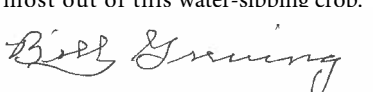
UNITED SORGHUM CHECKOFF PROGRAM

Eastern Forage Production Guide

Welcome to the United Sorghum Checkoff Program's East 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 "plants 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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Contents

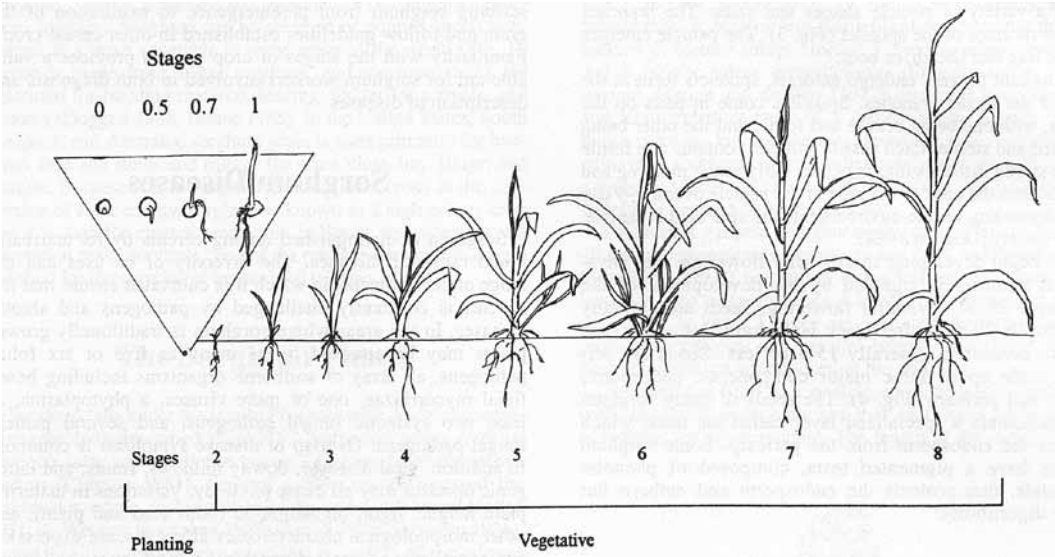
Growth Stages

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 (vegetative) would equate to stages 0 to 5 in this system. GS2 (floral initiation to bloom) would represent from stages 5 to 10, and finally, GS3 (bloom to maximum dry weight) 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 80, for more information about the sorghum plant.



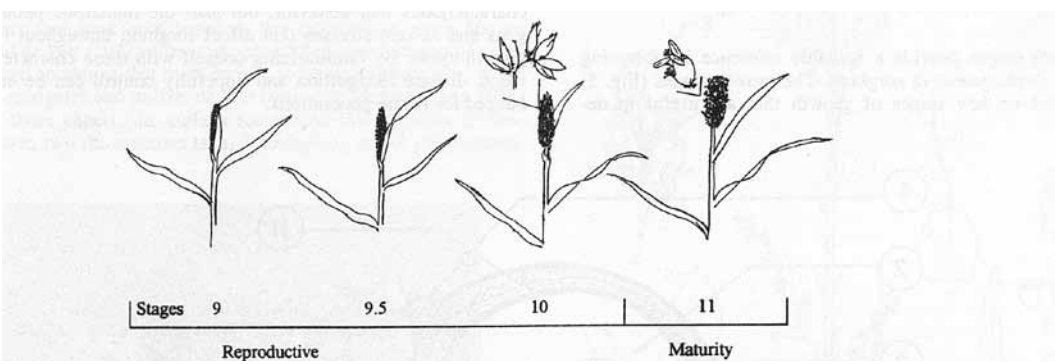


Fig. 1. Stages of sorghum growth: Stage 0: 0.0 planting; 0.1 start of imbibition; 0.5 radicle emergence from seed (caryopsis); 0.7 coleoptile emergence from seed (caryopsis); 0.9 leaf at coleoptile tip; Stage 1: emergence; Stage 2: first leaf visible; Stage 3: third leaf sheath visible; Stage 4: fifth 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 82.*

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 approxiamtely 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)

This key growth stage and its importance are largely unrecognized and unappreciated by producers. The stage occures 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 and 8 leaf stages. 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 approxiamtely 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.

Management: 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.

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.

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.

Management: If harvest aids are used, label guidelines target application no sooner than black layer and grain moisture are less than 30%.

Modified from 'Sorghum development and key growth stages.' Brent Bean, Extension Agronomist, and Carl Patrick, Extension Entomologist (retired), Texas AgriLife Extension Service, Amarillo.

Hybrid Selection

Hybrid Silage Sorghum

Hybrid forage sorghums (commonly referred to as forage sorghum) grow 8 to 10 feet tall and are relatively large in diameter. These varieties have been selected for a one-time harvest or a single cut for silage production. This crop can produce yields similar to corn, but the forage quality is generally lower. Varieties that possess the brown midrib (BMR) trait have brown vascular tissue as a result of reduced lignin content, which improves digestibility. However, this trait may also increase the incidence of lodging in some varieties. Hybrid forage sorghums, like corn, may produce a forage crop containing up to 50% grain, depending upon the hybrid and stage of maturity at harvest. Careful selection of BMR hybrids and timing of harvest are necessary to maximize total digestible nutrients (TDN). Highest crude protein and digestibility will usually be obtained by harvesting in the vegetative growth stage; whereas, dry matter production will be increased with more mature plants. Harvesting in the hard-dough stage will result in a lower average TDN value, but will maximize the amount of TDN harvested per acre.

