SORGHUM: AN ALTERNATIVE FEED, HAY AND FORAGE

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ABSTRACT

Sorghum is a drought tolerant cereal crop that has multiple uses, one of which is as a livestock feed. California is dealing with multiple water issues and sorghum can play a significant role in reducing some of the inputs, including water, that are needed to supply high quality grain and forage feed to the animal industry. We will review sorghum's use as a feed grain, forage, and hay crop and some of the issues and challenges facing farmers that may want to incorporate sorghum into their feed rations in California and the Western States. The University of California Sorghum Research team is working with California State University Fresno to begin evaluating sorghum grain production for adaptability to California and UC-ANR continues to evaluate sorghum forages at both Kearney (KARE) and the West Side (WSREC) Research and Extension Centers for adaptability and quality parameters to provide farmers with alternative forage sources for silage production. This presentation will highlight some of the findings from the hybrid trails and talk about the new genetics that are making sorghum more competitive with other forages for both yield and quality, while using less water and fertilizer inputs.

Key Words: sorghum, feed, forage, livestock, dairy, yield, drought tolerant, quality, brown mid-rib

INTRODUCTION

The Western United States is home to a multi-million dollar dairy and animal industry, which over the last several years has been under stress from poor winter rain and snowpack, impacting their ability to irrigate fields for production of feed, hay and forages. This has encouraged the evaluation of potentially more water-efficient crops that can produce good yields with less irrigation. *Sorghum bicolor* (L.) Moench is a drought tolerant cereal crop with a long history of utilization and cultivation in the United States. Brown and white durra sorghums were introduced as an animal feed to California by the USDA in 1847 and as recently as the early 1960s approximately 400,000 acres of grain sorghum were grown in California (USDA-NASS, 2015). To understand sorghum, one must understand the different types of sorghum that are available for cultivation and utilization. These include grain sorghum hybrids used primarily for animal feed, sudans, sudangrass, or sudangrass x sorghum hybrids used for hay production and grazing, and forage sorghums, that can be greenchopped or ensiled for feed.

Kansas and Texas remain the leading states for grain sorghum acreage and production, with more limited acreage of grain sorghum and forage sorghums in the far-west U.S. States (USDA NASS, 2015). Despite limited production in California, sorghum, especially forage sorghum can

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be an attractive crop for the state because of its ability to remain productive under limited water and nutrient conditions (Marsalis and Bean, 2010). Research from the Texas AgriLife Extension Center in Amarillo, TX has consistently shown that forage sorghums can be effectively grown under limited irrigation and still produce high yielding and good quality forages (see http://amarillo.tamu.edu/amarillo-center-programs/agronomy/forage-sorghum/). Although that Texas High Plains region has growing season rainfall in addition to irrigation, the results of field trials still indicate some relatively good yield potential at more moderate total evapotranspiration than with some other forage or grain crops such as corn. UC-ANR has begun evaluating sorghum forages at both KARE and the West Side Research and Extension Centers for adaptability and quality parameters to provide farmers with alternative forage sources for silage production. However, to understand sorghum, once must understand sorghums growth and management.

Growth and Development

Sorghum’s growth and development is like many of the other cereal crops; however, understanding its development stages will help in making critical irrigation and management strategies that can be used to optimize yield and quality with less water and inputs. Growth stages are based on key development stages from planting to maturity (Figure 1). A more simplified growth scale is also commonly used and correlates as follows: GS1 would equate to stages 0-5; GS2 would represent stages 5-10; and GS3 would equate to stages 10-11. For a more in-depth discussion of sorghum growth and development go to http://amarillo.tamu.edu/files/2010/11/sorghum_growth_development.pdf.

All sorghum seed responds to warm soil temperatures and is typically planted when soil temperatures are above 60º F. In cooler soil temperature, both germination and emergence can be delayed. Slow emergence may lead to more injury from preplant herbicides. The three leaf stage typically occurs about 10 days after emergence. Twenty days after emergence is typically when the 5 leaf is visible and the plant is approximately 8 to 10 inches tall. If cool air and soil temperatures are present with sunny days, this may trigger tillering. In sudans, sudangrass, and sudangrass x sorghum hybrids this tillering can be profuse. Good stand establishment is also critical for forage production and if needed may require additional irrigations to ensure good plant populations.

