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Nitrogen excretion from beef cattle for 6 cover crop mixes as estimated by a nutritional model[1]

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SUMMARY

Excretion of nitrogen (N) from cattle within crop-livestock systems is an important component of nutrient cycling, but measuring fecal and urinary N excretion in grazing cattle is a difficult and time-consuming task. Nutritional models are available to estimate feed utilization and have been used to predict N excretion in grazing cattle. Using the Large Ruminant Nutrition Model, we predicted N losses from mature pregnant beef cows and growing beef heifers from compositional analysis of cover crop mixes grown in central South Dakota. All of the mixes used contained crude protein (CP) concentrations greater than cattle requirements. Estimates of both total fecal and urinary N excretion were greater for cows than heifers due to the greater BW and N intake of cows, however, the proportion of total N intake excreted in the feces was not predicted to differ between cattle maturities. Urinary excretion of N was predicted to be less for heifers, both when expressed as lb/d of N excreted or as a percentage of N intake. When accounting for potential stocking rate differences, it was predicted that slightly less urinary N excretion per acre could be expected by grazing younger cattle that utilize some N for growth compared to a mature animal.

INTRODUCTION

Cover crops can be used in rotational cropping systems to improve soil tilth and soil nutrient cycling, decrease wind erosion, and potentially help with weed control (Gardner and Faulkner, 1991. Cover crops can also be grazed by livestock to fill nutrient gaps for beef production (McCartney et al., 2009). Livestock can be used to speed up nutrient cycling in some crop-livestock settings, providing more benefit than leaving fields ungrazed (Carvalho et al., 2010). Use of forage protein by cattle is affected by its solubility and degradability in the rumen and use for microbial growth. Excess ruminal N supply may result in absorption of ammonia into the bloodstream and excretion in the urine. Urinary N, the majority of which is the form of urea, is easily volatilized and may be a nutrient loss in a crop-livestock system. In contrast, lowly degradable protein may pass through the ruminant unutilized and be excreted in the feces. Research addressing the partitioning of N use and excretion for cattle can add to our understanding of N conversion efficiencies in crop-livestock systems. Nutritional models such as the Cornell Net Carbohydrate and Protein System (CNCPS; Fox et al., 2004) and the Large Ruminant Nutrition System have been successfully used to monitor and manage nutrient excretion at the farm level for dairy cattle (Higgs et al., 2012). The objective of this study was to predict fecal and urinary N excretion for different maturities of beef cattle using model simulations based on compositional analysis of cover crop mixes grown in South Dakota.

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MATERIALS AND METHODS

Samples were obtained from the study of Hansen (2012) and analyzed for additional nutrient composition. Only 2 of 4 replications were analyzed for the current study. Forages had initially been grown under dryland conditions at Dakota Lakes Research Farm near Pierre SD in 2010 and 2011. Six forage mixes were evaluated (Table 1). Samples were collected on 3 dates in each year, approximately Oct 1, Nov 1 and Dec 1. Full description of the growth and harvesting conditions can be found in Hansen (2012). Samples were submitted to a commercial laboratory (Dairy One Forage Testing Laboratory, Ithaca NY) for analysis of dry matter (DM), CP, soluble CP, acid detergent fiber, neutral detergent fiber, acid detergent insoluble CP, neutral detergent insoluble CP, lignin, starch, simple sugars and crude fat. Average CP concentrations used in the model predictions are presented in Table 2.

Data was entered into the Large Ruminant Nutrition System (LRNS) model (http://nutritionmodels.tamu.edu/lrns.html) for estimation of N excretion. Two animal scenarios were analyzed: 1) a non-lactating, pregnant beef cow and 2) replacement beef heifer. Animal inputs used in the model are described Table 3. All environment and management conditions were similar for cows and heifers. The model was set to use default options. A randomly selected feed was entered and DM intake estimated by the model. All remaining scenarios were set to the same DMI. Dry matter intake was 2.33% of BW (31.4 lb/d for cows and 13.9 lb/d for heifers) for all simulations comparing mixes.

Nitrogen excretion outputs from the LRNS model were analyzed using PROC MIXED in SAS (SAS Inst. Inc., Cary NC). This experiment was designed as a split-plot arrangement of a randomized complete block with animal type and cover crop mixture as the whole plot and harvest date as the sub-plot. Cover crop mixture and harvest date were treated as fixed factors and replications were considered random. Student's t-test was used to separate mean effects when an *F* test was significant (*P*=0.05).

