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Nitrogen Management for Sorghum Sudangrass
How to optimize N uptake efficiency?

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Introduction

Over the last two years we have evaluated brown midrib (BMR) sorghum sudangrass in New York State. In a previous issue of "What's Cropping Up?" Cerosaletti and others discussed the potential agronomic, economic and environmental benefits of growing BMR sorghum sudangrass as an alternative for corn silage and reported the results of a 2001 study in Delaware County on the effect of time of harvest (harvest stand height) on forage quality (What's Cropping Up? 12(3): 1-3). In this issue, we report on a nitrogen management study conducted in Columbia County in 2000. Our main objective was to determine yield, quality and N fertilizer uptake efficiency as affected by amount and timing of the N application (all at once at planting or split applications).

Materials and Methods

Field experiments were conducted on a Hoosic soil (pH 6.4, medium soil tests for P and K) at the Valatie Research Farm in Columbia County, NY. BMR sorghum sudangrass was planted at a rate of 66 lbs/acre on June 1, 2000, using a conventional grain drill with press wheels. Phosphorus (45 lbs P_2O_5/acre) and potassium (70 lbs K_2O/acre) were added as a starter fertilizer. Four N rates were tested for their effect on yield, quality and nutrient uptake efficiency: 0, 100, 150 and 200 lbs N/acre. The 150 and 200 lbs applications were applied either in full at planting (150/0 and 200/0) or as equally split applications at planting and after the first cutting (75/75 and 100/100). First cutting took place on July 28; 2 months after seeding and at a stand height of 48 inches. The second cutting followed on September 28; 4 months after seeding and at a stand height of 58 inches. We determined yield, dry matter (DM) content, %N, %P and %K. Nitrogen, P_2O_5 and K_2O removal were calculated and the N fertilizer uptake efficiency was determined using the following formula:

N fertilizer uptake efficiency (%) =

$$\frac{\text{N uptake} - \text{N uptake at 0 N application}}{\text{N application}} * 100$$

A high efficiency implies a high return on fertilizer and reduced potential for environmental pollution.

Forage DM was analyzed for neutral detergent fiber (NDF), crude protein (CP), in vitro true digestibility (IVTD), in vitro net energy for lactation (IVNEL), lignin (LIG), and non structural carbohydrate (NSC). Milk 2000, a model that integrates forage yield and quality characteristics, was used to calculate milk yield per ton and milk yield per acre. For a description of Milk2000, we refer to http://www.uwex.edu/ces/forage/pubs/milk2000.htm. For an explanation of the different forage quality terms, see Box 1.

Box 1: Forage quality parameters explained.

Crude protein (CP) includes true protein and non-protein nitrogen. Protein is required on a daily basis for maintenance, lactation, growth and reproduction. In vitro true digestibility (IVTD) is an anaerobic fermentation performed in the laboratory to simulate digestion as it occurs in the rumen. The result is a measure of digestibility that can be used to estimate energy. Neutral detergent fiber (NDF) is a measure of hemicellulose, cellulose and lignin representing the fibrous bulk of the forage. Hemicellulose and cellulose can be broken down by microbes in the rumen to provide energy to the animals. NDF is negatively correlated with intake. The end result of in-vitro analysis is the undigested fibrous residue. This value can be used to calculate how much of the NDF was actually digested. The result is called dNDF and can be used to rank forages on potential fiber digestibility. The dNDF is also used in calculating IVNEL, which is in vitro net energy of lactation, an estimate of energy from forages. Lignin is a main structural component of the plant. Lignin content is directly tied to the amount of cellulose that is digestible. As lignin concentration increases, cellulose digestibility decreases. Non structural carbohydrates (NSC) are carbohydrates that are not part of the cell wall and consist primarily of starches and sugar that serve as energy sources for the animals. In ruminants, NSC are broken down by the microbial population in the rumen and used as an energy source.

Results and Discussion

N application increased yields but little was gained by increasing the N application *at planting* beyond 100 lbs/acre (Figure 1). However, splitting the 150 and 200 lbs/acre applications into two (with the second application directly following first cutting) more than doubled the yield of the second cut and resulted in a yield that was comparable with corn yields on Hoosic soils (18 tons/acre corn yield potential). The N uptake efficiency of the fertilizer added at planting was very low possibly as a result of large leaching and denitrification losses in the cool and wet spring of 2000. Overall N efficiency greatly improved with split application mostly because of the high uptake efficiency for the second application. Thus, splitting the N application resulted in higher yields and reduced losses of N to the environment. It is unknown what the uptake efficiencies would have been for corn grown on the same site in 2000 and BMR sorghum sudangrass and corn silage comparison studies are needed to determine competitiveness in yield and environmental risk.

