GROWTH AND MANAGEMENT OF SORGHUMS FOR FORAGE PRODUCTION

F. R. Miller, PhD and J. A. Stroup, MSc. [1]

ABSTRACT

Forage sorghums can be grown in a wide variety of soil types, pH levels from 5.5 to 8.5, and varying moisture levels. Forage sorghums use approximately 40-50% less water than corn to produce the same dry matter. New genetic traits regulating photoperiod sensitivity, delayed maturity, brown midrib, and increased tillering and recovery are impacting quality. Increased palatability and digestibility has moved forage sorghum into a prominent production role in water-short agricultural production areas. Conflict exists whether to sow forage sorghum in rows or flat. Row sowing provides reduced seed costs and significantly greater control over production techniques. Its only disadvantage is equipment cost, but if corn is also grown there is no disadvantage to sowing in rows. Dual-purpose silage and photoperiod sensitive forage sorghums produce more IVTD energy per acre than grain sorghum hybrids. Forage sorghum harvested for hay can be safely stored in bales at 12-25% moisture depending upon type of bale used. Caution should be used to observe prussic acid potential and implement precautionary measures such as never feeding hungry cattle stressed green sorghum and use molasses or sulfur blocks to counteract dhurrin if consumed. Nitrate levels can be elevated in forage sorghum by low temperature, cloudy weather, hail, and treatment with herbicides such as 2,4-D, or over-fertilization. Haying or ensiling does not necessarily reduce nitrate levels whereas these practices do reduce or remove prussic acid potential.

Key words: sorghum, forage, silage, hay, quality, and crop management

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[1] F. R. Miller, PhD, Senior Sorghum Breeder, MMR Genetics LTD, Vega, Texas 79092: J. A. Stroup, MSc. Sorghum Breeder, MMR Genetics LTD, Vega, Texas 79092. Email: drfred@mmrgenetics.com; jastroup@mmrgenetics.com.
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INTRODUCTION

Sorghum bicolor (L.) Moench contains a wide variation of types of plants that have been developed into a number of useful products to serve mankind. Within the species there is an enormous potential for forage. It can be used for direct pasture, hay, haylage, silage, and green chop. In the past sorghum has frequently been looked upon as second-choice forage. Original sorghum had the capability to produce reasonable tonnage under severe conditions but it had little quality. There has not been, until recently, major efforts to develop forage sorghums with both high tonnage productivity and high quality. Direct importations from Africa (center of origin of sorghum) were used directly as forage and grain. When hybrids were developed (approximately 50 years ago) breeders took advantage of the new grain type females and used previously introduced sorghums such as, hegari, sumac, rox-orange, sudangrass, and a few others to produce hybrid forage sorghums. Total yield of dry material was the basic concern in these early forage hybrids. No attention was given to develop higher quality parameters.

When grown primarily as a forage crop, sorghum is unique. It is a productive warm season perennial used as an annual that is readily established using conventional farming equipment and cropping technology. Sorghum has significantly less water requirements than maize (corn) grown for silage etc. These characteristics provide considerable flexibility for forage/livestock producers in managing their resources and responding to the critical needs of their livestock. However, such flexibility of use makes identification of proper types and harvest technology difficult. Even the growth stage of utilization varies for the final product.

In the last 10-years there have been some very significant contributions made to the improvement of sorghum for forage utilization. Some of these improvements are:

- Photoperiod sensitivity
- Delayed maturity
- Brown midrib
- High tillering and recovery capacity

The advantage of photoperiod sensitivity and delayed maturity increases yield of green material. The "harvest window" is greatly enhanced, allowing growers more flexibility at harvest time. Incorporation of the brown midrib characteristic represents a major change in thinking and is a great step forward because QUALITY is now the driving objective in sorghum forages. Within brown midrib hybrids lignin may be reduced from 5 to 50% in stems and from 5 to 25% in leaves. When compared to normal sorghums increases in IVDMD are as much as 33% for the brown midrib types. Palatability of these materials has been excellent, increasing significantly intake and total utilization of the plant.

RESULTS AND DISCUSSION

***Cultural Issues*:**
Forage sorghums can be grown in a wide variety of soil types, ranging from heavy soils to the more sandy-loams. Sorghum performs best on the heavier soils because of their greater water holding capacity and fertility. Soil fertility requirements are somewhat similar to those of corn at the same general yield goals. Sorghum is usually more efficient in its use of phosphorus and potassium. Soil pH is a concern but good growth will occur in the range of pH 5.5 to 8.5, and it tolerates some degree of salinity, alkalinity, and poor drainage. There are differences among sorghum hybrids for their response to both acid and alkaline soils. Sorghum possesses twice as many secondary roots as corn at any given stage of growth. The ratios of roots to leaf area are of an order of four times that found in corn.

