UNITED SORGHUM CHECKOFF PROGRAM

Western Forage Production Guide

SORGHUM CHECKOFF

Welcome to the United Sorghum Checkoff Program's Western Forage Production Handbook. We have integrated research from various sources to produce an easy-to-use guide that can help farmers manage their crop more efficiently. Sorghum has tremendous potential to return a profit to your farm and the work of the Sorghum Checkoff will only improve that potential over time. As you manage your sorghum, keep these tips in mind:

- Make sure you are using the hybrid that works in your area and planting to get the right "yield per acre" in your field.
- Use an integrated weed management strategy.
- Most importantly, provide the crop with adequate fertilizer.

By following a few guidelines, you'll be amazed at what this crop can do for you. We strive to help you make sorghum more profitable for your operation. But remember, every situation is a bit different so contact your local county extension office, land-grant university or other area sorghum farmers to help you get the most out of this water-sipping crop.

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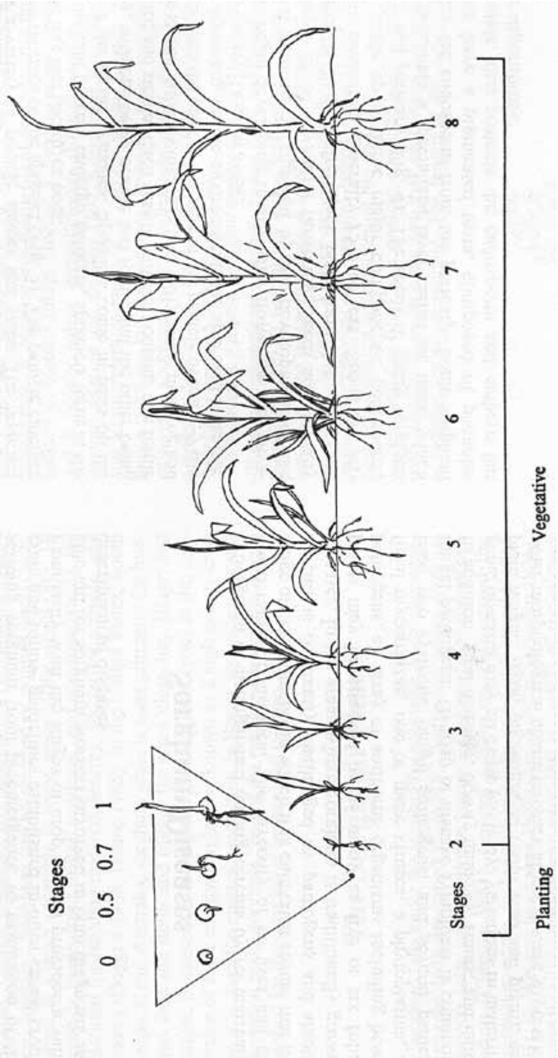
Growth Stages

It is important to understand the various developmental stages of sorghum since this understanding will assist in making irrigation and management decisions. The stages are based on key points of sorghum growth that are used to describe sorghum from planting to maturity.

Another common scale that is used among sorghum researchers is a more simplified growth scale. (Fig.1) GS1 would equate to stages 0-5 in this system. GS2 would represent from stages 5-10, and finally, GS3 would be from stage 10 to 11.5.

Comprehensive grain sorghum growth and development guides are available, such as Kansas State's "How a Sorghum Plant Develops" (http://www.oznet.ksu.edu, currently being revised with your sorghum checkoff dollars) and Texas AgriLife's "How a Sorghum Plant Grows," (http://agrilifebookstore.org). Either of these guides provides pictures of different growth stages, graphs of cumulative nutrient uptake relative to growth stages (KSU), or approximate heat unit requirements (base temperature 50ºF, maximum 100ºF) for attaining a particular growth stage (Texas AgriLife).

Refer to Appendix A, page 100, for more information about the sorghum plant.


Stages
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Stages
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Planting
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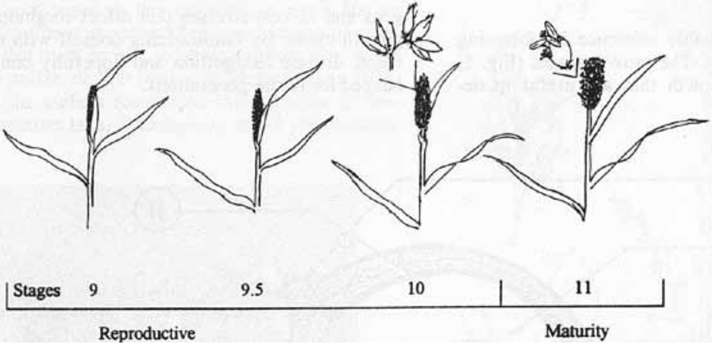


Fig. 1. Stages of sorghum growth: Stage 0: 0.0 planting; 0.1 start of imbibition; 0.5 radicle emergence from seed (caryopsis); 0.7 coleoptile emergence from seed (caryopsis); 0.9 leaf at coleoptile tip; Stage 1: emergence; Stage 2: first leaf visible; Stage 3: third leaf sheath visible; Stage 4: fifth leaf sheath visible; Stage 5: Panicle differentiation and start of tillering; 5.1 main shoot and one tiller; 5.9 main shoot and several tillers; Stage 6: stem elongation (late vegetative stage); Stage 7: flag leaf visible, whorl; Stage 8: booting (end of vegetative stage); Stage 9: panicle just showing, inflorescence emergence; Stage 10: anthesis (50% of panicle flowering); Stage 11: maturity; 11.1 grains at milk stage; 11.2 grains at early dough stage; 11.3 grains at late dough stage; 11.4 grains at physiological maturity (black layer, approximately 30% seed moisture); 11.5 mature grain (seed moisture approximately 15%). (Courtesy K. Cardwell). *For more information see Appendix A, page 65.*

A summary of sorghum growth and development is outlined below including:

- Key growth stages
- In-season management suggestions (fertility, post-emerge herbicide applications, irrigation)
- In-season insect activity, their potential effect on the crop, and scouting timing suggestions

Growth Stages	Description and Management Tips
Emergence	Coleoptile visible at soil surface. Coleoptile is the first leaf and is shorter than the later emerging leaves and has a rounded tip (leaf #1).
3-Leaf	Collar of third leaf is visible (once a leaf's collar forms the leaf no longer expands). This stage occurs approximately 10 days after emergence, depending on soil temperature, moisture, planting depth, etc. Slow emergence may lead to more injury from pre-emerge herbicides. Insects: Corn leaf aphids may infest the whorl and greenbugs may infest the leaves although not likely.
4-Leaf	Collar of fourth leaf is visible approximately 15 days after emergence.
5-Leaf	Collar of fifth leaf is visible approximately 20 days after emergence. May have lost 1st leaf (coleoptile) by this time. Plant is approximately 8 to 10 inches tall. Cool soil and air temperatures coupled with sunny days to this point may trigger more tillering especially for stands less than 3 plants per row-foot.

__Growing point differentiation (GPD)__

(In non-photoperiod sensitive varieties only)

This key growth stage and its importance are largely unrecognized and unappreciated by producers. The stage occurs approximately 30 to 35 days after emergence, perhaps a few days longer for full-season hybrids, and sooner for early maturity hybrids. It generally corresponds with the 7 to 8 leaf stage. Sorghum can tolerate significant stress from drought, hail, and even freezing temperatures prior to this stage, **however, stress at this stage can significantly impact yield.** Growing point is now above the soil surface, and the plant is approximately 12 to 15 inches tall. The plant may have lost one to three leaves from the bottom of the plant and is entering a period of rapid growth.

The maximum potential number of spikelets and seeds per spikelet is a major component of maximum yield potential and are determined over a period of seven to 10 days.

*Managemen*t: When applying midseason nitrogen in one application, ideally the N should be available in the root zone by GPD, and **irrigation, if available, is recommended to ensure that the growing point is not subject to moisture stress during GPD.** Both good fertility and moisture enhance GPD and the subsequent yield potential. Dryland producers can enhance GPD by applying N early and ensuring that plant population is modest so that each plant has sufficient moisture for good spikelet and seed set.

A note about brace roots, sorghum standability, and possible cultivation: Brace roots are key to sorghum's standability. If it appears brace roots are having trouble entering the soil (likely more common for sorghum planted on top of beds where the soil is hotter and drier), then cultivation may be needed to move soil around the base of the plant. If this must be done, ensure that any pruning of the expanding root system is minimized after 30 days.

Flag leaf visible

- Tips of the flag leaf (last leaf, which will be smaller) visible in the whorl.
- The last three to four leaves may not be fully expanded (collars visible).

Insects: Greenbug population may begin to rapidly increase.

Boot

- Leaf collars of all leaves now visible.
- Sorghum head is enclosed in the flag leaf sheath.
- Potential head size has been determined closer to GPD.
- Peduncle is beginning to elongate.
- Stress at this time will reduce the length of the peduncle.

Management: Maximum water use occurs at this stage. Crop will respond very favorably to irrigation at this stage. Historically, this stage of growth is the optimum time to apply limited irrigation if crop is stressed. If you delay up to

20% of N past GPD, the final N should be applied within 60 days of planting or mid-boot, whichever comes first.
Insect: Corn leaf aphids begin to decrease. Greenbugs may be approaching an economic threshold.

Heading

- 50% of the plants in the field have visible heads.

Insects: Greenbugs may be at economic threshold levels.

Flowering

- Occurs when 50% of the plants are in some stage of bloom.
- A plant is considered to be flowering when bloom progresses half way down the head.
- Peduncle is rapidly elongating.
- Flowering occurs over a four to nine day period.
- Stress or herbicide drift can lead to blasted heads.

Insects: Greenbugs may continue as a problem, and mummies may be present. Begin checking for headworms. Sorghum midge potential should be evaluated.

Soft dough

- Grain can be easily squeezed between the fingers.
- Eight to 12 functional leaves remain.
- One half of grain dry weight has accumulated.

- An early freeze will result in shriveled light grain.
- Susceptible to bird damage.

Insect: Greenbugs may continue as a problem. Mummies should be increasing. Continue to check for headworms.

Note: Harvest sorghum for silage between soft dough and hard dough.

Hard dough

- Cannot squeeze grain between the fingers.
- Three-fourths of grain dry weight has accumulated.
- Water stress during grain fill may cause lodging.

Insect: Greenbugs and headworms should be on the decline.

Black layer

- Dark spot appears on the tip of the kernel.
- Maximum total dry weight is achieved.
- Depending on the heat, an individual seed from flower to black layer is typically 30 to 35 days, but could stretch to 40 days or more in prolonged cool fall conditions.
- Sorghum maturation slows significantly once nighttime temperatures drop below 45°F.
- Grain is 25 to 35% moisture.

Hybrid Selection

Warm-season, annual grasses, specifically forage sorghums (*Sorghum* sp.), have the potential to produce large amounts of nutritious forage during summer months, and their inherent versatility allows them to fit into many different types of cropping or livestock operations. Sorghums may be particularly useful in regions with high concentrations of beef and dairy cattle. They fit well into dryland and limited irrigation situations because of their tolerance to drought; it is in these systems that sorghums may have the greatest potential. If managed properly, they make excellent hay for supplemental feeding during times of inadequate forage production. Another advantage is that they can be used as an emergency, late-planted crop to replace a primary crop that has been damaged by wind, hail or drought early in the growing season. Perhaps the greatest advantage of forage sorghums is the diversity of management options that the grower has to choose from in order to match his production needs. Depending on which species and variety selected, sorghums may be used for grazing pasture, hay production, and silage and green-chop. Their ability to tiller and regrow after cutting or defoliation makes them ideal for multiple cut hay crops and grazing situations. **The focus of this publication will be on growing sorghum forages specifically for the end-use of silage.**

Sorghum grown for silage in the Great Plains has increased in popularity in recent years due to the development of better quality varieties and the need to produce silage under limited irrigated conditions. In general, sorghums are warm season, coarse, erect grasses that vary in height from 2.5 to over 14 feet. Growth is favored by long days and warm temperature, with 77 to 86˚F being ideal. In the Great Plains, rapid growth will occur from mid-June to mid-September. Sorghums have the ability to tolerate significant moisture and high temperature stress. This characteristic makes them desirable for use in situations with inconsistent or lengthy, intermittent watering and dryland conditions. Almost all sorghums will tiller under favorable growing conditions to fill in open spaces between plants or to compensate for poor seed germination or plant establishment, loss of the main stem due to grazing, hail, pests or even mechanical injury.

The sorghum species that is generally considered for silage, is forage sorghum, however, grain sorghum and sorghum-sudangrass hybrids may be considered for silage and are briefly described below:

Grain sorghum hybrids were developed specifically for grain production. These are generally 3.0 to 5.5 feet in height, with large diameter stalks that resist lodging, and have compact grain heads with relatively large seed. Sorghum breeders have strived to increase the ratio of grain to stover. Because of their high grain content grain sorghum hybrids tend to make good quality silage, however, silage yield will be less than what can usually be obtained with forage sorghums. Occasionally, the high grain to stover taller grain hybrids are preferred for silage by dairies.

Sorghum-sudangrass hybrids are a cross between sorghum and sudangrass and are characterized by relatively small diameter stems, high tillering capacity, rapid re-growth potential and low grain yield. Sorghum-sudangrass hybrids can produce good quality silage, but are best suited for grazing or hay production. Heads of sorghum-sudangrass have an open panicle very similar in appearance to Johnsongrass.

Forage sorghum hybrids come in an array of characteristics. In general, forage sorghum hybrids are similar to grain sorghum, but are taller, leafier, and may produce less grain. Forage sorghums can range anywhere from 6 to 14 feet in height. Stalks are usually large in diameter and some may contain a sweet juice. Seed heads may have a more open panicle with smaller seed than grain sorghum. Milking and feeding trials have shown that forage sorghum silage can be equal to corn in milk production and cattle gain. One distinct advantage of forage sorghum over corn is that it requires significantly less water.