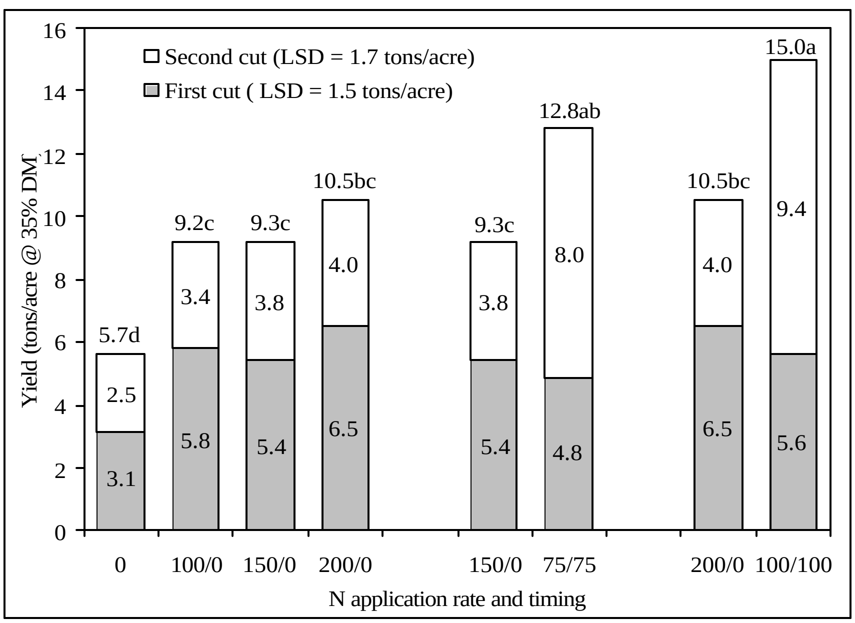

Figure 1: Yield of BMR sorghum sudangrass as affected by N management. Trials were conducted at the Valatie Research Farm in Columbia County, NY (2000 growing season).

Table 1: N, P and K removal, N fertilizer uptake efficiency and predicted milk yield (milk/ton and milk/acre) of brown mid rib sorghum sudangrass in response to N application rate and method (at planting/after the first cut) at the Valatie Research Farm, Columbia County, NY (2000 data).

N application		Nutrient Removal			N Uptake Efficiency		Predicted Milk Yield	
Total	Method	N	P_2O_5	K_2O	1st cut	Total		
------ lbs/acre ------		------------- lbs/acre -------------			------------ % ------------		lbs/ton	lbs/acre
0	0/0	50 d	35 c	117 c	-	-	3010 a	5981 d
100	100/0	86 c	46 b	155 bc	29 a	36 ab	3057 a	9772 c
150	150/0	83 c	46 b	172 ab	15 a	22 b	2989 a	9650 c
150	75/75	113 b	61 a	196 ab	17 a	42 a	3000 a	13428 ab
200	200/0	115 b	50 b	177 ab	26 a	32 ab	3000 a	10874 bc
200	100/100	146 a	70 a	227 a	22 a	48 a	2932 a	15590 a

Note 1: Milk yield predictions according to Milk 2000 (http://www.uwex.edu/ces/forage/pubs/milk2000.xls).
Note 2: See text for definition of N uptake efficiency.
Note 3: Average values *within columns* with different letters (a,b,c) are statistically different (α = 0.05).

Table 2: Crude protein (CP), %K, %P, in vitro true digestibility (IVTD), lignin (LIG), non-structural carbohydrate (NSC), neutral detergent fiber (NDF), neutral detergent fiber digestibility (dNDF) and in vitro net energy for lactation (IVNEL) of first and second cut brown mid rib sorghum sudangrass as affected by N rate and timing of application (at planting/after the first cut) at the Valatie Research Farm, Columbia County, NY (2000 data).