Panicle differentiation is a key growth stage for any of the photoperiod insensitive sorghums used for animal production. This typically occurs 30-35 days after emergence and generally corresponds to the 7-8 leaf stage. Panicle differentiation determines number of spikelets and seed per spikelet in grain sorghum and anything detrimental to growth, especially water stress, that impacts this developmental stage can impact yield potential. Good nitrogen availability and moisture will positively impact yield and are important to the success of the sorghum planting.

In forage sorghums, brace roots can be critical to good standability and avoidance of lodging. If sorghum is planted on beds, then brace roots may have trouble entering the soil and assisting in bracing the plant. Cultivation may be needed to move soil around the base of the sorghum plant and this is typically done around 30 days after emergence to minimize root damage.

The flag leaf is the last leaf to emerge and is typically smaller than the other leaves. Greenbugs (*Schizaphis graminum*) can be a problem if their numbers are great enough to cause economic damage (see http://lubbock.tamu.edu/files/2011/11/sorghum_guide_2007.pdf for more information on insects that impact sorghum). Typically in California production areas, experiences have been that greenbug populations tend to occur relatively late in plant development when impacts are generally more limited. When the flag leaf collar appears, sorghum is considered to be in the boot stage. This may typically be around 45 days after emergence, but all these growth stages are impacted by maturity genes and environmental issues in sorghum and can vary. The sorghum panicle is fully developed at this stage and maximum water use occurs at this stage (figure 2). In the past, this was the growth stage in which an application of a limited irrigation was suggested; however, it is extremely important in any limited irrigation strategy that sorghum is not stressed at panicle differentiation. Final N applications should be applied within 60 days of planting or at mid-boot. At that growth stage, often corn leaf aphids [*Rhopalsiphum maidis* (Fitch)] may be diminishing and greenbugs could be reaching economic thresholds.

Plants are considered to have reached the "flowering stage" when 50% of the panicles are in bloom. A panicle is considered to be flowering when half of the panicle is in bloom. Flowering occurs from the top of the panicle to the base. Flowering can take anywhere from 4 to 10 days and the panicle can be susceptible to stress or herbicide drift which might be expressed by blasting in the panicle. Sorghum midge [*Contarinia sorghicola* (Coquillett)] and headworms (various genus) can be a problem and should be evaluated for potential threats. Soft dough is when the grain can be easily squeezed between two fingers and a milk-like substance appears from the maturing grain. For silage sorghums, harvest should take place between soft and hard dough stage to optimize quality of the forage. Hard dough stage is when the grain cannot be squeezed between your fingers and water stress now can cause premature stem death and lodging. Black layer or physiological maturity is when a dark spot appears at the base of the grain where it attaches to the glumes. Maximum total dry weight is achieved and this typically occurs 30-35 days after flowering. Grain moisture is typically 25-35% and would need to be dried down for long term storage if harvest at this time. Typically, sorghum grain will dry down in the field until ready to harvest at about 15% moisture or less. A bushel of sorghum is typically reported at 13% moisture and weighs 56 pounds.

This is the typical growth stages of sorghum that produces a panicle and grain. A photoperiod sensitive sorghum, is a sorghum that requires short days to trigger the reproductive phase of the growth stages and will typically not flower in the United States in time to produce grain. These types of sorghum will remain in a vegetative growth stage throughout most of it economical (??) growth stages and are typically used for green chop or silage production. These are characterized by large yields and generally poorer nutritional quality.

