Northern NY Agricultural Development Program
2015-2016 Project Report

Brachytic Dwarf Brown Midrib Forage Sorghum for Improved Forage Production, Rotation Profitability, and Environmental Stewardship

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Collaborators:

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- Advanced Agricultural Systems: Tom Kilcer
- Participating farmers in Jefferson and St Lawrence counties

Background:

On-farm trials in northern NY and other parts of the state have shown that use of winter cereals as forage double crops in corn silage rotations can add, on average, 1.6 tons dry matter (DM)/acre for cereal rye and 2.2 tons/acre of triticale to the full season yield. However, in extreme weather years double cropping of winter cereals and corn silage can be challenging.

Past studies have evaluated fertility and crop management of summer annuals such as BMR sorghum sudangrass and teff. Both can result in acceptable yields and be successful emergency crops. However, sorghum sudangrass has a high nitrogen (N) demand and harvest can be a challenge due to wetness of the crop. For teff, establishment can be an issue given very small seed size, and yields are often lower than for other summer annuals. Forage sorghum was not considered in the past but more recent genetic improvements (dwarf brachytic varieties) and inclusion of the brown midrib (BMR) gene have resulted in varieties that are now known to perform well under NY growing conditions.

Methods:

In 2016, building on promising data from 2012-2015 trials conducted outside of northern NY, we implemented N-rate and harvest timing studies at three locations in northern NY to evaluate if brachytic dwarf BMR forage sorghum can be a suitable alternative to corn in rotation with winter cereals. Those three trials were added to the existing yield database with results from 2012-2015. Each trial was replicated four times and had five N rates (0, 50, 100, 150, 200 lbs N/acre). Yields were determined when the crop was at the soft-dough stage for all trials.

Results:

The yield data (with harvest at the soft dough stage) from these years show that, when properly managed, BMR forage sorghum can result in yields that reach 7-8 tons of dry matter (DM)/acre (20-23 tons/acre at 35% DM), but yields varied greatly from location to location and year to year (Table 1). The yields of one of the northern NY sites averaged 5.3 tons of DM/acre (15 tons/acre at 35% dry matter). However, for the 2nd and 3rd sites the yield averaged 11 and 8 tons of DM/acre, respectively (32 and 23 tons at 35% dry matter). The lower yielding site in northern NY had issues with stand consistencies (gaps) and early season weed issues (the site was planted with 30 inch row spacing versus 7 ½ or 15 inch row spacing for the other sites). Stand issues occurred at other sites as well.

Table 1. Sorghum yield, dry matter, crude protein, N removal, NDF, TDN and starch as influenced by nitrogen rate for brachytic dwarf brown midrib forage sorghum trials. For northern NY results, see Alexandria, Waddington and Lisbon data for 2016.

