Cornhusker Economics Agricultural Economics Department

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The Difference between Maximum Profit and Maximum Production

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Cornhusker Economics

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Market Report	Year Ago	4 Wks Ago	9-20-19
Livestock and Products, Weekly Average			
Nebraska Slaughter Steers, 35-65% Choice, Live Weight.	*	*	*
Nebraska Feeder Steers, Med. & Large Frame, 550-600 lb.	179.12	162.40	161.24
Nebraska Feeder Steers, Med. & Large Frame 750-800 lb.	167.53	152.91	152.97
Choice Boxed Beef, 600-750 lb. Carcass.	204.98	239.87	218.75
Western Corn Belt Base Hog Price Carcass, Negotiated	61.58	*	*
Pork Carcass Cutout, 185 lb. Carcass 51-52% Lean.	77.52	79.44	68.10
Slaughter Lambs, wooled and shorn, 135-165 lb. National.	137.78	153.60	150.16
National Carcass Lamb Cutout FOB.	378.76	387.84	392.70
Crops, Daily Spot Prices			
Wheat, No. 1, H.W. Imperial, bu.	4.61	3.42	3.55
Corn, No. 2, Yellow **Columbus**, bu.	3.22	3.67	3.70
Soybeans, No. 1, Yellow **Columbus**, bu.	7.18	7.66	7.93
Grain Sorghum, No.2, Yellow Dorchester, cwt.	5.10	5.48	5.68
Oats, No. 2, Heavy Minneapolis, Mn, bu.	3.02	3.02	3.08
Feed			
Alfalfa, Large Square Bales, Good to Premium, RFV 160-185 Northeast Nebraska, ton.	*	*	*
Alfalfa, Large Rounds, Good Platte Valley, ton.	102.50	110.00	105.00
Grass Hay, Large Rounds, Good Nebraska, ton.	102.50	105.00	105.00
Dried Distillers Grains, 10% Moisture Nebraska Average.	135.00	131.50	141.00
Wet Distillers Grains, 65-70% Moisture Nebraska Average.	43.00	44.00	42.50
* No Market			

Nitrogen fertilizer (N) is commonly used as a production input to increase crop yields. It is included as one of the six Testing Ag Performance Solutions (UNL TAPS) program decision choices and contributes much to productivity as well as costs. Its use however is not without controversy. The over-application of N gets into the groundwater and nearby waterways becoming a pollutant. Excessive use does little or nothing to increase revenue but can inflate costs, thereby reducing profit. For these reasons and others, using the *right* amount of N has become a popular and important topic among those that use and/or study it. The main problem in using this nutrient is determining the *right* amount to use and apply. Like many natural processes, at some usage level N exhibits a diminishing marginal effect that is, at a specific level of use the next added unit returns less than the previously applied unit. From the 2018 TAPS contest data it was estimated that the corn variety D60-69 on average for the 49th lb of added N increased yield by 1.0045 bu/acre, whereas the 50th lb increased yield by .998 bu/acre exhibiting marginal diminishing yields (MDY).The last column in Table 1 shows these incremental yield changes along with other pertinent information. The estimated yield response relationship for the D60-69 corn variety for the 2018 crop year had an average increase of 5.38 bu/acre for each additional acre inch of applied water, 1.34 bu/acre for each lb of N with an associated penalty of -0.0034 bu/acre for those additional lbs of N units squared. This response function is illustrated in Figure 1. Figure 2 illustrates the decreasing yield response of corn to N described above as the MDY. It is this physical

Table 1. Estimated yields, total N costs per acre, total revenue (value in dollars) per acre, marginal costs of N (MCN), and marginal revenue of N fertilizer (MRN), and marginal diminishing yield (MDY) per lb of N

