ESO 236

ECONOMIC APPLICATION OF NITROGEN ON CORN - HOW MUCH AT WHAT PRICE

by
D. Lynn Forster, Norman Rask,
and L. N. Shepherd

March, 1975

Department of Agricultural Economics
and Rural Sociology
The Ohio State University
2120 Fyffe Road
Columbus, Ohio 43210

ECONOMIC APPLICATION OF NITROGEN ON CORN - HOW MUCH AT WHAT PRICE

D. Lynn Forster, Norman Rask, and L. N. Shepherd*

Price uncertainty is a crucial problem for cash grain farmers during the current production year. Corn prices have softened recently after record levels during the autumn. Rumors of fertilizer shortages are with us again this year, and price quotations for nitrogen have ranged over a wide interval. These rapidly changing situations raise doubts concerning the "best" fertility program to follow in this spring's corn planting. Some of the questions being asked by farmers are the following. (1) How much nitrogen should be applied in order to produce the best economic results under new price relationships? (2) Will a shortage of nitrogen cause a substantial drop in corn yield? (3) How should scarce supplies of nitrogen be allocated among soil types and crops? These and other questions are being asked as farmers adjust to the new supply and cost/price situation.

Research results from The Ohio State University have been analyzed to provide some clues to these questions. The purpose of this report is to address the question of "how much nitrogen should be applied on corn in order to produce the best economic results under various price relationships?"

---

* The authors are assistant professor and professor, Department of Agricultural Economics and Rural Sociology, and extension specialist, Department of Agronomy, The Ohio State University, respectively.

Two general conclusions are apparent from the research reported here. First, nitrogen use is essential for obtaining high corn yields. Second, within the current expected range of nitrogen and corn prices, it will still be profitable to use substantial quantity of nitrogen. In fact if corn prices stay in the $3.00 range, farmers can probably continue to use about the same amount of nitrogen as they have in the past.

How do we arrive at these conclusions? How does each farmer judge his own particular price situation? This involves some "slightly complicated" economics analysis. We have attempted to show how this was done and how you can judge your special situation in the tables and description that follows.

How are Optimum "Economic Application Rates" Determined?

The decision facing farmers is how much should nitrogen applications be changed as nitrogen and corn prices change? In general, we know that a profit minded individual would tend to increase his use of nitrogen as corn prices increase. On the other hand he would decrease use if the price of nitrogen went up. But what happens if both the price of nitrogen and corn increase, both decrease, or as now seems the case, corn prices go down, while nitrogen prices go up.

To answer these economic questions, we need two sets of information. First, we need information on the yield of corn we can reasonably expect from added inputs of nitrogen. Secondly, we need to use various price combinations of corn and nitrogen. Using both sets of data in economic analysis, it is possible to determine the most profitable application rate for any combination of prices.

The concept used in finding the best economic application rates is called "marginal analysis." It can best be described as the principle of adding additional units of an input (nitrogen) until the cost of the last unit just equals the value of additional corn produced. This principle is consistent with the often observed phenomena that corn production tends to increase rapidly as the first units of nitrogen are applied, but the increases become continuously smaller at high application rates. This phenomena is commonly called the law of diminishing returns, and it has important implications for the profit minded farmer. One of the implications is that prices do affect the amount of fertilizer that should be applied and the amount of output produced. For example, if the price of corn increases, the profit minded farmer would tend to apply more nitrogen since the value of each additional unit of corn produced has increased. Conversely, as the price of nitrogen increases less nitrogen would be applied. We start the analysis by looking at the first set of information, the relationship between nitrogen and corn yields.

<u>Corn Yields and Nitrogen Levels</u>

Eight years of experimentation with various nitrogen levels on continuous corn on Brookston soils near Columbus give some excellent results to judge nitrogen response to corn. Brookston soils are high in organic matter (5 percent) and are typical of the dark colored soils found in western Ohio. Some companion work is also underway with Crosby soils which are lower in organic matter (2.5 percent) and typical of lighter colored soils in the state. Both soils show similar response to nitrogen fertilizer and the results are consistent with the law of diminishing returns. Figure 1 illustrates the responses of corn to nitrogen on the two soils. It should be noticed that additional units of nitrogen result in increasing levels of production but these increasing levels become smaller as high application rates are reached. Table 1 further identifies these increasing levels of production from increasing applications of nitrogen. Moreover, the table demonstrates the law of diminishing returns as the changing corn yields becoming continuously smaller with additional application rates of nitrogen (columns 3 and 5). Notice that the added production from additional units of nitrogen are nearly the same for both soil types.