Site (Year)	N Rate	Yield (35% DM)	Dry Matter	Dry Matter	Crude Protein	N Removal	NDF	TDN	Starch
	lbs/acre	tons/acre	tons/acre	%	% of DM	lbs/acre	% of DM	% of DM	% of DM
Caldwell	0	9.3 b	3.3 b	29.1 b	5.9 d	61 c	. .	. .	. .
(2012)	50	13.1 a	4.6 a	30.1 ab	6.3 cd	92 b	. .	. .	. .
	100	12.8 a	4.5 a	30.2 ab	6.9 bc	98 ab	. .	. .	. .
	150	15.1 a	5.3 a	30.7 a	7.6 ab	128 a	. .	. .	. .
	200	12.5 ab	4.4 ab	29.7 b	8.2 a	115 a	. .	. .	. .
	P-value	0.0014	0.0015	0.0493	<0.0001	<0.0001	.	.	.
Varna	0	12.2 b	4.3 b	24.9 b	5.4 b	74 c	57.1 a	64.5 b	9.3 b
(2013)	50	20.9 a	7.3 a	28.0 a	5.4 b	125 bc	53.5 ab	66.2 ab	12.7 a
	100	24.0 a	8.4 a	26.9 ab	7.2 ab	193 ab	52.6 b	66.5 a	13.0 a
	150	26.8 a	9.4 a	26.3 ab	7.5 ab	225 a	53.8 ab	65.9 ab	11.4 ab
	200	29.2 a	10.2 a	25.6 b	8.4 a	275 a	51.8 b	66.7 a	12.7 ab
	P-value	0.0004	0.0004	0.0085	0.0021	0.0003	0.0184	0.0098	0.0275
Valatie	0	23.7 a	8.3 a	36.6 a	6.9 b	183 a	51.9 a	69.3 a	22.1 a
(2013)	50	21.3 a	7.4 a	36.8 a	7.7 ab	182 a	50.7 a	69.6 a	22.5 a
	100	27.0 a	9.5 a	36.4 a	8.6 a	259 a	50.0 a	69.8 a	21.8 a
	150	26.1 a	9.1 a	36.4 a	8.8 a	258 a	48.0 a	70.7 a	24.3 a
	200	25.5 a	8.9 a	34.9 a	8.8 a	252 a	49.2 a	70.0 a	22.2 a
	P-value	0.5404	0.5261	0.1283	0.0016	0.0789	0.3459	0.5878	0.5988
Varna	0	8.8 c	3.1 b	28.6 a	5.1 d	50 b	. .	. .	. .
(2014)	50	14.3 b	5.0 a	28.7 a	4.6 d	74 b	. .	. .	. .
	100	18.2 ab	6.4 a	26.1 b	6.4 c	131 a	. .	. .	. .
	150	19.1 ab	6.7 a	25.4 b	7.3 b	157 a	. .	. .	. .
	200	18.5 a	6.5 a	25.1 b	8.1 a	200 a	. .	. .	. .
	P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	.	.	.
Valatie	0	22.9 a	8.0 a	29.1 a	6.2 b	157 b	. .	. .	. .
(2014)	50	26.2 a	9.2 a	29.3 a	6.7 ab	194 ab	. .	. .	. .
	100	22.1 a	7.7 a	29.5 a	6.9 ab	170 ab	. .	. .	. .
	150	26.5 a	9.3 a	29.7 a	8.0 a	239 a	. .	. .	. .
	200	23.7 a	8.3 a	30.5 a	7.7 ab	205 ab	. .	. .	. .
	P-value	0.3235	0.3237	0.0868	0.0173	0.0285	.	.	.
Aurora	0	11.3 c	4.0 c	26.0 a	5.0 a	64 c	. .	. .	. .
(2014)	50	15.6 b	5.5 b	25.3 ab	5.4 a	95 bc	. .	. .	. .
	100	18.0 b	6.3 b	24.7 ab	6.1 a	123 bc	. .	. .	. .
	150	19.2 ab	6.7 ab	23.8 ab	6.9 a	147 ab	. .	. .	. .
	200	22.8 a	8.0 a	23.7 b	7.4 a	188 a	. .	. .	. .
	P-value	<0.0001	<0.0001	0.0338	0.0677	0.0005	.	.	.

