UTILIZING THE BMR TRAIT IN SUDANGRASS AND SORGHUMS

J.M. Reich, Ph.D.[1]

ABSTRACT

Brown midrib (BMR) is a genetic mutation in several grass species. The BMR gene reduces lignin content in plant cell walls and vascular tissue and improves fiber and whole plant digestibility. Lignin is mostly indigestible and plays a critical role in forage quality by affecting digestibility of cell wall polysaccharides. Lignin also plays in important role in plant rigidity. During the past several years the BMR trait has been incorporated into corn, millet, forage sorghum, sudangrass, and sorghum x sudangrass hybrids. Productivity and commercial acceptability of early generation BMR materials was limited by linkage drag associated with the BMR gene. Focused breeding has overcome most of the initial limitations in sorghums. Palatability in BMR materials has been improved significantly over conventional types. Animal performance, i.e., animal gain from direct pasturage, has improved dramatically with the introduction of BMR into forage sorghum, sudangrass, and sorghum x sudangrass hybrids.

Key words: Sudangrass, sorghum, sorghum x sudangrass, brown midrib, lignin, water use

INTRODUCTION

The genus *Sorghum* includes three distinct morphotypes that are used as forages: forage sorghums, sudangrass, and sorghum x sudangrass hybrids. These three morphotypes have grossly different phenotypes and different modes of principal utilization. Forage sorghums have very coarse stems and wide leaves, similar to corn (*Zea mays* L.), very low tillering capacity, and very slow speed of regrowth after cutting. Consequently they are used predominantly as a silage crop, and occasionally for hay production and direct pasture. Sudangrass in comparison is very grassy, characterized by very fine stems and narrow leaf blades, profuse tiller development, and exceptionally rapid recovery after cutting or grazing. Sorghum x sudangrass hybrids which result from crossing a sorghum female with a sudangrass male are generally intermediate in character expression between sorghum and sudangrass.

A comparison of the phenotypic/morphological characteristics of sudangrass, forage sorghum and sorghum x sudangrass hybrids are provided in Table 1.

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[1] J.M. Reich, PhD, Executive Vice President, Cal/West Seeds, Woodland, CA 95776. Email: j.reich@calwestseeds.com . **In**: Proceedings, California Alfalfa and Forage Symposium, 12-14 December, 2005, Visalia, CA, UC Cooperative Extension, Agronomy Research and Extension Center, Plant Sciences Department, University of California, Davis 95616. (See http://alfalfa.ucdavis.edu for this and other proceedings.)

Table 1. Characteristics of sudangrass, forage sorghum, and sorghum x sudangrass hybrids, principal morphotypes of forage crops within the genus *Sorghum*. All measurements are provided as average ranges.

Characteristic	**Sudangrass**	**Sorghum x sudangrass**	**Forage Sorghum**
Stem diameter	0.25-0.375 inches	0.50-1.00 inches	1.50-2.50 inches
Leaf Width	0.75-1.00 inches	1.00-1.50 inches	1.50-2.50 inches
Tillering capacity	Very High	Medium	Very Low
Regrowth potential	Very High	Medium	Very Low
Adaptation for hay	Excellent	Fair	Poor
Adaptation for pasture	Excellent	Very Good	Poor
Adaptation for silage	Fair	Excellent	Excellent

Of the *Sorghum* species grown for forage, sudangrass has the finest stems, tillers most profusely, and has the most rapid regrowth following cutting or grazing. The finer stems give it better drying characteristics than other *Sorghums* for hay making (Undersander, 2000). The fine stems, extensive tillering, and rapid regrowth of sudangrass make it better suited to pasturing than other types of *Sorghum* (Anderson and Guyer, 1986; Leep, 2005). Sudangrass and sorghum x sudangrass hybrids are widely grown commercially for direct pasture, hay, haylage, greenchop, and silage.

