Conservation Discussion Paper

The Value of Nutrient Management

(revised for East Region)

Abstract

The purpose of this document is to demonstrate one method of identifying the optimal fertilizer application rate. The land user must decide between maximizing crop yields, maximizing profit or protecting water quality. This paper shows how to maximize profit and improve water quality simultaneously. This paper does not identify or evaluate all nutrient management activities but demonstrates one method that could be used for site-specific projects.

General Economic Discussion

There are relatively few "laws of nature" which do not change and apply to everything in nature. Laws of nature include the law of: Gravity, thermodynamics, relativity, and supply and demand. One of the most important laws for economic analysis is the Law of Diminishing Marginal Returns, which states that "at some point by adding an additional unit of input results in a smaller increase in output, holding all other inputs constant". For example, by adding more and more irrigation water to a row crop increases yield (at an increasing rate), continues to increase yield (at a decreasing rate), and then decreases yield if too much irrigation water is applied.

Understanding the law of Diminishing Marginal Returns is very important in managing agricultural inputs and understanding subsequent outputs in crop and livestock production. Other agricultural examples include: Adding livestock to a paddock, cross fencing a pasture, planting trees in a woodlot, managing wildlife populations, workers on a production line and fertilizer/nutrients rates.

Methodology

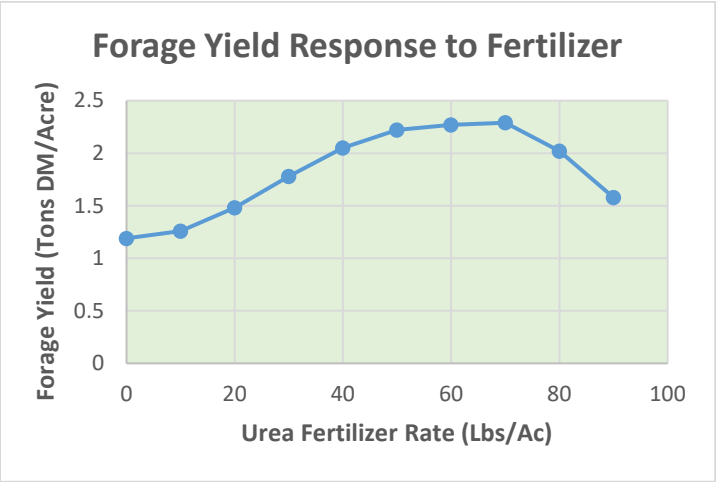
Physical input-output data, the cost of the input and the price of the output are required for the analysis. Physical data is available from land-grant universities, Extension Service, Agricultural Research Service, professional journals, agency specialists, land users and others. Cost and price data can come from the same sources and: Agricultural Statistics, Economic Research Service, local vendors and contractors. Only one agricultural input and one output can be evaluated at a time.

Pasture Fertilization Example

The following example demonstrates the law of Diminishing Marginal Returns and nutrient management. Nutrient Management has been defined as "managing the amount, source, placement and timing of plant nutrients and soil amendments". The following example focuses on adding increasing units of fertilizer to pastureland in order to increase forage production (managing the nutrient source, placement or timing is a separate analysis). The relationship between pasture fertilization rates and forage yield could be obtained from the local Extension Service research farm; the applied fertilizer cost came from the local Ag Co-op; and the forage price came from the land user. Obviously, the data will be different for your location – this paper only demonstrate the concept and methodology for analysis.

Fertilizer is applied in increments of 10-Pounds/Acre. As fertilizer application is increased, forage yield increases at an increasing rate up to about 40-Pounds/Acre of fertilizer application, continues to increase yield at a decreasing rate to 70-pounds/Acre of fertilizer, and then yield decreases as too much fertilizer burns the crop. If the land users' goal is to maximize yield regardless of price, 70-Pounds/Acre of fertilizer should be applied.

Urea fertilizer rate Lbs/Ac	Tons DM per acre
0	1.19
10	1.26
20	1.48
30	1.78
40	2.05
50	2.22
60	2.27
70	2.29
80	2.02
90	1.58



Farmers consider three possible goals when managing nutrients: Maximize yield, maximize profit, and/or protecting the environment. We know the amount of fertilizer to max yield: 70-pounds/Acre. What amount of fertilizer should be applied to max profit? We need to calculate the change (or margin) in both fertilizer and forage. We have the marginal "change" in fertilizer applied: 10-pound increments. Next, we calculate the "change" in forage resulting from increasing fertilizer application. For example, by going from 0 to 10-pounds fertilizer, Forage in Dry Matter (DM) basis increases from 1.9 to 1.26 Tons DM/Acre – a change of .07 Tons of Forage DM/Acre; from 0 to 20-pounds fertilizer, forage increases from 1.90 to 1.48 Tons DM/Acre – a change of .29 Tons of Forage DM/Acre; etc.

