Northern NY Agricultural Development Program
2017 Final Report

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

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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 2017, we implemented two N-rate studies (one on a clay soil and one on a sandy soil) and a corn versus sorghum comparison in Northern NY. This was in addition to two N rate plus timing of harvest studies and a corn versus sorghum comparison in Central NY. Each N rate 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 soft-dough. Unfortunately, a failed planting of the corn versus sorghum comparison at the Miner Institute made it impossible to obtain good data for that trial.

Results:

Yields ranged from a low of 3.8 tons DM/acre to a high of 12.4 tons DM/acre (Table 1), depending on location and N management. The yield at the most economic rate of N (MERN) for the five northern NY sites were 6.3, 10.6, and 9.9 tons DM/acre (18, 30, and 28 tons/acre at 35% dry matter) in 2016 and 6.8 and 9.6 tons of DM/acre (19 and 27 tons/acre at 35% dry matter) in 2017 (Table 2).

The lower yielding site in 2016, despite good soil fertility, was planted in 30-inch rows (not the recommended 15 inches) and had weed issues that may have impacted performance. The lower yielding site in 2017 was on a clay soil and likely reflected the very wet spring and summer; sorghum thrives better in dry and warm conditions, as occurred in 2016.

The higher yielding site in 2017 was on a sandy soil that would have been better drained in wet conditions. None of the sites were deficient in phosphorus (P). However, the Valatie site in 2013 and the sandy site at Willsboro in 2017 were low in potassium (K), which could have impacted yields and N response for those sites.

The MERNs across all sites varied from zero to more than 300 lbs N/acre (Table 2).

There were two northern NY sites with a MERN of 0, two with MERNs greater than 200 lbs N/acre, and one with a MERN of 158 lbs N/acre.

The northern NY site with a MERN of 0 which yielded 10.6 tons of DM/acre (31 tons/acre at 35% DM) was a site with a manure history, which could explain the high yield and lack of need for additional N. Crude protein levels at the MERN across all sites ranged from a low of 5.5% of DM for one of the central NY sites in 2015 to 10% for the Aurora and one of the northern NY sites in 2016. The crude protein values for the five northern NY sites ranged from 7.0 to 10.0%.

Table 1. Sorghum yield, dry matter, crude protein, N removal, NDF, TDN and starch as influenced by nitrogen rate for five brachytic dwarf brown midrib forage sorghum trials in northern NY, 2016-2017.

Site (Year)	N Rate	Yield (35% DM)	Yield (100% DM)	Dry Matter Content	Crude Protein	N Removal	NDF	TDN	Starch
	lbs/acre	tons/acre	tons/acre	%	% of DM	lbs N/acre	% of DM	% of DM	% of DM
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
Willsboro I (2017;clay)	0	10.8 B	3.8 A	27.2 a	5.8 a	70 b	57.7 a	64.5 a	7.5 a
	50	13.0 Ab	4.6 Ab	27.7 a	5.7 a	84 ab	54.2 a	65.0 a	9.9 a
	100	16.5 Ab	5.8 Ab	28.2 a	6.1 a	117 ab	52.0 b	65.5 a	10.5 a
	150	17.7 A	6.2 A	27.8 a	6.0 a	120 ab	51.4 b	65.7 a	10.5 a
	200	19.3 A	6.8 A	26.2 a	7.0 a	153 a	50.8 b	65.8 a	11.0 a
	P-value	0.0137	0.0137	0.2687	0.2361	0.0264	0.0093	0.2894	0.0517
Willsboro II (2017;sand)	0	12.3 D	4.3 D	24.8 b	6.0 b	82 c	59.9 a	65.4 a	7.3 b
	50	14.6 Cd	5.1 Cd	26.0 ab	6.8 ab	112 bc	53.6 b	67.0 a	10.9 ab
	100	20.2 B	7.1 B	26.6 a	6.8 ab	153 b	53.4 b	67.3 a	10.3 ab
	150	19.2 Bc	6.7 Bc	24.9 b	7.8 ab	168 b	52.3 b	67.6 a	11.7 a
	200	27.4 A	9.6 A	26.7 a	8.4 a	257 a	52.7 b	67.7 a	13.7 a
	P-value	< 0.0001	< 0.0001	0.007	0.044	< 0.0001	0.0021	0.0416	0.004

