Forage Fertilizer Decisions in an Uncertain Market

By Tom Bruulsema and Gilles Bélanger

An important principle of plant nutrition is that plants don't care about market conditions. Top yields of quality forage are crucial to the success of most ruminant livestock production systems. Both yield and quality depend on the application of the right source of nutrients at the right rate, at the right time, and in the right place.

High prices for fertilizers and crop commodities in 2008 focused a lot of attention on fertilizing cash crops. What about forages? A producer may ask, "What are the implications of economic uncertainty on the way I should fertilize my forage crops?"

Prices of both crops and fertilizers fluctuated widely in 2008, and price uncertainty continues. **Figure 1** shows that prices in the USA for both hay and fertilizer have increased since 1980. Prices for hay increased relative to fertilizer from 1980 to 2002, but from 2003 through 2008 the relative increase was larger for fertilizer than for hay.

The change in price ratio may reduce economically optimum rates, but the question is how much. It is important for the producer to thoroughly consider all consequences of rate reductions – to yield, quality, and soil fertility. Fertilizer price increases reduce profitability of fertilizer use more in the short term than in the long term.

When K prices increase, short-term optimum rates can fall substantially, as illustrated in **Figure 2**. Yields at these rates also decrease sharply when soil tests for K are less than high. A producer needs to consider the impact of the shortfall in forage production on the viability of the livestock operation. This is difficult to judge at the time of the fertilizer decision, since in years with poor weather, forage value may exceed average prices.

In this example, optimum rates fall well below removal for all three sites. If less is applied than removed, the resulting decline in soil test levels leads to an eventual increase in K requirements. So the optimum rates for a longer time frame become substantially higher than those in the short term.

Field research documents economic returns to NPK fertilizer for forages.

An example confirming the long-term difference comes from a study on timothy hay that was conducted near Fredericton in New Brunswick (Bélanger et al., 1989). This study had four levels each of N, P, and K fertilizer – a total of 64 plots. After the same rates had been applied annually for 25 years, yields measured in each plot for 3 more years were fit to a regression model that allowed computation of what the long-term yield would be for any combination of N, P, and K applied an-

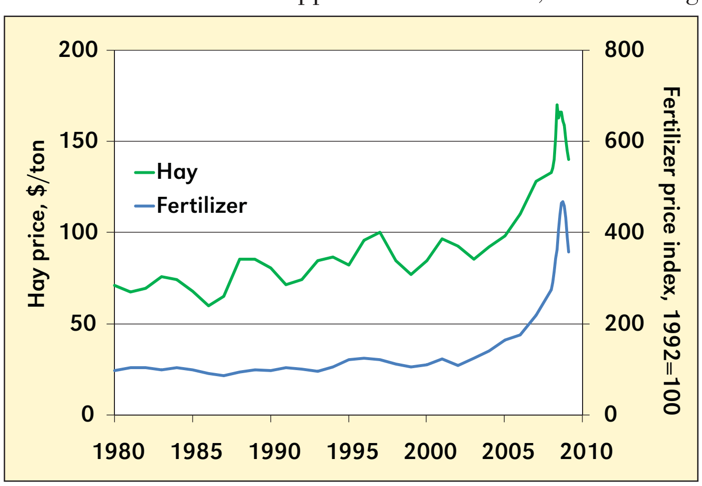

Figure 1. Average prices received for hay and paid for fertilizer (N, P, and K) by farmers in the USA, 1980-2008. (USDA-NASS).

Abbreviations and notes for this article: DCAD = dietary cation-anion difference; GT = grass tetany index; N = nitrogen; P = phosphorus; K = potassium; Ca = calcium; Mg = magnesium; Na = sodium; Cl^- = chloride; S = sulfur.