Site (Year)	N Rate	Yield (35% DM)		Dry Matter		Dry Matter		Crude Protein		N Removal		NDF		TDN		Starch	
	lbs/acre	tons/acre		tons/acre		%		% of DM		lbs/acre		% of DM		% of DM		% of DM	
Varna (2015)	0	16.5	a	5.8	a	37.2	a	5.5	b	101	b	50.5	a	68.7	b	18.8	b
	50	16.5	a	5.8	a	31.1	a	5.7	b	105	b	48.1	ab	70.1	ab	22.9	ab
	100	16.7	a	5.8	a	29.5	a	7.2	ab	131	ab	47.5	ab	70.2	ab	21.9	ab
	150	17.6	a	6.1	a	31.0	a	8.2	a	164	ab	46.9	ab	70.5	a	21.6	ab
	200	20.3	a	7.1	a	29.1	a	8.9	a	202	a	45.8	b	70.8	a	24.2	a
	P-value	0.7361		0.7361		0.1573		0.0005		0.0069		0.0199		0.0207		0.0272	
Aurora* (2015)	0	10.5	c	3.7	c	29.5	a	5.8	e	68	c	54.6	a	67.4	c	10.1	b
	50	16.8	bc	5.9	bc	31.0	a	5.7	e	108	c	50.2	b	68.6	b	14.4	ab
	100	21.6	abc	7.6	abc	31.0	a	7.1	d	171	bc	47.5	c	69.9	a	15.6	a
	150	21.9	abc	7.7	abc	29.8	a	8.0	c	195	abc	47.0	c	70.4	a	16.0	a
	200	33.5	a	11.7	a	37.1	a	8.5	bc	317	a	46.2	c	70.7	a	18.4	a
	250	26.4	ab	9.2	a	28.6	a	9.0	ab	265	ab	46.0	c	70.9	a	16.6	a
	300	27.0	ab	9.4	a	28.2	a	9.3	a	280	ab	47.2	c	70.3	a	15.6	a
	P-value	0.0017		0.0017		0.4798		< 0.0001		< 0.0001		< 0.0001		< 0.0001		0.0007	
Aurora* (2016)	0	14.7	b	5.2	b	31.6	a	6.3	c	103	c	47.6	a	70.0	b	20.0	a
	50	20.7	a	7.2	ab	31.5	a	7.9	b	185	bc	45.4	a	71.4	a	23.7	a
	100	20.2	a	7.1	ab	29.8	a	8.8	ab	198	ab	46.1	a	71.1	ab	22.7	a
	150	21.1	a	7.4	ab	29.3	a	9.4	a	223	ab	45.0	a	71.4	a	22.4	a
	200	21.4	a	7.5	ab	30.2	a	9.5	a	227	ab	44.8	a	71.8	a	23.1	a
	250	21.2	a	7.4	ab	29.3	a	9.7	a	229	ab	44.6	a	71.6	a	23.5	a
	300	24.7	a	8.7	a	29.7	a	10.1	a	277	a	44.4	a	71.7	a	23.9	a
	P-value	0.0136		0.0136		0.0639		< 0.0001		< 0.0001		0.0665		0.0044		0.1759	
Alexandria (2016)	0	15.2	a	5.3	a	32.3	a	10.1	a	171	a	43.1	a	70.4	a	22.3	a
	50	14.1	a	4.9	a	32.7	a	10.8	a	170	a	42.7	a	70.5	a	21.7	a
	100	15.3	a	5.4	a	32.7	a	10.6	a	182	a	42.3	a	70.5	a	23.2	a
	150	15.6	a	5.5	a	31.6	a	10.5	a	183	a	43.4	a	70.2	a	21.6	a
	200	15.8	a	5.5	a	31.9	a	10.5	a	185	a	42.4	a	70.6	a	22.2	a
	P-value	0.7285		0.7285		0.6543		0.102		0.7523		0.9459		0.9755		0.971	
Waddington (2016)	0	30.4	a	10.6	a	27.6	a	8.5	a	291	a	44.3	a	71.1	a	22.7	a
	50	30.6	a	10.7	a	26.4	a	9.0	a	307	a	44.8	a	70.9	a	22.3	a
	100	35.5	a	12.4	a	26.5	a	9.0	a	358	a	44.2	a	71.2	a	21.6	a
	150	33.8	a	11.8	a	25.7	a	9.0	a	340	a	45.8	a	70.7	a	20.3	a
	200	32.1	a	11.2	a	26.9	a	9.1	a	326	a	44.3	a	71.2	a	22.9	a
	P-value	0.7024		0.7024		0.6737		0.1197		0.4899		0.9457		0.9722		0.8968	
Lisbon (2016)	0	17.7	b	6.2	b	26.4	a	6.4	b	128	b	51.0	a	69.1	b	14.3	b
	50	22.3	ab	7.8	ab	27.3	a	7.6	ab	191	bc	45.9	b	70.9	a	21.1	a
	100	-	-	-	-	25.6	a	8.2	a	178	bc	48.2	ab	70.1	ab	16.0	ab
	150	28.4	a	9.9	a	25.5	a	8.9	a	281	a	45.4	b	70.9	a	19.1	ab
	200	28.1	a	9.8	a	25.7	a	8.6	a	271	ac	46.6	b	70.3	ab	17.3	ab
	P-value	0.0067		0.0118		0.0931		0.0004		0.0006		0.0071		0.0073		0.0297	
Combined Responsive Sites**	0	12.3	d	4.3	d	27.7	a	5.6	d	89	d	53.5	a	67.1	b	11.5	b
	50	17.9	c	6.3	c	28.5	a	6.1	d	123	cd	49.7	b	68.7	a	16.2	a
	100	19.8	bc	6.9	bc	27.4	a	7.2	c	155	bc	49.6	b	68.8	a	14.9	a
	150	22.0	ab	7.7	ab	26.9	a	7.9	b	190	ab	48.8	b	69.0	a	15.3	a
	200	24.0	a	8.4	a	27.8	a	8.3	ab	219	a	48.3	b	69.3	a	16.0	a
	250	21.7	abc	7.6	abc	25.7	a	8.8	ab	265	a	47.7	b	69.5	a	16.3	a
	300	23.7	ab	8.3	ab	25.7	a	9.1	a	280	a	48.3	b	69.3	a	15.9	a
	P-value	< 0.0001		< 0.0001		0.1461		< 0.0001		< 0.0001		< 0.0001		< 0.0001		< 0.0001	

*Two additional N rates were added to reach a yield plateau.
**All sites except Valatie, Varna in 2015, Aurora in 2016, and Waddington were responsive.

