Effect of Nitrogen Fertilization on Effective Ruminal Disappearance of Dry Matter, Fiber and Selected Macro–Minerals from Common Bermudagrass Harvested on Two Different Dates

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Story in Brief

Nutrient composition and digestibility of bermudagrass [*Cynodon dactylon* (L) Pers.] may vary with different management practices such as fertilization and time of harvest. This study evaluated nutritional value and ruminal disappearance of DM, neutral-detergent fiber (NDF) and selected macro-minerals from bermudagrass. Bermudagrass growing on a poultry layer–litter–amended site was fertilized with ammonium nitrate at four rates (0, 50, 100, and 150 lb N/acre) on April 28 and July 19, 2000, then harvested on May 30 and August 18, 2000. Five crossbred ruminally-cannulated steers (928 ± 45.0 lb BW) were used to determine DM, NDF, Ca, P, Mg, and K disappearance from dacron bags suspended in the rumen. Concentrations of NDF decreased ($P < 0.05$) and those of N, Ca, and Mg increased ($P < 0.10$) with increasing N fertilization rate on both harvest dates. Effective ruminal degradation of DM and NDF and effective ruminal disappearance of Mg increased ($P < 0.05$) with increasing N fertilization rate. Effective ruminal disappearance of Ca, P, and K were not affected ($P > 0.10$) by N fertilization rate on May 30, but effective ruminal disappearance of Ca increased and P decreased quadratically ($P < 0.05$) with increasing N fertilization rate on August 18. Effective ruminal disappearance of macro-minerals exceeded 70% in all cases and was highest for K followed by Mg, P, and Ca. Therefore, fertilization with higher rates of N has positive effects on nutritional quality and effective ruminal disappearance of common bermudagrass.

Introduction

Common bermudagrass is one of the most popular forage species adopted for beef production throughout the Southeastern U.S. due to its adaptability, persistence, aggressiveness (Aiken et al., 1995), high yield, and moderate nutritional quality. Bermudagrass responds well to N fertilization by increasing yield and N concentration in the plant. Crude protein and energy deficiencies are the principal factors associated with suboptimum ruminant livestock production. However, ruminants also require optimal levels of many mineral elements. Since a major goal of most livestock producers is to improve animal performance, it is essential to know the nutritional quality of bermudagrass and the proportion of those nutrients that may be utilized by the animal. The objective of this study was to determine the concentrations and effective ruminal disappearance of DM, neutral-detergent fiber (NDF), Ca, P, Mg, and K in bermudagrass fertilized with four N fertilization rates and harvested on two dates.

Experimental Procedures

Forage Samples. The forage used in this study was an established stand of common bermudagrass grown on a producer farm located near Lincoln, AR that had a poultry layer-waste application during 1999. Soil-test P and K concentrations were 571 and 496 lb/acre, respectively, and soil pH ranged from 6.8 to 7. In April 2000, 16 10-ft x 20-ft plots were arranged in a randomized complete block design with four replications. Nitrogen was applied as ammonium nitrate (34-0-0) in split applications of 0, 50, 100, and 150 lb/acre of actual N on April 28 and July 19. Bermudagrass from each plot was clipped to a 2-in stubble height with a sickle-bar mower on May 30 and August 18, 2000. Samples were composited across the four replications within each N fertilization rate for evaluation in an in-situ trial. The plots were also clipped on July 7, 2000, but no additional N was applied prior to this clipping and the forage samples were not used in the present experiment.

Forage Quality Analysis. Bermudagrass samples were dried to a constant weight under forced air at 122∞F and analyzed for N, NDF, and selected macro-minerals.

In Situ Procedures. Five ruminally-cannulated crossbred (Angus x Brangus x Angus) steers (mean BW = 928 ± 45.0 lb) were used in a randomized complete block design to determine the effective disappearance of DM, NDF and selected macro-minerals from bermudagrass. Steers were housed in individual 10 x 15 ft pens that were cleaned regularly. Steers were offered a basal diet of 86.4% bermudagrass hay and 13.6% concentrate mix. The basal diet was offered at 2% of body weight split into equal feedings at 0800 and 1700 h with ad libitum access to water.

The experimental forages were weighed into dacron bags and inserted into the rumen of all five steers simultaneously before feeding (0800 h) and incubated for 3, 6, 9, 12, 18, 24, 48, 72, or 96 h. After the appropriate time interval, dacron bags were removed from the rumen and subsequently, bags were placed into a top-loading washing machine and rinsed. Bags containing the 0-h samples were machine-rinsed also.

