THE RELATIONSHIP AMONG NITRATE CONTENT AND NUTRITIONAL VALUE IN HYBRID SUDANGRASS HAY

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Story in Brief

The relationship between nitrate (NO_3) concentration and nutritional measurements in hybrid sudangrass hay was examined in a two year study. One variety of SudanXSudan hybrid grass was grown in eastern and south central Oklahoma over two consecutive summers. The hay was grown after applying 0 lbs actual nitrogen (N) per acre, 2 split applications of 50 lbs N per acre, 100 lbs of N per acre, 150 lbs N per acre, or 200 lbs of N per acre. Hay samples (n=197) from these plots were measured for nitrate content, acid detergent fiber, neutral detergent fiber, crude protein, and moisture. Crude protein accounted for the largest source of variation (11%) in nitrate; whereas percentage acid detergent fiber of the sun-cured samples was negatively related to nitrate and accounted for 7% of the variation. As crude protein increased 1 %, nitrate concentration increased 1026 ppm.

(Key Words: Nitrate, Sudangrass hay, Crude protein, Fiber.)

Introduction

Nitrate in forage sorghum hay may cause toxicity and death to ruminant livestock that consume high nitrate hay. Little research has been conducted to quantify the relationship between the amount of nitrate and protein or energy content found in hay. Crude protein should be related to nitrate concentration because crude protein is estimated as percentage nitrogen in the forage sample times 6.25. Acid detergent fiber (ADF) is the insoluble residue left after a sample is boiled in an acid detergent for 1 hour and then filtered. ADF contains primarily cellulose, lignin, and silica. Total dry matter minus ADF is considered the best predictor of forage digestible dry matter and digestible energy. Neutral detergent fiber (NDF) is the insoluble fraction of the forage after 1 hour of boiling in non-acid or neutral detergent. NDF contains cellulose, hemicellulose, silica, some protein, and lignin. Cell wall or NDF components have lower digestibility than cell contents with digestion being entirely dependent on the microorganisms of the digestive tract.

Plots of one variety of sudangrass were grown with different levels and timing of nitrogen fertilization. Hay samples from the plots were tested for

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nitrate concentration, crude protein, ADF, and NDF. This study examined the relationships among nitrate concentration and the nutrient composition of hybrid sudangrass hay.

Materials and Methods

Various amounts of nitrogen fertilizer were applied to hybrid sudangrass at two Oklahoma State University Agronomy Research Stations, one at the Eastern Research Station near Haskell and the other at the South-Central Research Station near Chickasha. The Eastern Research Station plots were planted on a Taloka silt loam soil, whereas the South Central Research Station is located on a Reinach silt loam. Three cuttings of hay were taken at each location in the first year. Three cuttings were obtained from the Eastern Research Station in year two; but only two cuttings were available from the South Central Research Station in year two. Five fertilization treatments were replicated four times at each location each year. The five levels of nitrogen fertilization included:

1: No nitrogen fertilization applied
2: Two applications of 50 pounds of actual nitrogen per acre (50 pounds at planting time and 50 pounds per acre after the first cutting)
3: One application of 100 pounds of actual nitrogen per acre at planting
4: One application of 150 pounds of actual nitrogen per acre at planting
5: One application of 200 pounds of actual nitrogen per acre at planting

These different rates of nitrogen fertilization should create differences in nitrate accumulation and crude protein content. Differences in ADF and NDF should be related to stage of maturity at harvest rather than fertilization scheme.