When choosing a variety for silage production both yield and quality should be considered.

There is wide variability in dry matter yield and nutritive value among forage sorghum types. Which of these factors is emphasized will depend on how the silage is to be utilized. For lactating cows, quality will likely be the most important consideration. However, for dry cows, or even in the feedyard, yield may be more important, particularly if acreage to grow the silage is limiting. Agronomic characteristics such as potential for lodging or days to maturity may also be important factors.

Although dependent upon many environmental and management conditions, productivity of forage sorghum, if managed properly, can be as feed-valuable as corn. Yield, quality and agronomic characteristics of forage sorghums will vary considerably compared to what is typically observed in corn. This makes the choice of variety a very important decision. Four types of forage sorghum are currently marketed. Each has its own advantages and disadvantages. The four types are: conventional, brachytic dwarf, brown midrib (BMR) and photoperiod sensitive (PS).

Conventional forage sorghums have been grown for years. Some of the newer varieties are capable of producing grain yields comparable to that of grain sorghum. These when short enough for combining, can be considered dual-purpose in that they can be harvested for either grain or forage. Typically, silage sorghums are 6 to 10 feet in height. Quality can be variable, but there are some conventional varieties with excellent quality. In general, as the grain yield is increased in conventional forage sorghums so is the digestibility or energy value of the silage.

Brachytic dwarf forage sorghum as the name implies are generally shorter than conventional varieties being less than 6 feet in height (Photo 1). They are characterized by short internodes giving the plant a leafy lush green appearance. These varieties are new and little testing has been completed in university trials. However, it is expected that overall quality will be improved as a result of the higher leaf to stem ratio compared to conventional forage sorghum. Varieties are available that combine the brachytic dwarf and BMR traits.

BMR silage sorghums (brown midrib) get their name from the expression of a brown midrib trait on the leaf (Figure 2). Some varieties will also exhibit a brown stalk pith. Much interest has been generated in recent years by the introduction of sorghum plants containing the BMR trait. What is important about these varieties is that they have less lignin content than conventional sorghums. Lignin is the primary indigestible component of many forages and significantly reduces digestibility within animals consuming the plant material (leaves and stalks). Lowering the lignin content increases the overall digestibility of the fiber component of the forage, and

*All *Photos found in Appendix B, Page 103.*

thus improving overall quality. As a result, some sorghum varieties now have energy values equal to that of corn, and acceptance among feeding industries that require high energy (i.e., dairies) is growing. Research suggests that the BMR trait can lead to reduced dry matter yield and increased lodging. However, these problems are variety specific and certain cultivars perform better than others. The main issue associated with less lignin content is increased lodging potential. This potential problem however, can be compensated for with appropriate management practices. All of the BMR varieties currently on the market were developed from one of three chemically induced mutants labeled BMR 6, BMR 12 and BMR 18. There has been much debate between seed companies on the best source for the BMR trait. While some general inferences of the BMR source can be made in relation to yield, quality and agronomic characteristics, the over riding consideration in choosing a variety should be based on the traits of that particular variety rather than the source of the BMR trait.

PS forage sorghums(photoperiod sensitive) sorghum is characterized by tall growth and large dry matter yields. PS varieties will stay in the vegetative stage of growth until day length is less than 12 hour and 20 minutes. For much of the Great Plains this means these varieties are unlikely to produce a head before a hard freeze kills the plant. These varieties are capable of producing high yields and can reach heights of 14 feet or more (Photo 3). These varieties should be used primarily for grazing or hay production, or possibly as green chop. The problem for using these as silage is that their quality is not up to par with other sorghum types, and their moisture level at harvest is usually too high for proper ensiling.

Comparison of Forage Sorghum Types for Silage. If high yield is the goal, conventional forage sorghums on average will yield higher than BMRs. Table 1 is a summary of six years of data collected from variety trials at the Texas AgriLife Research station near Amarillo, Texas. BMR forage sorghum varieties yielded 3.4 ton per acre less than the conventionals. Stability of yield across environments appears to be more stable with conventionals. In 10 years of irrigated variety testing in the Texas Panhandle, in hot dry years an even greater difference between conventional and BMR forage sorghum yields has occurred. However, keep in mind that these are averages across varieties. Each variety, regardless of its type, should be examined on its own merits. Drawing conclusions about any particular variety based on the average of a group of sorghums can lead to poor decision making. There is a considerable amount of overlap in the range of yields between conventional and BMR varieties (Table 1). When possible, examine results from state university variety trials to get unbiased information on specific variety performance.

When choosing a variety for quality, three forage characteristics are often examined by nutritionists. These are neutral detergent fiber (NDF), acid detergent fiber (ADF), and in vitro true digestibility (IVTD). NDF represents all the fiber found in forage (cellulose, hemicellulose, lignin and heat-damaged protein). This NDF fiber is partially digestible and is positively correlated with bulk density making it useful for predicting feed intake. Lower NDF typically means greater intake. The ADF fraction represents all of the fiber components of NDF except hemicellulose. It is generally assumed that the lower the ADF of a particular forage, the greater the digestibility, and thus the greater the quality or energy value. The % IVTD is determined by digesting a small sample of forage in rumen fluid. Percent IVTD is considered the best analysis for predicting forage digestibility and cattle weight gain or milk production without actually feeding it to the animal. In Table 1, when averaged across years and varieties, percent ADF and NDF were about 2 percentage points lower in the BMR varieties compared to the conventionals, suggesting better quality with the BMRs.

Table 1. Comparison of Conventional and BMR Forage Sorghum

Characteristic		Sorghum Type: Conventional	Sorghum Type: BMR
Silage, Ton/Ac @ 65% Moist.	Mean	24.1	20.7
	Range	18.3-33.3	16.5-24.0
C. Protein	Mean	7.2	7.8
	Range	5.5-8.6	28.-8.5
NDF, %DM	Mean	47.7	45.4
	Range	39.8-59.6	42.3-56.2
ADF, %DM	Mean	28.6	26.9
	Range	24.5-36.5	24.7-33.4
IVTD, %DM	Mean	75.9	81.0
	Range	67.7-82.1	76.3-84.0

*Data collected from six years of variety trials at Texas AgriLife Research, Bushland, TX.

Difference in digestibility is even more dramatic when the % IVTD is examined. IVTD was approximately 5 percentage points higher in the BMR varieties. It is also important to note that for any given ADF or NDF value, the % IVTD will be higher for a BMR variety than for a conventional variety. This is best illustrated in Figure 4. This relationship difference should be taken into account when selecting a forage sorghum variety based solely on % ADF or NDF.

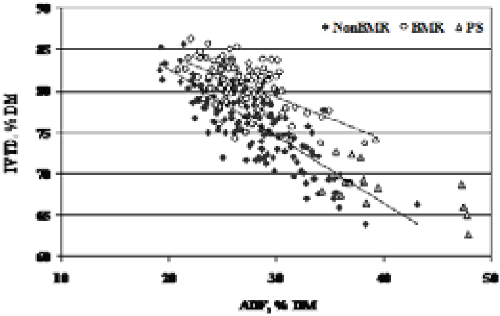


Figure 4. Acid detergent fiber (ADF) and in vitro true digestibility (IVTD) relationship for pre-ensiled conventional (non-BMR), brown midrib (BMR), and photoperiod-sensitive (PS) forage sorghum varieties. McCollum et al., Proc. Plains Nutrition Council. 2005).

It is often assumed that a high grain yield is necessary for forage sorghum to produce high quality forage. While this tends to be true with conventional forage sorghums, it is not true with BMRs. Research has shown that BMRs can have a very low percentage of grain in the silage, yet be very high in quality. In Figure 5, the percent grain in pre-ensiled forage was compared to the IVTD of the pre-ensiled forage sorghum. IVTD of the conventional forage sorghums increased quadratically and plateaued at 78% IVTD at 34.5% grain. In contrast, in the BMR forage sorghums, IVTD plateaued at 80.8% IVTD when grain content was 2%.

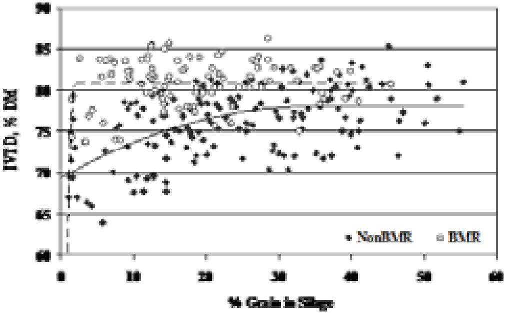


Figure 5. Grain content and in vitro true digestibility (IVTD) relationships for pre-ensiled conventional (non-BMR)and brown midrib (BMR),forage sorghum in four years of variety trials (Texas AgriLife Research, Amarillo, TX). McCollum et al., Proc. Plains Nutrition Council. 2005.

<u>Lodging</u> is a concern of many producers, particularly with BMRs. Both BMR and conventional forage sorghums can potentially lodge, but some varieties have better standability than others. The degree of lodging will be dependent on the environment (e.g., wind, soil type, etc.) and genetics but can be influenced by cultural practices such as seeding rate and nitrogen fertilization that will be discussed later. Some of the first BMR forage sorghum varieties marketed in the late 90s lodged much more often and at a greater severity level than conventionals. This tended to give all BMRs a bad reputation for lodging. However, more recently developed BMR varieties lodge no worse than their conventional counterparts when managed using the correct cultural practices. In fours years of variety trials conducted by Texas AgriLife Research near Amarillo, lodging was no worse with the BMR varieties compared to conventionals (Figure 6). There was no significant lodging with most of the varieties. Those varieties that did lodge consisted of both conventional and BMRs. **One key to limiting lodging is timely harvest. BMRs are more likely to lodge if harvest is delayed past the optimum harvest time for silage.**

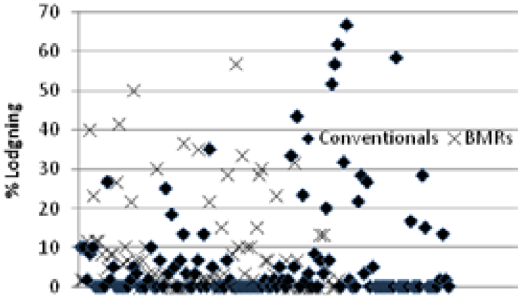


Figure 6. Percent lodging of conventional and BMR forage sorghum in four years of variety trials (Texas AgriLife Research, Amarillo).

Planting

Although forage sorghums can be broadcast or drilled, most are planted in rows with a planter in a similar fashion to corn, for ease of harvesting with silage equipment and weed cultivation. Planting in July can result in good yields in certain regions of the plains, and may allow for more flexibility in double cropping systems. Early maturing varieties should be used in late-planted situations to ensure that maximum tonnage (at soft dough) can be achieved before a freeze. Planting too early can result in non-uniform and poor stands because of low soil temperatures. Rather than using a calendar date for determining when to plant, it is best to base planting decisions on soil temperature. **The recommended soil temperature for rapid germination is 60°F or higher (at 6 inches deep for 10 days)**. However, earlier planting at 55°F is possible, but it runs the risk of delayed emergence and damage to the crop from late freezes. Sorghum is less tolerant of cool temperatures than corn. **The desired planting depth for sorghum is ¾ to 1½ inches**; planting deeper may lead to poor emergence and weak seedlings. Like most crops, a well-prepared, firm seedbed is necessary for proper seed-soil contact and subsequent good germination and establishment. In dryland situations, making sure that all or most of the seed is planted into moisture will help ensure uniform germination and emergence of the stand (i.e., fewer skips and late-emerged plants).

Seeding rates will vary depending upon intended use, row spacing, seed size and irrigation (Table 2). There is a broad range of number of seeds in a pound of forage type sorghums. Most forage sorghums range between 12,000 and 22,000 seeds per lb. Hence, it is perhaps better to use number of seeds per acre for estimating planting rates rather than using number of pounds per acre. In general, recommended rates range from 30,000-120,000 seeds per acre, depending on sorghum type, row spacing and anticipated irrigation amount (Table 2). Research in eastern New Mexico and the Texas Panhandle has shown that excellent silage yields can be obtained with irrigation from seeding rates as low as 75,000 seeds per acre (Figure 7); and little (if any) advantage has been seen with seeding rates over 120,000 seeds per acre. Narrow row spacing (6-20 inches) will require a higher seeding rate than wider row spacing (greater than 20 inches). If higher rates are used, competition of plants within a row will result in fewer established plants overall. In contrast, if lower rates are used, individual plants will tiller more extensively and will fill in the spaces within and between rows. Many growers underestimate the ability of sorghum to compensate for low seeding rates and will unnecessarily increase their production costs by planting at higher rates. Tillering, stem size, and leaf size at what seems to be somewhat lower plant populations can do an adequate job of compensating for gaps in the stand (even if due to poor emergence). If irrigation is limited, seeding rates should be reduced

Research has shown that lodging potential of forage sorghum will increase with higher seeding rates. Use the lowest seeding rate possible to reach the desired yield goal. Because of the increased concern of lodging with BMRs, it is recommended that under irrigation seeding rates

Table 2. Generalized seeding rated for Forage Sorghum Grown for Silage Based on Anticipated Irrigation applied.

Forage Sorghum Type	Irrigation Acre inches	Planting Rate 1000 seeds per acre
Conventional (non-BMR)	0	30-50
	4-5	50-90
	9-18	90-120
Brown Mid-rib (BMR)	0	30-50
	4-8	50-75
	9-18	75-100

Dryland seeding rates should be one-half or less of those for irrigated.