Nutrient Use and Fertilizer Recommendations
For Sorghum Production

<u>Nutrients Used</u>

Grain sorghum

	IN THE GRAIN	IN THE WHOLE PLANT
6,000 lbs/ac yield	220 lbs/ac of Nitrogen	274 lbs/ac of Nitrogen
	70 lbs/ac of Potassium	90 lbs/ac of Potassium
	35 lbs/ac of Phosphorus	85 lbs/ac of Phosphorus

(assumes a 50:50 grain/stover ratio)

Forage sorghum

5 – 7 tons/ac yield	120 lbs/ac of Nitrogen
	40 lbs/ac of Potassium
	180 lbs/ac of Phosphorus

Nutrient replacement:

Always use soil analysis and apply according to estimated yields. Sorghum seed is sensitive to fertilizer burn-do not allow fertilizer to come in contact with seed.

Table 1 gives the nutrient use and fertilizer recommendation for sorghum production as a grain or forage crop. A general rule to thumb for nutrient removal of NPKS is 24:8:32:5 lbs /ton of dry matter harvested. Large quantities of nitrogen and phosphorus and some potassium are translocated from other plant parts to the grain as it develops. Unless adequate nutrients are available during grain filling this translocation may cause deficiencies in the leaves and premature leaf loss, which may decrease yields. A large portion of nitrogen and phosphorus but only a small portion of potassium is removed in the grain. If the entire plant is harvested for silage or other forms of feed, much more potassium is removed because most of it is in vegetative parts of the plant.

In a study to determine a water use curve for forage sorghums (Bean etal.) used four different types of forage sorghums hybrids, two brown midrib silage, a brown midrib photoperiod sensitive, and a normal dual-purpose. A linear response to water rate was found with an R2 value of 0.94. Forage sorghum yield averaged 0.66 ton/ac-in of water used with the incremental response of 0.83 tons silage added per inch of water used. Previous information has shown that fully irrigated forage sorghum silage can be produced on 44% less water than corn without sacrificing yield.

There is a major consideration that should be taken concerning whether to plant sorghum for forage in rows or flat. Significant advantages and disadvantages are associated with each of these methods of sowing. Table 2 gives the recommended rates of seeding for hybrid forage sorghums for hay, direct pasture, and silage production. Sowing in rows reduces the seeding costs approximately one-third while ensuring a greater emergence of planted seeds over that of sowing broadcast. Planting technology is basically the same as

Planting Designs --- and --- Seeding Rates
(Irrigated)

Design	Seeding Rates
Flat (broadcast)	30 - 50 lbs/acre
Row (30 inch)	8 - 12 lbs/acre

Advantages	Disadvantages
Flat	Flat
Less equipment needed	Uneven seeding and emergence
	Uneven water distribution
	(soil crusting-poor germination)
	Increased lodging potential
Row	Row
Controlled seeding/planting rate	More equipment needed (like corn)
Control of water distribution	
Minimum tillage possible following corn	
Less lodging potential	
Ease of harvest	

that for corn production. However, when forage sorghum is to be sown after a corn crop is harvested planting in rows and/or flat becomes an option. To plant in rows the grower can rip and form the rows back where corn was previously and sow sorghum into the same row. This gives much better control of water movement, seedling emergence, and subsequent weed control. If the grower chooses to plant sorghum flat following corn harvest or as a first crop there is a significant loss of seeds to non-emergence, crusting, water distribution, and weeds.

General cultural practices for forage sorghum are variable but remain similar to those used for sorghum grain or corn production. Stage of maturity is probably the single factor most associated with forage quality in sorghum. This, of course, excludes the overriding quality factors of photoperiod sensitivity and brown midrib. The fallacy of planting to produce "finer stem size" for quality in sorghum is finally beginning to disappear from reality. Stem size is important to standability, lignification, and digestibility. Quality is a measure of real feed value of the forage and is related also to harvestable yield. Each type has its own specific stage of harvest, preservation, storage, and utilization technology.

