Profitable forage systems: Is double cropping BMR sorghum followed by a winter grain a viable cropping system alternative in the Northeast?

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Summary

The objective of this study was to observe and measure the performance of forage sorghum in a farm production scheme on typical soils found in our region and evaluate whether this cropping combination would be cost effective with consistent performance, adequate yield and feed quality. Case studies were used to document the practices and performance of forage sorghum on 4 farms in the South Central region of NY State. Three farms used conventional practices and one was certified organic. The study's sorghum yields were much lower than expected, averaging 5.1 tons/ac, while ranging from 2.2 -11.8 tons/ac @ 35% drymatter. Comparatively, nearby corn fields averaged 8.2 T/ac @ 35% drymatter. Forage quality was satisfactory. The growing season offered many challenges. Even though we selected a short season variety, it was still on the edge for our region, especially considering the cool, wet growing season.

Introduction

Adequate production of high quality forage is paramount in dairy and livestock production for farm profitability and sustainability. This study sought to gain experience with a crop that could potentially yield well at a reasonable cost of production. Viable alternative crops are needed for expanding options on less than optimal ground. At least half of the Southern Tier soils in NY State are characterized by low pH, poor drainage, steep and/or HEL (Highly Erodible Land) rated fields. As such, we wanted to gain experience with a crop or cropping system that showed promise for competitive performance under such conditions.

The crop chosen for this study was sorghum, a crop that has not traditionally been grown in the Northeast. According to the literature, sorghum appears to be a reasonable substitute for corn silage. The National

Sorghum Producers describe sorghum as “among the most efficient crops in conversion of solar energy and use of water” and that it has “inherent tolerance to marginal lands and environmental conditions” [1] It offers similar yields, at a lower cost and an equally efficient harvest, as a single chop system that can substitute for corn silage in livestock diets with nearly the same nutritional quality. Another aspect of the study investigated how well sorghum would fit in a double cropping system with a fall grain harvested for early spring forage.
[1] Sorghum 101. National Sorghum Producers. http://www.sorghumgrowers.com/sorghum%20101.html

Objectives/Performance Targets

The primary objective for this study was to determine if sorghum would yield well at a reasonable cost of production and serve as a viable crop option on less than optimal ground. To optimize production we planned for a double crop system: forage sorghum followed by a winter small grain. After the sorghum harvest, a winter small grain would be planted which could be harvested as forage the following spring to optimize production. Yields and forage quality would provide the main metrics for evaluating the crop’s performance. Understanding the necessary management to overcome some of these challenges with sorghum was the main interest for getting it out on farms to monitor its performance.

Materials and Methods

Four case studies documented the agronomic practices and performance of forage sorghum on four farms in the south central region of NY State. Three of the sites were managed conventionally and one site organically. Two sorghum varieties available from Alta seeds were selected for the study; AF7101 and AF7201. Seed catalog descriptions highlight that both have the BMR-6 gene giving high fiber digestibility, dry stalk for quick dry down and are good options for double cropping. AF7101 is rated for an 82-85 day maturity and AF7201 is rated for 90-95 day maturity. Nearby corn field yields were measured at harvest for a causal comparison with the sorghum on three of the farms. The Dawson corn variety was Pioneer 8906 (84 day maturity). Birdsall planted Dekalb EB90RR2, (90 day blend) and Tuning planted Doeblers UT24 (85 day maturity).
The Dawson site, managed conventionally, is located in the town of Homer, Cortland County. The 5.3 ac field’s soil type is a Chippewa channery silt loam, a poorly drained soil, and Mardin channery silt loam, a moderately well drained soil. “The Chippewa series consists of strongly acid, medium-textured soils that are poorly drained and have a fragipan that begins at depths between 8 and 12 inches. Surface water accumulates in the depressions. The fragipan restricts drainage.”[1]
Forage sorghum was planted June 5, 2013 with a conservation drill on 28 inch rows. Sorghum variety AF7201, treated with concep™, was planted at 10 lb/ac. To prepare for planting the field was disked three times and rolled. Two hundred pounds of 19-19-19 fertilizer was broadcast with 190 lbs of urea and disked in before planting. For weed control 1 qt/Ac of atrazine and oil and 4 oz/ac of Yukon herbicides were applied on July 12. The soil pH was 5.9 with low phosphorus and medium potassium levels. The previous crop was corn silage.
The Birdsall site, managed conventionally, is located in the town of Scott, Cortland County. The 4.3 ac field is comprised of Bath channery silt loam, a well-drained soil. “The Bath series consist of strongly acid, medium textured soils that are well drained. The soils have a hard, compact fragipan that generally begins at depths between 20 and 30 inches. The fragipan, however, is deep enough, so that drainage is not adversely affected. These soil have formed from glacial till. The soils occur on rolling areas of the uplands.”[2]