Table 1. Corn Yields from Various Levels of Nitrogen on Continuous Corn and the Change in Yield from Additional Pounds of Nitrogen

Nitrogen Pounds Per Acre	Corn Yield Per Acre Brookston Silty Clay Soil	Change in Corn Yield from an Additional 25 Pounds of Nitrogen per acre Brookston Soil	Corn Yield per Acre, Crosby Silt Loam Soil	Change in Corn Yield from an additional 25 pounds of Nitrogen per acre, Crosby Soil
(1) (lb.)	(2) (bu.)	(3) (bu.)	(4) (bu.)	(5) (bu.)
0	67	--	30	--
25	84	17	46	16
50	98	14	61	15
75	112	14	75	14
100	126	14	89	14
125	139	13	102	13
150	150	11	113	11
175	161	11	123	10
200	168	7	131	8
225	172	4	135	4
250	174	2	138	3
275	174	0	140	2

The primary difference in the two soils is the yield of corn with no nitrogen applications. With the dark colored soil, high in organic matter, applying no nitrogen results in nearly 67 bushels per acre. On the light colored soil with lower organic matter, a zero application rate produces only 30 bushels per acre. However, the additional production above these zero nitrogen levels as nitrogen is increased is similar for both soils.

It should be noted that these yield levels are for Crosby and Brookston soils from experimental plots with continuous corn. Furthermore, the crop yields in Table 1 are derived from unique crop growing conditions. The nutrients other than nitrogen were supplied in quantities necessary to produce maximum yield levels of corn. Weeds were well controlled on the plots, soils were well drained, planting was timely in order to gain maximum yields, and harvesting was accomplished with minimum harvesting losses. Thus, all inputs other than nitrogen were supplied at levels necessary to produce maximum corn yields. Ohio farmers generally do not supply these levels of inputs, nor are they able to perform all field operations at optimum times and control as well for losses. Therefore, caution should be taken in applying the following analysis directly to your situation unless the farmer is able to achieve these yield levels through careful attention to management practices. Corn response to nitrogen will change dramatically as fields are poorly drained, weeds are not controlled, planting and harvesting are delayed, and other nutrients are at deficiency levels.

The question which remains unanswered is how well the physical relationships between corn and nitrogen on experimental plots approximate the relationship on Ohio farms. Some rough estimates have been made by investigating county fertilizer sales data and county corn yield estimates in the 1972 crop year. All counties in Ohio harvesting more than 60,000 acres of corn for grain in 1972 were selected, and county nitrogen sales were compared to county corn yields. Table 2 illustrates this comparison.

Table 2. Average Corn Yield Per Acre and
Nitrogen Application Per Acre, by County in 1972

County	Estimated Nitrogen Application Per Acre [1]	Corn Yield Per Acre
	(lbs.)	(bu.)
Auglaize	91	88
Champaign	124	101
Clinton	92	91
Darke	101	94
Fayette	91	93
Fulton	195	104
Hancock	107	103
Henry	128	105
Madison	93	91
Mercer	91	96
Miami	101	94
Pickaway	89	91
Preble	95	87
Putnam	175	105
Seneca	117	96
Van Wert	140	108
Wayne	107	88
Wood	137	102

[1] Application rates for corn were estimated by multiplying the 1972 crop year fertilizer sales by 80 percent.