TYPES AND UTILIZATION OF SORGHUM FOR FEED

Sorghum is not new to California, being introduced into the state in 1847 as brown and white durra sorghums used as a source of drought tolerant animal feed. Since that introduction, sorghum in the US has evolved and several different types, used for a variety of applications have been bred and introduced to farmer's fields. These include hybrid grain sorghums, hay type sorghums referred to as sudans, sudangrass, or sudangrass x sorghum hybrids, sweet sorghums used for molasses or syrup production, grazing sorghums, hybrid forage sorghums used primarily for silage or greenchop, and more recently biomass sorghums as feedstocks for renewable fuels. Grain sorghum is well established as an excellent animal feed, but is also a gluten free cereal that can be used in human food systems. The other sorghums are used primarily as animal feed, but have been evaluated for their use as renewable feedstocks for biofuels. The following sections are synopses of various feeding guides put out by the US Sorghum Checkoff Program (see http://sorghumcheckoff.com/sorghum-markets/animal-nutrition/).

Grain sorghum

Cereal grains are typically used as energy sources for animals and sorghum is similar to barley, corn and wheat. Their particular uses are typically driven by local environmental conditions which influence yield potential and in some cases starch and protein contents. Sorghum grain is typically higher in crude protein than corn, but lower than barley or wheat and fiber is typically higher in sorghum and barley. Sorghum, if processed correctly, can be an effect source of starch for dairy cattle (Figure 3). Because of its unique protein matrix that surrounds the starch granules, processing is necessary to disrupt this matrix and make the starch more available. Normal processing methods of dry-rolling, grinding, steam-rolling, steam-flaking and pelleting can be used with sorghum; however, research indicates that particle size and/or further processing will increase the efficiency of starch availability in sorghum (http://sorghumcheckoff.com/sorghum-markets/animal-nutrition/).

Hay sorghum

Hybrid selection is extremely important for good hay production in which yield potential, regrowth, stalk size, and harvest flexibility are critical criteria for excellent overall yield production. Typically, hay should be harvest at around the boot stage to optimize quality. By harvesting earlier, stalks will be thinner which means easier conditioning, smaller windrows and more rapid curing. Moisture content is extremely important and high moisture can lead to bale overheating. To dry and the hay can lose leaf material and potentially reduce quality. Forage can be safely baled between 15-20% moisture content. Alta seed puts out an excellent guide for hay production (http://altaseeds.advantaus.com/sorghum-for-forage-field-guide/).

Forage/Silage sorghum

Forages are a complicated group of sorghums that range in types and uses depending upon hybrid selection (see http://sorghumcheckoff.com/wp-content/uploads/2012/06/westforageguideforweb092611.pdf for sorghum production guides for the Western States). Forage sorghums can be similar to grain sorghums and can be classified as dual-purpose if they produce good grain yields. They tend to be taller than typical hybrid grain sorghums. These forage types need some additional management in order to properly harvest them at the correct time and to also ensure that any grain is properly cracked to optimize the forage quality of the silage crop. There are also sorghum forages that will produce a flowering panicle with little grain production. There are also photoperiod sensitive sorghums that will not flower, remaining in a vegetative growth stage (stage 1-8 in Figure 1) throughout the growing season. The height of all these sorghums can be anywhere from 6 to 14 feet tall. Stalks can be thick or thin, juicy or dry, and in some cases quite sweet. Forages may also have the brown midrib trait that produces sorghum with less lignin and makes the plant more digestible; however, this can also lead to greater lodging issues. Newer genetics have brought into many of these bmr forages brachytic genes that shorten the internode length in sorghum and consequently provide great stalk strength and prevent some of the lodging associated with bmr sorghums. A summary of yield, agronomic traits and nutritional analyses are reported by types of forage sorghums grown in the two locations, Kearney and Westside in Table 1 (see http://sorghum.ucanr.edu/data/index.html for full reports from 2011-2014).

SUMMARY

Trying to adequately cover sorghums in terms of options for use in agriculture can be complicated, and understanding the differences in sorghum types is critical in making proper decisions for planting the correct sorghum for use in animal feed systems. Each has particular requirements, such as planting populations, irrigation requirements, fertility, and harvest dates to optimize both the yield potential and the quality of the animal feed. Done properly sorghum can be used in a wide range of feed programs without sacrificing feed quality and nutrition.