Sorghum AF7201, treated with concep™ was planted on June 5 with a no-till drill on 7" rows. The previous crop was corn silage. One hundred lbs of 19-19-19 fertilizer was broadcast and disked in before planting. Additional nitrogen sidedress was planned but was not applied because weather conditions did not permit. The herbicides; atrazine and oil at 1 qt/ac and 4 oz/ac of Banvel were applied for weed control on July 12, 2013. The soil pH was 5.8 with high phosphorus and potassium levels.

The Tuning site, located in Cincinnatus, Cortland County, was managed organically. The 3 ac field is comprised of poorly drained, Volusia channery silt loam soil. "The Volusia series consist of strongly acid, medium-textured soils that are somewhat poorly drained. The soils have a hard, dense, firm fragipan at depths of 8-14 inches. They have formed from firm, medium-textured, glacial till that was moderately acid to slightly acid. These soils occupy gently sloping to sloping areas in the uplands. They often receive runoff water from the water on the surface and the presence of a slowly permeable fragipan causes the soils to have restricted drainage."[3]

Prior to planting, the grass sod was moldboard plowed and disked 2 times to prepare the seedbed. Untreated sorghum seed, variety AF7201 was planted on June 25, 2013 at 15 lbs/ac. The sorghum was drilled on 30" rows to allow for mechanical weed control. An estimated 5 tons/ac of dairy cow manure was spread on the field to augment fertility. The field was tine weeded shortly after planting and cultivated 10 days later. The soil pH was 5.4 with low phosphorus and high potassium levels.

The Stow site is located in the Town of Breesport, Chemung County and managed conventionally. The 20 ac field is comprised of a Chenango channery silt loam. "The Chenango series consists of deep, well-drained and somewhat excessively drained, medium-textured soils. These soils developed in channery and gravelly materials on old alluvial fans. They are nearly level to gently sloping. In a typical profile in a cultivated area, the plow layer is very dark grayish-brown channery sil loam about 8 inches thick. The subsoil extends to a depth of about 28 inches. The water table is controlled by the general level of ground water in the valleys. It is normally at a depth of more than 4 feet. The rooting depth of plants is not restricted; however, most roots are in the topmost 3 feet of soil." [4]

The prior year crop was forage sorghum. The field was moldboard plowed and disked. Sorghum variety AF7101, treated with concep™, was planted at 100,080 seeds/ac with an International Harvester 900 air planter. One hundred lbs per acre of urea was applied pre-plant and 300 lbs/ac of 10-20-20 at planting. The herbicides; Prowl at 3.6 pt/ac and atrazine at 1 qt/ac acre were applied early post-emergence for weed control. See Table 1 - Summary of the sites and cultural practices

All of the farms used custom operators to harvest. The Dawson and Birdsall fields were harvested with a Claas Jaguar 850 self-propelled chopper with a 15 ft rotary style kemper head. Tuning used a pull behind 2 row New Holland corn chopper and Stow used a John Deer 8400 self-propelled chopper with a kemper head. Prior to harvest, all of the fields suffered from lodging but the severity varied from field to field. Lodging at the Dawson field was notably severe. An estimated 1/3 of the crop was left in the field because the harvester was unable to pick up lodged stalks and feed them through the rotary chopper head. Birdsall estimated 30% lodging across his field. Farmer Stow observed that the kemper head was not able to cleanly cut the sorghum and resulted in an estimated field loss of 20% not related to lodging.

The Dawson and Tuning field yields were calculated by weighing trucks or wagons using portable trooper scales and measuring the area harvested. A forage box with a built in scale was used at the Birdsall site. At the Stow site, the capacity of the storage units were estimated based on industry standards and the yield back calculated.

Forage samples were taken at harvest and sent to the Dairy One Forage Lab for quality analysis.

Post-harvest establishment of a cover crop was intended as a component of the cropping system. An early spring forage harvest would contribute to total crop yield. Unfortunately wet soils and late harvest were factors that prevented 3 of the 4 sites from establishing the triticale cover crop. At the Birdsall site, triticale was no-till drilled on October 1, 2013 seeded at 100 lb/ac and harvested for grain August 12, 2014.