The optimum economic N rates (MERNs) varied greatly (from zero to more than 200 lbs N/acre; Table 1). For two of the three northern NY sites, the MERN was zero. This included the site that yielded 11 tons of DM/acre, a site with a manure history.

The crude protein levels ranged from a low of 5.5% of DM for one of the central NY sites to 10% of DM for the Aurora and one of the northern NY sites in 2016. The crude protein values for the three northern NY sites ranged from 8.5 to 10.0% DM (Table 2).

The contrasts in MERN, crude protein, and yield levels reflect in part field management (row spacing, weed control), but also field histories (manure management) and suggest that forage sorghum can yield very well with minimal inputs on manured sites. Additional sites are needed to develop a recommendation system.

Table 2. Sorghum most economic rates of N (MERN), yield at the MERN, and crude protein at the MERN, for brachytic dwarf brown midrib forage sorghum trials.

Location	Year		MERN	Yield at MERN*	Crude protein at MERN
			lbs N/acre	tons DM/acre	% of DM
Caldwell	2012	Central NY	101	5.1	7.0
Varna	2013	Central NY	> 200	9.9	8.4
Valatie	2013	Eastern NY	0	8.3	6.9
Varna	2014	Central NY	140	6.7	7.0
Aurora	2014	Central NY	> 200	6.7	7.4
Valatie	2014	Eastern NY	0	8.0	.
Varna	2015	Central NY	0	5.8	5.5
Aurora	2015	Central NY	215	9.8	8.5
Aurora	2016	Central NY	> 300	10.1	10.0
Alexandria	2016	Northern NY	0	5.3	10.0
Waddington	2016	Northern NY	0	10.6	8.5
Lisbon	2016	Northern NY	158	9.9	8.6

*For sites with MERNs > 200, yield at MERN is the yield at the highest applied rate of N

A 2015 assessment of impact of timing of harvest on yield and quality is summarized in Figure 1. This figure shows little change in yield or forage quality in the last three weeks before soft dough, although the forage is slightly drier at soft-dough than at flowering (2-3% moisture difference). On average, there was about a month (30 ± 4 day) difference in time between flowering and soft dough stage. At the northern NY sites, flowering occurred between 8/30 and 9/6 versus 8/23 for the Aurora site that year. Flowering dates can vary among years. For example, in 2015, when plots were planted early July (late), flowering occurred September 17-18 in Varna and Aurora.

If harvest can be reliably done by early September (with no loss of yield or quality), this would enable earlier establishment of a winter cereal as double crop in dairy rotations. Waiting until soft-dough will delay planting of winter forages until October. However, the moisture content is rather high at flowering and this will need to be evaluated (work currently ongoing). Another year of research is needed to come to final conclusions.