Lbs of N Applied	Yield bu/acre	Total N $/acre	Value $/acre	MCN $/lb N	MRN $/lb N	MDY bu/lb N
49	200.71	19.6	642.27	0.4	3.21	1.0045
50	201.71	20	645.46	0.4	3.19	0.998
60	211.3	24	676.17	0.4	3.07	0.96
70	220.21	28	704.68	0.4	2.85	0.891
80	228.43	32	730.98	0.4	2.63	0.822
90	235.96	36	755.08	0.4	2.41	0.753
100	242.81	40	776.98	0.4	2.19	0.684
110	248.96	44	796.68	0.4	1.97	0.615
120	254.43	48	814.17	0.4	1.75	0.547
130	259.21	52	829.46	0.4	1.53	0.478
140	263.3	56	842.55	0.4	1.31	0.409
150	266.7	60	853.43	0.4	1.09	0.34
160	269.41	64	862.11	0.4	0.87	0.271
170	271.43	68	868.59	0.4	0.65	0.202
174	272.05	69.6	870.56	0.4	0.46	0.144
175	272.19	70.00	871.00	0.4	0.44	0.137
176	272.32	70.4	871.42	0.4	0.42	0.13
177	272.44	70.8	871.81	0.4	0.39	0.123
180	272.77	72	872.86	0.4	0.33	0.103
190	273.42	76	874.93	0.4	0.21	0.065
200	273.38	80	874.8	0.4	-0.01	-0.004

diminishing relationship that is important to remember and account for in making the decision to apply N fertilizer, or for that matter any variable input that has a similar diminishing effect. Using this response function and representative prices and costs, the economically *right* amount of N to apply was estimated and provides the basis for the following discussion.

Before moving forward with the economic analysis, it is helpful to understand the response function and the biological maximum. From the estimated yield response function drawn in Figure 1, it is apparent that the greatest grain yield occurs somewhere between 194 and 195 lbs of applied N/acre. Using some advanced math techniques (calculus), the level was estimated to be 194.4 lbs of N/acre. This amount of applied N fertilizer is estimated to yield 273.5 bu/acre. From Figure 1 it can be seen that N applied beyond this yield-maximizing point results in a yield decline. Agronomists often estimate this relationship as a kinked line recognizing that yields are not likely to decrease unless over application is severe. This would be represented in the figure as a horizontal line starting at the maximum point and moving to the right, this is illustrated by the red line in Figure 1. This graphical modification creates a yield plateau showing that any added N after the 194.4 lbs/acre maximum will result in no added yield. Regardless of which response function you use. there is a point when additional N has no more effect on productivity, where applying more N fertilizer is an exercise in futility. To re-emphasize this, biologically there is a level of N where physical production is maximized and going beyond that point makes no yield difference and definitely no economic sense since to do so means incurring expense (buying N) with no hope of a return (no yield response). Logically this might bring one to think that the biological optimum identifies the ideal amount of N fertilizer to apply. Unfortunately, the answer to this question is "absolutely not". A good way to explain why this is so is to follow this example through and determine the economic optimum level of N fertilizer.

Using the estimated response function described in the first paragraph, a $0.40/lb N purchase and application cost and a $ 3.20/bu corn price, the economic optimal lbs/acre of N can be estimated and compared to the biological optimum. To be clear the economic optimum is that point where each unit (lb) of N returns enough revenue to at least cover the costs of applying that unit. Simply, why apply fertilizer that costs more than the value of the corn grain produced by its use. In economics this "breakeven point" is where the marginal cost of N equals its marginal revenue. Marginal costs (MCN), costs for each additional lb/acre of N is constant at $0.40/lb. Marginal revenue (MRN) is the bushel value produced by using that additional lb of N. This is easily calculated as the number of additional bushels produced by the use of that lb of N times the value of a bushel of corn. MRN varies as productivity and corn price vary. From Figure 2 and Table 1, it is clear that each additional lb of added N after 49 lbs produces less and less corn grain per lb. The MDY from above is used as an example to illustrate how this works; By adding an additional lb/acre of N at the 49^{th} lb level, it is estimated that 0.998 bu/acre more corn grain will be produced. Multiplying this yield increase times the $3.20/bu corn grain value results in the MRN for the 50^{th} lb of N equaling $3.19. The MRN of $3.19 far exceeds the MCN of $0.40/lb N making the 50^{th} lb of N an economically wise and worthwhile expense. Doing these same calculations for 194 lbs of N/acre, near the biological optimum N rate of 194.4 lbs/acre produces a MRN of 0.0012, less than one cent (see Table 1 and Figure 2). This means the value returned by adding the 194 lb of N returns such a small yield that it is virtually nothing. This return is much smaller than its costs as reflected by the MCN of $0.40/lb/acre. As it turns out the economic optimal is between 176 and 177 lbs of applied N/acre (Table 1). The MRN for 176 is $0.43 and the MRN for 177 is $0.39. This value is nearly 20 lbs/acre less than the biological optimum which is a significant difference.