[1] From the chapter “Chippewa series” in *Soil Survey-CORTLAND COUNTY, NEW YORK-Series 1957, No. 10* , UNITED STATES DEPARTMENT OF AGRICULTURE Soil Conservation Service In Cooperation with CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION, May 1961, U.S. Government Printing Office, Washington 25, D.C.

[2] From the chapter “Bath series” in *Soil Survey-CORTLAND COUNTY, NEW YORK-Series 1957, No. 10*, UNITED STATES DEPARTMENT OF AGRICULTURE Soil Conservation Service In Cooperation with CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION, May 1961, U.S. Government Printing Office, Washington 25, D.C.

[3] From the chapter “Volusia series” in *Soil Survey-CORTLAND COUNTY, NEW YORK-Series 1957, No. 10*, UNITED STATES DEPARTMENT OF AGRICULTURE Soil Conservation Service In Cooperation with CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION, May 1961, U.S. Government Printing Office, Washington 25, D.C.

[4] From the chapter “Descriptions of the soils, Chenango series” in *Soil Survey of Chemung County, New York,* UNITED STATES DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE in cooperation with Cornell University Agricultural Experiment Station, September 1973, U.S. Government Printing Office: 1973, Washington, D.C.

Results and Discussion/Milestones

Harvest began with the Dawson site on September 17, 2013. The field was too wet to direct chop into trucks so a dump wagon had to be used. The custom harvester commented that it did not bode well to begin the harvest season using a dump wagon since it indicated a long, tedious harvest ahead.

The upper half of the Dawson field had a thin stand from poor establishment while the lower half was consistent. Unfortunately it lodged heavily (approximately 60-80% of the total field) by harvest. The field yielded 2.2 tons/ac sorghum at harvest. On October 5, 2013 the Tuning site yielded 2.7 tons/ac and Birdsall 3.7 tons/Ac. The Stow site was harvested October 30 and yielded 11.8 tons/ac. (All yields are adjusted to 35% drymatter.) Yields were measured from nearby cornfields for comparison for all but the Stow site. Tables 2 and 3 summarize sorghum and corn silage harvest. The forage analyses are summarized in Table 4.

Table 2. Sorghum Harvest Summary

Site	Harvest Date	Harvested Area (ac)	Drymatter at Harvest (%)	Equivalent Yield: T/Ac @ 35% Dry matter	Comments
Tuning	10/5/2013	1.5	21.2	2.7	Some lodging
Birdsall	10/5/2013	4.5	22.0	3.7	Moderate lodging
Dawson	9/17/2013	3.7	21.1	2.2	Severe lodging
Stow	10/30/2013	20	32.8	11.8	Localized lodging

Table 3. Corn Harvest Summary

Site	Silage Variety	Harvest Date	Harvested Area (ac)	Dry-matter at Harvest (%)	Equivalent Yield: T/Ac @ 35% Dry matter
Tuning	Doeblers UT 242 (85 day)	10/5/2013	.74	32	7.1
Birdsall	Dekalb EB90RR2 (90 day blend)	10/5/2013	.20	39	11.0
Dawson	Pioneer 8906 RR (84 day)	9/17/2013	1.5	36	6.6

The fall planted triticale stand at the Birdsall site was moderate. It yielded 42 bu /ac when it was combined on August 12, 2014. The farm did not need additional forage so they chose to harvest the triticale as grain. The straw was used for bedding on the farm.

Table 4. Forage Analysis Results

	FORAGE SORGHUM (Actual)				**Generalized Corn Silage**
Components	Stow-7101	Birdsall-7201	Tuning -7201	Dawson -7201	
	Dry Matter Basis	**Dry Matter Basis**	**Dry Matter Basis**	**Dry Matter Basis**	**Dry Matter Basis**
% Moisture	67.20	76.10	78.80	78.90	68.1
% Dry Matter	32.80	23.90	21.20	21.10	31.9
% Crude Protein	6.00	7.10	9.30	11.40	2.3
% Available Protein	5.70	6.70	8.70	10.50	2.0
% ADICP	0.30	0.40	0.50	0.80	0.7
% Adjusted Crude Protein	6.00	7.10	9.30	11.40	7.1
Soluble Protein % CP	36.00	59.00	37.00	45.00	41
Degradable Protein % CP	76.00	78.00	72.00	78.00	76
% NDICP	1.80	1.50	2.10	2.10	0.9
% Acid Detergent Fiber	33.00	36.10	36.20	38.00	22.9
% Neutral Detergent Fiber	53.30	57.70	60.00	64.10	47.9
% Lignin	2.20	4.30	2.30	3.50	2.5
% NFC	36.80	30.40	23.50	18.40	37.6
% Starch	8.50	2.70	1.50	0.50	29.3
% WSC (Water Sol. Carbs.)	22.80	25.80	17.60	16.00	6.5