N application		CP	K	P	IVTD	LIG	NSC	NDF	dNDF	IVNEL
Total	Method									
---- lbs/acre ----		------------------------------------ % of dry matter						-------------------------	% of NDF	Mcal/lb
					First Cut					
0	0/0	7.1 b	2.55 a	0.31 a	84.9 a	3.1 a	22.1 a	61.3 ab	75.4 a	0.65 a
100	100/0	8.0 b	1.99 b	0.28 b	82.7 ab	3.0 a	23.0 a	60.8 ab	71.6 ab	0.64 ab
150	150/0	7.8 b	2.23 ab	0.26 b	82.1 b	3.1 a	23.4 a	60.3 b	70.2 b	0.64 ab
150	75/75	7.1 b	2.24 ab	0.28 ab	83.1 ab	3.6 a	23.2 a	60.9 ab	72.2 ab	0.64 ab
200	200/0	10.6 a	2.14 ab	0.28 ab	81.8 b	2.9 a	21.9 a	58.8 c	69.0 b	0.65 a
200	100/100	7.3 b	2.12 ab	0.26 b	81.1 b	3.4 a	22.5 a	61.9 a	69.4 b	0.61 b
					Second Cut					
0	0/0	9.0 ab	2.22 a	0.47 a	81.7 ab	4.4 a	20.7 c	61.2 a	70.1 ab	0.62 b
100	100/0	8.8 ab	2.06 ab	0.38 b	84.7 a	4.2 ab	21.9 abc	60.3 ab	74.6 a	0.65 a
150	150/0	8.3 b	2.21 a	0.38 b	83.4 ab	3.8 b	21.7 bc	61.1 ab	72.8 ab	0.63 ab
150	75/75	8.4 ab	1.52 c	0.31 c	80.4 b	4.4 a	24.1 a	60.3 ab	67.5 b	0.63 ab
200	200/0	8.5 ab	1.79 bc	0.33 bc	82.6 ab	3.8 b	23.9 ab	59.1 b	70.4 ab	0.65 ab
200	100/100	9.3 a	1.55 c	0.31 c	80.6 b	3.8 ab	23.5 ab	59.5 ab	67.2 b	0.63 ab

Note: Average values *within columns* with different letters (a,b,c) are statistically different (α = 0.05).

Phosphorus removal ranged from 35 lbs P_2O_5/acre without N addition to 70 lbs/acre after two applications of 100 lbs N/acre each. K_2O removal increased from 117 (no N added) to 227 lbs K_2O (100/100 application). The increase P and K removal under split applications of N was a result of increases in yield only.

Predicted milk yield per acre was greatest when 200 lbs of N was added in split applications. Milk per ton did not show a response to N rate or timing, which indicates that the increase in milk yield per acre is primarily due to an increase in yield. Yield quality parameters support this observation. Although several of the quality parameters tested did show statistically significant differences, the differences generally were not of practical importance. Nitrogen fertilization of first-cut grass often results in a small decline in IVTD and dNDF, as occurred here. As is usually the case with grasses that do not form grain, IVTD is highly correlated with dNDF. Higher protein and energy levels would have been likely if the first and second cut had been taken at a shorter stand height (see our discussion in Cerosaletti and others, "What's Cropping Up?" 12(3): 1-3).

Conclusions

Under the growing conditions in Columbia County in the cold and wet 2000 growing season, BMR sorghum sudangrass grown on a Hoosic soil in Columbia County, NY, showed the greatest yields when 200 lbs N/acre were applied *in split applications*. The 15 tons/acre yield (35% dry matter) would likely have competed well with corn silage yields in the region that year. From the results of one growing season only, we cannot derive N recommendations that would be accurate over multiple years. Thus, further research is being done to determine optimum N application rates over multiple years and multiple locations. However, the results of this study clearly show the benefits of split applications of N; an increase in yield and predicted milk per acre production without impacting forage quality. As a result of this yield increase, split applications also result in an increase in N uptake efficiency.

Future work and contact information

To further refine N recommendations for this crop, trials were established in 2002 at the Valatie Farm and at the Mt Pleasant Farm (Tompkins County). At the Mt Pleasant site, the interactions with K applications are also being studied. Results will be reported in future issues of "What's Cropping Up?". For further information on BMR sorghum sudangrass contact Thomas Kilcer at the Rensselaer Cooperative Extension Office at tfk1@cornell.edu or 518-272-4210. You could also visit the BMR sorghum sudangrass website at http://www.css.cornell.edu/nmsp/projects/bmr.asp.

Nutrient Management Spear Program:

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