***Production Issues*:**
Various types of sorghum forages exist. These include both older and newer versions of sorghum/sudangrass, late maturing types, brown midrib hybrids, and photoperiod sensitive forms. Previous information has shown the levels of productivity of these

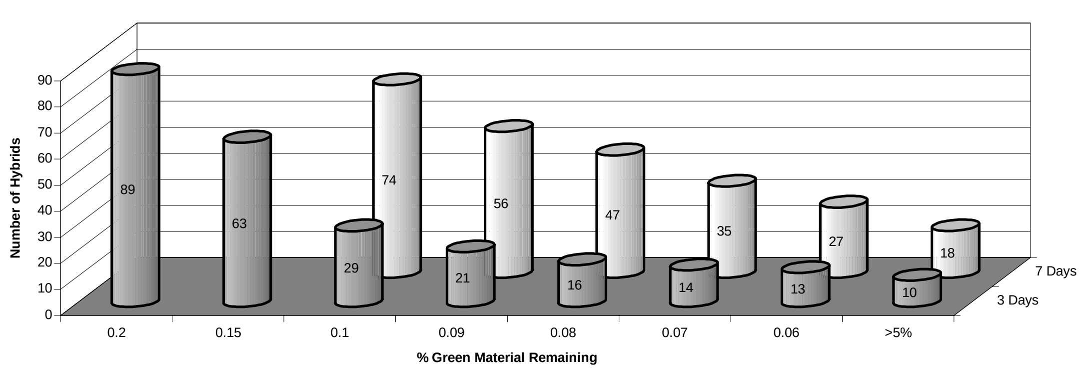
currently used types (Miller etal.). Perhaps one of the most obvious characteristics of variability in these forages is their inherent palatability. Very little information exists which compares the types for preference when exposed to free choice grazing. Table 3 shows the amount in percentage green material remaining following grazing for 14-days. Harvested

Loss of Photosynthetic Production via Non-Preference

Description	% Loss
Normal Sorghum/Sudangrass	35
Normal Photoperiod Sensitive	25
Normal Late-Maturing	21
BMR Sorghum/sudangrass	17
BMR Sorghum/sudangrass	10
BMR Male-sterile forage	8
BMR Photoperiod Sensitive	5

photosynthetic product was greatest for the brown midrib types. What is truly disturbing is the loss of 35% of the energy produced by the grower because the cattle would not harvest these particular sorghums. When we exposed these same hybrids to cattle following freezing, we observed basically the same response pattern. In order to use cattle and their preference for specific sorghums, we planted 195 experimental forage sorghum hybrids in 2-row, 20-foot plots surrounded by both conventional and brown midrib forage hybrids. Figure 1 shows that within 3 days the cattle had clearly separated hybrids they preferred. In 7 days the same separation existed but with more secondary choices made by the cattle. Because these same preferences remain in hay or silage it is essential seedsmen provide growers with the most highly palatable hybrids to maximize utilization.

Palatability Variation Among 195 Experimental Forage Sorghum Hybrids
(Exposed to 60 mother cows and calves, Vega - TX)
MMR Genetics



Because of the developing market for sorghum as an alternative to corn in areas where water is a concern, several types of hybrids are of interest. There is the issue of high grain yield and its greater digestibility vs. using the whole plant for energy. At Bushland, Texas during the past 5-years trials have been conducted to compare forage sorghums to conventional grain hybrids. The trial in 2003 was a good trial and represents a set of data where we can compare performance of these various types of sorghums for energy production. Table 4 presents data summarized from this trial. The grain sorghum hybrid types averaged the lowest total yield at 65% moisture for the total plant harvest and had the lowest IVTD yield per acre. The dual-purpose types (non-brown midrib) had a much

Comparison of Sorghum Types for Forage Yield and Quality

Type	Tons/Acre @ 65% Moisture	% Crude Protein	% NDF	%Lignin	%IVTD	IVTD/Yield (lbs/acre)
Grain Sorghum	15.6	8.34	35.62	3.10	82.75	25,801
Dual Purpose Silage	20.4	6.60	46.15	4.35	75.33	30,774
Normal Silage	18.0	7.45	44.57	4.38	76.93	27,763
BMR Silage	17.1	7.41	44.19	3.34	80.00	27,310
Normal PS Silage	25.1	5.27	59.63	5.01	70.22	35,207
BMR PS Silage	23.2	5.86	56.96	4.01	75.33	35,005

From: TAES 2003 (Brent Bean and Ted McCollum)

better yield because of more stem weight when compared to the grain sorghums. This type produces a high grain yield and a larger stem yield. The normal and brown midrib silage types were intermediate between the grain and dual-purpose hybrids for yield. However, what is interesting is the fact that the photoperiod sensitive types produced approximately 10,000 lbs/acre more IVTD yield than the grain hybrids and 5,000 lbs more than the dual-purpose types. These data raise the question to a grower of which type hybrid should he use in his forage production system. Information in Table 5 shows