In-Situ Residue Analysis. After rinsing, dacron bags containing the incubated forage residues were dried and the residual DM was analyzed for NDF and macro-minerals. The non-linear model of Mertens and Loften (1980) was used to separate the different nutrients into a water-soluble fraction, a slowly degraded fraction, and an undegradable fraction and to calculate the rate of nutrient disappearance from the dacron bags. Effective disappearance was also calculated and represents the proportion of the particular nutrient that would be degraded in the rumen. It was calculated by correcting the slowly degradable fraction for both disappearance rate of the nutrient and passage rate of the diet, then adding this value to the water-soluble fraction.

Statistical Methods. Data pertaining to disappearance from dacron bags in the rumen were analyzed using PROC GLM of SAS (SAS Inst., Inc., Cary, NC) as a randomized complete block design

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with a 2 x 4 (harvest date x N fertilization rate) factorial arrangement of treatments. Effects of steer, date, the linear and (or) quadratic effects of N fertilization rate, and their interaction were included in the statistical model. A linear model was used when the fit was not improved ($P > 0.05$) by the quadratic model. Significant interactions implied that the quadratic or linear functions differed ($P < 0.05$) across harvest dates. When interactions were not detected ($P > 0.05$), a single quadratic or linear parameter estimate was calculated across harvest dates and used to describe the overall relationships between fertilization rate and the response variable.

Results and Discussion

A quadratic N fertilization rate by harvest date interaction was observed ($P < 0.01$) for whole plant N concentration (Table 1). It is common to observe an increase in N concentrations following N fertilization. Concentrations of NDF decreased linearly ($P = 0.01$) on both harvest dates as N fertilization increased. The NDF fraction was higher for bermudagrass harvested on August 18 than on May 30. This difference is best explained by the positive relationship between temperature and NDF concentration in forages. Macro-mineral concentrations in bermudagrass were, in general, above the requirements recommended for beef cattle. Calcium (Ca) concentrations tended ($P = 0.08$) to increase linearly as N fertilization rates increased on May 30 and August 18. However, Ca content did not differ between harvest dates ($P > 0.05$). Phosphorus (P) concentration in the whole plant showed a linear N fertilization rate by harvest date interaction ($P < 0.05$). This effect could be explained by a lack of response ($P = 0.99$) of P content across N fertilization levels on May 30 harvest, but a decrease ($P < 0.01$) of 29.4% with increasing N fertilization rates on the August 18 harvest. The calculated Ca:P ratio averaged 1.9 and 2.6 for bermudagrass harvested on May 30 and August 18, respectively. This ratio is within the recommended range for beef cattle. Magnesium (Mg) concentrations increased linearly by increasing N fertilization rates ($P < 0.01$). However, no difference was observed in Mg content at both harvest dates. Potassium (K) content did not differ ($P = 0.37$) with increasing N fertilization levels, but K concentration was higher in the May 18 than in the August 30 harvest. Hypomagnesemia (grass tetany) is not typically a problem with warm season grasses, and this study supported that since the K/(Ca + Mg) ratio was below the ratio of 2.2. A ratio of 2.2 or higher is considered to have the potential to educe grass tetany (Grunes et al., 1989). Therefore, there is probably little risk of grass tetany in lactating cows grazing this bermudagrass.

Dry matter effective degradability exhibited a linear N fertilization rate by harvest date interaction ($P > 0.01$, Table 2). The effective degradability of NDF increased linearly ($P < 0.01$) by 1.1 percentage unit for each 100 lb/acre with increasing N fertilization rates at both harvest dates. Effective degradability was 3.1% higher ($P < 0.05$) on May 30 than on August 18. Forage intake is related to the NDF degradation. Therefore, increasing effective degradability of NDF, should result in higher forage intake. This resulted because of the relationship between elevated temperatures and reduced cell wall digestibility. A quadratic N fertilization rate by harvest date was observed for the effective disappearance of Ca and P ($P < 0.05$). The effective disappearance of Ca averaged 74% and was the lowest compared with K, P, and Mg, probably due to chemical binding of Ca to large indigestible fractions in the plant. Effective disappearance of Mg and K exhibited a linear N fertilization rate by harvest date interaction. The effective K disappearance was greater than 99%. Potassium had the most extensive effective disappearance among all the other elements evaluated because K is present in the forage almost entirely as free or readily exchangeable ions.

Implications

Increasing N fertilization rates substantially improved nutritional quality of bermudagrass by increasing N content, slightly reducing the NDF fraction, and increasing calcium and magnesium concentrations. In addition, effective DM, NDF and macrominerals disappearance improved at both harvest dates. Therefore, forage intake may be enhanced and the need for supplemental minerals could be reduced.