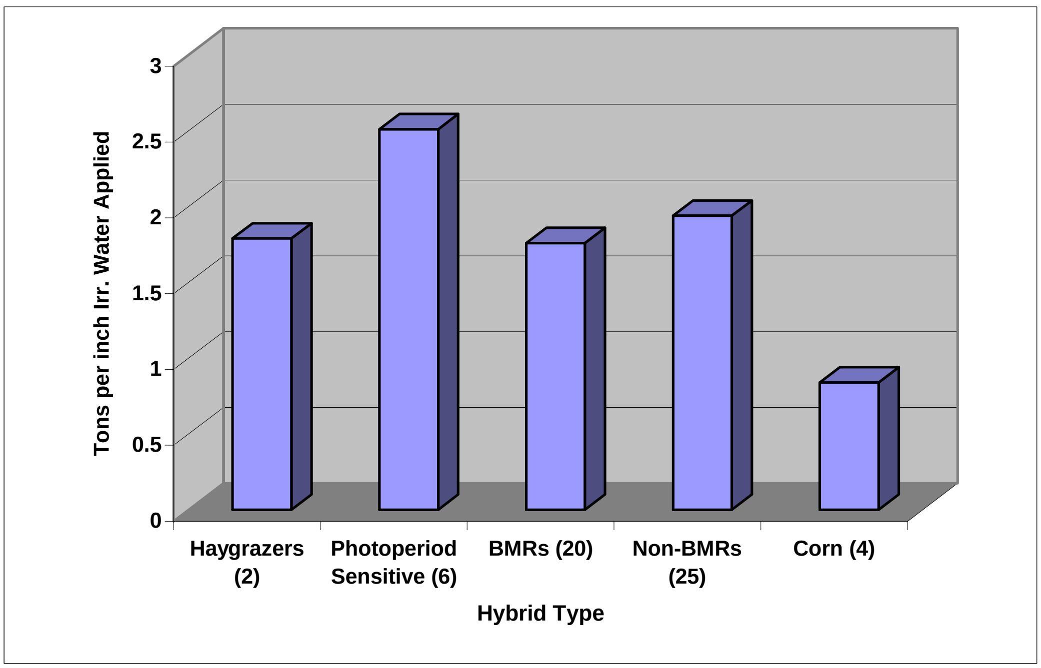
Brown midrib (BMR) is a visible marker associated with the reduction of lignin in corn, sorghum and pearl millet (Kuc and Nelson, 1964; Porter et al., 1978; Cherney et al., 1988). In *Sorghum* species the BMR trait is expressed in the midrib of young leaf tissue and in the stem, rind, pith, and vascular tissues of maturing plants. In many genotypes leaf coloration tends to dissipate in intensity with advancing maturity. Intensity of coloration is not a measure of the reduction in lignin and has no bearing on relative differences in forage quality. Expression of BMR is merely an indicator that the gene(s) are present. Jung and Fahey (1983) suggested that BMR plants have less polymerized lignin and contain less phenolic monomers affecting digestion. The effects of lignin composition, structure, and cross-linking on cell wall degradability has recently been thoroughly reviewed (Grabber, 2005). Studies with corn and sorghum document the improved forage digestibility associated with BMR genes (Lechtenberg et al., 1972; Fritz et al., 1981). Significant differences exist among sorghum cultivars for the amount of lignin reduction, its impact on forage quality as a direct pasture or silage crop, and related issues such as lodging associated with the BMR trait (McCollum et al., 2003).

In spite of well-understood benefits of BMR on forage quality, BMR mutants were not used commercially until the 1990s and widespread use was limited by reduced yield and vigor of BMR phenotypes in maize (Miller et al., 1983; Lee and Brubaker, 1984) and sorghum (Kalton et al., 1988). BMR forage sorghum and sorghum x sudangrass hybrids are being introduced into the market at a very fast rate (Miller and Stroup, 2003). The Sorghum Industry estimates that within five years as much as 80-85% of the forage market will be brown midrib. In the present market, some forage sorghum and sorghum x sudangrass hybrids have experienced significant problems with lodging under field production conditions. The first true sudangrass x sudangrass hybrids with the BMR trait are currently being introduced into the market.

