What's Cropping Up?

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Variable Rate N Management in Corn

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Corn yields often show significant spatial variability because of numerous factors including topography, drainage, organic matter content, and pest problems. Spatial variability of corn yield poses a significant challenge for N fertility management because excessive N results in NO_3-N contamination of surface and groundwater and inadequate N results in yield and profit losses. Studies have shown that about 70% of the NO_3-N that is leached comes from <30% of the field. Consequently, the application of variable N fertilizer rates has the potential to reduce NO_3-N contamination of surface and groundwater and increase profits by matching N fertilizer rates to the N fertility requirement of corn in different areas of a field. The challenge is to identify specific areas of a field that require more or less N for optimum corn yields.

Corn yields, however, frequently show more temporal variability than spatial variability. Consequently, the use of yield goal-based N applications, based on yield map data, may not be conducive to variable N rate management because high-yielding areas of a field are not consistent from year to year. The use of the presidedress soil nitrate test (PSNT) may predict some of the temporal yield variability by accounting for the net effects of spring weather conditions on mineralization of soil N, leaching and denitrification of NO_3-N.

We formed farmer-researcher partnerships to evaluate the spatial and temporal corn yield responses of two hybrids at two N levels (25 lbs/acre above and below the recommended rate) within five fields during the 1999, 2000, and 2001 growing seasons. Table 1 provides detailed information on the soils and N management at the five sites. Most notably, two sites, Onondaga 1 and Onondaga 2, received applications of 10 000 gallons per acre of manure in fall, followed by 10 000 gallons per acre in the spring. The Seneca sites were in corn for cash grain without manure application.

Weather conditions differed markedly among growing seasons. The 1999 growing season can be characterized as hot and dry, 2000 as cool and wet, and 2001 as warm and dry. The PSNT values also differed markedly across years and sites. Soil NO_3-N concentrations were exceedingly high at the manured Onondaga sites (above 100 ppm at Onodango 1) in the dry 1999 and 2001 growing seasons (Fig. 1). Although spatial variability existed at the Onondaga sites for soil NO_3-N concentrations in 1999 and 2001, all sampling sites within the field had concentrations above 25 ppm, the estimated threshhold concentration at which corn does not respond to additional sidedress N fertilizer. Soil NO_3-N concentrations averaged much less at the Onondaga 1 and 2 sites in 2000 because of cool and wet conditions (Fig. 1). About 15% of the field at the Onondaga 1 site and 25% of the field at the Onondaga 2 site had soil NO_3-N concentrations less than 25 ppm. Based on the soil NO_3-N concentrations, corn was not expected to respond to sidedress fertilizer N in 1999 and 2001 but was expected to respond to sidedress fertilizer N in the southeastern and central western regions at Onondaga 1 and the very southern and northwestern regions at the Onondaga 2 site in 2000.

Soil NO_3-N concentrations averaged much less at the cash crop sites compared with the dairy sites in all 3 years (Fig. 2). The Seneca 1 and 2 sites had the least spatial variability, whereas the Seneca 3 site had the most spatial variability for soil NO_3-N concentrations. In the drier year, 1999, the entire Seneca 3 site had soil NO_3-N concentrations above 25 ppm except for the very southern region where concentrations ranged from 12 to 24 ppm. In 2000 and 2001, soil NO_3-N concentrations at the Seneca 3 site ranged from 12 to 24 ppm kg^{-1} in the northern and from 0 to 12 ppm in the southern regions. The spatially distinct soil NO_3-N regions increase the probability that the Seneca 3 site will respond to variable N rate management.

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Corn yields showed significant spatial variability at all sites in 1999 and 2001 (Fig. 3 and 4). In contrast, corn yields showed much less spatial variability in 2000 despite the excessive spring precipitation (Fig. 3 and 4). Apparently, corn yields have more spatial variability in warm and dry compared with cool and wet growing conditions in New York. All sites have some type of subsurface drainage system, which evidently reduced the spatial variability of corn yields under the very wet spring conditions in 2000. All sites showed positive correlations for corn yields between the 1999 and 2001 growing seasons, which indicate temporal stability for the spatial relationship of corn yields at these sites in dry years (Table 2). Also, the Onondaga 1 and Seneca 3 sites had positive correlations between corn yields in 1999 and 2001 with yields in 2000, despite very different growing conditions. The temporal stability for the spatial relationship of corn yields increases the probability that both sites will respond to variable rate technology.