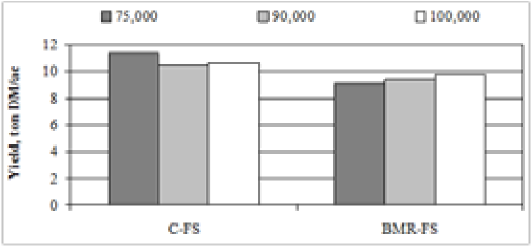


Figure 7. Yield of conventional (C-FS) and BMR (BMR-FS) at three seeding rates over 2 years (NMSU Agricultural Science Center at Clovis).

be reduced compared to conventional types. Planting at lower rates will increase individual stalk size and reduce the incidence of lodging. While large stems in conventional cultivars may adversely impact forage quality, it is suggested that the reduced lignin in BMRs will offset the negative effects associated with larger stems. Since BMRs are more digestible, stem diameter is much less of a concern. Your local seed dealer or Extension specialist may be able to provide proper seeding rates that are recommended for specific varieties as they relate to your production goals and growing conditions. Although forage sorghums are not the most desirable for growing hay, if used for this purpose, seeding rates should be higher than those recommended for silage in order to decrease stem size and drying time.

Irrigation

One of the advantages to growing forage sorghum for silage is that it is more drought and heat tolerant than corn and requires less water. Although forage sorghum will reach physiological maturity and can produce good yields in dryland situations, under most conditions irrigated forage sorghum will yield more than twice as much as non-irrigated. Forage sorghums have the potential to produce as much, and in many cases more dry matter than corn when grown with the same amount of water. Fully irrigated forage sorghum will require approximately 30% less water than corn. This makes it a good alternative to corn in those areas where precipitation is scarce and water for irrigation is limited (e.g., declining well capacities). In addition to the advantage of a later planting date, forage sorghums have the ability to maintain high yields under water stress conditions and resume growth after drought.

Evapotranspiration (ET) is the preferred method for measuring and estimating the total crop water use and the irrigation demand of a crop. ET is a measure of the amount of water evaporated from the soil and the water that transpires through the plant. ET values for sorghum can be obtained locally through extension services and in most agricultural regions, online through weather station networks such as http://agweather.mesonet.

org in Oklahoma, http://txhighplainset.tamu.edu/ and http://texaset.tamu.edu/ in Texas, http://wdl.agron.ksu.edu/ in Kansas, http://weather.nmsu.edu/ in New Mexico, etc. Over the 10 year period from 2000-2009, the peak daily sorghum ET was approximately 0.33 inches at the USDA Conservation and Production Research Laboratory at Bushland, Texas. Forage sorghum water use commences at planting (May-June), peaks during late July and early August, and continues through harvest. Under fully irrigated conditions, seasonal forage sorghum ET is 20-25 inches in the Southern Great Plains.

Under limited irrigation conditions, timeliness of irrigation becomes critical. In dry conditions, sorghum establishment nearly always improves with a 1 inch irrigation applied at planting. Once plants are established, key irrigation times are 35 days after emergence when the immature seed head is beginning to form, during the boot stage and during early grain fill. Forage sorghum reaches its maximum daily water use requirement during heading and early grain fill. The most significant sorghum yield response from irrigation occurs during sorghum's rapid growth stage, or the 50-day period encompassing 35 days after emergence, through early grain fill. A producer targeting maximum forage yield should be prepared to irrigate 6 to 8 inches or more during this period, depending on seasonal rainfall. Few producers will have the irrigation capacity to meet the daily water requirement during peak water usage (Table 3). During these times, plants must depend on stored soil moisture or they will stress to some degree. For this reason, producers should plan to have the soil profile thoroughly wet prior to sorghum heading. This will prevent sharp reductions in yield from occurring due to drought, high temperatures, or even problems with irrigation equipment during this time. In low capacity irrigation scenarios, preference should be given to the key growth stages stated above. It is particularly important that water stress be avoided prior to and during the boot stage. Reduction in potential yield during this time cannot be overcome with adequate or excess water later in the growing season.

The 40 day period following the boot stage, the reproductive stage, is important in maintaining yield and harvesting a high quality feedstock. Ensuring that the plants do not stress during these times will preserve grain yield potential; thereby leading to a maximum amount of grain content in the silage. This will increase yield as well as improve silage quality. Foliage mass no longer increases once the plant has reached the reproductive stage.

	Inches Applied					
GPM/Acre	Daily	Weekly	30 Days	45 Days	60 Days	90 Days
2	0.11	0.74	3.2	4.8	6.4	9.5
2.5	0.13	0.93	4.0	6.0	8.0	11.9
3	0.16	1.11	4.8	7.2	9.5	14.3
3.5	0.19	1.30	5.6	8.4	11.1	16.7
4	.021	1.48	6.4	9.5	12.7	19.1
4.5	0.24	1.67	7.2	10.7	14.3	21.5
5	0.27	1.86	8.0	11.9	15.9	23.9
6	0.32	2.23	9.5	14.3	19.1	28.6
7	0.37	2.60	11.1	16.7	22.3	33.4
8	0.42	2.97	12.7	19.1	25.5	38.2
9	0.48	3.34	14.3	21.5	28.6	43.0
10	0.53	3.71	15.9	23.9	31.8	47.7S

Table 3. Depth of Irrigation Water Applied at Verious Irrigation System Capacities

When to terminate irrigation is an area of debate. For the most part, forage sorghums do not dry down in a predictable manner like corn. Rain or irrigation late in the season can cause plants to continue to take up water and maintain high whole-plant moisture, even beyond the soft-dough stage of grain maturity. Because of this potential delay in dry down, it is recommended to terminate irrigation several days to two weeks prior to anticipated harvest, especially if soil moisture status is good.

Variety selection is very important in achieving end-product goals with forage sorghum and will dictate late season water management strategies. Fully irrigated BMR forage sorghum silage will yield about 1.1 tons per acre (65% moisture) per inch of total water used by the crop. This includes water supplied by irrigation, rainfall and stored soil water. Conventional, non-BMR forage sorghum would be expected to yield 1.1 to 1.3 tons per acre per inch of total water used. When estimating how much irrigation water will need to be supplied, producers need to keep in mind that this will vary greatly depending on the efficiency of the irrigation system, available soil moisture, amount and timeliness of rainfall and other environmental factors such as daily relative humidity, temperature, wind speed, etc. Forage sorghum silage demonstrations in the Texas Panhandle and research in New Mexico have shown responses to irrigation water to range from 1.1 to 3.3 tons per acre-inch of water applied. Average response has been 1.5 tons per acre-inch of irrigation water. Assuming this average, a yield goal of 26 tons per acre would require about 17 inches of irrigation. Again, keep in mind this can vary considerably depending on stored soil moisture, in-season rainfall, temperatures, etc.

Depending on location and weather patterns, in-season precipitation is typically a part of the water budget of forage sorghum, despite seasonal variations in quantity and timing. Although difficult to manage, the return on in-season precipitation can be optimized. In regards to irrigation scheduling, in-season precipitation should be evaluated on an "effective rainfall" basis. Research has shown that only a portion of the water received during a precipitation event will actually become useful to the sorghum crop. To avoid overestimating water received from precipitation, a producer should only credit precipitation events greater than 0.30 inch, or the peak daily sorghum ET. Consideration should be given to forgoing or delaying irrigation only if a precipitation event is larger than the scheduled irrigation depth or exceeds soil holding capacity. The benefit of in-season precipitation can often be redeemed at the end of growing season by terminating irrigation earlier with sufficient water stored in the soil profile.

Nutrient Management

Fertilization of forage sorghum should be similar to that of corn grown for silage. Although sorghums will grow on infertile, low and high pH soils, they respond well to increased fertility, and growth is optimized at pH levels of 6.0-7.0 on well-drained soils. Regional observations indicate that sorghums, in general, do not perform well on high pH (greater than 7.5), sandy soils that are shallow and high in calcium carbonate (e.g., caliche soils). Plants on these soils are often chlorotic (iron and/or zinc deficient) and low yielding. Fertilizer inputs should always be based on soil test results for a given field and will vary from one situation to the next. Forage sorghums will remove large amounts of nutrients from the soil, so it is imperative that producers test their soils frequently in order to accurately assess their fertilizer needs. Nitrogen (N) requirements are dependent upon expected yield. For high-yielding environments under irrigation, N requirement may be as high as 240 lb. N per acre. Under dryland conditions, little, if any, N fertilizer may be required. **A general rule of thumb is that 8-9 lbs. N will be used for every ton (wet) of silage produced; however, excellent yields have been obtained with as little as 6.5 lbs. N per acre per ton of expected yield.** Residual N in the soil associated with previous crops and inputs (e.g., legumes, manure) should be factored into fertilizer calculations. At high rates, nitrogen applications should be split (e.g., pre-plant and layby) for uniform utilization of the fertilizer. **Research suggests that in addition to reduced seeding rates, excess N should be avoided in BMR forage sorghums in order to reduce the incidence of lodging.** In the absence of a soil test, general recommendations for phosphorus (P) and potassium (K) are 30 to 80 lbs. per acre of each at planting; however, yield responses to these fertilizers may be minimal if soil levels of P and K are medium or higher. Phosphorus oftentimes is limiting, particularly in highly calcareous soils where levels of available P are low. Soil tests indicating P levels lower than 20 ppm (Olsen-P) will likely require a P fertilizer application. The general P recommendation for forage sorghum is 2.75 to 3.25 lbs. P_2O_5 per acre for every ton of expected yield. Regional soils are often adequate in K, and rarely is any benefit of adding K reported. However, silage crops tend to extract large amounts of nutrients including K; therefore, the likelihood of encountering a K deficiency is increased in high production silage systems grown year after year. Zinc, especially in crops such as sorghum and corn, can be deficient and applications (5 to 8 lbs. Zn per acre) are often recommended if soil tests indicate a 'low' (less than 0.5 ppm DTPA) condition.

Table 4.
Price of Common Nitrogen Fertilizers in Dollars per Pound of Nitrogen For Various Amounts of Nitrogen

		Cost per Ton										
Nitrogen Fertilizer	**Percent of N**	**$250**	**$300**	**$350**	**$400**	**$450**	**$500**	**$550**	**$600**	**$650**	**$700**	**$750**
Anhydrous Ammonia (NH3)	82%	0.15	0.18	0.21	0.24	0.27	0.30	0.34	0.37	0.40	0.43	0.46
Urea	46%	0.27	0.33	0.38	0.43	0.49	0.54	0.60	0.65	0.71	0.76	0.82
UAN (32-0-0)	32%	0.39	0.47	0.55	0.63	0.70	0.78	0.86	0.94	1.02	1.09	1.17

Weed Control

Weeds compete with forage sorghum for light, nutrients, soil and water and can harbor insects and diseases that affect yield and quality. Some broadleaf weeds like pigweed and kochia tend to accumulate large amounts of nitrate in their stalks when stressed. These high nitrate level stalks can end up in the silage. In addition, Johnsongrass may produce high levels of prussic acid (hydrogen cyanide).

Because few herbicides are labeled that can be used in forage sorghum, it is critical that weeds be controlled prior to planting. Weeds left uncontrolled during any fallow period will use up valuable soil moisture that could be stored for later use by the crop. Control weeds either by tillage or with herbicide application. If a residual herbicide is used, check the label to determine when sorghum can be planted after the application. During the fallow period, atrazine can be a good choice for broadleaf weed control. However, keep in mind that some weeds have developed resistance to atrazine.

Once forage sorghum is planted, few herbicide options are available. Yield loss will be the greatest when weeds emerge with the crop or soon afterwards. The most critical period for weed control is the first four weeks after planting. If weeds are controlled during this time, and control is maintained through the remainder of the season, little reduction in silage yield will occur. Yield reduction from weeds that emerge four weeks after planting is usually minimal. Annual grasses generally do not reduce yield as much as broadleaf weeds, but are more difficult to control.

Herbicide Options:

Pre-emergence Weed Control. Currently only two herbicide active ingredients are labeled for pre-emergence use in forage sorghum: atrazine and metolachlor (or s-metolachlor). These are sold either alone or in combination with each other (Table 5). Atrazine will control many annual broadleaf weeds and is relatively inexpensive. Restrictions and rates of atrazine use vary considerably depending on state/local requirements. Closely examine the label for use in any particular field. Generally, atrazine should only be applied prior to sorghum emergence in medium or fine textured soils at reduced rates, or crop injury can occur.

For pre-emergence grass control, metolachlor is the only option and should be used. Metolachlor will control most annual grasses. If grass population is very high, some escapes may occur, but this is currently the best option available for grass control in forage sorghum. The effectiveness of control will depend on the specific grass species as well as other factors. Sorghum seed MUST be treated with Concep II safener to avoid significant crop injury. Seed companies will apply Concep II to forage sorghum seed when asked. Although this will add to the seed cost, it is well worth it to control grass weeds. Both atrazine and metolachlor require a minimum of 0.5 inches of rain or irrigation to move into the soil to effectively control germinating grass seed. An alternative to rain or irrigation is to incorporate the herbicides with a rolling cultivator prior to grass emergence. However, care must be taken to avoid damaging the forage sorghum.

Post-emergence Weed Control. Although more herbicides are available for post-emergence control of broadleaf weeds compared to pre emergence, options are still limited. Atrazine can be applied post-emergence and is effective on small weeds while providing soil residual to control later weed flushes. Atrazine should always be applied post emergence with crop oil before the sorghum reaches 12 inches in height. The smaller the weeds, the better the control will be. Other herbicides to consider are listed in Table 5. All of these can be used in combination with each other or with atrazine. 2,4-D and dicamba have been used for decades for broadleaf weed control. However, these must be applied correctly or severe crop injury can occur. These should only be applied to sorghum that has not exceeded 8 inches in height. Drop nozzles that keep the herbicides out of the whorl of the sorghum can be used up to 15 inch sorghum. Care should be taken to minimize drift of 2,4-D and dicamba or damage to other broadleaf crops (e.g., cotton) and ornamentals can occur. Check label for rates, application timing and other restrictions.