Sudangrass

Sudangrass has finer stems, tillers more profusely, and is leafier than forage sorghums. They produce very few seed at their rate of regrowth after

cutting or grazing is generally superior to that of sorghums. For this reason, they are sometimes used for temporary rotational grazing. Further, sudangrass accumulates less of the poisonous compound prussic acid (HCN) than forage sorghums.

Sorghum x Sudangrass Hybrids

Hybrids of forage sorghum and sudangrass have the highest yield potential of any of the summer annuals if adequate rainfall is received or irrigation is provided. These hybrids are used for hay, greenshop and grazing. When grazed, the sorghum x sudan hybrids should be rotationally stocked, allowing the forage to reach 24 inches before grazing. At this stage, sorghum x sudan hybrids will generally have TDN values in excess of 53 to 60% and crude protein (CP) concentrations of 9 to 15%. Varieties with the BMR trait are usually preferred for grazing. Research in Texas has indicated that BMR varieties may improve animal gains by as much as 5 to 8% relative to non-BMR varieties.

In the southeastern United States, sorghum x sudan hybrids are commonly used as a forage crop for stocker cattle and brood cows following a winter or spring crop. Sorghum x sudan forage crops are designed for multiple harvests and can be used as hay, silage, pasture, or green chop. Unfortunately, these hybrids dry very slowly, even if an impeller (flail) or roller-crimper conditioner is used during crop harvest. Consequently,

hay production from these species is at greater risk of rain damage or being allowed to get too mature before hay harvesting is possible.

Because of the extended period when they can be planted, hybrid forage sorghum, sudangrass, and sorghum-sudan hybrids fit well in many crop rotation systems with winter-grown small grain or vegetable crops. Rotations utilize residual fertilizers from previous crops and are critical to pest management systems (e.g., root-knot nematode). Some vegetable producers sow sorghum cover crops to increase soil organic matter content, retain soil nutrients, reduce weed populations and reduce pest populations. Rotations following small grains or spring vegetable crops are common for grain production. The hybrid forage sorghums and sorghum-sudan hybrids work well in this rotation for dairy and beef cattle operations where high quality grazing, green-chop or silage is needed. When volunteer from shattering or contamination with traditional sorghum may be a concern, sterile hybrids are available.

Selection of Forage Sorghum (All Types)

Yield: Several hybrid forage sorghum varieties have shown promising productivity in Florida and Georgia. In variety trials conducted by University of Florida (UF) and University of Georgia (UGA), the average yields during the most recent five years (2004 to 2009) were 6.3 dry tons per acre in Georgia and 6.1 dry tons per acre

in Florida (Table 1). However, few hybrids have performed poorly in Georgia or Florida under favorable environmental (rainfall amounts and seasonal distribution) and optimum soil fertility conditions.

Table 1. The average yeild and range of hybrid forage sorghum varieties in university trials in Florida and Georgia during 2004-2008.

	Avg.	Min.	Max.
	-------(dry tons/acre)-------		
Florida	6.1	2.6	11.7
Georgia	6.3	2.4	9.7

Maturity: Hybrid forage sorghum yields differ based on the stage of maturity at which the crop is harvested (Table 2). Harvesting the crop at the vegetative stage ensures multiple harvests and results in the highest yields, producing yields exceeding 7 dry tons per acre. Lowest yields are obtained when the crop is harvested at the flowering stage. There are no significant differences in yields when the crop is harvested at either the soft or hard dough stage. For quality silage harvest at the soft dough stage is recommended.

Table 2. Stage of maturity effects on dry matter yields of hybrid forage sorghums in Florida and Georgia.

Maturity Stage	Min.	Max.	Avg.
	-------(dry tons/acre)-------		
Flowering	3.99	4.42	4.15
Soft Dough	3.72	6.16	5.64
Hard Dough	3.92	6.65	5.83
Vegetative	7.26	7.40	7.36

Stability of yield: Stability of the hybrid forage sorghum was evaluated on the basis of yield consistency (yield by year, and yield by season), and lodging rating. These are calculated as the total number of plants that lodged as a function of the total number of plants per area, and are expressed in percentages (Table 3). In general, high yielding forage sorghum hybrids, depending on the hybrid, can produce dry matter yields exceeding 11 dry tons per acre in good years where rainfall is evenly distributed throughout the growing season. In bad years, however, uneven rainfall distribution during the growing season results in low yields that generally range between 2.5 and 7.3 dry tons per acre; again, depending on the hybrid.

The planting dates also have an effect on the dry matter yields of forage sorghum. The five-year study showed that when the crop is planted in the spring season, yields are generally high and an average yield exceeding 8 dry tons per acre are reported. When the crop is planted in the summer months, yields tend to be low.

Hybrid forage sorghum has shown to be very stable in terms of lodging. Lodging was rated on several hybrids in trials in Florida during the 2009 growing season, and low lodging was observed among all the hybrids evaluated. The average number of the total plants that lodged, across all hybrids, was less than 1% of the total plant stand, suggesting that the plants are very stable.

Table 3. Stability of hybrid forage sorghum grown in Florida (2009).