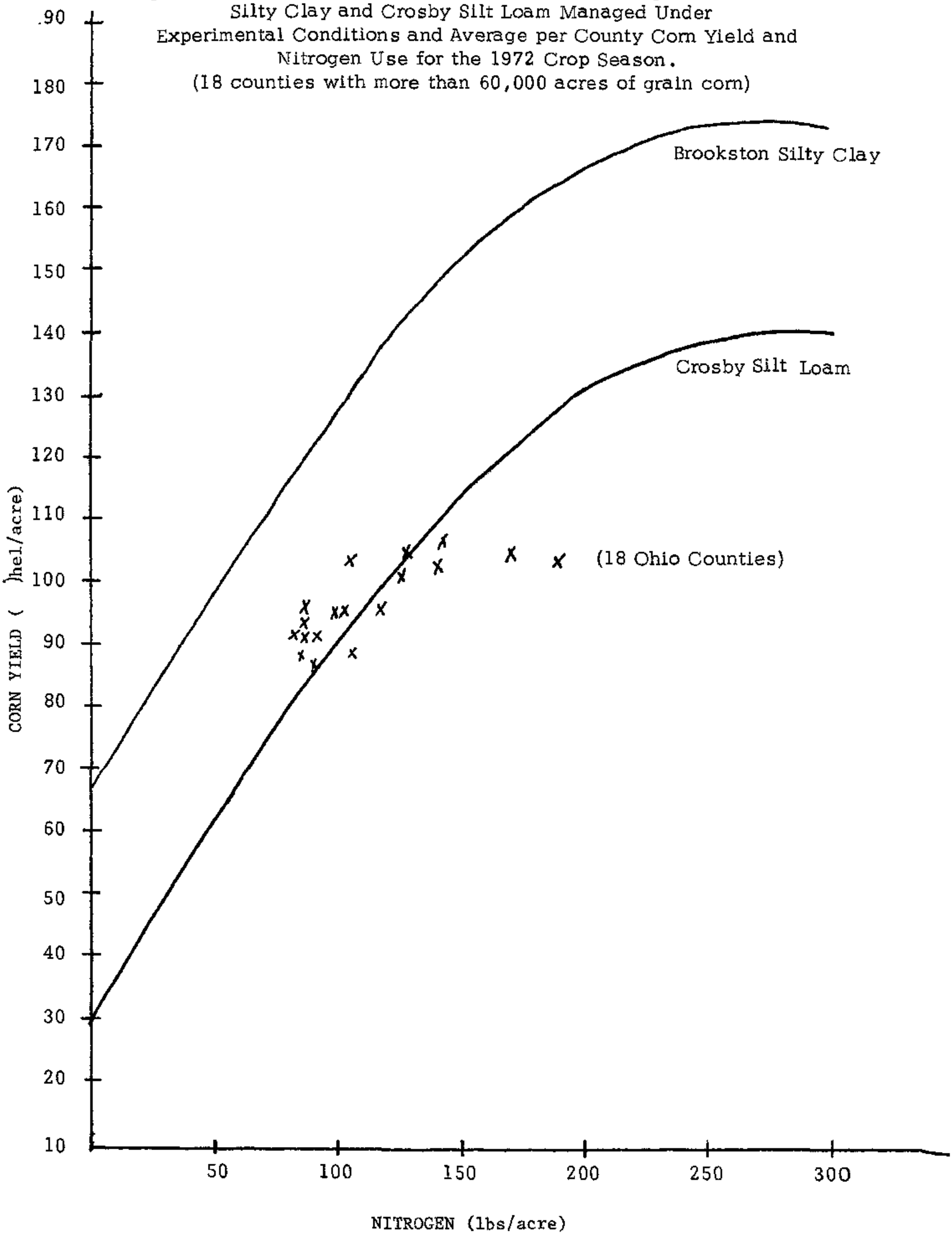
Figure 1 illustrates the nitrogen-corn relationship from experimental plots and the estimated nitrogen and corn relationship from Ohio counties using the 1972 nitrogen sales and crop yield data. The solid lines in Figure 1 illustrate the nitrogen and corn relationship on experimental plots and the observations for each county are shown by the points. Notice that in these major corn producing counties the average yield levels and nitrogen closely approximate the experimental results.

Economic Analysis

The next step is to understand how prices of nitrogen and corn affect the quantity of nitrogen used. The profit minded farmer tries to apply the amount of nitrogen where the last unit of nitrogen just pays for itself.

This optimum application rate is determined from the experimental data by multiplying the change in corn yield (column 3 and 5 in Table 1) by the price of corn, and the change in nitrogen applied (25# from column 1) by the price of nitrogen. These two figures give the additional returns from corn and the additional costs of nitrogen at each level of application. As long as the value of additional corn produced is greater than the cost of the additional nitrogen, more nitrogen should be used. When they are equal the optimum point has been reached. Let's use an example. Referring to Table 1, we see that if you are now applying 50 pounds of nitrogen per acre, an additional 25 pounds of nitrogen would result in an increase of 14 bushels of corn. If the price of nitrogen is $.30 per pound and the price of corn is $2.50 per bushel, applying this additional 25 pounds per acre would be pro-

Figure 1. Corn Yields from Various Levels of Nitrogen on Brookston Silty Clay and Crosby Silt Loam Managed Under Experimental Conditions and Average per County Corn Yield and Nitrogen Use for the 1972 Crop Season. (18 counties with more than 60,000 acres of grain corn)



fitable since the increased returns are \$35(14 x \$2.50), while the additional cost is \$7.50(25 x \$.30).