Corn yield had a significant field-average N response in only five of 13 site-year comparisons (Table 3). Corn yielded the same or higher at the lower compared with the higher N rate in five of six comparisons at the Seneca sites in 1999 and 2001. Furthermore, the 5 bu/acre yield response at the Seneca 1 site in 2001 was only marginally economic. Corn responded to the higher N rate in 2000 at only one of the three Seneca sites, in which case the response was economical. Overall, the response to N at the three cash crop sites was mostly consistent across years, despite different weather conditions and corn yields. Also, corn did not respond to additional fertilizer N at the manured Onondaga 2 site. Corn had a positive response to additional fertilizer N at the manured Onondaga 1 site in 2000, but the 6 bu/acre response was not economic because of the cost of fertilzer N and additional machinery costs for applying fertilizer N.

Corn did not respond differently to N rates within the Onondaga sites in 2000, when distinct areas at each site had soil NO_3-N concentrations below or above 25 ppm. The use of the PSNT, even with relatively dense sampling, did not allow us to identify specific areas within manured fields that would or would not respond to additional fertilizer N. Corn did respond differently to N rates at the Seneca 3 site in 1999 and 2001, which indicates that variable N rate management may be possible within this field in dry years. Surprisingly, corn did not respond to the higher N rate in the northwestern region of the field where yields exceeded 145 bu/acre , even when soil PSNT concentrations ranged from 12 to 24 ppm in 2001 (Fig. 5). In contrast, corn responded to the greater N rate on about 15% of the southern region of the field in 1999 and about 30% in 2001, where yields were less than 95 bu/acre . If the grower used a yield goal-based approach for the application of N fertilizer, sole reliance on yield map data would have misled the grower into applying too much fertilizer N in the northwestern region and too little fertilizer on about 25% of the southern region of the field. Likewise, if the grower relied on the PSNT, the entire field would have received the recommended N rate of 140 lbs/acre instead of 115 lbs/acre throughout most of the field.

Conclusion

Corn yields had significant to highly significant spatial variability with temporal stability at all sites in the dry years. Significant spatial variability with temporal stability would be expected to provide an opportunity to manage the yield variability via variable sidedress N application in mid to late-June. Furthermore, growers could plan to use the PSNT and/or yield map data as a guide for variable fertilizer N application. Unfortunately, on a dairy farm, the PSNT was not effective in identifying specific areas within manured fields that would respond to variable N rate management. Also, on a cash crop farm, yield goal-based N applications, based on yield map data, would have resulted in over fertilization of N in about 25% of the field where corn yields were greatest and under fertilization on about 15% of the field where corn yields were the least. Apparently, the successful adoption of variable N rate management requires more information than late spring soil NO_3-N concentrations and/or yield map data from previous years. Our current recommendations therefore continues to use field-uniform N rates. Field-scale N rates that were 25 lbs/acre below the Cornell recommended rate generally provided yields equal to those receiving 25 lbs/acre above it, suggesting that Cornell's recommendations are more than adequate. Some justification exists for slightly higher N rates in years with wet springs, as suggested by previous research.

Fig. 1. Soil NO_3-N in 1999, 2000 and 2001at the Onondaga 1(a, b,c) and Onondaga 2(d, e,f) sites.

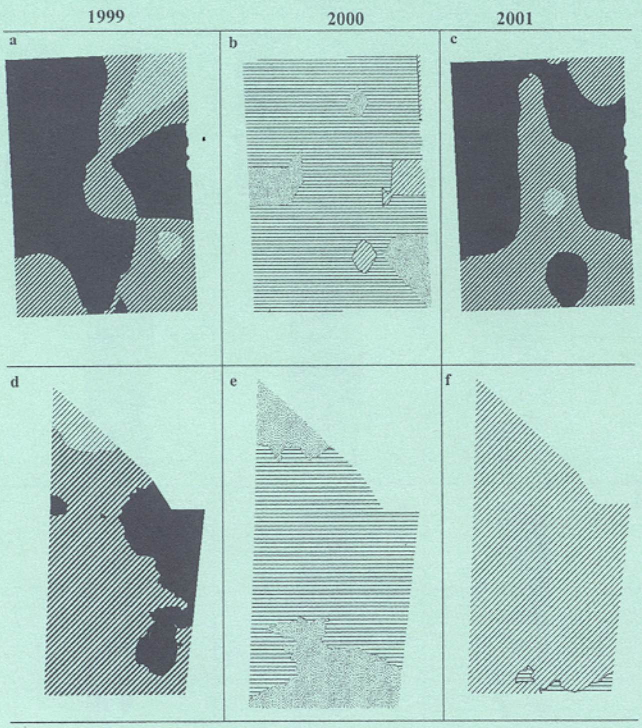

Fig. 2. Soil NO_3-N in 1999, 2000 and 2001at the Seneca 1(a, b,c), Seneca 2 (d, e,f) and Seneca 3 (g, h, i) sites.