Perennial Weeds. Johnsongrass and bindweed are the two perennial weeds that cause the most problems in forage sorghum. Prevention is the best method of control with these weeds. As soon as either weed is detected, producers should do everything possible to prevent their spread. Do not run tillage equipment through isolated spots of these weeds. Tillage will tend to spread the weeds to other parts of the field. Diligent spot treating with glyphosate (e.g., Roundup) for Johnsongrass, and dicamba, 2,4-D, glyphosate and even some soil sterilants for bindweed control, will be required to eradicate these two weeds. For Johnsongrass that is already widespread, the best control method is to allow the Johnsongrass to emerge prior to sorghum planting. Once the Johnsongrass has about 6 inches of growth, treat it with glyphosate. Sorghum should then be immediately planted with as little disturbance of the treated Johnsongrass as possible. Although this will not provide season long control, it will allow the sorghum to grow with very little Johnsongrass competition during the critical four weeks after planting. The glyphosate treatment procedure outlined for Johnsongrass can also be effective on bindweed. In addition, early in-season treatment of 2,4-D or dicamba should be considered.

New Advances. Some very promising new herbicides for both broadleaf and grass control will soon be on the market. Continue to check with herbicide dealers and the extension service for information about new products.

Other Information. Herbicide labels are constantly being updated. Before using any herbicide, check the label for specific use under your conditions. Most state extension services provide updated herbicide lists and specific weed control recommendations.

Table 5. Herbicides labeled for Use in Forage Sorghum by Active Ingredient (common trade names).

Pre-emergence:	
Atrazine (AAtrex, atrazine)	Broadleaf weed control.
Metolachlor or S-Metolachlor (Dual II Magnum, Cinch, Parallel, Me-Too-lachlor)	Good annual grass control. Must use Concep II treated sorghum seed.
Atrazine + S-Metolachlor (Bicep II Magnum, Cinch ATZ)	Broadleaf weed and grass control. Must use Concep II treated sorghum seed.
Post-emergence:	
Atrazine (AAtrex, atrazine)	Effective on most broadleaf weeds and ill provide soil residual econtrol. Apply with crop oil.
2,4-D (2,4-D, Unison, Barrage, others)	Will control most broadleaf weeds, crop injury can be significant and drift to cotton fields is a comcern.
Dicamba (Banvel, Clarity, Vision)	Will control lost broadleaf weeds, crop injury can be significant and dift to cotton fields is a concern but safer than 2,4-D.
Fluroxypyr (Starane)	Weak on pigweed. Good on kochia, morningglory, and devisclaw.
Carfentrazone (Aim)	Fast burn down. Effective only on small weed (<2 inches).
Bromoxynil (Buctril)	Good coverage is essential. Most effective on small weeds (<2 inches)

Diseases

Many of the diseases that affect grain sorghum also affect forage sorghum. Diseases that directly affect the grain are not usually important in forage sorghum production, while diseases that affect leaf yield and stalk development are more important. Diseases are not a constant limitation to productivity. Yield loss from a particular disease can vary from year to year. However, generally diseases are a minor problem in forage sorghum production. The most important step in disease management is proper diagnosis of the disease.

By itself, a plant pathogen, specifically fungi, bacteria and viruses, can not cause disease. It must occur in combination with a susceptible host plant, under environmental conditions that favor infection and subsequent pathogen growth. Furthermore, a plant growing under optimal conditions can often withstand the effects of a pathogen. For example, good root development and regeneration greatly reduce severity of fungal root rot, while an abundance of leaves diminishes the impact of foliar pathogens on yield. Healthy plants can grow more to compensate for neighboring plants affected by diseases.

Control Methods:

There are three major disease control strategies available to the grower: host resistance, fungicide seed treatments, and cultural practices. The use of host resistance is the most important strategy. Fungicide seed treatments that contain metalaxyl will control downy mildew, except in areas of Texas where metalaxyl-resistant populations occur. Cultural practices will either make environmental conditions unfavorable for the pathogen to develop or enhance the growth of the plant. Crop rotation is a cultural practice that allows for pathogens surviving in crop residue to die out. Burial of residue may speed up the destruction of pathogens surviving on foliage, in particular, the fungus causing anthracnose. This control measure is more successful when combined with crop rotation. On the other hand, continuous cropping with sorghum can enhance disease problems, by allowing pathogen populations to increase. The use of high-quality seed encourages rapid development of seedlings, minimizing the impact of seedling diseases.

Diagnosis and Management of Specific Diseases:

Early Season Diseases

Seedling Disease: Cause: A fungus, *Pythium* spp. (Other fungi may also play a role).

*All *Photos found in Appendix B, Page 103.*

Symptoms: Seedling root rot caused by various species of Pythium may result in sparse or irregular stands. On mature plants, symptoms found on large brace roots are darkening, blackening and formation of sunken, red-brown to black lesions. Pythium root rot also contributes to lodging. (Photo 4).
Management: Planting poor quality seed in soil exposed to moisture and temperature extremes predisposes sorghum seedlings to fungal diseases. Use high-quality seed. Seed treatment fungicides may have some control activity.

Downy Mildew: Cause: A fungus, *Peronosclerospora sorghi*
Symptoms: Infections of the roots lead to foliar symptoms in young seedlings, as the fungal infection grows to the growing point. The first leaf with symptoms appears lighter green or yellow, later becoming more chlorotic (Photo 5). Abundant downy white growth (spores of the fungus known as conidia) is produced at night on the under surfaces of infected portions of leaves during humid weather (Photo 5). Later, leaves emerging from the whorl are more bleached, sometimes in streaks or stripes of green and white tissue and sometimes over the entire leaf surface (Photo 6). The bleached leaf tissues are packed with spores (oospores) that survive in soil. As the infected bleached leaves mature, the white tissue dies and the leaf tissues between the veins disintegrate and become shredded, releasing oospores to soil, where they overwinter

(Photo 6). Early in the spring, the short-lived conidia will be blown to other leaves, resulting in dark, blocky lesions that do not develop further (Photo 6). These localized infections are usually confined to lower leaves and require cool, wet weather to occur. They do not generally cause yield loss, but extensive development of systemic infections will result in a loss of yield.
Management: Seed with either Apron XL or Allegiance fungicide, which protects germinating seedlings from oospore infection, except in some coastal growing areas of Texas, where isolates resistant to metalaxyl have developed. Seed treatment should be used in combination with resistant varieties. A crop rotation with corn, which can become infected, but does not support oospore development, can help minimize populations of oospores in soil that can infect future plantings of sorghum. Other crops, such as cotton, rice and soybean are not infected. The fungus can also infect Johnsongrass. If sorghum downy mildew was present in a field, a two-year crop rotation should be practiced, to prevent build-up of oospores in soil.

Maize Dwarf Mosaic: Cause: Maize dwarf mosaic virus
Symptoms: The mosaic symptom is most prominent on the upper two or three leaves as an irregular mottling of dark and light green (Photo 7). In some susceptible varieties, if the temperature is below 55°F, an infected leaf may have elongated red stripes with necrotic centers and red margins.

The earlier the infection, the more severe the symptoms will be. In severe cases, plants may be stunted or die. Tolerant hybrids may develop mosaic symptoms, which disappear eventually and have no apparent effect on yield.
Management: This virus also infects Johnson-grass, sugarcane, and other grasses, which can serve as reservoirs for the virus. The virus is transmitted by aphids. Early in the season, Johnsongrass within the field or along field borders should be controlled to reduce the rate of virus spread from these plants. However, because aphids can move from other fields, it may be impossible to avoid infection. Resistant sorghum hosts must be used to prevent crop losses in areas where maize dwarf mosaic is a problem.

Mid to Late Season Diseases

Anthracnose: Cause: A fungus, *Colletotrichum sublineolum*
Symptoms: This pathogen infects leaves and stalks. The disease is likely to occur if sorghum matures during a rainy season. The foliar symptoms are small elliptical to circular spots, less than 0.2 inch in diameter, which develop small circular straw colored centers and wide margins that are red, orange, blackish purple, or tan, depending on the variety. Small black spots, the fruiting bodies of the fungus, are seen in the centers of the lesions (Photo 8). Many lesions may develop close together and kill large portions of a leaf. Anthracnose may defoliate

sorghum plants and reduce growth and further development. In severe cases, plants die before they reach maturity.

Stalk rot usually occurs after leaf symptoms. Conidia of the fungus produced on leaves are washed behind leaf sheaths by rain and enter the peduncle or panicle. The first symptoms are water soaked, discolored elliptical lesions on the panicle, which later become tan to blackish purple. When infected stalks are split open, they have a marbled, discolored appearance (Photo 9). *Management*: One approach for partial control of anthracnose is achieved by growing sorghum to avoid maturation during wet weather. Additionally, since the fungus produces long-lived survival structures (sclerotia), a two-year crop rotation is recommended to eliminate the fungus from soil. Several resistant forage sorghum hybrids may be available commercially for use in the southern, coastal areas of Texas where anthracnose is more of a problem. A high level of resistance is not necessary in areas where conditions are not favorable for disease development, which is favored by warm, humid and rainy weather. Since there are different races of *Colletotrichum sublineolum*, sorghum resistant to anthracnose in one area may be susceptible to it somewhere else.

Foliar Diseases: Cause: Several pathogens, as follows:

Zonate leaf spo*t:* A fungus, *Gloeocercospora sorghi*
Symptoms: This fungus can cause seedling disease, severe foliar damage on mature plants, and sheath blight. The disease is conspicuous on sorghum leaves as circular, reddish purple bands alternating with straw colored or tan areas, which form a concentric, or zonate, pattern with irregular borders (Photo 10). Lesion diameters range from 0.4 0.8 inch in early stages to 1.2 2.75 inches in later stages, and lesions may cover the entire width of a leaf. A high incidence of the disease on plants in the seedling stage may result in severe defoliation and even death of infected plants. Abundant spotting on leaves of older plants may cause premature destruction of foliage.

Rust: A fungus, Puccinia *purpurea*
Symptoms: This fungus occurs on foliage peduncles and in rachis branches. It is more severe under moderately cool (60 to 80°F) than high temperatures. Typical symptoms are more readily expressed in plants that are 1.5 to three months old. Scattered purple, red or tan flecks appear on both surfaces of leaves. In susceptible cultivars, the flecks enlarge to form blisterlike, dark reddish brown pustules about 0.08 inch long, which lie parallel to and between the leaf veins. The pustules rupture and reveal powdery masses of reddish brown spores (Photo 11).

<u>Gray Leaf Spot:</u> A fungus, *Cercospora sorghi*
Symptoms: Initial symptoms of gray leaf spot are small, red spots on leaves. The spots enlarge to form narrow, rectangular lesions that may coalesce to form longitudinal stripe or irregular blotches and possibly cause leaf death. With severe infection, leaf sheaths and upper stalks may become infected. Sporulating lesions give leaves a grayish cast.

<u>Sooty Stripe:</u> A fungus, *Ramulispora sorgh*i
Symptoms: The first symptoms of sooty stripe usually are small, circular, reddish brown or tan spots with a yellow halo on leaves and sheaths. These spots enlarge to form elongated to elliptic or spindle shaped lesions with straw colored centers and reddish purple or tan margins. Fully developed lesions are 0.2 to 5.5 inches long and 0.4 to 0.8 inch wide and are regular in outline. As the season progresses, adjacent lesions may coalesce to form extensive necrotic areas causing leaf death. Lesions become grayish, then black or sooty (Photo 12).

<u>Bacterial stripe:</u> A bacterium, *Burkholderia andropogonis*
Symptoms: This disease can develop in a wide variety of environments, but few cultivars are very susceptible. The initial symptoms are small (0.4 inch), linear lesions. Lesions on leaves and sheaths are purple, red, yellow or tan, depending on the host reaction. Under conditions favorable for their development, lesions may exceed

7.9 inch in length and usually coalesce along the width of the leaf. Moderately severe infections may produce shorter lesions. Bacterial exudate is usually observed on infected portions of the leaf. Lesions may also occur on the kernel, peduncle and rachis branches, and in the interior of the stalk (Photo 13).

Leaf blight: A fungus, *Exserohilum turcicum*
Symptoms: Elongated, elliptical reddish purple or tan lesions. Reddish margins may be present. Under moist conditions which favor spore production by the fungus, the lesions may have a gray or black appearance (Photo 14). Symptoms usually appear first on lower leaves, then spread to upper leaves.
Management of foliar diseases: Levels of foliar diseases are usually not high enough to cause economic loss. Most foliar diseases other than rust or leaf blight can be avoided by practices that reduce the survival of inoculum from one growing season to the next, (i.e., crop rotation and destruction of debris).

Several air borne foliar pathogens, for example, rust, are not affected by cultural practices, and consequently, host resistance is the only control. If a variety is highly susceptible to a particular foliar disease, it should not be grown in that area in the future.

Ergot: Cause: A fungus, *Claviceps Africana*
Symptoms: Infection occurs only in the ovary

of the flower and only prior to its fertilization. Consequently, this disease will not be seen if sorghum is harvested before flowering. The initial symptom is a white, swollen fungal structure that is formed between the glumes, where the seed normally develops. This structure exudes a sweet, sticky liquid that contains sugars and spores. The exudate may be colorless to honey brown or opaque white. The exudate will drip onto uninfected portions of the panicle, onto foliage or soil, and will turn white when it dries. Later, where honeydew has dripped onto the panicle, saprophytic fungi will grow, giving it a dark, moldy appearance. For a sure diagnosis, grab the panicle. If it is sticky, it is infected with ergot (Photo 15). Extensive ergot in a field can interfere with harvest because of the stickiness. There is no toxicity to animals with this particular species of ergot.
Management: Ergot is endemic in south Texas, surviving on Johnsongrass. Spores, produced in rainy or humid weather, can be blown long distances. Fields should be cut before flowering.