Stabillity Parameter	Min.	Max.	Avg.
-------(dry tons/acre)-------			
Yeilds in good years (T/A)	3.52	11.67	6.25
Yeilds in bad years (T/A)	2.55	7.27	4.97
Yeilds for spring Planting(T/A)	6.29	10.50	8.40
Yeilds for summer planting (T/A)	2.93	5.21	3.96
Lodging Rating(%)	0.00	1.00	0.62

Seed Treatments

Seed safeners

Recent advances in seed treatments for sorghum producers offer some advantages. Seed safeners, such as Concep®III, protect sorghum from herbicide injury following planting, allowing for the use of herbicides for pre-emergent grass and broadleaf weed control. Concep III, protects sorghum from chloroacetamide herbicide, such as metolachlor and dimethenamid. These herbicides can be highly valuable for pre-emergent grass and broadleaf weed control . However, if the seed safener is not present, use of these herbicides will result in severe sorghum injury or death.

Seed safeners

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Insecticides

Seeds can also be treated with insecticides, such as Cruiser® and Gaucho®. These treatments eliminate the need for in-furrow applications of insecticides like Counter®. These safeners protect your sorghum seed prior to emergence from below-ground pests like wireworm. In addition, they are systemic and protect your sorghum crop following emergence from above-ground pests like chinch bugs, greenbugs, red fire ants and yellow sugarcane aphids. These treatments can enhance germination, plant stand and vigor, as well as improve yield stability. The treatments have to be performed according to instructions provided by the manufacturer. Treated seed is also available from seed companies.

Fungicides

It is recommended to coat the seeds with a commercial fungicide prior to planting. The fungicide will reduce the risk of damping off, kernel smut and downy mildew. Commercial products that can be considered are thiram (Thiram 50WP or Gustafson 42-S), fludioxonil (Maxim 4FS), pentachloronitrobenzene (RTU-PCNB), metalaxyl

(Apron 50WP), and mefenoxam (Apron XL LS). All of these products will protect against damping off; whereas, protection against additional pathogens depends on the specific compound. The treatment has to be performed according to instructions provided by the manufacturer.

Planting

Seedbed Preparation and Planting Practices

Understanding targeted yield based on your situation

There are many sorghum varieties and large differences in sorghum production practices. This has led to some confusion and unrealistic expectations regarding yields. Sorghum can tolerate a wide range of soil conditions and withstands drought better than most other cereals. Although, optimal yields still require nutrients and water. Therefore, it is critical to understand the differences in yield potential between the sorghum species/varieties, the yield potential of the site, and the production goals necessary for your situation.

Planting date

There is a relatively wide range in planting dates for sorghum in the southeastern United States, mainly because sorghum germination is closely linked to soil temperature. For good stand development, it is important to ensure that the soil temperature at the 2-inch depth is at least 65° F. Cold soils result in poor germination and emergence and lead to poor stand development. Planting too early is one of the most common causes of poor establishment.

Plantings may begin in March in south Florida, early to mid-April in central and north Florida, mid-April in central and south Georgia, late April to early May in north Georgia, and as late as mid-May in the southern parts of the Appalachian range. (See map for optimal planting dates). New plantings can be made into summer until about 120 days prior to desired harvest, or the first frost. Plantings made after mid-June may have lower yields and experience more disease and insect pressure. Plantings made after early July may produce very limited yields because of shortening daylengths. Early planted silage sorghums will produce a second (ratoon) crop in Florida, but yields are generally less than the original harvest.

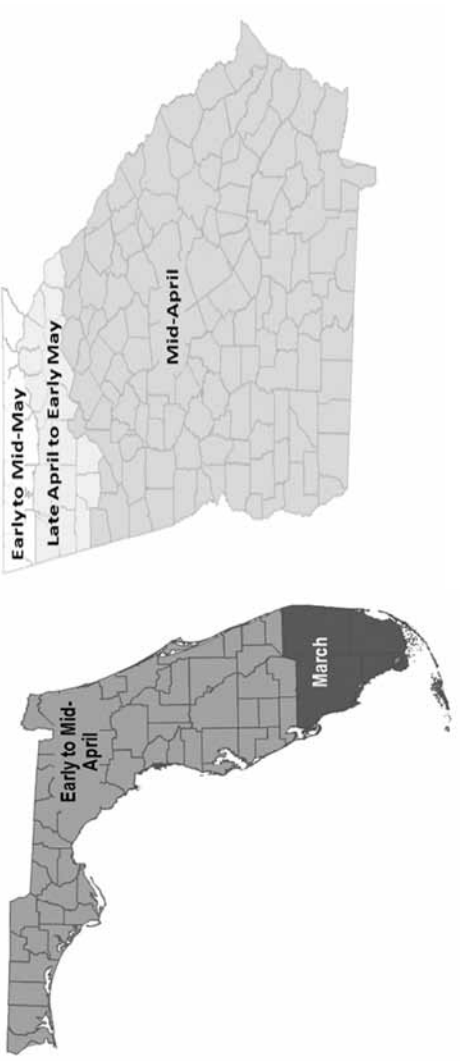

Figure 2. Map of Sorghum Optimal Beginning Planting Dates in Georgia and Florida.

Seeding rate (seed number per acre vs pounds per acre)

Sudangrass and sorghum x sudan hybrids can be broadcast (B) or drilled. Hybrid forage sorghum (single cut) is usually planted in wide (20 to 36 inch) rows (R) to facilitate harvest and in-season field operations. The planter may need special plates or other modifications to handle sorghum seed. Recommended seeding rate for forage sorghum intended for silage use in Florida and Georgia is 6 to 8 lbs. per acre (R) and 10–15 lb. per acre (B). Recommended seeding rate for sorghum-sudan hybrids in Florida and Georgia is 8 to 20 lbs. per acre (R) and 25 to 30 lbs. per acre (B). Excessive seeding can increase lodging (Table 4).

Table 4. Seeding rate for sorghums in Florida and Georgia.