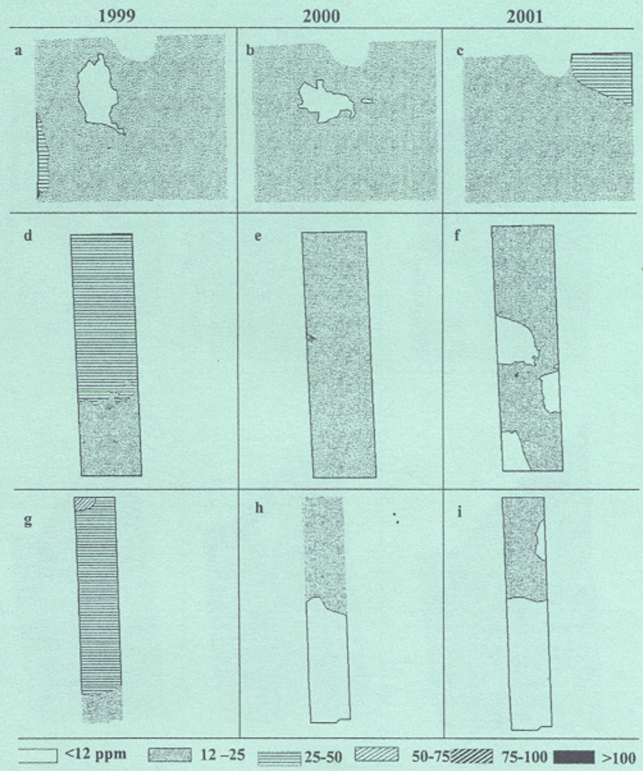

Table 1. Field size and dominant soils of the five sites in central New York, and the starter and sidedress N fertilizer rates for the low (L) and high (H) N levels in 1999, 2000, and 2001.

Site	Size	Soils	Starter N Fertilizer			Sidedress N Fertilizer					
	Acres		1999	2000	2001	1999		2000		2001	
						L	H	L	H	L	H
			------lbs/acre-----			--------------lbs/acre----------------					
Onondaga 1	13.8	Honeoye & Lima	26	24	28	0	0	0	50	0	50
Onondaga 2	24.0	Honeoye & Lima	20	24	28	0	0	0	50	0	50
Seneca 1	18.3	Cazenovia & Darien	49	40	40	50	100	75	125	75	125
Seneca 2	13.8	Schohaie & Ovid	50	30	40	50	100	85	135	75	125
Seneca 3	17.8	Collamer	35	30	35	60	110	85	135	80	130

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Fig. 3. Corn yields in 1999, 2000 and 2001 at the Onondaga 1(a, b,c) and Onondaga 2(d, e,f) sites.

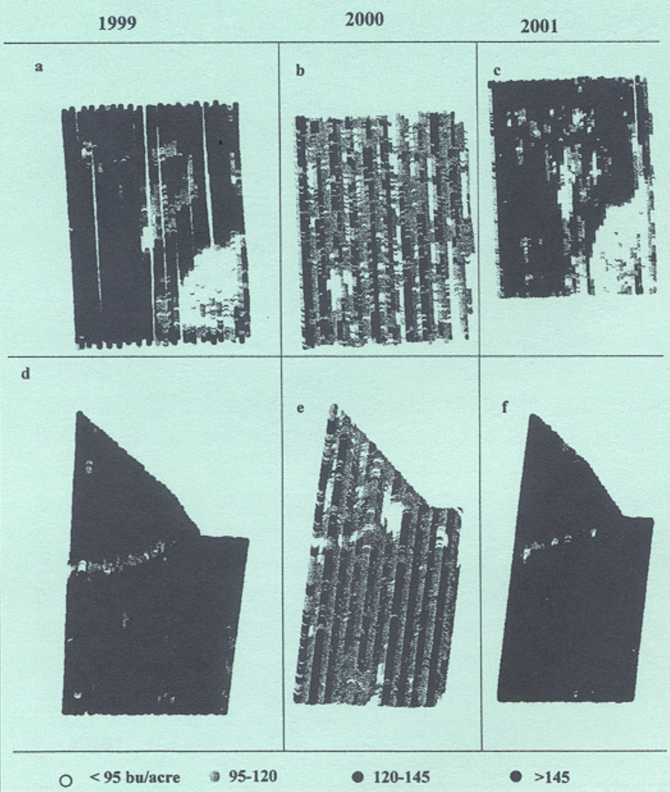

Fig. 4. Corn yields in 1999, 2000 and 2001 at the Seneca 1(a, b,c), Seneca 2 (d, e,f) and Seneca 3 (g, h, i) sites.