RESULTS AND DISCUSSION

A 1999 study compared forage quality among conventional (normal midrib) and BMR forage sorghum and sorghum x sudangrass hybrids from ten seed companies at the Texas A&M University Bushland, Texas Research Center. Lignin content of BMR hybrids was 33% lower (3.1% vs. 4.6%) and IVTD was 20% higher (78.6% vs. 65.6%). A 2001 study compared 53 sorghum and 4 corn hybrids in an irrigated trial at Bushland. The 53 sorghum hybrids (combination of BMR and conventional) averaged 1.93 tons/inch of water consumed; BMR hybrids produced 1.76 tons/ inch while conventional hybrids produced 1.94 tons/inch. Photoperiod sensitive hybrids produced 2.51 tons/inch of water consumed. In contrast, corn was very inefficient in water use producing only 0.84 tons/inch of water consumed or 56% less efficient than the average of the sorghum hybrids (see Graph 1). From the same 2001 trial at Bushland, 20 BMR sorghum hybrids averaged 18% lower in lignin, 6% lower in NDF, 8% lower in ADF and 8% higher in IVTD compared to the 25 non-BMR hybrids.

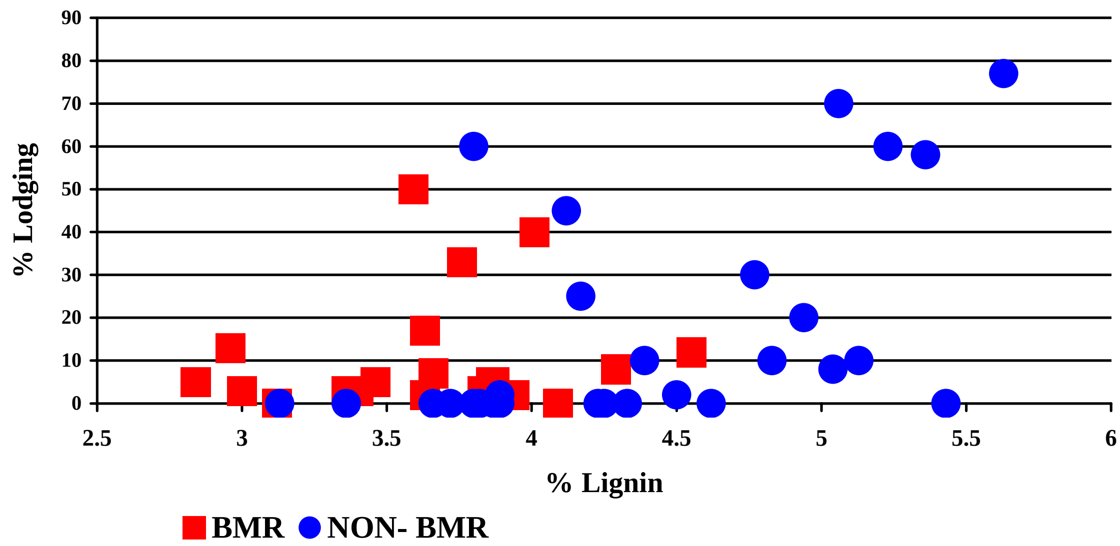
Graph 1. Irrigated Sorghum Silage Trial – Water Use Efficiency



Courtesy of TAMU Research Center, Bushland, TX. http://soilcrop.tamu.edu/research/crops/corn-sorghum/croptesting

Lodging scores taken on the 2001 trial at Bushland show that lodging is not associated with the BMR trait, per se, but with the genetic background of a particular hybrid. The scatter diagram shown in Graph 2 shows the relationship between % lignin and % lodging for the 53 hybrids. Certain non-BMR hybrids with high lodging scores are actually high in lignin content while certain BMR hybrids that are among the lowest in % lignin are also among the lowest in % lodging. The data clearly indicates that it is not possible to generalize about lodging in BMR or non-BMR hybrids or the relationship between % lignin and % lodging.