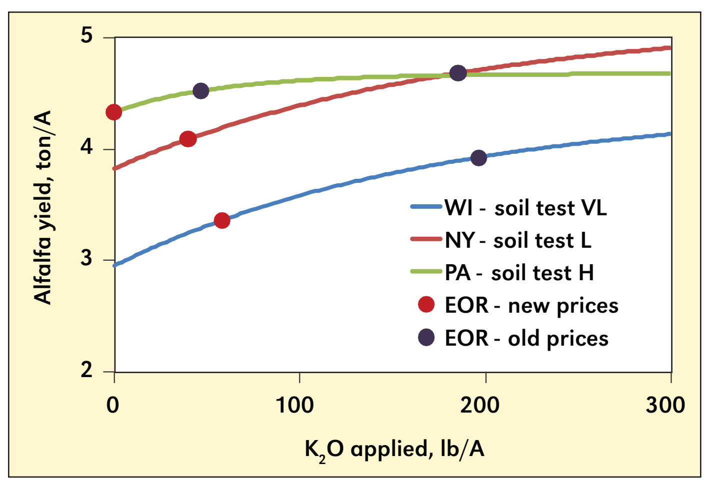

Figure 2. Responses of alfalfa to annual application of K over 3- to 4-year periods. Old and new prices assume $75 and $140/ton for hay and $0.20 and $0.83/lb for K_2O, respectively. Data from S.D. Klausner (New York), D.B. Beegle (Pennsylvania), and D. Smith, Agron J. 67:60-64 (Wisconsin).

nually, long-term. The factorial experimental design—all possible combinations of four levels of each of the three nutrients – allowed for the inclusion of interaction effects as well. One of the main findings of this long-term study was that balanced N, P, and K application was required for persistence of highly productive species…in this case timothy.

A comparison of two price scenarios, from 1989 and 2009, is shown in **Table 1**. The 2009 scenario has higher prices for both hay and fertilizer. Optimum rates of each of the three major nutrients declined, reducing hay yields by 14%. However, the net return to fertilizer use increased for N and P, and was still substantial for K. In fact, each dollar invested in fertilizer would still return more than two dollars, and this was true for each of the three nutrients. These data demonstrate that fertilizer use continues to be profitable. The response model developed from these data also confirms the "law of the minimum" in that responses to each of the three nutrients depend on adequate supply of the others.

If an old stand of timothy shows economic responses to even the currently high-priced K, the same would be expected in the long term for forages produced from legumes and mixtures as well. Forages remove large amounts of K, and production is simply not sustainable without inputs to replace the removal.

Table 1. Yields and net economic return to fertilizer use for timothy hay production, from a long-term NPK factorial experiment in New Brunswick, with price scenarios from 1989 and 2009.

	Scenario	
Price Assumptions	1989	2009
Hay price, $/ton	$75	$140
Fertilizer price, $/lb		
N	$0.32	$0.43
P_2O_5	$0.36	$0.37
K_2O	$0.12	$0.83
Results		
Optimum annual rate, lb/A		
N	136	115
P_2O_5	90	47
K_2O	114	77
Net return to fertilizer use, $/A		
N	$45	$57
P_2O_5	$54	$90
K_2O	$87	$74
Hay yield, ton/A	3.0	2.6

Table 2. Mineral nutrient concentration and removal in farm forages analyzed by Dairy One Laboratories, Ithaca, New York, from 2000 to 2008.

	Hay				Silage				
	Legume	Mixed mostly legume	Mixed mostly grass	Grass	Legume	Mixed mostly legume	Mixed mostly grass	Grass	Corn
Samples	90,191	15,645	25,638	34,629	30,800	72,679	64,383	26,176	139,501
Dry matter, %	91	90	91	92	40	39	38	40	34
Nutrient concentration, % dry matter basis									
Crude protein	21	17	12	11	21	19	16	15	8
P	0.28	0.29	0.26	0.24	0.34	0.33	0.32	0.33	0.24
K	2.4	2.2	1.9	1.9	2.8	2.7	2.4	2.5	1.1
Ca	1.5	1.2	0.7	0.5	1.4	1.2	0.8	0.7	0.3
Mg	0.31	0.28	0.22	0.20	0.28	0.26	0.24	0.23	0.17
S	0.27	0.21	0.18	0.17	0.25	0.23	0.21	0.21	0.10
Cl	0.73	0.54	0.52	0.63	0.68	0.64	0.65	0.79	0.28
DCAD[2], meq/kg	422	388	334	298	502	476	434	420	192
GT[2], meq ratio	0.6	0.7	0.9	1.1	0.8	0.8	1.0	1.2	1.1
Nutrient removal, lb/ton fresh basis[1]									
N	54 - 70	40 - 60	25 - 46	20 - 44	23 - 31	20 - 27	15 - 23	14 - 24	8 - 10
P_2O_5	9 - 14	10 - 14	8 - 14	7 - 14	5 - 7	5 - 7	4 - 7	4 - 8	3 - 4
K_2O	41 - 64	36 - 58	30 - 55	28 - 56	22 - 32	20 - 29	17 - 27	17 - 30	7 - 11
Ca	23 - 33	16 - 28	8 - 18	5 - 14	9 - 14	7 - 12	4 - 8	3 - 7	1 - 2
Mg	4 - 7	4 - 6	3 - 5	2 - 5	2 - 3	2	1 - 2	1 - 3	1
S	3 - 7	3 - 5	2 - 4	2 - 4	2	2	1 - 2	1 - 2	1
Cl	7 - 19	5 - 15	3 - 16	4 - 19	3 - 8	3 - 7	3 - 7	3 - 10	1 - 3