Literature Cited

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Table 1. Concentrations of nitrogen, NDF, and selected macro-minerals from bermudagrass fertilized with four N rates and harvested on May 30 and August 18

		N fertilization rates (lb/acre)[a]						Regression coefficients				
Item	Date	0	50	100	150	RMSE[b]	Fit[c]	Quadratic	Linear[d]	Intercept	R^2	P[e]
		------------ % of DM ----------										
N, %	May 30	2.7	2.8	3.0	3.2	0.002	Quadratic	0.00001	0.0010	2.7[f]	0.99	<0.01
	Aug 18	1.8	2.1	2.3	2.4	0.002	Quadratic	-0.00002	0.0060	1.8[g]	0.99	<0.01
NDF, %	May 30	65.9	65.8	65.4	64.1	0.39	Linear		-0.009	66.0[g]	0.97	0.01
	Aug 18	68.9	69.2	68.5	67.9	0.39	Linear			69.3[f]		
Ca, %	May 30	0.69	0.71	0.69	0.72	0.04	Linear		0.0006	0.66	0.79	0.08
	Aug 18	0.63	0.70	0.79	0.77	0.04	Linear			0.68		
P, %	May 30	0.37	0.37	0.37	0.37	0.009	NS		-0.000001	0.37[f]	0.98	0.99
	Aug 18	0.34	0.30	0.26	0.24	0.009	Linear		-0.0006	0.33[g]	0.98	<0.01
Mg, %	May 30	0.19	0.22	0.22	0.23	0.007	Linear		0.0003	0.20	0.88	<0.01
	Aug 18	0.20	0.21	0.24	0.24	0.007	Linear			0.20		
K, %	May 30	2.85	3.05	3.31	2.89	0.16	NS		0.0010	2.95[f]	0.87	0.37
	Aug 18	2.24	2.38	2.45	2.42	0.16	NS			2.31[g]		

[a] Nitrogen fertilization was applied on April 28 and July 19, 2000.
[b] RMSE = root mean square error for the polynomial model. If not significant for both linear and quadratic regression models, linear RMSE was used.
[c] Best fit of linear and quadratic effects of N fertilization rate.
[d] When only one slope is represented for an item, the date x fertilization level interaction was not significant ($P<0.05$). Therefore the slopes did not differ and the average slope of the linear effect of N fertilization rates across harvest dates is presented.
[e] P = Probability that the linear or quadratic parameter estimate was different from zero.
[f,g] Intercepts for an item differed ($P<0.05$) between May 30 and August 18 harvest dates.

Table 2. Effective disappearance of DM, NDF and selected macro-minerals from common bermudagrass fertilized with four N rates and harvested on May 30 and August 18

		N fertilization rates (lb/acre)[a]						Regression coefficients				
Item	Date	0	50	100	150	RMSE[b]	Fit[c]	Quadratic	Linear[d]	Intercept	R^2	P[e]
		------------ % of DM -----------										
DM, %	May 30	51.3	53.1	54.2	55.3	0.89	Linear		0.026	52.23[f]	0.90	<0.01
	Aug 18	49.0	50.0	49.8	51.7	0.89	Linear		0.015	49.63[g]	0.90	<0.01
NDF, %	May 30	38.1	39.4	39.8	40.7	1.36	Linear		0.011	39.57[f]	0.71	<0.01
	Aug 18	37.4	39.6	37.2	39.2	1.36	Linear			38.42[g]		
Ca, %	May 30	71.6	74.5	70.6	75.7	1.53	NS	0.00021	-0.015	71.8	0.76	0.13
	Aug 18	70.8	75.0	77.1	77.4	1.53	Quadratic	-0.00039	0.102	70.3	0.76	<0.0
P, %	May 30	86.8	87.4	87.6	87.8	0.54	NS	-0.00004	0.012	86.7[f]	0.95	0.40
	Aug 18	85.9	84.7	82.2	82.7	0.54	Quadratic	0.00018	-0.051	86.0[g]	0.95	<0.01
Mg, %	May 30	92.3	92.9	92.8	93.3	0.016	Linear		0.006	92.4f	0.92	<0.01
	Aug 18	92.1	92.5	93.1	93.7	0.016	Linear		0.009	92.0[g]	0.92	<0.01
K, %	May 30	99.8	99.8	99.8	99.8	0.04	NS		-0.0002	99.8f	0.43	0.25
	Aug 18	99.7	99.8	99.8	99.8	0.04	Linear		0.0005	99.7[g]	0.43	<0.01

[a] Nitrogen fertilization was applied on April 28 and July 19, 2000.
[b] RMSE = root mean square error for the polynomial model. If not significant for both linear and quadratic regression models, linear RMSE was used.
[c] Best fit of linear and quadratic effects of N fertilization rate.
[d] When only one slope is represented for a item, the date x fertilization level interaction was not significant (P<0.05). Therefore the slopes did not differ and the average slope of the linear effect of N fertilization rate across harvest dates is presented.
[e] P = Probability that the linear or quadratic parameter estimate was different from zero.
[f g] Intercepts for an item differed (P<0.05) between May 30 and August 18 harvest dates.