Economics of Nitrogen Use in Crop Production

Roger G. Johnson and Mir Basith Ali

Nitrogen fertilizer expenditures by North Dakota farmers in 1978 totaled $68,207,088, or $3.34 per harvested acre (1, 2). Since nitrogen fertilizers are manufactured from natural gas, the price of nitrogen fertilizer is directly affected by the rising cost of energy.

The effect of anticipated higher nitrogen prices on the amount that it is profitable to apply and the economic feasibility of using summer fallowing as an alternative to purchased nitrogen are discussed in this article.

Effect of Price on Optimum Nitrogen Level

The yield response from nitrogen, the price of nitrogen, and the price of the crop determine the most profitable level of application. Average yields increase with each additional nitrogen increment, but at a decreasing rate at higher nitrogen levels. Nitrogen fertilizer application will increase net returns per acre up to the point where the value of the yield increase from the last unit of nitrogen applied equals the price of nitrogen.

The shape of the crop response curve to nitrogen fertilizer determines the extent to which the relative price of nitrogen and the crop affect the most profitable rate of application. Most non-forage crops have a nitrogen yield response characterized by a fairly abrupt reduction in yield increases near maximum yield (3).

The data on sunflower yield response to nitrogen discussed by Zubriski in this issue of North Dakota Farm Research gives an example of the rapid reduction in yield increases near maximum yield. The value of the extra sunflower yield resulting from each additional unit of nitrogen is shown in Figure 1 based on a $.10 a pound sunflower price.[1] The level of nitrogen where the value of the extra yield equals the price of nitrogen gives maximum profit per acre. A doubling of the nitrogen price from $.15 to $.30 per pound reduces the most profitable level from 134 pounds to 121 pounds–only a 13 pound reduction.

Similar stability in optimum fertilizer rates exists for small grains and many other non-forage crops. Forage crops, on the other hand, tend to have yield response curves that level out less abruptly and, therefore, the value of the extra yield declines more slowly with increasing amounts of nitrogen. For this reason, optimum rates of nitrogen application for forages are more sensitive to price changes (3).

Dr. Johnson is professor and Ali is a graduate assistant, Department of Agricultural Economics.

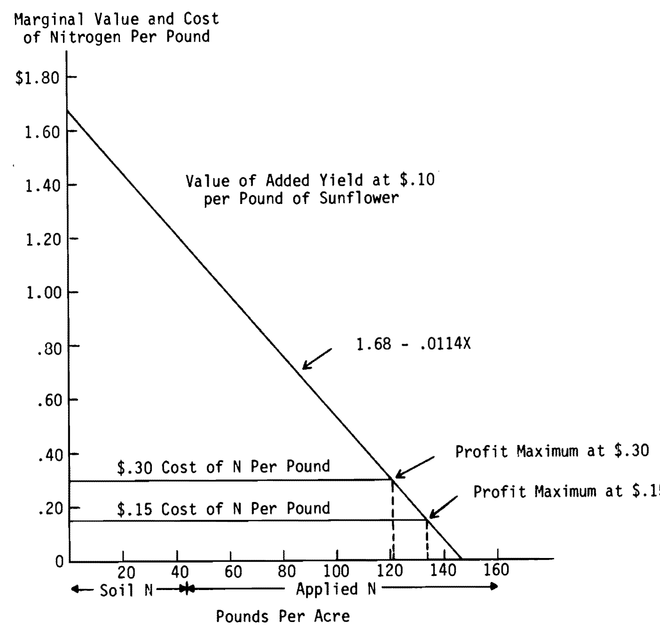

Figure 1. Profit Maximizing Amounts of Nitrogen for Sunflower at Two Nitrogen Fertilizer Prices

[1] *The value of the marginal yield is the first derivative of the nitrogen yield response equation times the price of sunflower.*

$Y = 12.77 + 16.8X - .057X^2$ *(yield response equation)*

$dY/dX = 16.8 - .114X$ *(marginal physical product)*

$(dY/dX)\ (Py) = 1.68 - .0114X$ *(marginal value product)*

Where Y = *yield of sunflower in pounds per acre*

X = *pounds of nitrogen in soil plus applied nitrogen per acre*

Py = *price of sunflower ($.10 per pound)*

Nitrogen from Summer Fallowing

The anticipated increase in price of commercial nitrogen raises the question of the profitability of increasing reliance on alternative nitrogen sources.

