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Beef Science Cluster

Historical review of forage fertilization research

Project Code:	TEC.01.13
Completed:	*January 2014*

Project Title:

Literature Review of Fertilizing Forages Research

Numerous researchers in the past forty years have studied the effectiveness of fertilization on forage production. However, the variability in response means a well-developed yield response model is not available. Without standard yield responses, economic analyses in this area are lagging behind annual crops. Within the limited amount of economic analyses, there is currently no strong evidence for economic benefit of fertilizing forage crops, especially on grass-legume mixtures.

Malhi *et al.* (2002)[1] found that the economic optimum rates of N for pure bromegrass were much higher than the recommended rates at Lacombe and Eckville, Alberta. However, the application of N to bromegrass:alfalfa mixtures at rates greater than 50 kg/ha seldom produced an economic benefit. The application of N on pure alfalfa was not profitable under any situation.

Khakbazan (2009) showed that application of commercial fertilizer, the addition of alfalfa or another N-fixing legume in Manitoba increased forage yields from 1994-2004. While fertilizing grass-only or alfalfa-grass pastures to full soil test recommendations improved pasture productivity, it did not improve profitability compared to unfertilized pasture as the yield gain was not large enough to justify the expense.

The above studies were all on hay fields where the additional production was harvested. In pasture situations this is more difficult to measure but to take advantage of additional production stocking rates must be adjusted and gains monitored. Kopp *et al.* (2003)[2] discusses the cost effectiveness of using fertilizer to improve meadow bromegrass pastures in Manitoba. The study shows that fertilization on meadow bromegrass pasture and incorporating alfalfa with fertilization both improved carrying capacity of the pasture. However, the two treatments entailed significant financial risk as they were only cost-effective when precipitation was not limiting.

The residual effect of fertilizer can last for three or more years after the year of application. Therefore, economic returns from forage fertilization need to be measured over a period of several years.[3] A five year study on Dark Brown Loam at Scott, Saskatchewan and a nine year study on a Gray Luvisolic loam at Loon Lake, Saskatchewan showed high profitability from annual applications of nitrogen on bromegrass when evaluating the discounted net present value (Zentner *et al.* 1989[4]). The study found that the financial optimum rate of nitrogen were generally higher than the recommended rate and producers were typically under-fertilizing their grass crop.

Simulations: Maximize Profits & Minimize Costs

Using the yield data from the three studies[5] referenced above, where soil types are representative of the highest beef cow density and alfalfa/grass areas in Alberta and Saskatchewan, the following section simulates the economic impacts of fertilization and the optimum fertilization rates under different price scenarios.

The results can be found in this Excel file: http://www.beefresearch.ca/files/xls/BCRC_fertilizing_forages_economic_scenarios.xlsx

The simulations showed that higher yields do not necessarily translate into lower costs or higher profits. In the spreadsheet, the red cells (representing highest yield) do not line up with the green cells (representing maximum profit/minimum cost) in many scenarios.

The simulations showed that the per unit costs of pure grass are generally higher than grass-legume mixtures – reflecting the yield data with pure grass having lower base yields than grass-legume mixtures and higher yield response to fertilizer. The application of nitrogen fertilizer usually brings higher profits to pure grass stands, but not necessarily to alfalfa-grass mixtures (see *N AB, Profit Max* and *N & P SK, Profit Max* tabs).

The optimum fertilization rates tended to be higher in poorer soil types. Simulations based on Malhi *et al.* (2002) data showed that optimum nitrogen fertilization rates are higher in Grey Luviso than in Black Chernozem for bromegrass-alfalfa 2:1 and 1:1 mixtures (*N AB, Profit Max* tab). Simulations based on Mahil *et al.* (1992) data, showed that optimum phosphorus fertilization rates for alfalfa in Thin Black Chernozem at 40 kg/ha are generally higher than in Black Chernozem soil at 20 kg/ha (*P AB, Profit Max* tab).

Optimum fertilization rates vary when a longer period is taken into account. Simulations based on Malhi *et al.* (1992) shows annual application of phosphorus fertilizer on alfalfa in Thin Black soil result in a negative margin with a higher per unit cost in the first year. However, when 40 kgs/ha of phosphorus fertilizer is applied annually, the five year average yield provides the lowest cost of production (see *P AB, Costs Min* tab).