<u>Stalk Rot</u>: Cause: *Macrophomina phaseolina* (Charcoal Rot), Colletotrichum graminicola (Stalk Red Rot/Anthracnose)
Symptoms: Stalk is spongy, and internal tissue (pith) is shredded and often discolored. Plants sometimes turn grayish-green after jointing.
Management: Use hybrids resistant to Stalk Red Rot and tolerant to Charcoal Rot. Avoid excessive plant populations. Maintain proper soil fertility.

Rotate away from sorghum for two or more years following a severe outbreak of either disease. Avoid soybeans and corn for two or more years following severe outbreaks of Charcoal Rot. Azoxystrobin is labeled for management of C. graminicola and Charcoal Rot.

Fungi survive on crop residue. High plant population, high nitrogen and low potash can aggravate the diseases. Charcoal Rot is prevalent in hot, dry weather. Stalk Red Rot is prevalent during warm weather with alternating wet and dry periods.

Anthracnose Stalk Rot: see pg 47-48

Insect Management

<u>Soil-Inhabiting Pests</u>. White grubs, corn rootworms, cutworms, wireworms, sod webworms, seedcorn beetles and seedcorn maggots are the most common soil insects attacking forage sorghum. Non-crop plant residues are important alternate food sources for these soil pests. Cultural practices are very important in reducing damage by these pests. Crop rotation, cultivation and/or the use of herbicides are important for reducing crop residue and weedy hosts. Proper seedbed preparation will promote rapid seedling emergence and plant stand establishment, which can be important in avoiding damage from these pests. Pre-plant soil inspection for the presence of soil pest populations is key for making management decisions. If chemical treatment is necessary, soil treatment or seed treatment methods are available.

<u>False and True Wireworm, several species in *Tenebrionidae* (Darkling Beetle) and *Elateridae* (Click Beetle) families</u>. The immature larvae of these species are generally colored yellow to brown and are shiny, slender, cylindrical and hard bodied (Photo 16), but some are small, slender, white soft bodied with a brown band behind the hard reddish brown head. They will destroy planted seed and to a lesser degree feed on seedling roots, which reduce plant stands and plant

*All *Photos found in Appendix B, Page 103.*

vigor. Cultural practices that reduce non-crop plant material in fields and rotation to tap-rooted crops that are unfavorable for wireworm development are important in reducing and preventing damage. Sample fields before planting by taking eight to 10 soil samples 1 foot square by 4 inches deep from the rows and examine thoroughly. When two or more wireworm larvae per linear foot of row are detected, control measures are warranted. No post-emergence rescue treatments are registered for wireworm control. However, seed treatments are available for controlling wireworms.

White Grub, *Phyllophaga* spp. & *Cyclocephala* spp. White grubs are the larval stages of May and June beetles. Larvae are characteristically C-shaped with white bodies and tan to brown heads. The last abdominal segment is transparent, and digested material can be seen inside the larvae. Larvae feed on plant roots and may cause substantial stand loss. Larvae can severely prune roots of larger plants which may cause stunting, plant lodging and increase susceptibility to drought and stalk root diseases. To determine the need for white grub control before planting, examine a 1 square foot soil sample for each five to 10 acres. An average of two white grub per square foot is enough to cause significant stand loss. No products are labeled for use on forage sorghum for control of white grubs. Several products labeled on sorghum may suppress white grubs.

Cutworms. Cutworms are dingy, grayish-black, smooth "worms" that are the larval stages of many different moths. Most cutworm species hide in the soil during the day and are not visible on the plants. Larvae are active at night and damage seedling plants by cutting the stalk just above ground level, which looks like plants have been closely grazed (Photo 17). Large numbers of cutworms may be found in grassy or weedy areas. Therefore, cultivation three weeks prior to planting, crop rotation and using herbicides to kill weeds are important control methods. An application of insecticide by ground or by air will usually give adequate control. Best results are obtained when insecticides are applied in the late afternoon and by increasing total spray volume. If the soil is dry, cloddy or crusty at the time of treatment, control may not be as effective as in moist soil. Well-defined treatment thresholds do not exist for cutworms on forage sorghums. Therefore, control decisions become a matter of individual judgment about plant stand loss.

Corn Rootworm, *Diabrotica* spp. Corn rootworms are the larval stages of a complex of leaf-feeding beetles. The southern corn rootworm and the western corn rootworm can be important forage sorghum pests from this rootworm complex. Unlike the western corn rootworm, the southern corn rootworm has more than one generation per year. Rootworms are small, creamy-white larvae with brown heads. They feed in the root and crown of a plant. Poor stands, reduced plant vigor and dead heart in young plants are characteristic of rootworm damage. Damage to the roots predisposes the plant to moisture stress under drought conditions. Plant lodging may occur later in the season. Severe infestations require an at-planting soil insecticide. The decision to apply an at-planting insecticide is based primarily on damage in previous years. The single generation of the western corn rootworm makes crop rotation to a tap-rooted crop a good method for controlling this pest.

Lesser Cornstalk Borer, *Elasmopalpus lignosellus (Zeller)*. The lesser cornstalk borer is an occasional pest of forage sorghum. The larvae are slender and small, up to ¾ inch long and have a distinct bluish-green striped coloration (Photo 18). In the spring moths emerge and lay eggs on the seedling leaves or stems. The hatching larvae form silken tubes below the soil surface and injure plants by boring into the plant crown near the soil level. When disturbed the larvae will wiggle violently. Damaging infestations are more prevalent on sandy soils and under dry conditions. Rainfall and irrigation will kill larvae, so irrigation timing and irrigation amounts can be used for control. Insecticides applied for corn rootworms may also control this pest.

Above-ground Pests:

Greenbug, *Schizaphis graminum* Rondani. The greenbug is an aphid and is pale green, approximately 1/16 inch long and has a dark green stripe on the back (Photo 19). Females give birth to live young at seven to 18 days of age, reproduce for about 20 to 30 days and produce 50 to 60 young each (all females). These aphids suck plant juices and while feeding toxic saliva cause young leaves to turn yellow and older leaves to develop orange-red spots. Greenbugs are typically not as damaging in forage sorghum as in grain sorghum. However, when abundant they can cause stand loss, stunting and even plant death. Populations often occur in concentrated patches within a field, damaging small circular patches that radiate from dead spots. Fields should be inspected frequently from emergence until the plants are 6 to 10 inches tall, but inspections should be continued through harvest. The action level from emergence to about 6 to 10 inches is any visible damage (plants beginning to yellow) with greenbug colonies (Photo 19) present and probable excessive stand loss. Maturing sorghum may infrequently have excessive leaf loss that requires treatment. For a discussion of the management and control strategies for greenbugs, refer to extension service publications for your state or region.

European Corn Borer, *Ostrina nubilalis* (Hubner), and Southwestern Corn Borer, *Diatrea grandiosella*. The European corn borer and the Southwestern corn borer are common pests of corn and will infest forage sorghum. Infestations by these pests differ by geographic regions in the United States. The European corn borer has a wider distribution range than the southwestern corn borer with European corn borer being in northern and southeastern regions and southwestern corn borer in southern regions. Some states have overlapping infestations of both corn borers. Depending on the geographic region there may be two to three generations a year, but in the far northern localities there may be just one generation for the European corn borer. In the central plains states both corn borers commonly have two generations a year and their development is similar. Larvae overwinter in the corn and sorghum stubble, pupate, and emerge as first brood moths in the spring. Moths lay eggs on whorl stage plants and hatching larvae feed on leaves in the whorl for a short time. Whorl feeding damage becomes visible as small round holes, "shot-holes", when leaves grow and unroll from the whorl. Older larvae then bore into the stalk and tunnel up and down the pith as the forage sorghum plant grow. Larvae for this first brood will pupate and the second brood moths emerge typically in July and August. Larvae hatching from the second brood moth egg lay will move behind the leaf sheath and leaf collar before boring in to the stalk. In regions with two generations per year these second brood larvae will overwinter.

Whorl infestations of either corn borer seldom cause damage that warrants insecticide treatment. Infestations from the second brood are more damaging and may on occasion require an insecticide application to control larvae before they tunnel into the stalk. Tunneling damage makes the plant more susceptible to stalk rot diseases. The damage caused by southwestern corn borer girdling the stalk may result in substantial plant lodging. However, no information is available, for either corn borer, on threshold levels for forage sorghum. Planting early will enable fields to be harvested before lodging becomes excessive. Shredding stalks very close to the ground or plowing and disking stubble destroys overwintering larvae by exposing them to the cold winter temperatures. This cultural practice reduces borer abundance the next year, but the impact is limited if other producers do not destroy corn and sorghum stalks in the area.

European corn borer eggs are laid in clusters of 12 or more individual eggs which resemble fish scales. Eggs change from white to a yellowish color. Just before hatching the head of the developing larvae appears as a dark spot in each egg and will hatch in one to two days. Larvae are light brown or pinkish gray in color with round dark spots on each body segment (Figure 24). Tunneling by the larvae can weaken the stalk.

Southwestern corn borer eggs are laid singly or in clusters of two or more. Freshly laid eggs are creamy white and as the embryo develops, three red bands appear across the egg. Also, the head appears as a dark spot just before hatching. Mature corn borer larvae reach 1 to 1 ½ inches in length. The body is white with raised black dots on each body segment (Figure 24). In the late summer to early fall, larvae tunnel to the base of the stalk and root crown. In preparation for winter these larvae will lose their spots and become completely white. Larvae girdle the stalk from 1 to 6 inches above the ground during September. Girdled plants are easily lodged by wind and the lodged plants are difficult to cut for silage.

Corn Earworm, *Helicoverpa zea* Broddie, and Fall Amyworm, *Spodoptera frugiperda* (J.E. Smith). Populations of fall armyworm in late summer or early fall can severely damage forage sorghums. Fall armyworm larvae range from a light tan to a dark green or black color (Photo 21). Light and dark stripes run longitudinally on the body. Dark spots or bumps occur in a pattern over the body, especially when viewed from the top. The head of a larva has a prominent inverted Y, in a light color that contrasts with the dark head capsule. There are no established treatment thresholds for fall armyworm infestations. Therefore, treatment decisions become a matter of individual judgment about leaf defoliation.

Corn earworm and fall armyworm moths deposit eggs on leaves. Newly hatched larvae begin to feed in the whorl. Larval feeding will cause the leaves to appear ragged, but insecticide treatments are seldom recommended and economical control is seldom achieved. If, however, there is excessive defoliation, yields and quality will be reduced.

Both corn earworm and fall armyworm larvae will feed on the developing grain of the forage sorghum heads (Photo 22). As with grain sorghum, feeding by these larvae can reduce grain yield. Extensive information is available on the damage potential of these pests infesting grain heads. Refer to Extension publications on grain sorghum for further information on management and control of these pests.

Spider Mites. Economic infestations of spider mites primarily occur on corn in the High Plains, but infestations can occur on forage sorghums as well. Both the Banks grass mite and twospotted spider mite can occur on forage sorghum. The Banks grass mite is the predominant species in early and mid-season, and is more widely distributed than the twospotted spider mite. A few fields, however, will have high numbers of twospotted spider mites. These mites are members of the *Acari* family, *Tetranychidae,* which are more closely related to spiders and ticks. They have eight legs and produce webbing. Adult female mites are the largest life form and are approximately 1/20 inch long. Damage is caused as mites puncture the cell wall and suck out the plant juices. Damage symptoms appear as yellow mottled stippling on the leaf. As populations build leaves turn yellow and can be killed. Mites first appear on the lower leaves, but can move upward until all the leaves are infested. Heavy infestations cause extensive webbing on the leaves and may be associated with stalk rot and lodging. Periods of hot, dry weather favor rapid mite population increase. Proper irrigation timing will help plants withstand mite feeding damage. Insecticide applications for other pests often cause mite outbreaks. No action levels are established for mite damage, but control may be warranted where a substantial number of lower leaves are killed.

Grasshoppers. A number of grasshopper species are common pests of forage sorghum. These pests generally migrate into the field from adjoining fence rows, ditch banks, field margins or native pastures. All grasshopper nymphs and adults feeding on foliage can cause extensive forage loss. Grasshoppers are usually most damaging during dry years. An average of six to seven grasshoppers per square yard can consume as much forage as a cow. Damaging infestations need to be controlled early while grasshoppers are small and still in crop border areas. The action level is 15 to 20 grasshopper nymphs per square yard in crop margins. In the field, populations of seven to 10 grasshoppers per square yard accompanied by excessive leaf loss warrant control measures.

Sugar Cane Rootstock Weevil, *Anacentrinus deplanatus* **(Casy)**. The sugarcane rootstock weevil is a sporadic pest of forage sorghum. Infestations occur more frequently during dry years and in fields where Johnsongrass is abundant. The adult weevil is dark brown or black, about 1/8 inch long and 1/16 inch wide. In early spring, weevils infest wild grasses and later move to forage sorghum. Adults feed on young plants and crowns, but damage is rarely significant. The female weevil chews a small hole in the stalk near the base of the plant and lays an egg. About 16 eggs are laid per female and they hatch in six days. Larvae are white, legless grubs about 1/5-inch long when fully grown. Larvae tunnel into the stalk and feed for 25 days. Feeding tunnels resemble those made by other borers, except they are much smaller and do not extend up the stalk. Feeding damage is responsible for a drought-stressed appearance and plant lodging. Exit holes and feeding tunnels provide favorable sites for disease pathogens, such as charcoal rot, to enter the plant. Economic thresholds have not been established for this pest because of the sporadic infestations.