Summer fallowing results in an accumulation of soil nitrogen as well as soil moisture. An increase in nitrogen occurs through the decomposition of crop residues and soil organic matter. The amount of nitrogen accumulated varies by soil characteristics and is influenced by soil environment (moisture and temperature) soil microbes and past fertilizing practices. The average difference in soil nitrate-nitrogen test results to the two-foot depth between fallowed and non-fallowed soils from 1975-1978 is presented by area in Figure 2 (4).

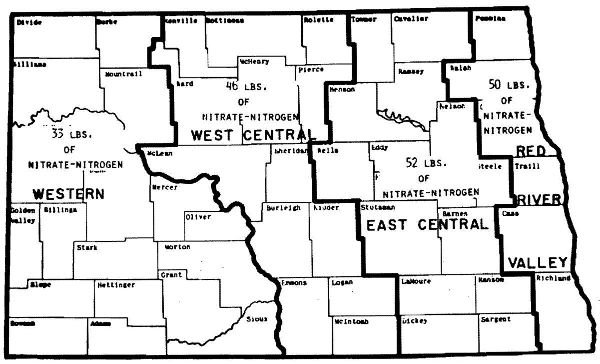

Figure 2. Average Difference in Pounds Per Acre of Nitrate-Nitrogen to Two-Foot Depth Between Fallowed and Cropped Soils, 1975-1978 Soil Test Results, North Dakota State University Soil Testing Lab.

Nitrogen accumulated by summer fallowing has a cost which can be compared with the cost of purchasing nitrogen fertilizer. The cost of the nitrogen accumulated and soil moisture conserved by summer fallowing is the summer fallowing cost plus the net income foregone by not cropping the land for a growing season. To determine the cost of the nitrogen alone, an estimate of the value of the soil moisture needs to be subtracted from the aforementioned costs. The value of the extra soil moisture is equal to the net value of the higher crop yield after summer fallow compared to previously cropped land. The yield increase from fallow needs to represent situations where nitrogen is not a yield limiting factor either on the fallow or previously cropped land.

The cost of accumulating nitrogen by summer fallowing can be calculated using the following formula:

$$X = \frac{[C_s + Y_c P_c - C_c - N_c P_n] - [Y_i P_d - H - N_f P_n]}{A}$$

Where X = cost per pound of nitrogen accumulated in summer fallow

C_s = cost of fallowing (excluding land)

Y_c = yield of crop on previously cropped land

P_c = price of crop on previously cropped land

C_c = cost of crop on previously cropped land (excluding nitrogen and land)

N_c = pounds of nitrogen applied to crop on previously cropped land

P_n = price of nitrogen fertilizer

Y_i = yield increase of crop after fallow

P_d = price of crop after fallow

H = harvest and handling cost of yield increase after fallow

N_f = pounds of nitrogen fertilizer applied to crop on fallow

A = difference in pounds of nitrogen in the soil between fallowed and cropped soil

This formula was applied using wheat as both the crop given up for summer fallow and the crop with increased yield due to fallowing. Based on 1979 average production costs, the cost of accumulating nitrogen by summer fallowing was calculated for three areas of North Dakota. The per acre cost, yield, and nitrogen fertilizer data used are shown in Table 1.

Table 1. Cost, Yield, and Nitrogen Fertilizer Data Per Acre Used in Calculating the Cost of Nitrogen Accumulation in Summer Fallow

Variable	Western	West Central	East Central
C_s	$ 9.91	$11.85	$15.75
Y_c - wheat	20.59 bu.	22.82 bu.	27.24 bu.
C_c	$50.66	$53.60	$59.69
N_c	20.90 lbs.	26.12 lbs.	34.30 lbs.
Y_i - wheat	6.61 bu.	6.22 bu.	5.05 bu.
H	$ 3.31	$ 3.11	$ 2.22
N_f	8.92 lbs.	7.65 lbs.	12.22 lbs.