The hybrid sudangrass variety utilized at both locations and both years was a "SudanXSudan" hybrid named Monarch V. Planting date both years was in late May for both locations. However, the year 2 planting was washed away at the Eastern Research Station; replanting took place in late June. Each location was cut prior to seed head appearance and plots in treatment 2 were top dressed to provide the additional nitrogen. Hay was harvested from each of the 13 feet by 9 feet plots; an approximate 1 pound sample of each plot was labeled and taken to Stillwater for dry matter and nitrate concentration determination. Nitrate analysis was achieved by the salicyclic acid method described by Cataldo, et. al. (1975). Nitrate concentration for each sample was expressed as parts per million on a 100% dry matter basis. Crude protein was

estimated by Kjeldahl analysis for nitrogen content and then determined by multiplying 6.25 times the percentage nitrogen. Acid detergent fiber and neutral detergent fiber were measured by the methods described by Van Soest (1967). Moisture content was determined by the difference in hay sample weight as brought to the laboratory and weight of the sample after oven drying. Total Digestible Nutrients (TDN) were estimated using the equation: TDN = 88.9 - (0.779 x percent ADF). These determinations were made by the OSU Forage and Water Testing Laboratory.

Data were analyzed by stepwise regression analysis of variance to examine the amount of variation in nitrate content that could be attributed to moisture, crude protein, ADF, and NDF concentrations.

Results and Discussion

The means, ranges, and standard deviations of nitrate concentration and nutrient contents of all samples are listed in Table 1. Nitrate concentrations for the different fertilization schemes were reported previously (Selk, et al, 1993).

Crude protein, moisture, and ADF were all significant ($P < .05$) sources of variation in the nitrate content of the samples. Neutral detergent fiber accounted for a smaller (1.5%; $P = .051$) proportion of the variation in nitrate concentration. A regression equation with all of the above parameters (moisture, crude protein, ADF, and NDF) accounted for only 24.9% of the variation in nitrate content. Regression coefficients and percentage of variation (r^2) in nitrate are presented for each of the proximate analysis parameters (Table 2).

The concentration of nitrate was decreased (1289 ppm) for each 1 percent increase in moisture. Although all of these samples were sun cured in the windrow, the relationship between drought stressed plants and nitrate concentration was still evident. Drought-stressed sudangrass plants were lower in moisture content and have been shown to accumulate nitrate. Protein content was positively related to nitrate accumulation. For each 1 percentage increase in crude protein, nitrate increased by 1026 ppm. This relationship is to be expected because a portion of the nitrogen calculated to be in protein is in the form of nitrate. Plants with more nitrogen fertilizer available would also be expected to be higher in both crude protein and nitrate concentration.

The small positive relationships among ADF, NDF and nitrate accumulation may indicate that drought-stressed forage which accumulates nitrate contains higher percentage of fiber. These relationships would not be expected to remain in plants with adequate rainfall. Under conditions of abundant rainfall , young (low fiber concentrations) plants often have greater nitrate content than mature (high fiber) plants with normal growing conditions.

These data suggest that higher nitrate sudangrass hays may have corresponding increases in crude protein, but often are the product of drought and therefore have decreased moisture content and increased acid detergent fiber and neutral detergent fiber.

Literature Cited

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Table 1. Minimums, maximums, means, and standard deviations for samples of sudangrass hay analyzed for nitrate (ppm), percentage moisture, crude protein (CP), total digestible nutrients (TDN), acid detergent fiber (ADF) and neutral detergent fiber (NDF).

Variable	N[a]	Minimum	Maximum	Mean	Std. Dev.
Nitrate(ppm)	218	147.54	39127.31	6570.44	6168.31
% Moisture	199	2.10	7.90	5.42	1.50
% CP	199	6.00	25.00	13.74	2.95
% TDN	199	46.60	65.20	58.61	3.73
% ADF	199	10.30	50.10	38.81	3.95
% NDF	199	52.70	80.20	64.55	5.49

[a] One cutting from South-Central station was not analyzed for protein, moisture, ADF and NDF.

Table 2. Regression coefficients and amount variation in nitrate content accounted for by nutrient values in sudangrass hay.

	Regression coefficient	% of variation in nitrate
Percent moisture	-1289.6	5.4
Crude protein	1026.7	11.0
ADF	296.8	7.0
NDF	201.6	1.5
Total		24.9