Chinch Bug, *Blissus leucopterus*. Chinch bugs occasionally damage forage sorghum, but infestations are localized and confined to different regions in a state where forage sorghum and grain sorghum are grown. Adults are black, with reddish yellow legs and with white forewings, each with a conspicuous black triangular spot at the middle of the outer margin (Photo 23). Immature chinch bug nymphs resemble adults in shape but are reddish with a white band across the back. Both adult and immature chinch bugs suck plant juices and damage results in wilting and severe stunting of plants. Chinch bugs congregate and feed behind the lower leaf sheaths of a plant. Infestations occasionally occur from adults flying into the field from overwintering grasses, late-maturing wheat, or from infested sorghum fields. Heaviest infestations are along field edges where wingless nymphs migrate from these hosts. The action level is reached when two or more adult chinch bugs are found on 20% of the seedlings less than 6 inches tall. On taller plants, control is warranted when immature and adult bugs infest 75% of the plants. Control with ground application equipment is improved when the spray is directed to the infested portion of the plants and spray volumes are 20 to 30 gallons of water per acre. Seed treatments at planting can decrease damage for a few weeks, but the effectiveness of the treatments will decline over time. So, follow-up sprays may be needed along field margins if chinch bug migration continues to be a problem.

Insecticide Products Labeled for Forage Sorghum:

Policy Statement for Making Pest Management Suggestions. A listing of products for use on forage sorghum is difficult to assemble because products oftentimes are not specifically labeled for forage sorghum. Labels list product uses for sorghum grown for grain and/or silage and generically for sorghum. When using products it is impossible to eliminate all risks and conditions or circumstances that are unforeseen or unexpected that could result in less than satisfactory results. Such responsibility shall be assumed by the user of this publication. Pesticides must be labeled for use by the Environmental Protection Agency. The status of pesticide label clearances is subject to change and may be changed since this publication was printed. The USER is always responsible for the effects of pesticide residues on his livestock and crops as well as problems that could arise from drift or movement of the pesticide. Always read and follow carefully the instructions on the container label. Pay particular attention to those practices that ensure worker safety. For information about the registration status of a product and product use, contact a local chemical company representative, a dealer representative, and/or your county extension staff.

Harvesting

Although forage sorghums can be harvested multiple times as green feed or hay, most silage sorghums are grown for single-cut silage or green-chop operations because of the achievable high tonnage and poor regrowth after cutting. The advantage of a one-time harvest is that the relationship between yield and forage quality is optimized. In addition, when harvested near soft-dough stage, the crop can be directly chopped and stored without wilting. Forage sorghum meets the proper characteristics for a crop to be ensiled; it has high levels of water-soluble carbohydrates, low crude protein content, and low buffering capacity. The important part of the ensiling process is to create, as soon as possible, an anaerobic environment to promote the natural population of lactic acid bacteria to grow, which will reduce the pH in the silo by producing lactic acid. Lactic acid is critical to preserving the nutritive value of the forage sorghum. It is reported that the main issue with ensiling forage sorghum is the great variability that exists among cultivars and the high moisture content at the time of ensiling, which makes ensilability of forage sorghum more challenging than other crops. Therefore, the discussion of this section will focus on maturity at harvest, silage management, and the use of additives, all of which are issues that should be considered for successful ensiling of forage sorghum.

Conventional and BMR Forage Sorghum. The differences in nutritive value between conventional forage sorghum and BMR forage sorghum before ensiling discussed in the previous sections are maintained after fermentation. Silage fermentation characteristics such as pH, acetic acid, and ethanol concentration are similar between conventional forage sorghum and BMR forage sorghum, but lignin concentration is lower and digestibility greater in BMR forage sorghum (Table 6).

Maturity at Harvest. Years of research with conventional forage sorghum have concluded that maturity at harvest for ensiling should be between late-dough and hard-dough stage (Table 7). Forage sorghum grown for silage should be harvested when whole plant moisture content is between 60 and 70% (or 30-40% dry matter, DM). Harvesting both too early or too late will reduce energy of the fed product. At milk stage whole plant moisture is greater than 70% and NDF and ADF are greater than late-dough and hard-dough stages. In addition, harvesting forage sorghum at moisture content greater than 70%, can results in excessive amount of effluent, high acetic acid and ethanol concentration, high DM losses during storage and potentially lower DM intake by beef or dairy cattle. In contrast, forage sorghum ensiled at moisture content lower than 55% will be difficult to pack and exclude oxygen, thereby making it difficult to create the necessary anaerobic environment. There are situations where forage sorghum is at the proper maturity, but still has a moisture content above 70%. In these cases, the addition of additives could reduce the impact of the high moisture. Producers must weigh the pros and cons of harvesting at high moisture and decide if it is worth running the risk of high DM losses and producing effluent. When forage sorghum is harvested at hard-dough stage, starch availability from the kernels could be a concern, particularly if the kernels are not processed. Years of research have shown that processing forage sorghum kernels improves the utilization of starch. Even though differences in animal outputs may not be significant between unprocessed and processed silage, feed conversion may be greater with the processed silage. (Photo 24)

The BMR forage sorghum varieties can be harvested and ensiled at later maturity stages without losing nutritive value. Research results reported in Figure 29 indicate that BMR forage sorghum can be harvested at later maturity stage than non-BMR forage sorghum without decreasing in digestibility. BMR forage sorghums tend to yield 10 to 15% less than conventional forage sorghum, consequently, harvesting at a later maturity stage can potentially compensate yield without affecting the ensilability of the crop. However, keep in mind that delaying harvest of BMR varieties will increase the potential for lodging.

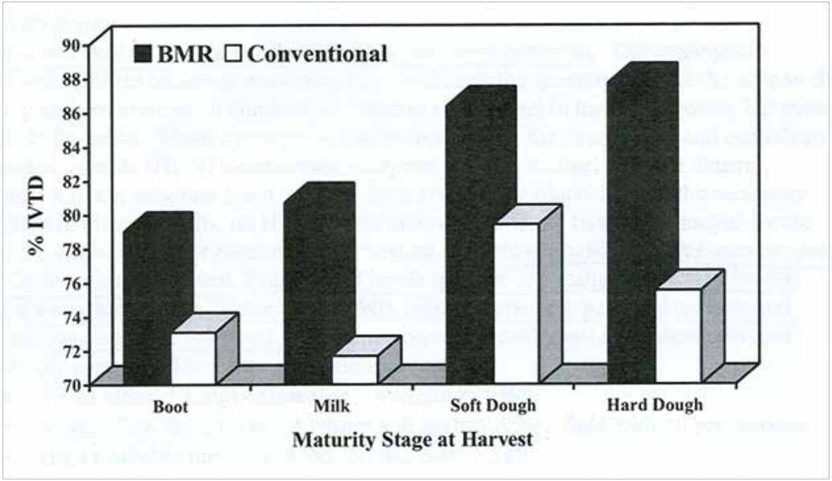
Table 6. Silage Fermentation Composition of Conventional and BMR Forage Sorghum (Miron et al., 2007 Anim. Feed Sci. and Technol. 136:203-215)

Silage description	Conventional	BMR
Dry matter content (%)	28.0	23.7
pH	3.63	3.93
Lactic acid (%)	6.7	8.1
Acetic acid (%)	1.6	1.8
Ethanol (%)	3.2	3.8
Neutral detergent fiber (%)	60.3	58.1
Lignin (%)	7.2	5.5
In vitro DM digestibility (%)	63	66
In vitro NDF digestibility (%)	53	58

Table 7. Forage Sorghum Harvested at Three DIfferent Maturity Stages and the Effect on DM Yield and Nutritive Value (Bolsen, 2004. SE Herd Mgmt Conf. Proc.)

Maturity	DM	DM yield	CP	NDF	ADF
	%	Ton/acre	%	%	%
Late-Milk	25.4	4.53	10.2	60.2	33.7
Late-dough	30.0	4.98	9.6	54.1	31.2
Hard-dough	38.0	5.46	9.3	53.9	31.6

Figure 8. Effect of Maturity on in Vitro True Digestibility (IVTS) of Silage BMR Forage Sorghum and non-BMR Forage Sorghum (Miller and Stroup, 2004, *In Proc.* Alfalfa Symposium).



Silage Management. Chopping, packing, and creating an anaerobic environment in the silo as soon as possible are crucial to reduce dry matter losses and promote a favorable fermentation, which will result in high-quality silage. Most of the studies related to packing density and chop length have been conducted in alfalfa, corn and grasses, therefore, packing density and chop length for forage sorghum are extrapolated values recommended for corn silage. Long chop lengths will decrease packing density which leads to greater DM losses due to greater air movement. In addition, higher ADF concentration has been observed with long chop length. Overall the chop length recommended is between 0.25 and 1 inch. Packing is important because high density reduces the presence of air in the forage, which reduces plant respiration and DM losses, and improves fermentation. Packing density for bunker silos is recommended to be no lower than 14 lbs/ft^3. A study conducted in bunker silos shows that DM losses decrease from 20.2% to 10.0% by increasing density from 10 to 22 lbs/ft^3 (Table 8).

Use of Additives. Silage fermentation occurs naturally under anaerobic conditions. Forage sorghum contains a natural population of lactic acid bacteria that produce lactic acid after oxygen is depleted from the environment. However, lactic acid bacteria are not the only microorganism in plants. Bacteria like clostridia and enterobacter, and yeast and molds, are present and compete with lactic acid bacteria for sugars. These other microorganisms cannot survive at low pH. High moisture content (greater than 70%) makes it more challenging for the lactic acid bacteria to drop the pH below the point where other microorganisms are inactivated. Therefore, the use of silage microbial inoculants will help the natural lactic acid bacteria population to decrease pH faster and stop growth of these other microorganisms. Silage microbial inoculants that promote lactic acid production will be the best option when forage sorghum is ensiled at moisture contents greater than 70%.

Silage Feed-Out. Once the silo is open, care should be taken to prevent aerobic deterioration of the forage sorghum silage. The presence of oxygen reactivates aerobic microorganisms like yeast and molds that consume sugars and fermentation products, thereby producing heat and decreasing the nutritive value of silage. How soon that will happen depends on the density of the silage and feed-out rate. It is reported that air can penetrate 39 inches or more in bunker silos depending of density. For this reason, it is suggested to remove only what is necessary to be fed immediately and to limit exposure of the silage face as much as possible.

Table 8. Dry Matter Loss at Different Silage Densities (RUppel, 1992. M.S. Thesis, Cornel; Univ.).

Density (lbs./ft^3)	DM Loss, 180 days (%)
10	20.2
14*	16.8
15	15.9
16	15.1
18	13.4
22	10.0

*Suggested silage density

Toxicity Concerns in Forage Sorghum. Sorghums have the potential to be very toxic to animals. Two concerns that producers should be aware of are nitrate toxicity and prussic acid poisoning. Prussic acid, or hydrocyanic acid (HCN), is formed from naturally occurring cyanogenic glucosides in the plant and is readily absorbed in the bloodstream, leading to respiratory problems and eventual death if high enough concentrations are consumed. Blood of animals becomes cherry red. Anything that potentially injures plant cells can raise HCN levels in the plant. Nitrates (NO_3-), when converted to nitrites in the rumen, interfere with the ability of red blood cells to carry oxygen, and animal death can result from asphyxiation. Both of these conditions can develop rapidly without much warning and many times it is too late by the time the problem has been diagnosed.

Prussic acid dissipates after sorghum x sudan-grass hybrids reach 18 inches high. Avoid grazing after lush growth has occured or rotate animals from new growth to older when heavy consumption is likely. Discontinue grazing for a few days following a light frost and at least a week to 10 days after a killing frost. Greenchop silage and haying prussic acid to dissipate.

As a general rule, anything that suppresses or disrupts growth of leaves relative to root absorption (i.e., drought, overcast days, frost, low temperatures, shading, herbicide damage, hail, disease) could contribute to increased levels of NO_3- in the plant. Excessive nitrogen fertilization may result in toxic forage as well, especially when combined with drought stress. Caution is warranted when NO_3- levels exceed 2,500 ppm (0.25%) or HCN exceeds 600 ppm (0.06%) on a dry matter basis (Tables 9 & 10). Waiting four days to one week after a stressful environmental condition (drought or frost) before chopping for silage or greenchop is recommended to avoid high NO_3- levels. Because HCN converts rapidly to a gas, usually toxic levels are greatly reduced during chopping prior to ensiling. For this reason, HCN is seldom a problem in silage. In contrast, NO_3- remains in chopped and even dried forage; however, ensiling has been shown to reduce NO_3- by about 50%.

Ensiling forage sorghum with high NO_3- concentration can produce the lethal gas nitrogen dioxide (NO_2), which is toxic to humans and animals. For this reason, care should be taken when a silage pit or bag is first opened when high NO_3- levels are suspected. Nitrogen oxide is a yellowish-brown color, has an odor similar to laundry bleach and is heavier than air, meaning it accumulates in low places. If NO_3- concentration in forage sorghum is an issue, add 8lbs. of sodium metabisulfite per ton of fresh material to reduce the risk of NO_2 formation. High-nitrate feed should be limited in the animal's diet (Table 9) and it is always critical to check NO_3- concentrations before feeding.

For more information on nitrate toxicity and prussic acid poisoning consult *Nitrate Poisoning of Livestock, Guide B-807, Cooperative Extension Service, NMSU* and *Prussic Acid Poisoning in Livestock, Guide B-808, Cooperative Extension Service, NMSU.*

Table 9. Nitrate Concentrations and Respective Management

Nitrate Level (ppm, DM basis)	Status	Comments
0- 2,500	SAFE	Generally considered safe to feed.
2,500- 5,000	CAUTION	Generally safe when fed with a balanced ration. Limit to 1/2 of total dry ration for pregnant animals. Do not feed with other non0protein nitrogen supplements. Caution with young animals.
5,000- 15,000	DANGER	Limit 1/4 of ration. Possible ocurrence of reproduction problems and milk losses.
Over 15,000	TOXIC	Do not use in free choice feeding program. Should be ground and limited to 15% of total ration.
Source: Ball, D.M, C.S. Hoveland, and G.D. Lacefield. 1991. Southern Forages.		