As mentioned earlier the three key ingredients to doing this analysis are 1) knowing the response relationship of corn yield to N (the biological relationship of N to corn grain yield), 2) N fertilizer costs, and 3) the value of the grain being sold. So what happens if one of the two price variables change, such as an increase in the value of corn grain? Let's say the expected value of the corn grain increased to $4.00/bu. Should we expect an increase or a decrease in the economically optimal amount of N applied? Logically increased corn value should support more use of fertilizer; therefore, as expected the optimal amount of N fertilizer increases, in this case by about 4 lbs/acre, to between 180 and 181 lbs of applied N/acre. Conversely if corn prices dropped to $3.00/bu, it would be expected that the optimal levels of N fertilizer would also fall, however only by about a lb/acre to between 175 and 176 lbs of applied N/acre. Now what would happen to economically optimal N rates with a change in fertilizer expense? Less expensive N prices would logically lead to increased use while increased costs would lead to a reduction in N use. But by how much? This relationship is inverse to corn grain since corn is a revenue source and N fertilizer a cost source. A spike in N fertilizer costs at $0.60/lb would result in the optimal fertilizer rate falling by about 10 lbs/acre, to between 167 and 168 lbs of applied N/acre. A loosening of price for each lb of N to $0.25 would result in an increase of about 6 lbs/acre to between 183 and 184 lbs of applied N/acre. Remember that these last two scenarios are based on a corn price of $3.20/bu.

From this case study and thanks to the TAPS data, several facts have been reinforced and are more clearly observed. First having individual area or field N response functions would enable the implementation of precision farming. Second having N response functions for individual areas and/or fields would save applying excessive N fertilizer that makes farmers no money and may become a contaminant in the local ground or surface water thus increasing the likelihood for future regulation. Third, low commodity prices call for the use of less N than high prices, and that N expense plays a role in the economically optimal quantity of N to be applied.