Different letters indicate statistical differences between treatments. Alexandria and Waddington were non-responsive. The Lisbon and Willsboro trials were responsive to N. The Willsboro trials are on a clay soil (I) and a sandy soil (II)

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. The Northern New York trials are highlighted in gray.

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
Varna	2017	Central NY	134	9.3	8.0
Aurora	2017	Central NY	234	8.3	7.5
Willsboro I	2017	Northern NY	> 200	6.8	7.0
Willsboro II	2017	Northern NY	> 200	9.6	8.4

*For sites with MERNs > 200, yield at MERN is the average yield at the highest applied rate of N. For sites with MERNs = 0, yield at the MERN is the average yield across all N rates.

The contrasts in the most economic rates of N (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 when manure has been applied. This will need to be taken into account when an N recommendation system is developed.

A summary of the impact of timing of harvest on yield and quality is summarized in Figure 1. This figure shows that yield continues to increase with maturity. However, the 2015 data showed little change in yield or forage quality in the last three weeks before soft-dough, and the 2017 data suggests that yield levels off after the milk stage, so the impact of maturity on yield is year-dependent. On average, there was about a month (30 ± 4 day) difference in time between flowering and soft-dough.

The NDF and NDF digestibility ($NDFD_{30}$) decreased after the flowering stage; CP decreased steadily with maturity; and starch, TDN, NFC, and DM increased with maturity. In 2015, when plots were planted early July (late), flowering occurred 9/17-18 in Varna and Aurora. At the Northern NY sites in 2016, flowering occurred between 8/30 and 9/6 versus 8/23 for the Aurora site that year. In 2017, the Central NY trials had increased yield up to the milk stage, which occurred on 9/19 and 9/26 for the Varna and Aurora sites, respectively.

If harvest can be reliably done by early to mid-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 the flowering and milk stages.

