, 21-0-0-24	180	0.43	3.5	4.1	4.7
Urea, 46-0-0	230	0.25	6.0	7.0	8.0
UAN solution, 28-0-0	175	0.31	4.8	5.6	6.5

Figure 1. Corn response to N fertilizer and economic returns (corn:N = 13.3) for Lancaster, WI, 1967-1990 (from Vanotti and Bundy, 1994).

unlimited, this would be the best rate to apply. As shown in Table 2, the economic optimum N rate changes slightly (from 180 to 160 to 140 lb N/acre) as the corn:N ratio changes from 13.3 to 10 to 8. However, further decreases in the ratio do not depress EONR. Even at a corn:N ratio of 5.7, the economic optimum remains at 140 lb N/acre. These data clearly show that neither marginally depressed commodity prices (as we are currently experiencing) nor substantial increases in the cost of N fertilizer (as is expected) should cause farmers to significantly change their N application rate. This insensitivity to value or price changes is primarily due to the steepness of slope in the corn nitrogen response curve and is not unique to the Fayette soil. Table 3 shows that this trend holds true for a wide range of soils.

Table 2. Calculation of economic optimum N rate (EONR) for the long-term Lancaster corn data based on several corn:N price ratios.†

N rate	Actual yield	Yield increase	Corn ‡ increase value	Inc. N fertilizer cost/lb 0.15 (13.3)§	0.20 (10)	0.25 (8)	0.30 (6.7)	0.35 (5.7)
lb/acre	------ bu/acre		---------------------------------	$/acre	----------------------------------			
0	78.0	---	---					
20	89.0	11.0	22.00	3.00	4.00	5.00	6.00	7.00
40	98.0	9.0	18.00	3.00	4.00	5.00	6.00	7.00
60	106.5	8.5	17.00	3.00	4.00	5.00	6.00	7.00
80	114.0	7.5	15.00	3.00	4.00	5.00	6.00	7.00
100	119.5	5.5	11.00	3.00	4.00	5.00	6.00	7.00
120	124.2	4.7	9.40	3.00	4.00	5.00	6.00	7.00
140	128.0	3.8	7.60	3.00	4.00	5.00	6.00	7.00
160	130.3	2.3	4.60	3.00	4.00	5.00	6.00	7.00
180	132.0	1.7	3.40	3.00	4.00	5.00	6.00	7.00
200	132.5	0.5	1.00	3.00	4.00	5.00	6.00	7.00

† Adapted from data presented in Vanotti and Bundy (1994).

‡ Corn values = $2.00/bushel.
§ Numbers in parentheses are the net corn:N price ratios.

Table 3. Net economic return from fertilizer N at the recommended N rate and higher or lower N rates for corn production on several Wisconsin soils. †

Soil	N rate	Yield increase from fertilizer N	Net economic return from fertilizer‡ Corn:N price ratios 16.7	13.3	10.0
	lb/acre	bu/acre	$/acre		
Plano	130	31.4	53.90	38.20	22.50
	160§	34.7	57.60	40.30	23.00
	190	36.5	57.70	39.50	21.20
Fayette	130	37.4	69.00	50.30	31.60
	160§	40.7	72.00	52.30	32.00
	190	41.9	71.40	50.40	29.40
Withee	90	24.3	42.20	30.10	17.90
	120§	27.5	45.70	31.90	18.20
	150	28.2	42.90	28.80	14.80
Meridian	90	21.7	35.90	25.00	14.10
	120§	25.2	39.90	27.40	14.80
	150	26.7	39.30	25.90	12.60
Plainfield	170	109.1	224.20	173.30	122.30
	200§	106.9	232.40	178.90	125.40
	230	108.1	230.80	176.70	122.70

† Adapted from Vanotti and Bundy (1994).

‡ Value of yield increase due to N – cost of N – cost of application ($5/acre).

§ Indicates recommended (base) N rates.

Insensitivity of EONR to Yearly Variation

While high corn yields result in more N uptake than lower yields, the greater N uptake at higher yield levels apparently does not require higher N applications. Good growing conditions may enhance soil N mineralization and improve the efficiency of N use through higher recovery of available N by the crop. This results in a relatively constant requirement for added N to optimize yields. This is illustrated by data from 3 years of a long-term continuous corn experiment on a Plano silt loam soil at Arlington, WI, characterized by very low spring residual nitrate and contrasting growing conditions (Fig. 2). Although the yield range in these 3 years was more than 100 bu/acre, the optimum N rate in each year was about 150 lb N/acre. Apparent recovery of fertilizer N by corn was high under favorable growing conditions in 1986, but recovery was low under the poor growing conditions caused by soil moisture stress in 1988. Schlegel et al. (1996) also reported a relatively constant EONR across low- to high-yielding years from a 31-year study in Kansas, as did Blackmer et al. (1993) from a variety of Iowa studies.

Figure 2. Corn yield response to applied N at Arlington, WI (adapted from Vanotti and Bundy, 1994).

Recognize Diminishing Nature of Response

Figure 1 and Table 2 also show that the largest returns per unit of N applied are attained with the first units added. As the EONR is approached, the returns become smaller (diminish) and at the EONR are zero. This means that if capital is short (not enough dollars available to apply the EONR to all of the acres), it would be better to apply some N to all corn acres than it would be to apply the EONR on some acres and no N on others. Applying N following this scenario does not maximize the farmer's potential returns for the whole farm, but it does use the available dollars as efficiently as possible.

Account for All Nitrogen Inputs

Although verified management recommendations and diagnostic tests for improving N application rate decisions are available, and the environmental effects of excess N use are well known, surveys of farmer practices show substantial evidence of excess N applications. While there are many factors contributing to excess N use, the most apparent is inadequate accounting for legume and manure N conditions. The frequently stated reason for inadequate N crediting is that farmers fear economic loss due to N deficiencies if recommended optimum N rates are used. Data from over 100 N response experiments conducted in Wisconsin during 1989 to 1999 were used to evaluate economic returns associated with using "book value" N credits and adjustments based on the presidedress nitrate test (PSNT) compared with ignoring these adjustments (Table 4). Results showed that making appropriate adjustments for organic N inputs was consistently more profitable when the credits were taken or the test was used not only when the corn:N ratio is high, but even more so when it is low. With narrow corn:N ratios, there is a substantial penalty for over-applying N that is somewhat avoided by using these advanced management techniques.

Table 4. Economic gain from N recommendations based on N credits or the presidedress nitrate test (PSNT).

			Corn:N price ratio†	
Legume/manure history	Sites	Method	High (16.7)	Low (5.1)
			--- Economic gain, $/acre ---	
< 1 year	50	BVNC	15	37
		PSNT	14	35
1 to 3 years	29	BVNC	3	10
		PSNT	6	20
> 3 years	22	BVNC	0	0

PSNT	0	12

† High = ($2.50:$0.15); Low = ($1.80:$0.35).

Advice for Y2K Plus One

Every farm differs as to where the greatest impact can be made with those dollars that are available for investment. Wise choices are based on a good system of personal farm records so that individualized decisions can be made. At the risk of over-generalizing, and recognizing that individual cases must be evaluated within their own context, we provide the following priority listing of how available nitrogen fertilizer dollars might be spent.

Use the right rate of nitrogen as calibrated for your soil and local conditions;

Credit all sources of nutrients, including legumes and manure for what they contribute to the next crop;

Improve nitrogen efficiency by guarding against loss by leaching, denitrification, or volatilization;

Fertilize each field according to recommendations rather than fertilizing the whole farm the same;

Use the best possible crop management to take advantage of the dollars spent on inputs.

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