[1]Range is one standard deviation above and below average (includes two-thirds of all samples).
[2]DCAD calculated as K+Na-Cl-0.6S. GT = grass tetany index, calculated as K/(Ca+Mg). Forage DCAD should be below 290 for dry cows, and GT should be below 2.2 (Pelletier et al., 2008).

Intensive management of forage fertilizer pays economic returns.

Forage analysis information is useful for managing mineral nutrition, just as much for field crops as for animals. The information in **Table 2** shows nutrient concentrations and removals measured in different categories of hay and silage submitted for analysis from farms in the Northeastern USA. Most cool season forages, when fertilized at levels adequate for optimum yields, will contain 2.6 to 3.4% N, 0.27 to 0.33% P (Bélanger and Ziadi, 2008), and 2.0 to 3.0 % K. These very general ranges will be modified depending on:

- species (legumes tend to have higher nutrient concentration);
- stage of growth at harvest (nutrient concentrations decline as the sward matures);
- harvest conditions (hay that is rained on loses mineral nutrients; fermentation of silage tends to increase nutrient concentration).
- age of the sward (older grass swards tend to have lower nutrient concentration)

For diagnostic purposes, consult guidelines for critical nutrient concentrations appropriate to the crop species, stage of growth, and harvest conditions.

Mineral nutrient concentrations in forages play major roles in the indexes for either grass tetany or milk fever. The ratio of K to Ca and Mg is critical for grass tetany, and the DCAD, calculated from K, Na, Cl^-, and S, is important for minimizing risk of milk fever when feeding dry cows. Choosing the right sources, rates, timing, and placement of fertilizers helps ensure a forage composition meeting the needs of the livestock.

Forages remove large amounts of nutrients, whether harvested as hay or haylage (**Table 2**). Nutrient removals give approximate values of fertilizer replacement required per unit of forage harvested from the field. This information guides decision-making in selecting best management practices for fertilizing forages.

Changes in price ratios rarely call for large changes in application rates. When prices increase, first ensure the agronomy behind the management of plant nutrients is sound. Is every tool available being used to choose the right product, to predict the right rate, to apply it at the right time, and to place it where it's most effective? Price ratio theory can help fine-tune rates, but only after sound agronomic principles have been applied. Here is a decision checklist for the fundamentals of fertilizing forages.

Right Source

- Balance NPK, as well as secondary nutrients and micronutrients.
- Analyze for nutrients in manures and composts.
- Credit N from legumes.

Right Rate

- Assess soil nutrient supply using soil tests, forage analysis, and crop scouting.
- Consider long-term as well as short-term.
- Calculate nutrient removal and balance.

Right Time

- Build up soil fertility before establishing a stand.
- Apply P and K, if required, after first cut and before critical fall harvest period.
- Split-apply N for each cut from grasses.

Right Place

- Calibrate equipment for accurate spread.
- Map soil zones for site-specific management.
- Near-seed placement for forage establishment. BC

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References

Bélanger, G., J.E. Richards, and R.B. Walton. 1989. Can. J. Plant Sci. 69: 501-512.

Bélanger, G. and N. Ziadi. 2008. Agron. J. 100: 1757-1762.

DairyOne Laboratories. 2009. http://www.dairyone.com/default.htm.

Pelletier, S., G. Bélanger, G.F. Tremblay, P. Virkajärvi, and G. Allard. 2008. Can. J. Plant Sci. 88: 1043-1055.

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