Table 1. Summary of key forage characteristics by type of forage grown at two locations, Kearney and Westside.

Sorghum Type[1]	% Lodging @ Harvest[2]	Tons/ac @65% Moist.[2]	% Crude Protein[2]	% ADF[2]	% NDF[2]	% Lignin[2]	% Starch[2]	% NDFd[2]	% IVTD[2]	Milk lbs/ton DM[2]	Relative Feed Value (RFV)[2]
PSBMR (3)	61.67 a	16.33 b	5.63 b	43.5 b	65.6 a	5.43 bc	4.00 b	54.85 a	70.30 b	2075.2 b	79.62 b
BMR (16)	27.60 b	18.01 b	7.31 a	39.0 c	59.7 b	5.15 c	8.16 a	57.04 a	74.31 a	2462.8 a	94.05 a
PSNonBMR (9)	26.94 b	21.36 a	4.66 c	46.2 a	68.4 a	6.69 a	3.05 b	45.30 c	62.29 c	1848.3 c	72.94 b
NonBMR (14)	24.21 b	18.63 b	5.98 b	40.0 c	59.8 b	5.74 b	9.03 a	50.11 b	69.96 b	2338.9 a	94.00 a
Trial Avg.	28.78	18.82	6.18	41.17	62.02	5.70	7.06	52.06	70.00	2262.2	88.47

[1]Number in parenthesis is the number of hybrids in each sorghum type. BMR = brown midrib, PS = Photoperiod sensitive.

[2]Means followed by the same letter do not significantly differ using LSD (P=0.01)