Species	(Row Planting) lbs. per acre	(Broadcast) lbs. per acre
Hybrid Forage Sorghum	6-8	10-15
Sorghum X Sudan Hybrids	8-20*	25-30

**If finer stems are desired choose the higher rate.*

To calculate seeds per acre:

$$\frac{\text{(lbs. of seed)}}{\text{acre}} \times \frac{\text{(seeds)}}{\text{(1 lb. of seed)}} = \frac{\text{(number of seeds)}}{\text{acre}}$$

To calculate seeds per foot of row:

$$\text{Row spacing (inches)} \times 0.0833 \times \frac{\text{(lbs./acre)}}{\text{43560}} \times \frac{\text{seeds}}{\text{(1 lb. of seed)}} = \frac{\text{seeds}}{\text{(foot of row)}}$$

Table 5. Number of seeds per pound for different sorghum types.

	Seeds per lb.
Hybrid Forage Sorghum	14,000-17,000
Sorghum x Sudangrass	15,000-21,000
Sudangrass	35,000-45,000

Plant population/row width

Forage sorghum yields tend to increase with narrower rows. Final plant density should be adjusted to growth conditions in your region. In drier regions or regions with sandy soils that hold little water, planting density should be on the low end of the recommended range. Forage sorghums tend to be planted at relatively high densities to improve quality, but for BMR forage sorghums this is unnecessary. Recommended plant populations for BMR are 60,000-80,000 plants per acre (rows, irrigated), 70,000-100,000 plants per acre (drilled, irrigated), 40,000-80,000 plants per acre (rows, rainfed), and 50,000-80,000 plants per acre (drilled, rainfed).

Tillage practices
Preparation of soil for planting generally includes plowing and harrowing. Plowing can be done in the fall or just before planting. In areas where soil erosion due to wind and water are a concern, conservation tillage may be appropriate. Sorghum also does well in no-till production systems. Studies have shown no consistent differences in biomass yield when comparing no-till and conventional tillage practices. No-till has proven beneficial for yields in continuous sorghum rotations.

Planting practices
Sorghum planting practices should match intended usage. Forage sorghum used in pasture can be planted by drill, a broadcast seeder or in rows.

Seeding depth
Recommended planting depth for hybrid forage sorghum is 1 to 1.5 inches for sandy soils and .75 to 1.25 inches in heavy soils. Seeds should be planted in moist soil and can be planted slightly deeper if necessary to reach moisture. However, shallower planting will result in quicker emergence and minimize disease and herbicide problems that can be associated with delayed emergence. Sudangrass and sorghum x sudan hybrids should be planted no deeper than 1 inch; specifically 0.25 to 0.5 inches in heavy soils, and 0.5 to 0.75 inches in sandy soils.

Irrigation

Water-use Requirements
Forage sorghums will respond to irrigation like most crops. However, due to its low market value, it is seldom irrigated. The increase in sorghum yield due to the added moisture may not pay for the irrigation costs. Forage sorghum is often grown after irrigated corn since irrigation is available from corn.

Forage Sorghum is able to grow and survive in regions where rainfall is relatively low or where frequent dry periods occur. Still, growth and yield responses are closely related to available water. Limited data for water-use requirements are available in the southeastern U.S. Water use estimates reported elsewhere typically range from about 15 to 30 inches of water to produce a forage sorghum crop. Across this range of water use, a recent study using a BMR forage sorghum near Bushland, Texas, showed an increase in yield of approximately 0.83 tons per acre for each additional inch of water use, from about 10 tons per acre at 15 inches of water use to about 22 tons per acre at 30 inches of water use. Another recent study from the same location comparing sorghum and corn silage production reported lower seasonal crop water use by sorghum (19.3 compared to 26.4 inches). However, yields per unit water use were similar among sorghum and corn. These findings indicate that sorghum can be produced with less water but yields will

be commensurate with water use. So, in regions where water availability is low, irrigation is not available or water use is restricted, sorghum offers an attractive alternative for forage production, but lower yields must be expected.

Timing of Moisture

Soil moisture is critical for germination. Water stress during booting, flowering and grain fill can greatly reduce grain yields for grain sorghums. Other than germination, forage sorghums do not have the growth stages where water availability is critical, so they tend to use water more efficiently and timing of moisture is less of a concern. Dormancy is frequently noted in forage sorghum with a good response following rainfall. As a result, forage sorghum planted in June in the southeastern U.S. will need little irrigation because rainfall is generally sufficient to produce a good crop. However, earlier planting will run into moisture deficits and irrigation will greatly increase yields.

Nutrient Management

Timing of application

For row plantings, preplant fertilization requirements can be broadcast and plowed down before planting. Alternatively, fertilizer can be applied at time of planting in continuous bands 2 to 3 inches to each side and 2 to 3 inches below the seed. For drill or broadcast plantings the initial fertilization should be broadcast and disked into the soil ahead of planting, making sure not to place fertilizer in direct contact with the seed. Splitting the total fertilizer that is to be applied equally between an "at-planting" application and one or more additional applications during the growing season is highly recommended. This practice increases nutrient use efficiency and reduces the risk of nutrient runoff, leaching or gaseous loss. When the crop is produced for silage, the second applications should be applied when the crop reaches a height of about 12 inches (and 24 inches if split three times). If the crop is grazed or cut for hay, split applications should be made after each grazing/harvest event.

Soil/Plant Testing for Nutrition

Adequate soil fertility is necessary for optimum yield, and soil testing is the means to evaluate soil fertility. Based on removal of the crop, 120 lbs. nitrogen (N; supplied as ammonium nitrate), 65 lbs. phosphorous (P; supplied as P_2O_5), and 120

lbs. potassium (K; supplied as K_2O) are recommended for 21-ton-per-acre yield potential. Adjust by 30–15–30 lbs. for each 4-ton-per-acre change in yield goal.