RESULTS AND DISCUSSION

Crude protein concentrations of cover crops mixes were always at least 14% (Table 2) and met nutrient requirements for both classes of animal (NRC, 1996). Mixes differed (P < 0.01) in CP content with differences affected by month within year (P < 0.01). Differences in mix CP content then affected N intake estimates for cattle. Predictions of N utilization, except lbs/d of fecal N excreted, were affected by cover crop mix (Table 4). Fecal N excretion ranged for 33.6 to 43.7% of N intake and urinary excretion from 52.5 to 58.8 % of N intake for the six cover crop mixes.

Predicted N intake was greater for cows than heifers due to the increased body weight of cows (Tables 4 and 5). Predicted N intake varied by month within year due to varied CP concentration of the mixes, with N intake in Oct 2010 being greater than for other months for both animal maturities and was less for cows in Dec 2011 than other months. Differences in N intake resulted in difference in the amount (lb/d) of predicted N excreted for cows, but not heifers. The predicted percentage of N intake excreted in feces did not differ by animal maturity. There was an animal maturity by month within year interaction for urinary excretion both when expressed as total lb/d excreted and percentage of N intake. Urinary nitrogen excretion varied from a low of 43.8 % of intake for heifers in Dec 2011 to a high of 66.4% for cows in Oct 2010. The estimates suggest that delaying grazing until November or December 2010 would have decreased urinary N excretion compared to Oct 2010 but this relationship did not hold for 2011 and a general conclusion about delaying grazing date cannot be made.

The amount of N excreted on a unit of land will be affected by stocking rate. In this example, heifers weighed 598 lb compared to 1346 lb for cows. Therefore, 2.25 heifers would provide the same BW/acre as one cow. Multiplying the estimate of N excretion (lb/d) for heifers by 2.25 gives a predicted fecal N excretion of 0.41 lb/d and a range in urinary N excretion of 0.38 to 0.72 lb/d on a specific land area. One cow on the same unit of land is predicted to excrete about 0.40 lb/d fecal N and 0.51 to 0.90 lb/d urinary N Therefore, slightly less urinary N excretion per acre could be expected by grazing younger cattle that may retain greater amounts of N for growth compared to cows.

Cover crop mixes that are lower in CP than those used in this study could potentially be used to limit urinary N excretion. This might be accomplished by planting cover crop mixes with less legumes or, at times, by delaying the time of grazing. This exercise was conducted with complete mixes and did not account for differences in diet selection by cattle for specific species in the mixes. Additionally, intake will be affected by diet characteristics and would likely differ by both mix and dates. Further research is needed to evaluate the actual N intake and utilization for cattle grazing cover crop mixes, but estimates can be made using modeled values.

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Table 1. Cover crop mixtures planted at the Dakota Lakes Research Farm in central South Dakota in 2010 and 2011, including species, cultivar, and seeding rates (from Hansen 2012).

Mixture	Crop	Cultivar	Seed Rate lbs/acre
Mixture 1	Chickling Vetch	AC Greenfix	33.0
	Lentil	Redberry	6.3
	Cowpea	Red Ripper	3.6
	Flax	Golden	7.1
Mixture 2	Chickling Vetch	AC Greenfix	33.0
	Lentil	Redberry	6.3
	Cowpea	Red Ripper	3.6
	Flax	Golden	7.1
	Rape	Dwarf Essex	3.6
Mixture 3	Chickling Vetch	AC Greenfix	23.2
	Lentil	Redberry	9.8
	Field pea	Austrian winter	7.1
	Flax	Golden	5.4
Mixture 4	Chickling Vetch	AC Greenfix	23.2
	Lentil	Redberry	9.8
	Field Pea	Austrian winter	7.1
	Flax	Golden	5.4
	Rape	Dwarf Essex	3.6
Mixture 5	Field Pea	Austrian winter	17.0
	Soybean	Pioneer 93M11	23.2
	Flax	Golden	9.8
Mixture 6	Field Pea	Austrian winter	17.0
	Soybean	Pioneer 93M11	23.2
	Flax	Golden	9.8
	Rape	Dwarf Essex	3.6

Table 2. Average crude protein concentration of cover crops mixes on three dates in two years used in the LRNS model. SE = 1.33.