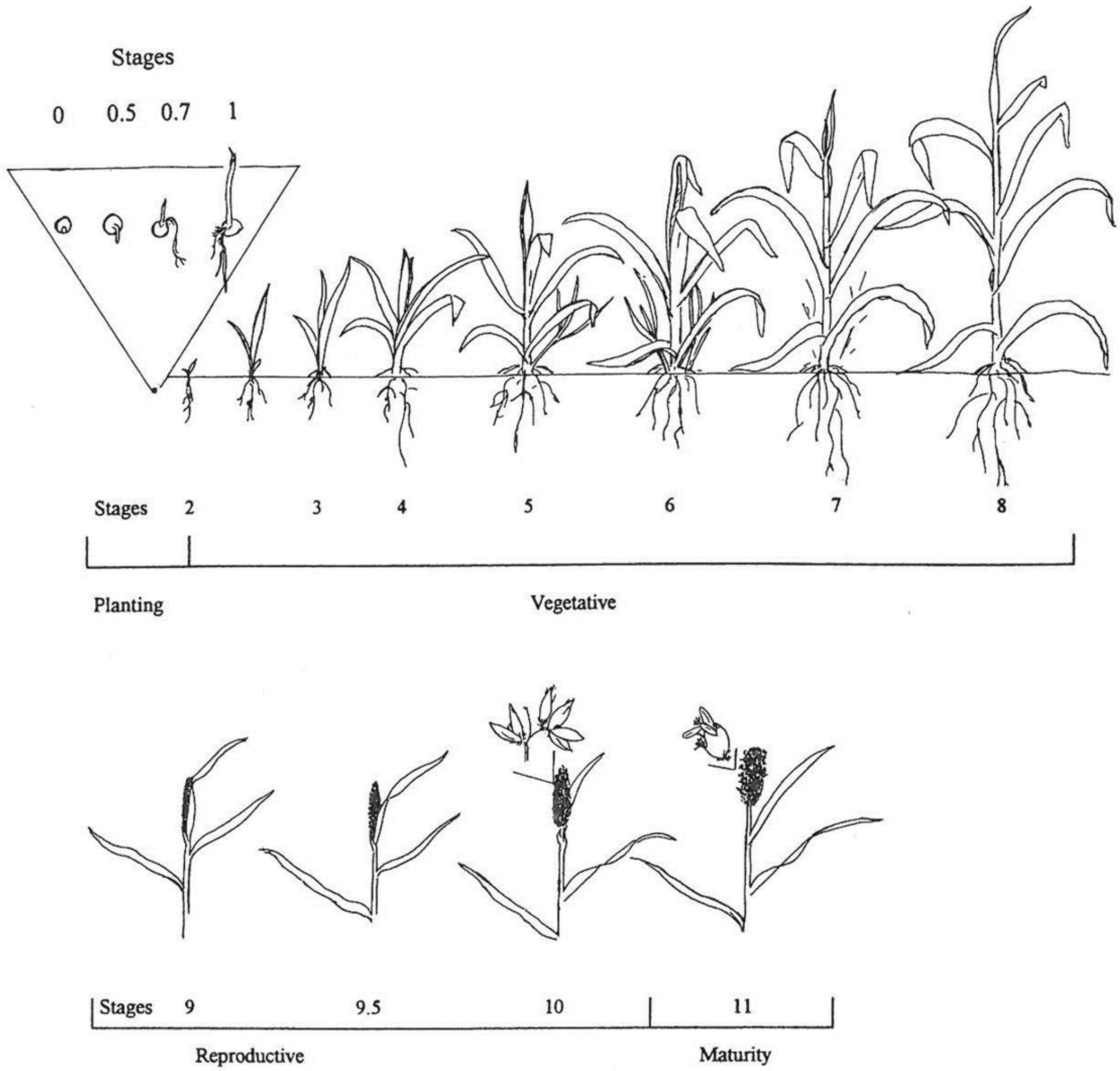

Figure 1. Growth stages of sorghum. Stages 0 through 1 planting, radicle emergence and coleoptile tip emergence; Stage 2, First leaf visible; Stage 3, Third leaf visible; Stage 4, Fifth leaf sheath visible; Stage 5, Start of tillering; Stage 6, Stem elongation; Stage 7, Flag leaf visible, whorl; Stage 8, Boot and end of vegetative stage; Stage 9 Panicle just emerging and free from whorl; Stage 10, Anthesis (50% of panicle flowering); Stage 11, bilk, early dough, late dough and black layer (physiological maturity with seed at approximately 30% moisture); Mature grain where seed is approximately 15% moisture and ready for harvest. (Courtesy K. Cardwell and modified by J. Dahlberg)