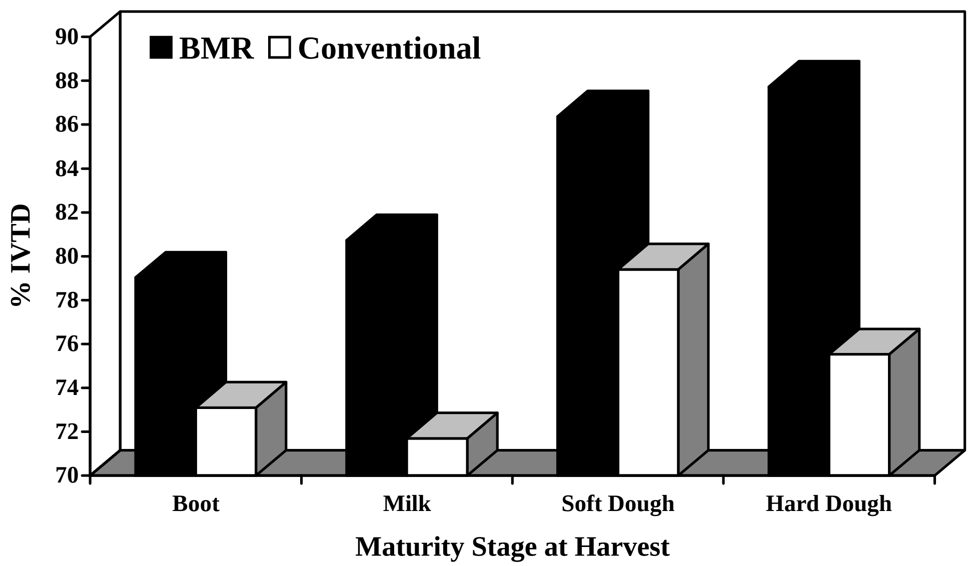
Quality Measurements of Various Sorghum Hybrids After 70-days in Micro-silos

Hybrid	pH	IVTD	NDF	ADF	Lignin	Protein	ME*
Dairy Master (S)**	3.5	59.9	48.5	28.1	4.2	6.5	2.05
P8232 (G)	4	58.6	53.5	33.1	5.7	8.3	2.10
Jowar (G)	4.5	58.4	51.4	32.1	6.3	7.7	2.20
AGS 200 (S)	4	57.6	53.0	35.8	5.9	6.5	2.21
CERES (S)	3.5	56.1	50.4	32.1	7.0	5.8	2.18
SR 1767 (G)	4	55.5	52.3	33.6	5.4	6.1	2.13
P 8118 (G)	4.5	55.2	54.7	36.4	6.0	6.8	2.15
P (0.05)	0.4	2.2	2.9	1.9	1.1	1.2	0.4

*ME = Mcal/kg dry matter; ** Brown midrib that after 70-days in micro-silos the brown midrib silage type had the lowest pH and highest IVTD. However, the grain sorghum hybrids, Jowar and P8232, had very good IVTD values also because of their high quality grain yields. The lower lignin content of the brown midrib hybrid was evident through the ensiling process.

Which type hybrid the grower chooses should fit his production capability and need. It is important to remember that whichever hybrid type one chooses the "stage of maturity" for harvest is the critical quality issue when grain is concerned. Figure 2 shows that maximum digestible energy is obtained when harvest is made between the soft and hard dough stages of grain development. There are differences between the brown midrib and normal types because brown midrib hybrids can be harvested a bit later since the stem is so much more digestible.

Effects of Maturity Stages on Silage Quality



Hay production from sorghum forage is one of the crops greatest attributes. There are some issues to keep in mind when determining when to harvest and store sorghum forage for hay. Quality of forage crops changes over time, as they grow older and taller. The time to cut will depend on the quantity and quality of hay required. For maximum quality, cut the sorghum when it is still young and vegetative. Cutting forage sorghum 50 to 60 inches tall, or before boot stage will result in high quality hay. It is best to use a mower with a conditioner or crimper to crush the stems and reduce the drying time in the field. Cutting a hay crop during the afternoon will allow plant sugars to reach their highest level. It is also best to harvest on a full sunny day rather than during cloudy or overcast conditions. The crop should be cut when there is sufficient time remaining in the day to allow the crop to wilt before nightfall.

Moisture content of forage when it is baled affects hay quality. High moisture content when baling can lead to hay overheating. This heat destroys protein, lowers hay quality and can also lead to a fire risk. On the other hand, allowing the crop to dry for too long can result in significant loss of leaves, which are the most nutritious part of the plant. Forage can be safely stored in a stack or bale, when the moisture content has been reduced to 15-20%. The following is a guide to safe forage sorghum hay storage:

	Moisture Level	
Small squares	Ideal 18 –20%	Maximum 23 –25%
Large rounds	Ideal 14 –18 %	Maximum 20 – 22%
Large squares	Ideal 12 –14%	Maximum 15 – 18%

Hay requires a dry storage site for long-term preservation. Hay sheds are very good, but can be expensive. Plastic covers work well provided the hay is well dried, stacked to form a rain water removal pathway and the plastic is anchored well to prevent blowing.