The cost per pound of nitrate-nitrogen accumulated in summer fallow at nitrogen fertilizer prices ranging from $.10 to $.30 per pound of nitrogen and $3.50 and $4.00 wheat prices are presented in Table 2. Current nitrogen fertilizer prices range from $.10 to $.20 per pound of nitrogen depending upon the source.

Table 2. Unit Cost of Accumulated Nitrate-Nitrogen in Summer Fallow at Different Prices of Wheat and Nitrogen Fertilizer for Three Farming Areas of North Dakota.

Price of Nitrogen Fertilizer	Western Price of Wheat $3.50	Western Price of Wheat $4.00	West Central Price of Wheat $3.50	West Central Price of Wheat $4.00	East Central Price of Wheat $3.50	East Central Price of Wheat $4.00
$0.10	$0.31	$0.52	$0.38	$0.56	$0.65	$0.86
0.15	0.29	0.51	0.36	0.54	0.63	0.84
0.20	0.28	0.49	0.34	0.52	0.61	0.82
0.25	0.26	0.47	0.32	0.50	0.59	0.80
0.30	0.24	0.45	0.30	0.48	0.56	0.78

An example illustrates the use of the data in Table 2. The cost of accumulating nitrate-nitrogen in summer fallow in the Western area would be $.28 at a $3.50 wheat and $.20 a pound nitrogen fertilizer price. In this situation, summer fallowing would be more expensive than fertilizer as a source of nitrogen.

The data in Table 2 lead to the following conclusions:

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1. The cost of accumulating nitrogen by summer fallowing increases rapidly with higher crop prices. Higher crop prices increase the value of the crop given up for summer fallow more than it raises the value of the increased crop yield the year after fallowing.

2. The cost of nitrogen from summer fallowing decreases as nitrogen fertilizer prices increase. Higher nitrogen prices increase the cost of the crop foregone for summer fallow more than it increases the cost of the extra crop yield after fallow.

3. Nitrogen accumulated in summer fallow costs the least in western North Dakota and increases in cost in eastern areas. Although the amount of nitrogen build up from summer fallow is less in the west, both the summer fallowing cost and the value of the crop given up are lower in the west. In addition, the extra moisture increases yields more in the west than in the east, making summer fallowing a more profitable practice.

At very high nitrogen fertilizer prices and low crop prices, summer fallowing is an economic means of acquiring nitrogen in West and West Central North Dakota. Even when summer fallowing is not an inexpensive means of acquiring nitrogen, farmers use the practice to reduce income variability, improve labor distribution, and control weeds. Higher nitrogen fertilizer prices will tend to reduce the cost of accomplishing these objectives.

REFERENCES

1. Commercial Fertilizers Consumption by Class for Year Ending, June 30, 1978. United States Department of Agriculture, Crop Reporting Board; Economics, Statistics, and Cooperative Service, Washington, D.C., December, 1978.

2. Agricultural Prices, Annual Summary, 1978. United States Department of Agriculture, Economics, Statistics, and Cooperative Service, Washington, D.C., June, 1979.

3. Hildreth, R. J. and Moyle S. Williams, "Fertilizer Use Economics," **Changing Patterns in Fertilizer Use**, Soil Science Society of America, Madison, Wisconsin, 1968; p. 451.

4. Dahnke, William C., Unpublished soil test results by counties, 1975-1978, Soil testing lab, North Dakota State University.

Continued from Page 33.

host animal. Research has demonstrated that if some of the better quality protein supplied in the feed could "by-pass" degradation by the "bugs" and "pass-through" the rumen unaltered, the host animal could be provided with a better balance of amino acids for its own use. This area of research, getting protein to "by-pass" bacterial degradation, is challenging. Several factors affect the amount which passes through the rumen. Lower solubility of the protein in the rumen, either inherent in the protein or altered by heat treatment, increases the amount of protein passed through the rumen. Treatment with certain chemicals such as formaldehyde prevents the "bugs" from degrading the protein.

Research is needed to know how much protein should be by-passed and how much should go to the "bugs". In the past, quality of protein was not considered of much consequence in ruminants but with a better understanding of this concept, quality of protein is becoming important in ruminant rations in increasing the efficiency of protein utilization.

Research to uncover the truths of nitrogen use and metabolism leaves much to be learned on the efficient use of protein in animal production in spite of all research that has been completed.