Table 10. Prussic Acid Concentrations and Respective Management

Prussic Acid Content (ppm)		Comments
As Fed Basis	Dry Matter Basis	
<200	<600	Safe to feed.
200-600	600-1800	Potentially toxic. Should be fed at a restricted rate.
>600	>1800	Potentially very toxic. Dry, ensile, or allow to mature prior to feeding or grazing. Retest before feeding.

Sorghum Economics

There is no established futures market for sorghum silage making it a commodity that needs to be marketed carefully and usually in advance of planting. The price is basically what is negotiated between the producer and the end user (feedlot or dairy). The price can vary significantly depending on specifications of the end user, negotiation skills of the parties involved and the local supply and demand for silage. A general rule of thumb is seven to 10 times the price of the anticipated harvest price of corn as determined from the futures market or forward cash offers being made by local elevators in the area.

Therefore, if the forward contract price for corn, or alternatively December futures price adjusted for local basis, is $4.00 per bushel, the anticipated sorghum silage price range would be $28.00 - $40.00 per ton. In the case where the sorghum silage varieties planted are considered nutritionally equivalent to corn silage a price of eight to 10 times the price of the anticipated harvest price of corn should be expected.

The silage market is specialized with a limited number of buyers and the transportation expense can reduce the access to multiple buyers. Therefore, producers should have a contract prior to planting silage and it is highly recommended that the contract be written to protect both the producer and end user. Developing a written contract helps clarify between parties exactly what is expected avoiding potential misunderstandings. It should be noted that a contract is only as good as the integrity of the parties who sign it.

What is included in the contract is up to the buyer and seller. Some common provisions include: production (tons or acres); acceptable varieties; acceptable moisture level range and the associated sliding scale of discounts/premiums; acceptable nutrient levels; harvesting methods; who is harvesting and where/when it is to be delivered, as well as, who is paying for harvest/delivery; and price and payment terms. Another provision that could be included is the height from the ground from which the silage is to be harvested. Inclusion of all or some of these terms, as well as additional provisions is up to the parties involved. It is recommended that an attorney be involved in drafting the contract to insure that it meets all the standards to make it legally binding.

Table 11. Sorghum SIlage Wstimated Costs and Returns per Acre Under Sprinkler Irrigating

ITEM	UNIT	PRICE	QUANTITY	AMOUNT	YOUR FARM
		dollars		dollars	________
INCOME					________
sorghum silage	ton	34.75	21.0000	729.75	________
TOTAL INCONE				729.75	________
DIRECT EXPENSES					________
SEED					________
seed-sorghum	lb.	1.70	7.0000	11.90	________
HERBICIDE					________
Herb+applic-SS	lb.	7.20	1.0000	7..20	________
FERTILIZER					________
fert (N)- ANH3	lb.	0.22	174.0000	38.28	________
fert(P)- dry	lb.	0.36	60.0000	21.60	________
					________

CUSTOM					
fert appl- ANH3	acre	11.00	1.0000	11.00	________
fert application	acre	5.00	1.0000	5.00	________
insec+ appl- sorg	appl	14.50	0.3300	4.78	________
harv & haul-sorg	ton	6.75	21.0000	141.75	________
CROP INSURANCE					
sorg-silage-irr.	acre	17.00	1.0000	17.00	________
OPERATOR LABOR					
Implements	hour	10.80	0.3796	4.10	________
Tractors	hour	10.80	0.4691	5.06	________
HAND LABOR					
Implements	hour	10.80	0.1527	1.64	________

IRRIGATION LABOR					
Center Pivot	hour	10.80	0.8320	8.98	________
DIESEL FUEL					
Tractors	gal	1.98	2.4264	4.80	________
GASOLINE					
Self-Propelled Eq.	gal	2.36	3.0150	7.11	________
NATURAL GAS					
Center Pivot	Mcf	6.75	13.0000	87.75	________
REPAIR & MAINT					
Implements	acre	6.28	1.0000	6.28	________
Tractors	acre	5.90	1.0000	5.90	________
Self-Propelled Eq.	acre	0.24	1.0000	0.24	________
Center Pivot	ac-in	2.03	13.0000	26.39	________
INTERST ON OP. CAP.	acre	8.13	1.0000	8.13	________

TOTAL DIRECT EXPENSES				424.94	________
RETURNS ABOVE DIRECT EXP.				304.80	________
FIXED EXPENSES					
Implements	acre	9.70	1.0000	9.70	________
Tractors	acre	8.56	1.0000	8.56	________
Self-Propelled Eq.	acre	0.37	1.0000	0.37	________
Center Pivot	acre	33.60	1.0000	33.60	________
TOTAL FIXED EXP.				5.2.24	________
TOTAL SPECIFIED EXP				477.18	________
RETURNS ABOVE TOTAL SPEC. EXP.				252.56	________
ALLOCATED COST ITEMS					
cash rent-sorghsil	acre	115.00	1.0000	115.00	________
RESIDUAL RETURNS				137.56	________

Projections for planning purposed only. Developed by Texas Cooperative Extension Service on 2010 prices.

Table 12. Sorghum Silage estimated Resource Use and Costs for Field Operations, per acre.

Operation/ Operating Input	Size/ Unit	Tractor Size	Perf Rate	Times Over	MTH	Tractor Cost		Equip Cost		Alloc Labor		Operating Input			Total Cost
						Direct	Fixed	Direct	Fixed	Hours	Cost	Amount	Price	Cost	
						---------------Dollars---------------					Dollars		----------Dollars---------		
disc	offset	100	0.078	1.00	Nov	1.89	1.60	1.54	2.22	0.173	1.87				9.13
chisel		125	0.099	1.00	Dec	2.90	2.41	.069	1.13	0.219	2.36				9.52
disc	tandem	100	0.138	1.00	Feb	3.31	2.81	1.52	2.19	0.303	3.27				13.12
sorg-silage-irr	acre			1.00	Mar							1.0000	17.00	17.00	17.00
fert (N)- ANH3	lb.			1.00	Apr							174.0000	0.22	38.28	38.28
fert(P)-dry	lb.											60.0000	0.36	21.60	21.60
fert appl-ANH3	acre											1.0000	11.00	11.00	11.00
fert application	acre											1.0000	5.00	5.00	5.00
planter		75	0.152	1.00	May	2.58	1.73	2.51	4.14	0.305	3.29				14.28
Center Pivot	ac-in						35.12	33.60	0.256	2.76	4.000				71.48

seed- sorghum	lb.										7.0000	1.70	11.90	11.90
Herb + applic -SS	lb.										1.0000	7.20	7.20	7.20
Pickup Truck	3/4 ton	0.006	30.00	May			7.36	0..37						7.73
Center Pivot	ac-in		1.00	Jun			26.34		0.192	2.07	3.0000			28.41
Center Pivot	ac-in		1.00	Jul			26.34		0.192	2.07	3.0000			28.41
insec+appl-sorg appl											0.3300	14.50	4.78	4.78
Center Pivot	ac-in		1.00	Aug			26.34		0.192	2.07	3.0000			28.41
harv & haul- sorg	ton		1.00	Oct							21.0000	6.75	141.75	141.75
TOTALS					10.70	8.56	127.78	43.67	1.833	19.80			258.51	469.05
INTEREST ON OPERATING CAPITAL														8.13
UNALLOCATED LABOR														0.00
TOTAL SPECIFIED COST														477.18

Projections for Planning Purposes Only. Prepared by Texas Cooperative Extension Serice based on 2010 prices

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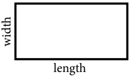
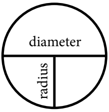
Calculations & Conversions

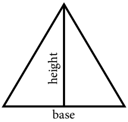


Area of a rectangle or square = length x width

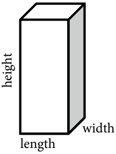


Area of a circle = 3.1416 x radius squared; or 0.7854 x diameter squared

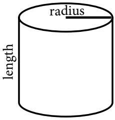
Circumference of a circle = 3.1416 x diameter; or 6.2832 x radius



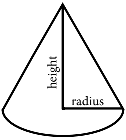
Area of triangle = base x height ÷ 2



Volume of rectangle box or cube = length x width x height

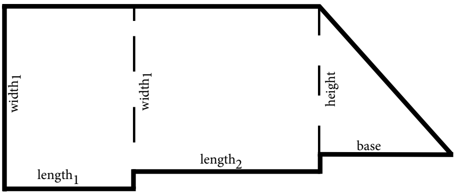


Volume of a cylinder = 3.1416 x radius squared x length



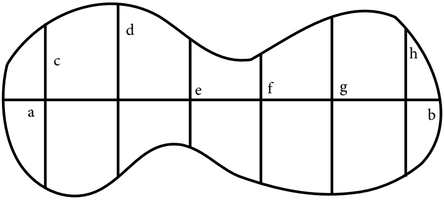
Volume of cone = 1.0472 x radius squared x height

Reduce irregularly shaped areas to a combination of rectangles, circles and triangles. Calculate the area of each and add them together to get the total area.



Example: If b = 25', h = 25', L_1 = 30', W_1 = 42', L_2 = 33', W_2 = 31', then the equation is:
Area = ((b x h) ÷2) + (L_1 x W_1) +(L_2 x W_2)
= ((25 x 25) ÷2) + (30 x 42) + (31 x 33)
= 2595 sq. ft.

Another way is to draw a line down the middle of the property for length. Measure from side to side at several points along this line. Use the average of these values as the width. Calculate the area as a rectangle.



Example: If ab = 45', c = 19', d = 22', e = 15', f = 17', g = 21', h = 22', then the equation is:
Area = (ab) x (c + d + e + f + g + h) ÷ 6
= (45) x (19 + 22 + 15 + 17 + 21 + 22) ÷ 6
= 870 sq. ft.

Conversion Factors

Acres (A)	x0.405	Hectares
Acres	x43,560	Square feet
Acres	x4047	Square Meters
Acres	x160	Square rods
Acres	x4840	Square yards
Bushels (bu)	x2150.42	Cubic inches
Bushels	x1.24	Cubic feet
Bushels	x35.24	Liters
Bushels	x4	Pecks
Bushels	x64	Pints
Bushels	x32	Quarts
Bushel Sorghum		56 pounds
$CaCO_3$	x0.40	Calcium
$CaCO_3$	x0.84	$MgCO_3$
Calcium (ca)	x2.50	$CaCO_3$
Centimeters (cm)	x0.3937	Inches
Centimeters	x0.01	Meters
Cord (4'x4'x8')	x8	Cord feet
Cord foot (4'x4'1')	x16	Cubic feet
Cubic centimeter (cm^3)	x0.061	Cubic inch
Cubit feet (ft^3)	x1728	Cubic inches
Cubic feet	x0.03704	Cubic yards
Cubic feet	x7.4805	Gallons
Cubic feet	x59.84	Pints (liq.)
Cubic feet	x29.92	Quarts (liq.)
Cubic feet	x25.71	Quarts (dry)
Cubic feet	x0.084	Bushels
Cubic feet	x28.32	Liters
Cubic inches (in^3)	x16.39	Cubic cms
Cubic meters (m^3)	x1,000,000	Cubic cms
Cubic meters	x35.31	Cubic feet
Cubic meters	x61,023	Cubic inches
Cubic meters	x1.308	Cubic yards
Cubic meters	x264.2	Gallons
Cubic meters	x2113	Pints (liq.)
Cubic meters	x1057	Quarts (liq.)
Cubic yards (yd^3)	x27	Cubic feet
Cubic yards	x46,656	Cubic inches
Cubic yards	x0.7646	Cubic meters
Cubic yards	x21.71	Bushels
Cubic yards	x202	Gallons
Cubic yards	x1616	Pints (liq.)
Cubic yards	x807.9	Quarts (liq.)

Cup	x8	Fluid ounces
Cup	x236.5	Milliliters
Cup	x0.5	Pint
Cup	x0.25	Quart
Cup	x16	Tablespoons
Cup	x48	Teaspoons
°Celsius (°C)	(+17.98)x1.8	Fahrenheit
°Fahrenheit (°F)	(-32)x0.5555	Celsius
Fathom	x6	Feet
Feet (ft)	x30.48	Centimeters
Feet	x12	Inches
Feet	x0.3048	Meters
Feet	x0.33333	Yards
Feet/minute	x0.01667	Feet/second
Feet/minute	x0.01136	Miles/hour
Fluid ounce	x1.805	Cubic inches
Fluid ounce	x2	Tablespoons
Fluid ounce	x6	Teaspoons
Fluid ounce	x29.57	Milliliters
Furlong	x40	Rods
Gallons (gal)	x269	Cubic in. (dry)
Gallons	x231	Cubic in. (liq.)
Gallons	x3785	Cubic cms
Gallons	x0.1337	Cubic feet
Gallons	x231	Cubic inches
Gallons	x3.785	Liters
Gallons	x128	Ounces (liq.)
Gallons	x8	Pints (liq.)
Gallons	x4	Quarts (liq.)
Gallons of Water	x8.3453	Pounds of Wa
Grains	x0.0648	Grams
Grams (g)	x15.43	Grains
Grams	x0.001	Kilograms
Grams	x1000	Milligrams
Grams	x0.0353	Ounces
Grams/liter	x1000	Parts/million
Hectares (ha)	x2.471	Acres
Hundred wt (cwt)	x100	Pounds
Inches (in)	x2.54	Centimenters
Inches	x0.08333	Feet
Inches	x0.02778	Yards
K_2O	x0.83	Potassium (K)
Kilogram (kg)	x1000	Grams (g)
Kilogram	x2.205	Pounds