***Toxicity issues*:**

Prussic acid and nitrates in sorghum forages can cause concerns. The cyanogenic glycoside, dhurrin occurs in most sorghums, although the quantity depends both upon the variety and environmental conditions. Dhurrin is localized in the plant tissues, but none exists in the grain. These cyanogenic glucosides contain the cyanide ion and can release hydrogen cyanide (HCN) when certain enzymes come in contact with the dhurrin. Because a living sorghum plant contains both cyanogenic glucoside and the necessary enzymes in different cells, no HCN can be produced until the tissue is damaged by the animal's consumption or mechanical harvesting etc. Prussic acid interferes with oxygen and the cytochrome system. Prussic acid levels (ppm of dry matter as HCN) of 0-600 ppm are considered safe. If the level is 600-1000 ppm there is potential toxicity and precautions should be followed. Prussic poisoning is usually not a problem provided some very simple and obvious precautions are taken.

- Never allow a hungry animal into a sorghum field
- Never allow animals into a severely drought stressed field without precautions
- High available nitrogen in the soil increases levels
- Low phosphorus increases levels
- Plants less than 18 inches tall have increased levels

Precautions are:

- Always feed dry hay to animals prior to introduction
- Always have sulfur blocks or molasses freely available

What happens to the prussic acid potential when forage sorghum is harvested for hay or silage? It is generally believed that haying and subsequent drying will evolve the HCN and render the hay safe if there was a previously high level of HCN. By the same token, if sorghum is frosted it should not be consumed until it is dry, perhaps 4-5 days after frosting. If the green crop is harvested directly for silage without wilting there is the possibility that some HCN could remain in an air-tight silo. However, with wilting and subsequent ensiling there is not likely to be a toxic level remaining. Generally speaking, prussic acid poisoning is not a major concern because of the inherent levels in the current hybrids and with the use of common sense and use of a few precautions.

Nitrate poisoning is quite a different thing. Levels of nitrates do not dissipate completely with harvest. There is much confusion about the reporting of nitrate information. To a Large degree this confusion is a direst result of the different methods used by laboratories to report nitrates. Table 6 gives the formulas for converting the various reporting of nitrates. Table 7 gives the interpretation of laboratory nitrate results for nitrates. Because there is a high use of

Formulas for Converting Methods of Reporting

Potassium Nitrate (KNO_3) = Nitrate (NO_3) x 1.6
Potassium Nitrate (KNO_3) = Nitrate Nitrogen (NO_3-N) x 7.0
Nitrate (NO_3) = Potassium Nitrate (KNO_3) x0.6
Nitrate (NO_3) = Nitrate Nitrogen (NO_3-N) x 4.4
Nitrate Nitrogen (NO_3-N) = Potassium Nitrate (KNO_3) x 0.14
Nitrate Nitrogen (NO_3-N) = Nitrate (NO_3) x 0.23
Parts per Million = Percent x 10,000
Percent = parts per million / 10,000

Interpretation of Laboratory Nitrate Results

KNO_3	**NO_3-N***	**NO_3**	**Feeding Recommendations**
Level of Nitrate			
0-10,000ppm	0-1,500ppm	0-6,500ppm	Generally Considered Safe for Livestock
10,000-30,000ppm	1,500-4,500ppm	6,500-20,000ppm	Caution: Problems can occurre at this level
>30,000ppm	>4,500ppm	>20,000ppm	GENERALLY CONSIDERED DANGEROUS

* Most commonly used measure

nitrogen and manure on forage sorghum it is important to know what is a safe level and how one should handle materials with various levels of nitrates. Higher levels of nitrates accumulate when some form of stress such as drought, cloudy days, low or excessively high temperatures, disrupts growth. Hail damage to leaves can cause an increase in nitrates. Generally, the highest levels of nitrates are in the lower 1/3 of the plant. Plants suspected of having high levels of nitrate should be tested prior to feeding. Hay made from a high nitrate crop will still have a high nitrate level. Wait until good growth has returned and the level of nitrate has dropped before harvesting. When forage is ensiled the fermentation process may reduce the nitrate level, sometimes to half. However, one should be very cautious of silage made from high nitrate level forage. If nitrate poisoning is suspected – call a veterinarian immediately.

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