% ESC (Simple Sugars)	28.00	17.90	8.70	11.00	3.5
% TDN	73.00	69.00	69.00	67.00	70
NEL, Mcal / Lb	0.69	0.64	0.63	0.58	.70
IVTD 30hr % of DM	82.00	79.00	81.00	78.00	NA
NDFD 30hr % of NDF	66.00	64.00	68.00	65.00	NA
Kd, %/hr	5.31	6.08	5.44	5.57	NA

Impact of Results/Outcomes

The growing season offered many challenges. Planting got off to a great start in May, but crops were plagued by heavy rains by the end of that month which lasted through June. The wet conditions affected the emergence and final stand in the upper half of the Dawson field. It delayed herbicide application at Birdsall and Dawson and cultivation for Tuning. A nitrogen treatment for Birdsall was abandoned because the field was too wet for treatment at sidedress time.

During the season we had a heat wave that persisted for about three weeks followed by a significant cool down which lasted the rest of the summer. Night temperatures were sometimes in the 60's and lower. Sorghum prefers hot and dry temperatures. Cool night temperatures can shock the plant or temporarily shut it down. Findings concluded that sorghum does not do well on our upland hill soils with poorer drainage. Sorghum does not thrive in wet ground and it is much better suited to droughty soil. Even though we selected a short season variety, it was still on the edge for our region, especially considering the cool, wet growing season. Sorghum in all the fields lodged which complicated harvest and led to field loss.

We did try two experimental varieties at the Stow site; AFX4452 and AFX4456. They were brachytic dwarfs but with slightly longer maturities. The dwarfs are a shorter, stockier plant that are said to have equivalent yield. Brachytic dwarfs, because they are thicker stemmed, tend not to fall over as easily as the general BMR types. This benefit was observed in the Stow fields. The longer season brachytic dwarf varieties were 4 points wetter at harvest.

The study encountered more hurdles than anticipated because we were growing an “alternative” crop on small acreage with reliance on custom operators. The plan was to use custom operators for planting, weed control, sidedress application and harvest. The weather created complications that delayed custom applicators in covering their contracted acreage, causing a backup so that they were unable to switch gears to accommodate unique herbicide recipes for small acreage around the county. This is an important detail to consider before growing an alternative crop.

Sorghum is a subtropical crop that thrives in warm, dry soils. The challenge with sorghum will be the unpredictable variability in our growing seasons. If we have an unusually cool summer with cool night temperatures it will be challenging for the crop to mature and reach an appropriate dry matter for proper ensiling. If we have an unseasonably warm and dry summer, it could outperform corn on drought prone soils. It was also interesting to watch the development of nearby corn fields throughout the growing season. The heavy early season rains and waterlogged soils delayed corn development as well as the development of sorghum. During the early season the sorghum suffered from weed pressure and nitrogen shortage. There

was a point of stark contrast when the soils dried out and warmed up in mid to late July, where corn perked up and started to grow, and changing color from light green to a healthy green. Corn, our standby crop, demonstrated resilience in the face of challenging soil and weather conditions.

Our cooperators are experienced in growing corn and using good cropping practices, but we did not anticipate the number of management hurdles as mentioned previously. Yields were lower than expected which in part must be attributed to shortfalls in agronomic practices, including stand establishment, late weed control, and inadequate supplemental fertilizer. Sorghum was expected to yield closer to average corn silage yields but the corn yields were nearly double compared to the sorghum. Good management and agronomic practices are necessary regardless of the crop. The Stow stand was the most consistent and highest yielding. Farmer Stow applied adequate fertilizer, timely weed control, used a planter with good seed placement on a well-drained soil.

If we look at some of the key nutritional factors and compare across sorghum samples:

- The adjusted crude protein has an approximate 4 point range. The average value is 8, which is similar to most corn silage (CS) samples.
- ADF: average is ~8-10 pts higher than CS samples, can vary greatly among samples
- NDF: were quite variable between samples with a 16 point range. Values generally higher than CS.
- Sugar/Water Soluble Carbohydrates (WSC): a couple samples were low but still at least 2x that of CS. Most are about 15 pts higher than CS
- Starch: sorghum samples varied 0-10 pts which is much lower than CS which averages about 30
- NFC (non-fiber carbohydrates): the higher sugar samples have NFC's comparable to CS samples, low sugar samples are about 20 pts lower than CS
- NEl (Net energy of lactation): The higher sugar samples had NEl's comparable to CS samples. Lower sugars are about .5- 1.0 less than CS.