Kilograms/hectare	x0.8929	Pounds/acre
Kilometers (K)	x3281	Feet
Kilometers	x1000	Meters
Kilometers	x0.6214	Miles
Kilometers	x1094	Yards
Knot	x6086	Feet
Liters (l)	x1000	Milliliters
Liters	x1000	Cubic cms
Liters	x0.0353	Cubic Feet
Liters	x61.02	Cubic inches
Liters	x0.001	Cubic meters
Liters	x0.2642	Gallons
Liters	x2.113	Pints (liq.)
Liters	x1.057	Quarts (liq.)
Liters	x0.908	U.S. dry quart
Magnesium (mg)	x3.48	$MgCO^3$
Meters (m)	x100	Centimeters
Meters	x3.281	Feet
Meters	x39.37	Inches
Meters	x0.001	Kilometers
Meters	x1000	Millimeters
Meters	x1.094	Yards
$MgCO^3$	x0.29	Magnesium (Mg)
$MgCO^3$	x1.18	$CaCO^3$
Miles	x5280	Feet
Miles	x1.69093	Kilometers
Miles	x320	Rods
Miles	x1760	Yards
Miles/hour	x88	Feet/minute
Miles/hour	x1.467	Feet/second
Miles/minute	x88	Feet/second
Miles/minute	x60	Miles/hour
Milliliter (ml)	x0.034	Fluid ounces
Ounces (dry)	x437.5	Grains
Ounces (dry)	x28.3495	Grams
Ounces (dry)	x0.0625	Pounds
Ounces (liq.)	x1.805	Cubic inches
Ounces (liq.)	x0.0078125	Gallons
Ounces (liq.)	x29.573	Cubic cms
Ounces (liq.)	x0.0625	Pints (liq.)
Ounces (liq.)	x0.03125	Quarts (liq.)
Ounces (oz.)	x16	Drams
P_2O_5	x0.44	Phosphorus (P)
Parts per million (ppm)	x0.0584	Grains/gallon

Parts per million	x0.001	Grams/liter
Parts per million	x0.0001	Percent
Parts per million	x1	Milligram/kg
Parts per million	x1	Milligram/liter
Pecks	x0.25	Bushels
Pecks	x537.605	Cubic inches
Pecks	x16	Pints (dry)
Pecks	x8	Quarts (dry)
Phosphorus (P)	x2.29	P_2O_5
Pints (p)	x28.875	Cubic inches
Pints	x2	Cups
Pints	x0.125	Gallon
Pints	x473	Milliliters
Pints	x32	Tablespoons
Pints (dry)	x0.015625	Bushels
Pints (dry)	x33.6003	Cubic inches
Pints (dry)	x0.0625	Pecks
Pints (dry)	x0.5	Quarts (dry)
Pints (liq.)	x28.875	Cubic inches
Pints (liq.)	x0.125	Gallons
Pints (liq.)	x0.4732	Liters
Pints (liq.)	x16	Ounces (liq.)
Pints (liq.)	x0.5	Quarts (liq.)
Potash (K_2O)	x0.83	Potassium (K)
Potassium (K)	x1.20	Potash (K_2O)
Pounds (lb.)	x7000	Grains
Pounds	x453.5924	Grams
Pounds	x16	Ounces
Pounds	x0.0005	Tons
Pounds	x0.45369	Kilograms (kg)
Pounds of water	x0.01602	Cubic feet
Pounds of water	x27.68	Cubic inches
Pounds of water	x0.1198	Gallons
Pounds/acre	x1.12	Kilograms/ha
Quarts (qt)	x946	Milliliters
Quarts (dry)	x0.03125	Bushels
Quarts (dry)	x67.20	Cubic inches
Quarts (dry)	x0.125	Pecks
Quarts (dry)	x2	Pints (dry)
Quarts (liq.)	x57.75	Cubic inches
Quarts (liq.)	x0.25	Gallons
Quarts (liq.)	x0.9463	Liters
Quarts (liq.)	x32	Ounces (liq.)
Quarts (liq.)	x2	Pints (liq.)

Rods	x16.5	Feet
Square feet (ft^2)	x0.000247	Acres
Square feet	x144	Square inches
Square feet	x0.11111	Square yards
Square inches (in^2)	x0.00694	Square feet
Square meters (m^2)	x0.0001	Hectares (ha)
Square miles (mi^2)	x640	Acres
Square miles	x28,878,400	Square feet
Square miles	x3,097,600	Square yards
Square yards (yd^2)	x0.0002066	Acres
Square yards	x9	Square feet
Square yards	x1296	Square inches
Tablespoons (Tbsp)	x15	Milliliters
Tablespoons	x3	Teaspoons
Tablespoons	x0.5	Fluid ounces
Teaspoons (tsp)	x0.17	Fluid ounces
Teaspoons	x0.333	Tablespoons
Teaspoons	x5	Milliliters
Ton	x907.1849	Kilograms
Ton	x32,000	Ounces
Ton (long)	x2240	Pounds
Ton (short)	x2000	Pounds
U.S. bushel	x0.3524	Hectoliters
U.S. dry quart	x1.101	Liters
U.S. gallon	x3.785	Liters
Yards (yd)	x3	Feet
Yards	x36	Inches
Yards	x0.9144	Meters
Yards	x0.000568	Miles

Appendices

a. The Sorghum Plant

Sorghum grain is found on the panicle, commonly referred to as the head. The panicle consists of a central axis with whorls of main branches, each of which contains secondary and at times, tertiary branching. The length of the branches allows for a wide range of shapes and sizes in sorghum and for sorghums with very open panicles or sorghums with very compact panicles. The branches carry the racemes of the spikelets where the grain is found (see Figure 3). The panicle emerges at boot from the flag leaf sheath.

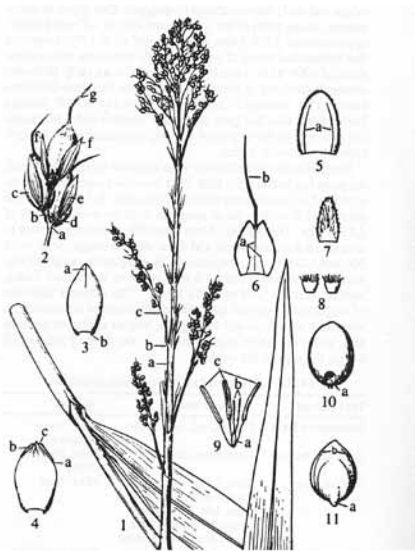


Fig. 3. The panicle of *Sorghum bicolor* subsp. *bicolor* which consists of the inflorescence and spikelets. 1. Part of panicle: a = internode of rachis; b = node with branches; c = branch with several racemes. 2. Raceme: a = node; b = internode; c = sessile spikelet; d = pedicel; e = pedicelled spikelet; f = terminal pedicelled spikelets; g = awn. 3. Upper glume: a = keel; b = incurved margin. 4. Lower glume: a = keel; b = keel wing; c = minute tooth terminating keel. 5 Lower lemma: a = nerves. 6. Upper lemma: a = nerves; b = awn. 7. Palea. 8. Lodicules. 9. Flower: a = ovary; b = stigma; c = anthers. 10. Grain: a = hilum. 11. Grain: a = embryon-mark; b = lateral lines. (Drawing by G. Atkinson. Reprinted, with permission, from J. D. Snowden, 1936, The Cultivated Races of sorghum, Adlard and Son, London. Copyright Bentham - Moxon Trust - Royal Botanical Gardens, Kew, England.

Seeds begin developing shortly after flowering and reach physiological maturity when the black layer is formed between the germ and the endosperm, some 25 to 40 days after flowering. Seeds are normally harvested 10 to 20 days after black layer when moisture content is generally 15% or less. Black layer can be seen at the base of the grain where it attaches to the rachis branch and indicates that the grain is physiologically mature. Seeds are made up of three major components, the endosperm, embryo, and pericarp (Figure 4). All sorghums contain a testa, which separates the pericarp from the endosperm. If the testa is pigmented, sorghum will contain tannins, if not, the grain is free of tannins. None of the commercial U.S. grain sorghums have a pigmented testa and all are said to be free of tannins.

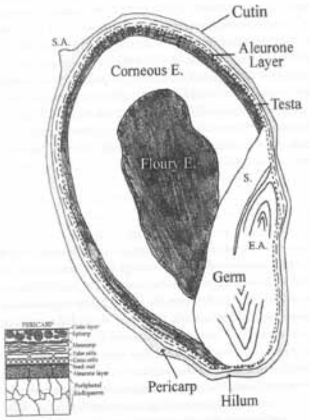


Fig. 4. Sorghum grain, showing the pericarp (cutin, epicarp, mesocarp, cross cells, tube cells, testa, pedicel, and stylar area (SA)), endosperm (aleurone layer, corneous and floury), and the germ (scutellum (S) and embryonic axis (EA). Adapted from L. W. Rooney and Miller, 1982).

b. Photos

Photo 1. *Brachytic Dwarf Sorghum*

Brachytic dwarf (left) and conventional (right) forage sorghum. Note the differnce in height and length between nodes (internode region); Photo courtesy of Sangu Angadi, NMSU Agriculture Science Center at Clovis.

Photo 2. *BMR Forage Sorghum*

Leaf midribs of brown midrib (BMR, left) and conventional) right) forage sorghum. Note the brown coloration on the BMR leaf. Photo courtesy of Mark Marsalis, NMSU Agriculture Science Center at Clovis.

Photo 3. *Photoperiod Sensitive Forage Sorghum*

Note the tall height and lack of seed head. Photo courtesy of Mark Marsalis, NMSU Agriculture Science Center at Clovis

Photo 4. *Root Rot*

Photo courtesy of T. Isakeit, TAMU Extension

***Photo 5**. Downy Mildew*

Chlorotic leaves (left) and spores on leaf (right). Photos courtesy of T. Isakeit, TAMU Extension

***Photo 6**. Downy Mildew*

Bleached striping of leaves (left), shredding of leaves (center), and lesions cause by wind-blown conidia (right). Photos courtesy of T. Isakeit, TAMU Extension.

Photo 7. *Maize Dwarf Mosiac*

Photo courtesy of T. Ikakeit, TAMU Extension

Photo 8. *Anthracnose Symptoms on Leaf*

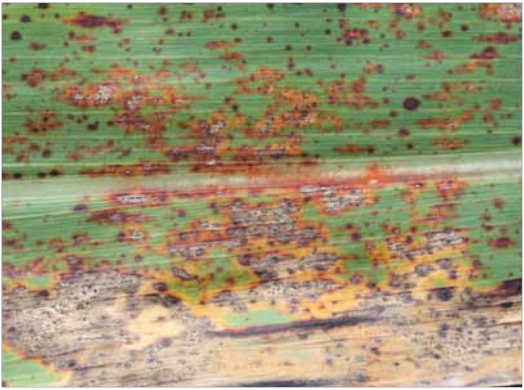


Photo courtesy of T. IsaKeit, TAMU Extension

***Photo 9**. Anthracnose Symptoms in Stem*

Photo courtesy of T. Isakeit, TAMU Extension

***Photo 10**. Zonate Leaf Spot*

Photo courtesy on T. Isakeit, TAMU Extension

Photo 11*. Rust Pustules*

Photo courtesy of T. Isakeit, TAMU Extensionl

Photo 12*. Sooty Stripe*

Photo courtesy of T. Isakeit, TAMU Extension

***Photo 13**. Bacterial Leaf Stripe*

Photo courtesy of T. Ikakeit, TAMU Extension

***Photo 14**. Leaf Blight*

Photo courtesy of T. Isakeit, TAMU Extension

Photo 15. *Ergot*

Notes "honeydew" on panicle. Photo courtesy of T. Isakeit, TAMU Extension

Photo 16. *Wireworm*

Photo courtesy of B. Dress, TAMU Extension

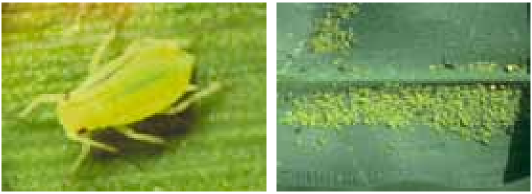
***Photo 17**. Cutworm*

Photo to left shows damage to plant caused by cutworm. Left photo courtesy og B. Drees, TAMU Extension and right photo, army cutworm, photo courtesy of M. Vandiver, TAMU Extension

***Photo 18**. Lesser cornstalk borer*

Photo courtesy of L. Brooks, KSU Entemology

Photo 19. *Greenbug and Greenbug Colony*



Left photo courtesy of B. Dress, TAMU Extension. Right photo courtesy of k. Bell, Kansas Department of Agriculture.

Photo 20. *Southwesten and European Corn Borer*

Southwesten corn borer (left) and Europeam core borer (right) photos courtesy of F. Pears, Colorado State University Extension

***Photo 21**. Fall Armyworm*

Photo courtesy of M. Vandiver, TAMU Extension

***Photo 22**. Corn Earworm*

Photo courtesy of KSU-SWREC

***Photo 23**. Chinch Bugs*

Photo courtesy on B. Wright, University of Nebraska Extension Entomology

***Photo 24**. Soft-Dough Stage of Maturity*

Note photo shows forage sorghum harvested at soft-dough stage of maturity. Photo courtesy of Mark Marsalis, NMSU Agriculture Science Center at Clovis.

Sorghum Facts

Sorghum is the fifth most important cereal crop in the world. It is used in a wide range of applications, such as ethanol production, animal feed, pet food, food products, building material, brooms and other industrial uses. Sorghum originated in Northeast Africa and spread to Asia, Europe and the Western Hemisphere. In the United States, sorghum is the second most important feed grain for biofuel production and is known for its excellent drought tolerance and superior adaptability to different environments. The first written record of sorghum in the U.S. traces to a letter that Benjamin Franklin wrote in 1757.

United Sorghum Checkoff Program

DISCLAIMER

Some of the information presented in this handbook is specific to the East Forage. Producers in all states should check with their own Cooperative Extension Service or county agents for state-specific information. Reference to products in this publication is not intended to be an endorsement of a particular product to the exclusion of others which may have similar uses. Any person using products listed in this handbook assumes full responsibility for their use in accordance with current label or information directions of the manufacturer.