As with all crops, an ample supply of available nutrients must be provided for optimal forage sorghum production. Maintaining optimum soil fertility is critically important for ensuring good establishment, persistence, pest resistance, drought tolerance, forage quality, yields, and, most importantly, economic returns. If any nutrient is deficient, problems in one or all of these areas can occur. Thus, it is critical that a good soil fertility program be the basis of the management system for forage sorghums.

A soil test is the best tool for assessing soil fertility. Soil testing is a chemical analysis that reveals any soil fertility issues that may be limiting production. The key to soil testing is to ensure that the sample is representative of the area of interest. At the very least, each field should be sampled separately. Soil pH and some nutrients will often vary with soil type. Fields with substantially different soil types should be sampled separately within major soil types.

Table 6.

		Potassium			
		Low K	Medium K	High K	Very High K
Soil Test Rating		Coast: 0-60 lbs./A	Coast: 61-150 lbs./A	Coast 151-250 lbs./A	Coast: 250+ lbs./A
Phosphorus Low P		Recomended Pounds $N\text{-}P_2O_3\text{-}K_20$ per acre			
Coast:0-30 lbs./A	GA				
Pied: 0-20 lbs./A	GA				
	GA	150-80-160	150-80-120	150-20-90	150-80-80
	FL	150-100-100	150-100-50	150-100-0	150-100-0
	FL	150-100-125 (very low K)			

Medium P					
COats:31-60 lbs./A	GA				
Pied: 21-40 lbs./A	GA				
	GA	150-0-160	150-0-120	150-0-90	150-0-80
	FL	150-50-100	150-50-50	150-50-0	150-50-0
	FL	150-50-125 (very low K)			
HIgh P					
Coast:61-100 lbs./A					
Pied: 41-75 lbs./A					
	GA	150-140-160	150-40-120	150-40-90	150-40-80
	FL	150-0-100	150-0-50	150-0-0	150-0-0
	FL	150-0-125			

Very High P					
Coast:100+ lbs./A					
Pied:75+ lbs./A					
	GA	150-40-160	150-40-120	150-0-90	150-0-80
	FL	150-0-100	150-0-50	150-0-0	150-0-0
	FL	150-0-125			

Coast= Coastal Plain Pied=Piedmont, Mountain, and Limestone Valley

The soil sample analysis provides a guideline for the amount of lime or fertilizer needed to correct deficiencies or imbalances in soil pH or available nutrients. These amounts are determined by the specific needs of the crop being grown. Furthermore, soil test recommendations from Land Grant Universities are based on decades of scientific studies. Thus, by regularly testing soil and following the recommendations, soil fertility can be maintained at levels that result in optimum productivity. In this section, the importance of several essential elements is briefly conveyed and generalized recommendations are relayed. However, one should follow the soil test recommendations for their state or region, as they have been refined for those conditions.

Nitrogen

Rate of N application will vary depending on soil quality and production goals. For each green ton (600 dry lbs.) of sorghum forage produced, approximately 9 lbs. of N are removed. With good management, some varieties can produce 40 or more green tons (12 dry tons) per acre from a single crop.

In general, forage sorghum should receive 120 to 150 lbs. N per acre for a yield goal of 20 to 25 green tons (6 to 7.5 dry tons) per acre. Irrigated forage sorghums should receive up to 30% more N. When calculating N needed, consider residual soil N, soil organic matter, N content in irrigation water, and manure applications. Reduce the

N rate by 20 to 40 lbs. per acre following peanuts and soybeans, and by 80 to 100 lbs. per acre following alfalfa or a legume winter cover crop that is allowed to bloom.

General recommendations are that one-fourth to one-third of the total recommended N rate per acre should be applied just prior to or at planting. For silage production, topdress or sidedress the remaining N according to production goals when the crop reaches 18 to 24 inches (approximately 4 to 6 weeks after planting). If a second (ratoon) crop is attempted, fertilize at half the original rate when plants are 12 to 24 inches in height. For grazing purposes apply 30 to 50 lbs. N per acre after each grazing period or harvest, as needed.

Table 7. 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

Phosphorus (P)

Sorghum response to P is typically only seen in soils with very low available P. Apply the entire soil test recommended P fertilizer in a preplant or planting application. In acid soils with low available P, banding P fertilizer near the furrow at planting may be warranted.

Potassium (K)

Potassium availability for sorghum production is important, as K is an essential element for the plant and markedly improves disease and pest resistance. The addition of K is crucial, since removal rates by forage sorghum can be relatively high. The most common K formulation (muriate of potash or potassium chloride (KCl)) has also been shown to increase stalk strength, and thus plays an important role in minimizing lodging. Recent evidence suggests that the chloride (Cl^-) in KCl contributes to lodging resistance. If the forage sorghum production is intended for silage use, apply 30% of the soil-test recommended K fertilizer as a pre-plant broadcast or as a starter application at planting. when the crop reaches 18 to 24 inches (approximately 4 to 6 weeks after planting) topdress or sidedress the remaining 70% of the K fertilizer before planting. If a second (ratoon) crop is desired, fertilize at half the original rate. For sudangrass or sorghum-sudan hybrid crops that are intended for grazing, apply 50% of the soil-test recommended K fertilizer as a pre-plant broadcast or starter application at planting. Apply the remaining 50% of the K fertilizer after the first grazing.