Nutritionist's comments on quality analyses.

Betsy Hicks, South Central NY Extension Dairy Specialist interprets, "Timing of cutting is necessary to get the fiber levels correct as well as maximize the amount of sugar available. If you can time harvest appropriately, you'll have a forage that will be comparable in energy to corn silage, but the source of energy is from sugar, not starch. This has implications for feeding dry cows, heifers, and transition cow diets where a lot of starch in the diet is not desirable. A later maturity harvest is still appropriate for heifer diets and far off dry cows. When feeding sorghum to lactating cows realize that they're going to use the energy from sugar differently than starch. One could potentially see different results when switching to sorghum, such as component increase (as long as fermentation and DM of the crop are good), better rumen pH (not loading with starch), possible increase in milk, depending on where sugar/starch numbers and fiber levels were before switching to sorghum."

Lessons Learned:

- Sorghum is not well suited to heavy wet soils.
- Sorghum is well suited to drought prone soils.
- Sorghum is sensitive to cool growing seasons.
- Whole plant moisture at harvest can be a challenge
- Recognize the limits when relying on custom operators (Consider their customer demand, capacity and availability.)
- Farmers must have a strong commitment to double crop to overcome late season challenges
- Until we have earlier maturing varieties, sorghum has the challenge of reaching a desirable moisture for good fermentation at the best maturity for harvesting high quality feed.

Economic Analysis
Cost of Production

Relative to corn silage production, the main savings in the cost of production of sorghum is the seed cost. Tillage, establishment, weed control, plant nutrition and harvest are all similar. The cost of corn seed ranges from $100-150 per acre. The sorghum seed costs approximately $25 per acre.

Publications/Outreach

Two regional twilight meetings, attended by farmers and agriservice professionals were held to show the crop in season and discuss the establishment practices and observations of the crop during the growing season. A PowerPoint presentation and discussion were held with extension field crop colleagues and faculty at the Cornell Cooperative Extension annual Agriculture and Food Systems Inservice, Nov. 2014.

Farmer Adoption

Farmer Tuning felt that the sorghum did well considering the ground it was on, even though it didn't yield as well as the neighboring corn field. He thought it would have yielded more on a better drained soil. The cows ate the sorghum ok. At feeding it looked similar to the corn although its fermentation smelled differently.
Farmer Stow grew forage sorghum for two seasons. In 2012 his corn crop suffered severely from drought injury. The impact of that loss and having read promising reports on sorghum he was motivated to try sorghum. He admits there is a learning curve for growing the crop and two of the biggest issues are standability and dry-down at harvest. He likes being able to plant 6-7 acres with a bag of seed vs 2-3 acres with corn. In regards to feeding and preservation, it stores well in ag bags, ferments well and feeds well. Its fermentation was acceptable even at high moisture. He admits there is significant effluent at 70% or higher moisture. Farmer Stow will continue to grow sorghum and is looking forward to the potential of early maturing brachytic dwarf varieties.
Farmer Birdsall thought the sorghum showed promise until it lodged. His criteria for evaluating an alternative crop were yield potential, palatability and cost. If farmer Birdall were to grow the crop again he would like assurance that it will stand through harvest and would prefer that it would be available as glyphosate tolerant variety so that custom weed control would be straightforward.
Farmers Dawson were satisfied with the sorghum as a feed. It fermented well and made nice feed. Their conclusion of sorghum as a crop was that it was too sensitive to wet soils and cool conditions. It did not compete with corn for yield and the forage can't replace corn silage because it doesn't contain grain. They likened the sorghum silage to a super hay crop. Corn will remain one of their main forage crops.

Areas Needing Additional Study

Management practices under Northeast conditions can be better defined. Brachytic dwarf varieties show promise for reducing incidence of lodging and good yield. Shorter season varieties are needed for our area and variable growing season.

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Supporting File(s):

Field Day Announcement: http://mysare.sare.org/mySARE/assocfiles/1001294Sorghum Field Days 2013.pdf
Pictoral View of Sorghum Trials Season Long: http://mysare.sare.org/mySARE/assocfiles/1001295Forage Sorghum Trials 2013_web version.pdf
View this report online: http://mysare.sare.org/sare_main.aspx?do=viewRept&pn=ONE13-181&y=2014&t=1

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