In addition to the biological factors mentioned above, optimum fertilization rates are also affected by economic factors such as hay, fertilizer and land costs. Based on yield data in Malhi *et al.* 2002 (see *N AB, Profit Max* tab), changes in hay and fertilizer prices have little impact on optimum nitrogen rates for the pure grass, bromegrass-alfafa 2:1 mixture or pure alfalfa stands in black and grey soil types. However, the optimum nitrogen rates are positively related to hay prices and negatively related to fertilizer prices on bro on bromegrass-alfafa 1:1 and bromegrass-alfalfa 1:2 mixtures. When hay prices increase from $60/tonne ($0.06/kg) to $100/tonne ($0.10/kg), the profit maximizing fertilizer rates for a bromegrass:alfalfa 1:2 mixture in Lacombe, Alberta increased from 50-150 kg/ha to 150-200 kg/ha. Holding hay price constant at $80/tonne ($0.08/kg), the profit maximizing nitrogen rates decrease from 150 kg/ha to 100 kg/ha when nitrogen price exceed $120/tonne ($1.20/kg).

If hay is not traded and the focus is on cost minimization the land (base) cost is the main factor contributing to per unit cost of production. Land and fertilizer prices influence the optimum nitrogen rates for the bromegrass-alfalfa mix in Grey Luviso soil. When land costs increase, the cost minimizing nitrogen rate tends to be higher, indicating it will be more cost efficient to reach target production by increasing yield via fertilization than increasing grazing area when fertilizer is relatively cheaper.

When hay prices are high, producers should be willing to pay more for fertilizer. Lkhagvasuren *et al.* 2011 (*N & P SK, Profit Max* tab) data, implies that the optimum fertilization rate (56 kg N/ha) is relatively steady despite changes in hay prices. However, as hay prices increase to the point at which the optimum fertilization rate increases to 112 kg N/ha in response to different fertilizer prices does change. When hay prices are $60/tonne ($0.06/kg), the optimum nitrogen rate for a grass-alfalfa mixture in Vanscoy, Saskatchewan increases from 56 kg/ha to 112 kg/ha only when nitrogen prices are below $1.00/kg. Over the last ten years nitrogen prices have averaged $1.07/kg (adjusted to actual nutrient value) with a range of $0.80-1.43/kg and have averaged $1.34/kg in 2013. When hay prices are $100/tonne ($0.10/kg), the optimum nitrogen rate only increases when nitrogen prices are below $1.40/kg. In the cost minimization scenario (*N & P SK, Cost Min* tab), producers with higher base production costs will be more willing to pay higher fertilization prices.

References:

[1] Malhi, S. S., R. P. Zentner, and K. Heier. "Effectiveness of alfalfa in reducing fertilizer N input for optimum forage yield, protein concentration, returns and energy performance of bromegrass-alfalfa mixtures." Nutrient Cycling in Agroecosystems 62.3 (2002): 219-227.

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[3] Malhi, S. S., et al. "Fertilizer management of forage crops in the Canadian Great Plains." Recent Res Dev Crop Sci 1 (2004): 237-71.

[4] Zentner R.P et al. July 1989. “The Economics of Fertilizing Bromegrass in Saskatchewan” Can J. Plant Sci 69:841-859

[5] Malhi et al. (2002) "Effectiveness of alfalfa in reducing fertilizer N input for optimum forage yield, protein concentration, returns and energy performance of bromegrass-alfalfa mixtures."; Malhi et al. (1992) "Response of alfalfa hay yield to phosphorus fertilization in two soils in central alberta."; and Lkhagvasuren et al. (2011) "Plant and soil responses to nitrogen and phosphorus fertilization of bromegrass-dominated haylands in Saskatchewan, Canada."

Proudly Funded By:

The Beef Cattle Industry Science Cluster is funded by the Beef Cattle Research Council, a division of the Canadian Cattlemen's Association, and Agriculture and Agri-Food Canada to advance research and technology transfer supporting the Canadian beef industry's vision to be recognized as a preferred supplier of healthy, high quality beef, cattle and genetics.

For More Information Contact:
Beef Cattle Research Council
#180, 6815 - 8th St. NE
Calgary, AB T2E 7H7
Tel: (403) 275-8558 Fax: (403) 274-5686
info@beefresearch.ca

For More Information Visit:
www.beefresearch.ca