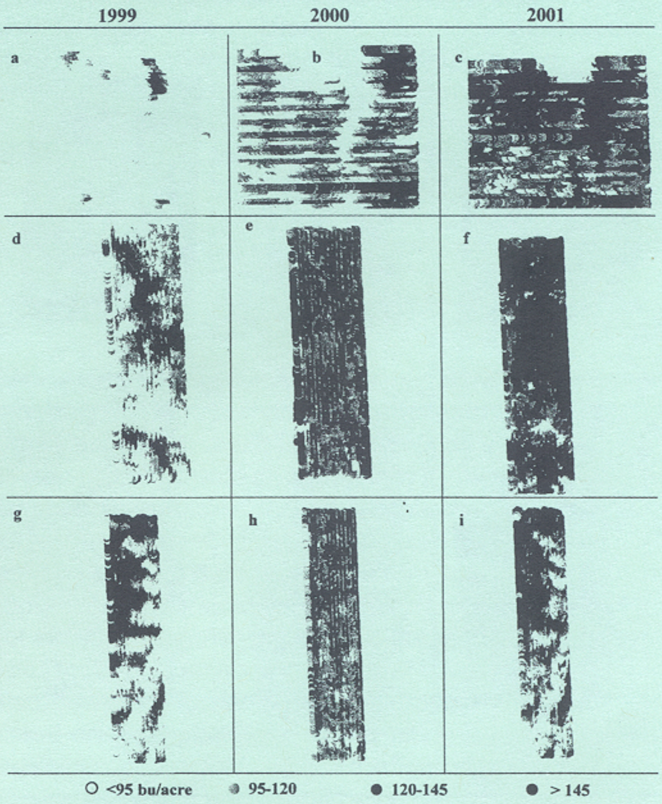

Table 2. Correlations between corn yields at individual stations within sites among the 1999, 2000, and 2001 growing seasons.

	2000					2001				
Year	Onondaga 1	Onondaga 2	Seneca 1	Seneca 2	Seneca 3	Onondaga 1	Onondaga 2	Seneca 1	Seneca 2	Seneca 3
1999	0.54 **	0.10	-0.58 **	0.01	0.51 *	0.88 ***	0.75 ***	0.48 *	0.81 ***	0.96 ***
2000						0.42 *	0.16	-0.09	0.06	0.56 **

*Significant at the 0.05 probability level.
**Significant at the 0.01 probability level.
***Significant at the 0.001 probability level.

Fig. 5. Corn yield differences based on LSD (0.05) interaction Values, in 1999 and 2001 between N rates at Seneca 3 (a= 16 bu/acre LSD, b= 14 bu/acre).

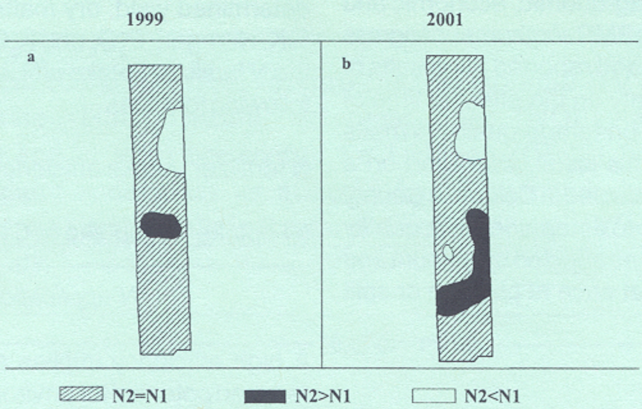

Table 3. Corn grain yield of two hybrids at a high (H) and low (L) N rate at five sites in New York during the 1999, 2000, and 2001 growing seasons.

	ONONDAGA 1			ONONDAGA 2			SENECA 1			SENECA 2			SENECA 3		
Hybrid	H	L	Avg	H	L	Avg	H	L	Avg	H	L	Avg	H	L	Avg
							bu/acre								
							1999								
37M81	-	-	145	-	-	154	60	57	59	94	95	94	100	105	102
3752	-	-	138	-	-	145	56	57	56	97	105	102	107	107	107
Avg	-	-		-	-		57	57		95	100		103	107	
LSD 0.05†							NS			3			NS		
							2000								
37M81	109	116	118	126	121	122	118	92	105	126	127	126	116	113	114
3752	105	97	102	103	100	102	103	89	97	119	116	118	113	111	111
Avg	113	107		114	111		110	91		122	121		114	113	
LSD 0.05	3			NS			5			NS			NS		
							2001								
37M81	134	134	134	162	161	162	119	116	118	135	135	135	116	110	113
3752	118	107	113	156	156	156	127	121	124	142	137	138	116	119	118
Avg	126	121		159	159		124	119		138	137		116	114	
LSD 0.05	5			NS			3			NS			NS		

†Comparison of means between N levels.
NS, nonsignificant at the 0.05 probability level.