Sulfur (S)

Fertilizer additions to forage sorghums should contain sufficient S to supply 10 lbs. of S per acre. Since S is highly leachable, especially on deep sands, application of S with post plant nitrogen applications may improve efficiency.

pH

Sorghum is tolerant to a wide range of soil pH conditions (soil pH range from 5.5 to 8.5), but the optimum pH is 6 to 6.5. Soils in the south-eastern United States are typically low in soil pH. Low soil pH can result in a poorly developed root system. Additionally, low soil pH alters the availability of many of the essential nutrients. Low soil pH reduces the nutrient use efficiency of major nutrients like N, P, K, and S, and it frequently induces deficiencies or toxicities of minor nutrients like molybdenum (Mo), boron (B), zinc (Zn), and manganese (Mn). For these reasons, care should be taken to keep soil pH in the optimum range.

Minor/Trace Nutrients

Most minor nutrients should be available to the plant if soil pH values in the optimum range. However, some soils may be deficient in one or more of the minor nutrients. The addition of minor nutrients should be applied according to soil test results.

Weed Control

Pre-plant Weed Strategies

In order to minimize the competition with weeds, a pre-emergence herbicide may be applied to the field prior to seeding the sorghum. Unlike corn, sorghum tends to be much more sensitive to herbicides sprayed to kill grassy weeds (Dual®, Bicep®, Primextra®), especially during the early developmental stages. Therefore, treating the seed with a safener is strongly recommended to minimize damage to the seedlings. Safeners are applied to the seed in a liquid form, followed by air-drying, which will leave a thin coating of the safener on the seed. Approved brands of safener include Concep II® and Concep III® (Syngenta) and CSI Safener 500FS® (Bayer). These protect against metolachlor and S-metolachlor herbicides. It is important to use the recommended dose and to follow all safety instructions.

The most important consideration is control of grasses during emergence and seedling development of the sorghum. If grasses are not controlled at this stage and are as large as the sorghum, then cultivation will not control the grasses without killing the sorghum. Sorghum should not be planted in fields that are heavily infested with johnsongrass. If grasses can be controlled until the sorghum gets an initial height differential, cultivation can then be effective. If such a height differential is achieved, post-directed sprays can also be effective.

Broadleaf weeds are a less serious problem since several herbicides can be effectively used for their control.

Table 8. Herbicides Applied at Planting. Pre-Emergence Herbicide Recomendation from University of Florida.

Trade Name and Rate of Commercial Product Per Acre	**Common Name and Rate of Active Ingredient Per Acre**	**Remarks**
Dual II Magnum or Dual Magnum 1.0 - 1.33 pt	S-metolachlor	Use on seed that has been treated with a chemical safener such as Concep. If seed is not properly treated, severe injury will occur. Good control of many grasses and certain small seeded broadleaf weeds. Apply after planting before weeds and sorghum emerge. It can also be applied with fluid fertilizer.2
Stalwart, Parallel, Me-too-lachlor 1 to 1.3 pt	metolachlor	See above. Note that metolachlor products will commonly provide less soil residual control that those containing S-metolachlor.
Outlook 13 oz	dimethenamid	Similar to S-metolachlor.

Post-Emergence Weed Strategies from University of Florida

Mechanical weed control (mowing, tilling) can be applied to the edges of the field and alleyways. Post-emergence weed control inside the field can include the application of atrazine (controls broad leaf and weedy grasses), typically while the weeds are still small. It is best to apply atrazine selectively, as the sorghum plants can be easily damaged as well. Broadleaf weeds can be controlled with broadleaf herbicide such as mesotrione. Sorghum plants will not be damaged by such herbicides and aerial applications are therefore possible.

Table 9. Post Emergence Herbicide Recommendation from University of Florida (Ferrell et al 2009).		
Trade Name and Rate of Commercial Product Per Acre	**Common Name and Rate of Active Ingredient Per Acre**	**Remarks**
AAtrex or Atrazine[3] (several formulations)	atrazine 1 to 2 lb. ai/acre	Apply after sorghum reaches the 3-leaf stage and before broadleaf weeds are 4 inches tall. For ground applications add emulsifiable oil concentrate at 1 qt/A. Do not apply more than 2 lb. per application and do not apply more than 2.5 lb./A/season. Do not graze or feed forage for 21 days following application. A restricted use pesticide.
Aim EC 0.5 - 1 oz	carfentrazone	Can be applied to sorghum from 30 days prior to planting to the 6 leaf collar growth stage. Controls many broadleaf weeds, but good coverage is essential. Addition of non-ionic surfactant (0.25% v/v) is required, but crop oil is not recommended due to increased crop injury. Directed applications are recommended if rates higher than 0.5 oz will be used. Expect moderate leaf burning from over-the-top applications. Do not apply to sweet sorghum.
2,4-D amine[4] (several brands) 2/3 to 1 pt of 4 lb./gal	2,4-D	Broadleaf weeds controlled. Sorghum is not as tolerant to 2,4-D as corn. Broadcast after sorghum is 6 to 8 inches tall. If sorghum is 10 to 15 inches, use drop nozzles to direct spray toward base of plant. Over-the-top applications are most likely to result in herbicide injury. Do not treat sorghum in boot, tassel, or soft-dough stage. Avoid drift.
Banvel, Clarity, Sterling [4] 0.5 pt	dicamba	Controlls broadleaf weeds. Apply from the three-leaf stage until plant reaches 8 inches tall. Apply only as a directed spray on plants between 8 and 15 inches. Do not graze or feed treated sorghum, forage, or silage prior to mature grain stage. Avoid drift.
Basagran 1.5 - 2.0 pt	bentazon	Apply over the top before weeds exceed 4 to 6 inches in height. Grain sorghum should be fully emerged. Sorghum is very tolerant to bentazon, but do not apply to sorghum that is heading or blooming. Apply with a crop oil adjuvant at a rate of 1 qt/acre.
Buctril 2EC 1 - 1.5 pt	bromoxynil	Apply to sorghum between the three-leaf stage to 12 inches height or pre-boot stage to control most broadleaf weeds in the 2 to 4 leaf stage of growth. Use 10 or more gallons of water per acre.