It should be noted that the price of corn used in this example is the net price calculated by subtracting from the gross market price those drying and handling costs which vary as yield varies. For example, each additional bushel of yield costs approximately 13¢ in drying costs and 7¢ in handling costs. Thus, a market price of \$2.70 per bushel would result in a net market price of \$2.50 which is the price we have used in calculating the economic optimum application rates.

In order to cover several corn and nitrogen price possiblities, we took the response data mentioned above and applied many different combinations of corn and nitrogen prices, ranging from \$1.50-\$4.00 per bushel for the net corn price and \$0.10-\$0.50 per pound for nitrogen costs. The results of this analysis are shown in Table 3. This table shows 117 different corn-nitrogen price combinations. Thus, you can pick the combination for your farm and quickly determine the change in application rate.

At recent net corn prices of \$2.50 to \$2.75 per bushel for corn and \$0.30 to \$0.35 per pound for nitrogen, application rates of 221 pounds per acre to 232 pounds per acre would produce the best profits for corn grown on the experimental plots.

<u>Conclusions</u>

The above research results demonstrate once again that nitrogen fertilization is very important for high corn yields. Further, within the current

Table 3. Effects of Corn and Nitrogen Prices on the Profit Maximizing Levels of Nitrogen Application (Pounds per Acre) on Brookston Soil Managed under Experimental Conditions

Net Price of Corn[1] ($/bu.)	Price of N ($/lb.)								
	.10	.15	.20	.25	.30	.35	.40	.45	.50
	(pounds of nitrogen per acre)								
1.50	244	232	221	209	197	186	174	163	151
1.75	248	238	228	219	209	199	189	179	170
2.00	251	242	234	225	217	208	200	192	182
2.25	253	245	238	230	223	216	208	199	194
2.50	254	248	241	237	228	221	215	208	202
2.75	256	250	244	238	232	226	220	214	208
3.00	257	251	246	240	235	230	224	219	213
3.25	258	253	248	243	238	233	228	223	218
3.50	258	254	249	244	240	235	231	226	222
3.75	259	255	250	246	242	238	233	229	225
4.00	259	255	251	248	244	240	236	232	228
4.25	260	256	252	249	245	241	238	234	230
4.50	260	258	253	250	246	243	239	236	232

[1]Net corn price is calculated by subtracting drying and handling costs from the expected market price. Generally, the net price is 20-25¢ per bushel lower than the market price.

expected range of corn and nitrogen prices, it will still be profitable to use substantial quantities of nitrogen if it is available. However, we caution again that results are possible only when all other cultural practices are efficiently performed.

More specifically: <u>What is the impact of an increase in nitrogen costs?</u>

1) At high net corn prices ($2.75 and above)? You can continue to use almost the same quantity of nitrogen. For example, if the net corn price is $2.75, an increase of $.10 per pound of nitrogen would only reduce the optimum level of nitrogen application by 12 pounds per acre in our experimental data.

2) At lower net corn prices (under $2.75)? If, at planting time, you expect net corn prices to be less than $2.75 per bushel and nitrogen prices are higher, then a greater reduction in use is called for. For example, if the net corn price is $1.75, an increase of $.10 per pound of nitrogen would reduce the optimum level of nitrogen application by 20 pounds per acre.

<u>What if I only receive a portion of the nitrogen needed?</u> This has to be an individual decision based on the number and types of crops you grow and the different soil types on your farm. However, the above analysis would indicate that for corn on similar soil, an equal reduction in nitrogen across all your acreage would be in order. Thus, if you normally apply 200 pounds of nitrogen per acre of corn and will receive only three-fourths of your normal amount, the best procedure would be to apply 150 pounds of nitrogen per acre to all your corn ground.

The important question unanswered by this report is how should acreage be allocated to corn and soybeans to best take advantage of short supplies of nitrogen. Further work is now underway to provide some insights into this question.

In summary, high nitrogen prices should not change your normal fertility practices very much, especially if you expect or can look forward to corn prices in the $3.00 or above range. The bigger problem may be the availability of nitrogen.