Mix	2010			2011		
	Oct	Nov	Dec	Oct	Nov	Dec
	-----------------------------------CP, % of DM-----------------------------------					
1	25.8^{Aa}	23.1^{ABab}	23.5^{Aa}	22.3^{b}	26.2^{Aa}	19.4^{ABb}
2	25.0^{Aa}	21.6^{ABab}	21.9^{ABa}	18.8^{bc}	16.6^{BCc}	15.3^{Cc}
3	32.2^{Ba}	25.4^{Ab}	23.4^{Aa}	21.3^{c}	23.9^{Abc}	22.0^{Abc}
4	30.5^{Ba}	21.3^{Bb}	22.8^{ABa}	19.4^{bc}	16.9^{BCc}	15.6^{BCc}
5	25.9^{Aa}	21.5^{Bbc}	21.9^{ABa}	20.1^{bc}	19.0^{Bbc}	17.8^{BCc}
6	22.3^{Aa}	20.4^{Ba}	19.5^{Ba}	20.4^{a}	13.9^{Cb}	14.3^{Cb}

^{abc} Means in rows (months) with differing superscripts differ, P < 0.05.
^{ABC} Means in columns (mixes) with differing superscripts differ), P < 0.05

Table 3. Model conditions for animals used in the LRNS evaluation of cover crop mixes

Animal type	Dry Cow	Growing/ Finishing
Animal age, mo	60	10
Current BW, lb	1346	598
Expected weight at 22% Body fat	1393	1393
Days pregnant	162	-
Days since calving	245	-
Lactation number	5.0	-
Calving interval, mon	12	-
Expected calf birth weight, lb	86	-
Age at first calving, mo	23	-
Breed type	Beef	Beef
Breeding system	2-Way cross	2-Way Cross
Dam Breed	Hereford	Hereford
Sire Breed	Angus	Angus
Condition score	5.0	5.0

Table 4. Effect of date and year on predicted fecal and urinary nitrogen excretion for 2 beef cattle types consuming a diet of cover crops in the autumn

	Cover Crop Mix						
	1	2	3	4	5	6	SE
N Intake, lbs/d							
Cow	1.78^{Aa}	0.99^{Abc}	1.24^{Aa}	1.06^{Ad}	1.05^{Acd}	0.94^{Ab}	0.03
Heifer	0.52^{Bab}	0.44^{Bc}	0.55^{Bb}	0.47^{Bac}	0.46^{Bac}	0.42^{Bc}	0.03
Fecal N excretion							
lbs/d	0.29	0.29	0.30	0.30	0.29	0.29	0.01
% of N intake	35.4^{a}	41.4^{bc}	33.6^{a}	39.9^{b}	39.6^{b}	43.7^{c}	1.23
Urinary N excretion							
lbs/d	0.49^{a}	0.39^{b}	0.56^{c}	0.45^{ad}	0.42^{bd}	0.38^{b}	0.02
% of N intake	56.9^{ab}	52.5^{c}	58.8^{a}	54.8^{bd}	53.2^{cd}	52.9^{cd}	0.78

^{abcd} Means in rows with differing superscripts differ, $P < 0.05$.

^{AB} Means in columns for N intake with differing superscripts differ for animal maturity, $P < 0.05$.

Table 5. Effect of date and year on predicted fecal and urinary nitrogen excretion for female beef cattle of 2 maturities consuming a diet of cover crops in the autumn

	2010			2011			
	Oct	Nov	Dec	Oct	Nov	Dec	SE
Cow							
N Intake, lbs/d^{A}	1.35^{a}	1.12^{b}	1.11^{b}	1.00^{c}	0.98^{d}	0.88^{e}	0.02
Fecal N Excretion							
lb/d^{A}	0.42^{a}	0.40^{ab}	0.41^{a}	0.40^{ab}	0.38^{c}	0.40^{b}	0.01
% of N intake	31.6^{a}	36.6^{b}	37.4^{bc}	39.4^{c}	42.4^{d}	46.7^{e}	1.01
Urinary N excretion							
lbs/d^{A}	0.90^{a}	0.70^{b}	0.68^{b}	0.61^{c}	0.56^{cd}	0.51^{d}	0.02
% of N intake^{A}	66.4^{a}	61.5^{b}	61.2^{b}	59.2^{bc}	60.0^{bc}	58.3^{c}	0.92
Heifer							
N Intake, kg/d^{B}	0.60^{a}	0.50^{b}	0.49^{bc}	0.46^{cd}	0.43^{de}	0.39^{e}	0.02
Fecal N Excretion							
lbs/d^{B}	0.18	0.18	0.18	0.18	0.18	0.18	0.01
% of N intake	31.6^{a}	36.3^{b}	37.4^{bc}	39.4^{c}	42.4^{d}	46.6^{e}	1.01
Urinary N excretion							
g/d^{B}	0.32^{a}	0.26^{b}	0.25^{b}	0.21^{bc}	0.20^{bc}	0.17^{c}	0.02
% of N intake^{B}	54.7^{a}	52.3^{ab}	50.2^{b}	45.5^{c}	44.9^{c}	43.8^{c}	0.92

^{abcd} Means in rows with differing superscripts differ, $P < 0.05$.

^{AB} Overall mean differs between cows and heifers, $P < 0.01$.