Graph 2. Comparison of % Lodging and % Lignin Among BMR and Conventional Forage Sorghum and Sorghum x Sudangrass Hybrids



Courtesy of TAMU Research Center, Bushland, TX. http://soilcrop.tamu.edu/research/crops/corn-sorghum/croptesting

Data presented at a prior Symposium from replicated trials comparing BMR sorghum x sudangrass hybrids with a standard non-BMR check (SX 17) showed that while the BMR hybrids had somewhat lower forage dry matter yield (4.65 vs. 5.08 tons/acre) they were significantly higher in forage quality having 28% lower lignin (4.4 vs. 6.1%) and 17% higher TDN (61.8 vs. 52.7%) (Miller and Stroup, 2003). Predicted milk produced per ton of forage consumed was 27% higher (2525 vs. 1988 lb) and milk production per acre was 14% higher (11,560 vs. 10,096 lb/acre) for BMR vs. conventional sorghum x sudangrass hybrids.

The first sudangrass x sudangrass hybrids with the BMR trait are becoming commercialized. Replicated trials comparing BMR sudangrass x sudangrass hybrids with Piper demonstrate that the BMR hybrids have similar forage dry matter yield and improved forage quality. Across locations and years, the BMR hybrids average 4.4% lower NDF, 20.1% lower lignin, 6.4% higher crude protein, 7.8% higher fiber digestibility, 11.0% higher milk per ton, and 16% higher milk per acre (See Table 2). Replicated grazing trials conducted at Mississippi State University in 2005 documented that beef cattle grazing a BMR sudangrass x sudangrass hybrid produced 20% more weight gain per head per day and 20% more weight gain per acre compared to Piper. Commercial hay of a BMR hybrid sudangrass and Piper were produced side by side under identical management in a field near El Centro, CA in 2005. Composite bale samples of dry hay were analyzed using wet chemistry by Dairyland Laboratories in Arcadia, WI. Lignin content of the BMR sudangrass hay was 7.6% lower than Piper hay and 24-hour fiber digestibility (estimated by NDFd) was 18.9% higher. Nitrate content of the BMR sudangrass hay was also significantly lower than the Piper hay, while sugar content was higher. Commercial hay brokers and buyers from Japanese trading companies rated the BMR sudangrass hay as acceptable as the Piper hay based on physical characteristics. These results suggest that over the next several years Piper sudangrass being produced in the Imperial Valley for the export hay market to Pacific Rim countries will largely be replaced by BMR sudangrass x sudangrass hybrids.

Table 2. Forage quality of three BMR sudangrass hybrids compared to Piper in replicated trials conducted between 2002 and 2005.

	# Cuts	CP	NDF	ADL	NDFd	Milk/Pound
BMR 1	16	16.2	56.8	6.4	77.0	2917
Piper	16	15.4	59.1	8.0	71.6	2654
% Advantage BMR 1		5.2%	-3.9%	-20.0%	7.5%	9.9%
BMR 2	11	16.5	59.8	6.2	76.1	2796
Piper	11	15.7	61.8	7.5	71.5	2564
% Advantage BMR 2		5.1%	-3.2%	-17.3%	6.4%	9.1%
BMR 3	8	17.2	57.0	5.7	75.5	2854
Piper	8	15.8	60.7	7.4	69.0	2503
% Advantage BMR 3		8.9%	-6.1%	-23.0%	9.4%	14.0%
Average BMR Advantage		6.4%	-4.4%	-20.1%	7.8%	11.0%

SUMMARY

Sudangrass, forage sorghum, and sorghum x sudangrass hybrids represent distinct morphotypes within the genus *Sorghum* and possess different modes of principal utilization. Sudangrass is best adapted for hay production and responds most favorably to intensive rotational grazing systems. Sudangrass is one of the preferred forages for the sizable export hay market to Japan. Sorghum x sudangrass hybrids are well adapted for direct pasturage and silage and are suitable for production of coarse hay. Forage sorghums are adapted for production of silage in one-cut systems and can be grazed in situations where rapid recovery after grazing is not important. Sudangrass, forage sorghum, and sorghum x sudangrass hybrids with the BMR trait demonstrate acceptable yield with superior forage quality compared to conventional (non-BMR) counterparts. The BMR gene conditions significant reductions in lignin content which contributes to higher fiber and whole plant digestibility. BMR hybrids are consumed preferentially by cattle, enable higher weight gain per head per day and per acre in beef cattle, and higher milk production per ton of feed consumed and per acre compared to conventional types.

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