Soil Management

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:

$$\text{N fertilizer uptake efficiency (\%)} = \frac{\text{(N uptake} - \text{N uptake at 0 N application)}}{\textit{N application}} * 100$$

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.

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

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	-	-	6020 a	5981 d
100	100/0	86 c	46 b	155 bc	29 a	36 ab	6113 a	9772 c
150	150/0	83 c	46 b	172 ab	15 a	22 b	5978 a	9650 c
150	75/75	113 b	61 a	196 ab	17 a	42 a	5999 a	13428 ab
200	200/0	115 b	50 b	177 ab	26 a	32 ab	5999 a	10874 bc
200	100/100	146 a	70 a	227 a	22 a	48 a	5864 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 ($\alpha = 0.05$).

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.

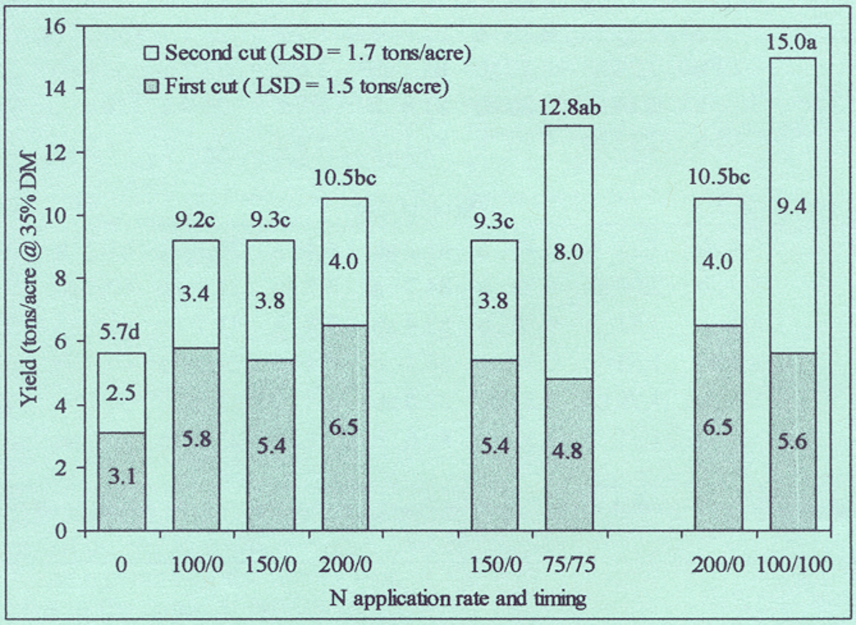

Figure 1: Yield of BMR sorghum sudangrass as affected by N management. Trials were conducted at the Valatie Research Farm in Columbia County, NY (2000 growing season).

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.

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 Total	Method	CP	K	P	IVTD	LIG	NSC	NDF	dNDF	IVNEL
---- 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 ($\alpha = 0.05$).

Calendar of Events

October 2-4	Northeastern Division of American Phytopathological Society, Bromont, Quebec
October 22, 2002	Field Crop Dealer Meeting, Chaucers Rest. & Banquet House, Clifton Park, NY
October 23, 2002	Field Crop Dealer Meeting, Ramada Inn, New Hartford, NY
October 24, 2002	Field Crop Dealer Meeting, Batavia Party House, Batavia, NY
October 25, 2002	Field Crop Dealer Meeting, Holiday Inn, Auburn, NY
November 10-14, 2002	ASA-CSSA-SSSA Annual Meetings, Indianapolis, IN
December 4-6	Certified Crop Advisor Training, Ramada Inn, Ithaca, NY
December 7-9	National Fusarium Head Blight Conference, Erlanger, KY

What's Cropping Up? is a bimonthly newsletter distributed by the Crop and Soil Sciences Department at Cornell University. The purpose of the newsletter is to provide timely information on field crop production and environmental issues as it relates to New York agriculture. Articles are regularly contributed by the following Departments at Cornell University: Crop and Soil Sciences, Plant Breeding, Plant Pathology, and Entomology. **To get on the mailing list, send your name and address to Pam Kline, 234 Emerson Hall, Cornell University, Ithaca, NY 14853.**

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