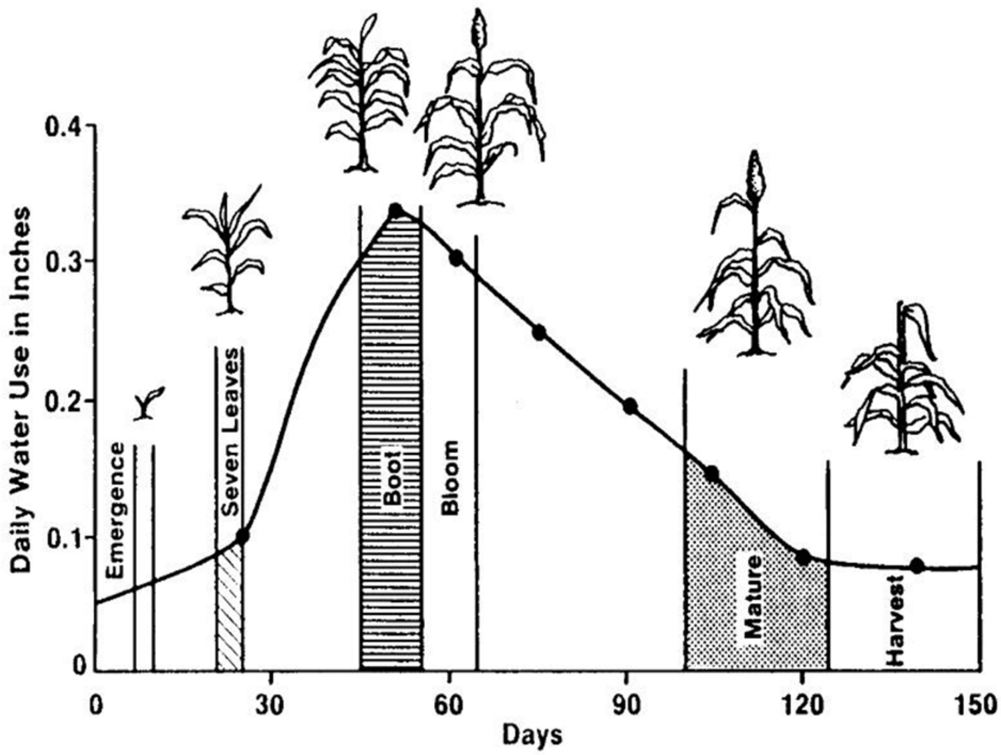

Figure 2. Daily use of water by sorghum throughout its different growth stages (Bennett et al., 1990.)

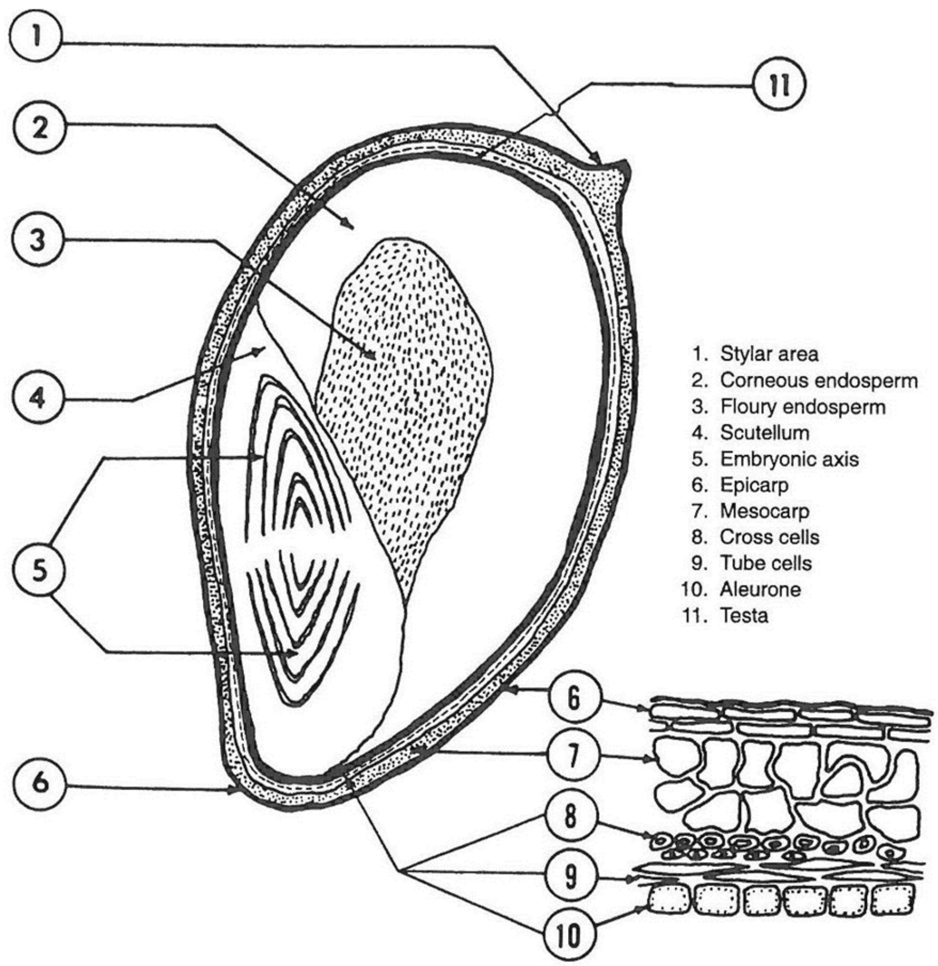

Figure 3. Makeup of the sorghum kernel (Curtesy O. Ziv).