Urea fertilizer rate Lbs/Ac	Tons DM per acre	Change in Tons DM per acre
0	1.19	0
10	1.26	0.07
20	1.48	0.29
30	1.78	0.59
40	2.05	0.86
50	2.22	1.03
60	2.27	1.08
70	2.29	1.10
80	2.02	0.83
90	1.58	0.39

Next, we put a dollar value on Fertilizer and Forage. If hay forage is worth $90/Ton on a wet basis (15% moisture), then we need to calculate the value of hay in a dry matter (DM) basis. This would be $90/85% or about $106/Ton DM. Therefore, if fertilizer cost is $.50/Lb and if forage is worth $106/Ton DM, then we can calculate Total Fertilizer Cost and Total Forage Benefit (for example: 10-Pounds Fertilizer x $.50/Lb = $5.00 and .07 Tons of DM Forage/Ac x $106/Ton = $7.42:

Urea fertilizer rate Lbs/Ac	Tons DM per acre	Change in Tons DM per acre	Total Fertilizer Cost	Total Forage Benefit
0	1.19	0	$0	$0.00
10	1.26	0.07	$5	$7.42
20	1.48	0.29	$10	$30.74
30	1.78	0.59	$15	$62.54
40	2.05	0.86	$20	$91.16
50	2.22	1.03	$25	$109.18
60	2.27	1.08	$30	$114.48
70	2.29	1.1	$35	$116.60
80	2.02	0.83	$40	$87.98
90	1.58	0.39	$45	$41.34

We can now calculate Profit by subtracting Total Fertilizer Cost from Total Forage Benefit (for example: 10-Pounds Fertilizer will cost $5.00 and create $7.42 forage value, profit would be $2.41):

Urea fertilizer rate Lbs/Ac	Tons DM per acre	Change in Tons DM per acre	Total Fertilizer Cost	Total Forage Benefit	Forage DM Profit $/Ac
0	1.19	0	$0	$0.00	$0.00
10	1.26	0.07	$5	$7.42	$2.41
20	1.48	0.29	$10	$30.74	$20.71
30	1.78	0.59	$15	$62.54	$47.47
40	2.05	0.86	$20	$91.16	$71.06
50	2.22	1.03	$25	$109.18	$84.06
60	2.27	1.08	$30	$114.48	$84.35
70	2.29	1.1	$35	$116.60	$81.47
80	2.02	0.83	$40	$87.98	$47.88
90	1.58	0.39	$45	$41.34	-$3.71

Note that we maximize forage yield at 2.29 Tons DM/Acre with 70-Pounds Fertilizer/Acre and maximize profit at $84.35/Acre with 60-Pounds Fertilizer/Acre. Doing nutrient management, the land user can make $2.88 more income per acre than maximizing yield (the difference between $84,35 and $81.47). **The land user can achieve two goals simultaneously – improving water quality (by applying less fertilizer) and making more profit!**

Results:

Max Forage Yield: **70 lbs/Acre Urea Fertilizer = 2.29 Tons Forage(DM)**
Max Profit: **60 lbs/AcreUrea Fertilizer = $84.35 $/Acre**

If fertilizer application was free (no cost), then max yield and max profit would be the same amount of fertilizer, in our example 70-pounds/Acre. So why would a land user overapply fertilizer? There are several plausible reasons: A) They may not have the data showing the relationship between fertilizer application and profit; B) They want to minimize risk of improper fertilizer application; C) They want to brag about crop yield to impress a neighbor, or enter a crop-yield contest; D) They want insurance against unexpected weather conditions, or; E) They are looking for a temporarily increase in crop productivity to sell the property in the near future (real-estate values are a function of land productivity).

Conclusion

We have demonstrated one method of analyzing nutrient management, using the concept of Diminishing Marginal Returns, to identify maximum forage yield and maximum forage profit. We have shown that a land user can both increase income and improve water quality (with reduced nutrient application) at the same time. Of course, actual data on a site-specific project are necessary to develop more defensible forage yield and profit estimates for individual producers.

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