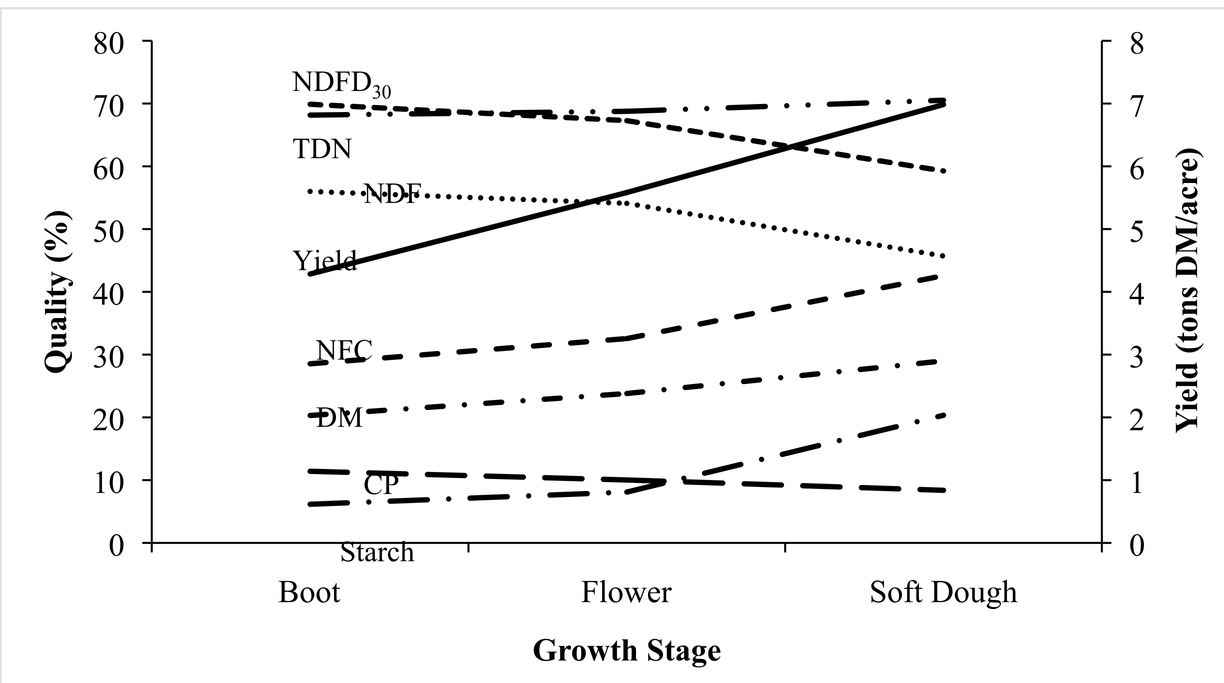

Figure 1: Impact of timing of harvest of forage sorghum on forage quality and yield for brachytic dwarf brown midrib forage sorghum trials from 2015-2017.

Unfortunately, the corn versus sorghum trial planted at the Miner Institute in Chazy in 2017 did not result in a regular stand for either of the crops so the only comparisons we have are two trials conducted in Central NY. These two Central NY corn silage vs. sorghum trials had very different results.

In 2016, the sorghum out-performed the corn in yield (6.9 tons sorghum DM/acre and 5.6 tons corn DM/acre) likely resulting from both the drought and weed issues in the corn stand. In 2017, the corn performed better than the sorghum (6.7 tons corn DM/acre and 5.8 tons sorghum DM/acre). These trials suggest that sorghum may be a better option in very dry years while corn is more likely the better option in normal to wet years, but additional trials need to be conducted in multiple locations.

Conclusions/Outcomes/Impacts:

Forage sorghum can have competitive yields and high nutritive quality if managed properly. Sorghum might be more competitive with corn in dry and warm summers than in extremely wet conditions but further research is needed to test this hypothesis.

The MERNs for sorghum ranged from 0 to more than 300 lbs of N/acre, likely reflecting differences in soil fertility and past manure applications.

For all sites (2015-2017), $NDFD_{30}$, NDF, and CP decreased over time, while starch, TDN 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, early harvest can result in a yield cut, higher moisture content of the forage, and lower starch levels. Management of fertility, timing of planting, and timing of harvest are important for successful production of forage sorghum.

Outreach:

This project was featured at the 2017 Crop Congresses in Canton and at Miner Institute, Chazy, NY, in February of 2017, in addition to presentations on the research at the Musgrave Research Farm Field Day in July of 2017. Two impact statements and an Agronomy Factsheet were shared (http://nmsp.cals.cornell.edu/publications/impactstatements/SorghumMikeHunter2017.pdf; http://nmsp.cals.cornell.edu/publications/factsheets/factsheet92.pdf) at these meetings and made available through our project websites as well (see below).

Next Steps:

The results so far will be combined to create N guidelines for forage sorghum. We are working on an additional factsheet on tradeoffs between yield and quality and timing of harvest. We also have a project ongoing to evaluate forage sorghum and a winter cereals in a rotation with N rates and timing of harvest of the sorghum as the main treatments that are evaluated. This type of work is more intense (hence mainly feasible to conduct at research stations) but it is needed to evaluate the new rotation in terms of benefits and tradeoffs as it is clear from the work over the past years that tradeoffs exist.

Acknowledgments:

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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
3. http://nmsp.cals.cornell.edu/publications/impactstatements/SorghumMikeHunter2017.pdf
4. http://nmsp.cals.cornell.edu/publications/impactstatements/SorghumKittyOneil2017.pdf

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