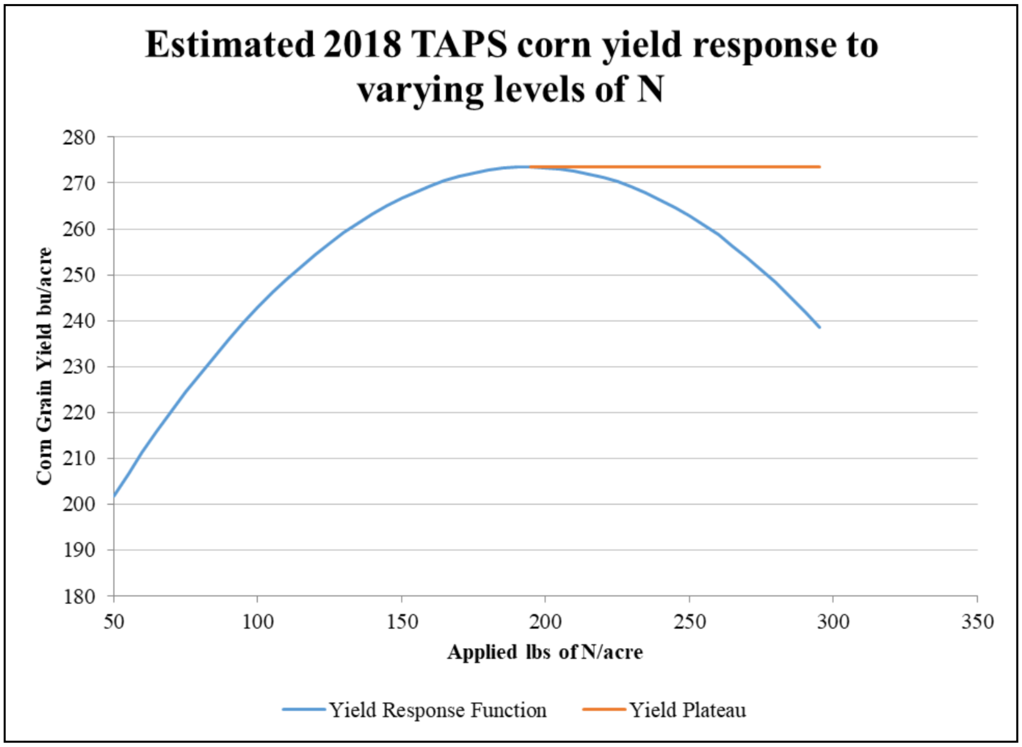

Figure 1

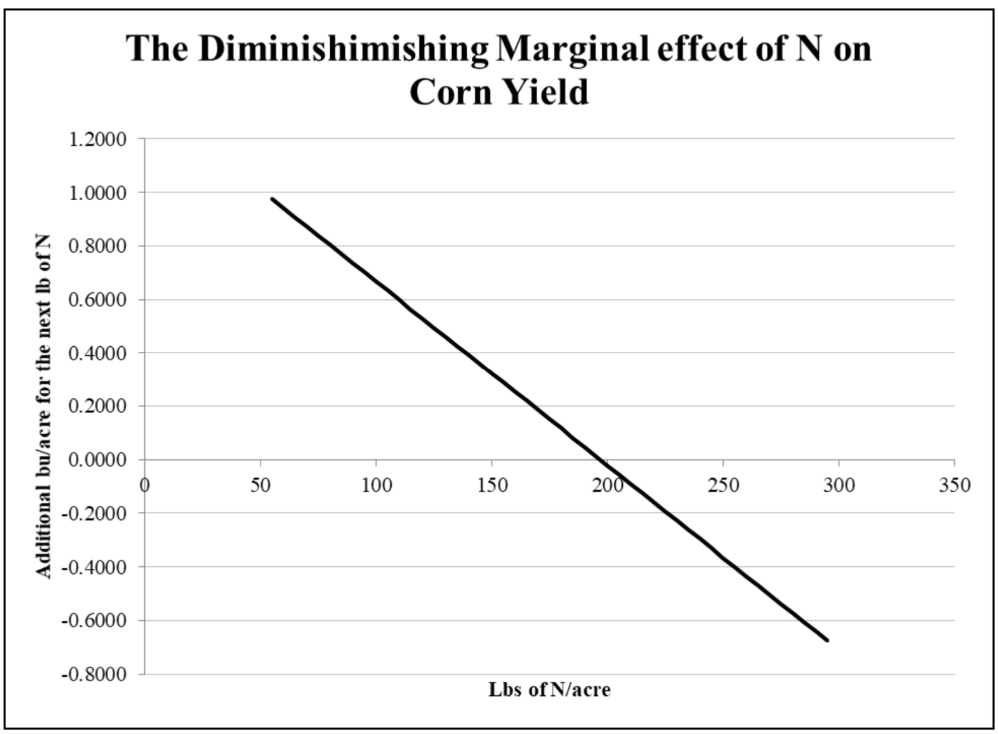

Figure2

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