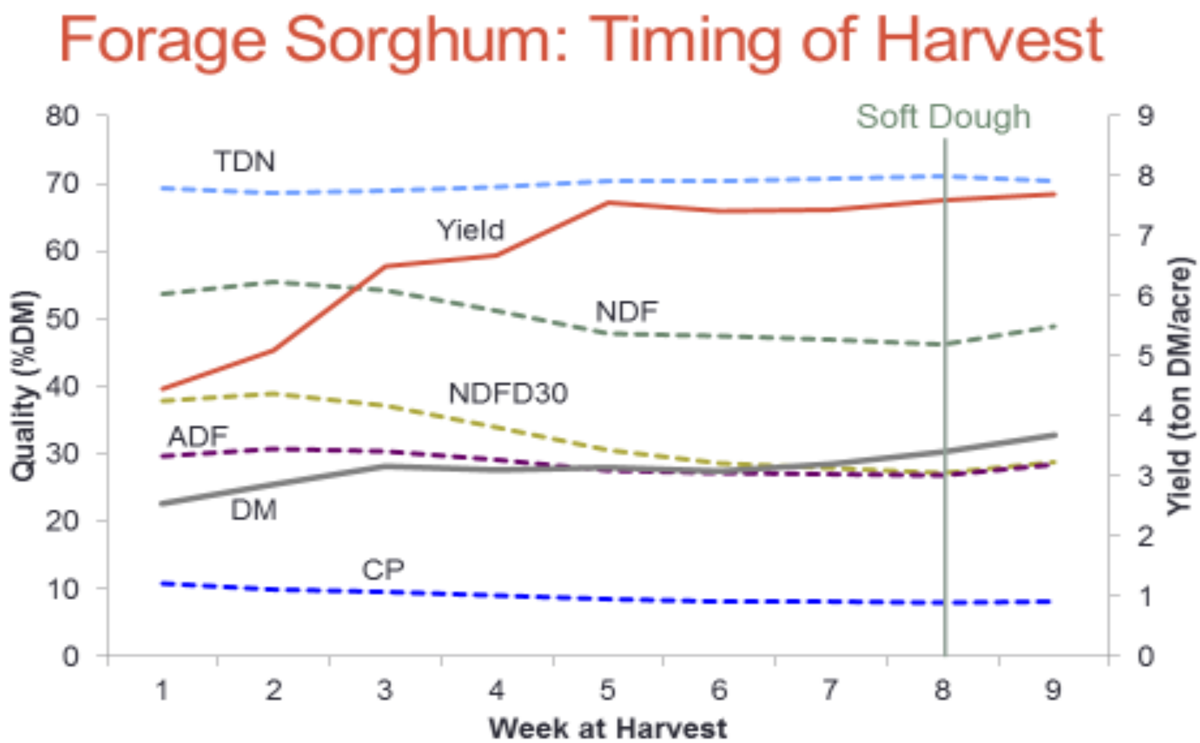

Figure 1: Impact of timing of harvest of forage sorghum on forage quality and yield for brachytic dwarf brown midrib forage sorghum trials.

Conclusions/Outcomes/Impacts:

Forage sorghum is a viable option for dairy forage rotations and can have competitive yields and high nutritive quality if managed properly.

MERNs range from 0 to more than 200 lbs of N/acre, likely due to soil fertility and past manure applications. Two sites in NNY in 2016 did not require additional N to reach optimal yields or protein levels.

For all sites, $NDFD_{30}$, NDF, ADF, and CP decreased over time, while starch and DM increased over time. Although harvesting forage sorghum early, or before the soft dough stage, would be ideal in terms of planting a double crop earlier, some yield, DM, and starch could be compromised.

These trials demonstrate that management of fertility and timing of planting and harvest are both essential for successful production of forage sorghum.

Outreach:

A new factsheet was added to the Agronomy Factsheet Series, summarizing current best management practices for growing brachytic dwarf BMR forage sorghum: http://nmsp.cals.cornell.edu/publications/factsheets/factsheet92.pdf. Results were presented at the Ag-In Service meetings at Cornell University, the Big Flats Cover Crop and Soil Health workshop, Certified Crop Advisor training, and the Cornell Nutrition conference. Extension articles will be written and the project was featured at the 2017 Crop Congress in Canton and at Miner Institute, Chazy, NY.

Next Steps:

We propose to follow up on the 2016 growing season by conducting two corn versus forage sorghum trials as was done at the Aurora Research Farm in 2016, directly comparing yields of corn and forage sorghum in a randomized complete block design with four replications (8 plots per trial) in trials in Jefferson County and at Miner Institute in Clinton County. We also propose to conduct three additional on-farm N rate studies, similar to the trials conducted in 2016 (but without the timing of harvest aspect), to expand the database to six on-farm N rate studies in northern New York, to be added to the statewide database, to ensure northern New York soils and growing conditions are represented as we develop additional guidelines for management of forage sorghum in double crop rotations.

Acknowledgments:

In addition to NNYADP funding, we received funding from NESARE, NYFVI and Federal Formula Funding that allowed us conduct trials in central and eastern New York as well and build on the database of field trials.

Reports/articles in which the results of this project have already been published:

Project website (includes protocols)

1. http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/ForageSorghum.html.
2. http://nmsp.cals.cornell.edu/publications/factsheets/factsheet92.pdf

For More Information:

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