Lorox 4L 1 - 2 pt	linuron	Apply as a directed spray after sorghum is 12 inches tall. Use low rate when sorghum is 12 to 15 inches tall, and a sprayer equipped with skids, shoes or shields. Use the high rate when sorghum is 15 inches tall and weeds are up to 4 inches in height. Make only one application per season. Add non-ionic surfactant (1pt/25 gal spray). DO NOT graze or feed plant parts to livestock within 3 months after application.
Gramoxone Inteon 1 - 2 pt	paraquat	Controls grass and broadleaf. Apply as a directed spray when sorghum is a minimum of 12 inches tall and weeds are less than 3 inches tall. Do not spray higher than 3inches on the sorghum plant. Add non-ionic surfactant at 1 qt per 100 gal of spray.
Peak 57DF	prosulfuron	Provides postemergence and residual controls of many annual broadleaf weeds. Apply after sorghum reaches 5 inches in height and before 30 inches. Refer to label for specific weed sizes but as a general rule apply before weeds reach greater than 4 to 6 inches high. The use of a non-ionic surfactant or crop oil is recommended. May be tank-mixed

		with Banvel, 2,4-D, or atrazine. Do not apply Peak within 15 days to sorghum treated with foliarly applied organophosphate insecticides. Do not graze within 30 days, or harvest silage within 40 days, of application. Do not apply to sweet sorghum. Rotational restrictions include the following: wheat, barley, rye, oats - 0 months; field corn - 1 month; peanuts, tobacco, cotton - 10 months.
Sandea 2/3 - 1 oz	halosulfuron	May be applied from the two-leaf stage through layby (before head emergence) to control nutsedge and other broadleaf weeds. Do not apply more than 1 oz/A/yr. Applications to a stressed crop will increase injury for 7 to 10 days.
Pendimax, Prowl 3.3 EC 1.2 - 1.8 pt or Prowl H20, 1.5 pt (culti-spray)	pendimethalin	For extended control of late-season grasses, cultivate so that brace roots and stems are covered and protected when sorghum is 4 inches in height or in the 2-leaf stage. Immediately spray with Prowl. If rainfall (0.5 inches) is not received within 7 days after application, incorporate with a sweep-type or rolling cultivator. Can be tank-mixed with atrazine.

[1] Concep III, manufactured by Syngenta Corp., is a seed protectant which is applied to sorghum seed to minimize injury when the herbicides Dual Magnum or Dual II Magnum are used on sorghum for weed control. Screen, manufactured by Monsanto Company, is a seed protectant which is applied to sorghum seed to minimize injury when the herbicides Dual Magnum or Dual II Magnum are used on sorghum for weed control.

[2] Observations in wheat fields indicate crop damage when 2,4-D is tank mixed with liquid nitrogen. This also may be evident with other herbicide-nitrogen mixtures. To avoid possible damage and obtain better weed control, herbicides and nitrogen should be applied separately.

[3] WARNING: THE FOLLOWING STATEMENT HAS BEEN ADDED TO THE ATRAZINE LABEL.
THE FOLLOWING STATEMENT HAS BEEN ADDED TO THE ATRAZINE LABE. THIS STATEMENT SHOULD BE HEEDED BY ALL PROSPECTIVE USERS AND STEPS SHOULD BE TAKEN TO COMPLY WITH THIS LABEL CHANGE. ATRAZINE IS A CHEMICAL WHICH CAN TRAVEL (SEEP OR LEACH) THROUGH SOIL AND CAN CONTAMINATE GROUNDWATER AS A RESULT OF AGRICULTURAL USE. USERS ARE ADVISED NOT TO APPLY ATRAZINE WHERE THE WATER TABLE (GROUNDWATER) IS CLOSE TO THE SURFACE AND WHERE THE

SOILS ARE VERY PERMEABLE, i.e., WELL-DRAINED SOILS SUCH AS LOAMY SANDS. YOUR LOCAL AGRICULTURAL AGENCIES CAN PROVIDE FURTHER PRODUCT LABEL STATEMENTS INCLUSDE AS A FURTHER QUALIFICATION OF RISKY SOILS, SOILS CONTAININ SINKHOLES OVER LIMESTONE BEDROCK, SEVERELY FRACTURED SUFACES, AND SUBSTRATES WHICH WOULD ALLOW DIRECT INTRODUCTION INTO AN AQUIFER.

[4] See fact sheet SS-AGR-12 *Florida Organo-Auxin Herbicide Rule* for state rules pertaining to application of organo-auxin herbicides in Florida.

Herbicide recommendations in this report are contingent upon their registration by the Environmental Protection Agency. If a registration is canceled, the herbicide would no longer be recommended.

Table 10. Estimated effectiveness of herbicides on Common Weeds found in Sorghum plantings in Florida and Georgia.

Weeds	Herbicide									
	Dual or Outlook	**Basagran**	**Pendimax or Prowl**	**AAtrex or Atrazine**	**Banvel or 2,4-D**	**Gramoxone Extra**	**Sandea**	**Aim**	**Peak**	**Buctril**
Time of Application	POT/ culti-spray	POT	PRE	POT	POT/PDS	PDS	POT	POT	POT	POT
BROADLEAF										
Bristly starbur	P	G	P	E	G	G-E	G	-	-	F
Cocklebur	P	E	P	E	E	E	E	F	G	E
Florida Berggerweed	F-G	F	F-G	G	G	G-E	P	-	-	F
Florida pusley	G-E	G	G-E	E	G	G	-	-	-	G
Morning-glories	P	P	P	E	E	G	P	G	F	G
Pigweed	E	P	E	E	E	G-E	G	F	G-E	F
Ragweed	F	F	F	E	E	G-E	G	F	G	F
Sicklepod	P	P	P	E	E	G-E	P	P	F-G	P
Grass										
Crabgrass	E	P	E	G	P	E	P	P	P	P
Goosegrass	E	P	E	G	P	E	P	P	P	P
Johnsongrass (from seed)	F	P	F	G	P	E	P	P	P	P
Sandbur	G	P	G	G	P	E	P	P	P	P
Texas panicum	P	P	P	F-G	P	E	P	P	P	P

Sedge											
Purple Nutsedge	P	P	P	P	P	P	F-G	G-E	P	P	P
Yellow Nutsedge	F	G	F	P	P	P	F-G	G	P	P	P

1 Estimated effectiveness based on herbicide rates recommended in this report. Effectiveness may vary depending on factors such as herbicide, size of weeds, time of application, soil type, and weather conditions.

Time of Application: PRE = Pre-emergence; POT = Post-emergence broadcast; PDS = Directed post-emergence;

Weed Control Symbols: E = 90-100% control; G = 80-90% control; F = 60-80% control; P = Less than 60% control

Additional information on herbicide effectiveness can be found in Extension Weed Control in Florida (http://weedext.ifas.ufl.edu) or in the Georgia Pest Management Handbook (http://www.ent.uga.edu/pmh/).

Insect Management

A number of insect pests cause economic damage to sorghum plantings in the southeastern United States. Many of the insects that attack corn can also attack sorghum. Three insect pests that are commonly found on sorghum in the southeastern United States are sorghum midge (Contarinia sorghicola Coquillett), greenbug (Schizaphis graminum Rondani) and chinch bug (Blissus insularis). A description and picture of each of these three insects can be found below.

Sorghum Midge (*Contarinia sorghicola* Coquillet) (Photo 1)*

Description and Damage: Sorghum midge is the most damaging of the pests. It is a small (1.3 mm) orange-red fly with a yellow head, brown antennae and legs, and gray wings. The female fly lays her eggs in the panicle of the sorghum plant, between the glumes of open (flowering) spikelets. Because of its short generation time (2 weeks), high infestation rates can occur. Infestation with sorghum midge will result in reduced seed production. The Sorghum Midge is not an issue with the grazing type sorghums.

Management: Damage due to sorghum midge can be reduced by planting early, and by uniform panicle emergence, so that there is limited opportunity for later generations to thrive on

*All *Photos found in Appendix B, Page 89.*

more slowly maturing panicles. Application of insecticides can further reduce damage

Greenbug (*Schizaphis graminum* **Rondani) (Photo 2)***
Description and Damage: Greenbugs are aphids and have a light green or dark green appearance. Adults are approximately 1.6 mm long.
They live on the underside of the leaves and produce a sticky residue known as honeydew. Greenbugs seen were severe on the high sugar sorghums.
Damage to sorghum results when the aphids suck juice out of the plant and inject toxins. The toxins will damage the leaves and weaken the plant, resulting in reduced stand, lodging, and yield losses. Greenbug populations generally decline towards the end of the season because of the parasitic braconid wasp (*Lysiphlebus testaceipes* Cresson).

Management: Damage due to greenbugs can be controlled by organophosphorous insecticdes, which have to be applied at low rates to avoid damaging other insects.

Chinchbug (*Blissus insularis*) **(Photos 3 and 4)***
Description and Damage: Chinch bugs affect mostly seedlings. Adult chinch bugs are 4.2 mm in length and are dark in color with white forewings. The larvae are red to black with a light stripe across the abdomen. The eggs are laid behind the sheath of the lower leaves. With a

30- to 40-day life cycle, it is common to have two to three generations of chinch bug per growing season.
Both young and adult chinch bugs suck juice from the stem and roots, resulting in weakened and stunted plants, and yield losses.

Management: Chinch bug damage can be limited by planting sorghum early, and at high density. Insecticides can be used to control chinch bug during the early stages of plant development.

Additional information:
Sorghum midge:
http://sorghumipm.tamu.edu/pests/panicles/smidge.htm
Greenbug:
http://sorghumipm.tamu.edu/pests/leaves/grn-bug.htm
Chinch bug:
http://sorghumipm.tamu.edu/pests/seedling/cbug.htm
http://www.lsuagcenter.com/NR/rdonlyres/322D2121-2EE3-496B-9256-1402339916D7/10285/pub2496cinchbugs4.pdf

Nematodes
Many plant-parasitic nematodes that parasitize other crops also attack forage sorghum and sorghum sudan hybrids, and can limit sorghum yields when sorghum is following sorghum with a grain crop in between the sorghum crops. However, out of the many plant-parasitic

nematodes, *Pratylenchus* spp. and *Belonolaimus* spp seem to be responsible for reduction in yield of most hybrids. Their levels have been found to build up to levels that can destroy sorghum root systems sufficiently to cause a crop failure on well-drained sandy soils. In Florida,this can occur in just two seasons, where spring grain sorghum was followed by rye for grazing in the winter, then followed by summer silage sorghum the second year. Similar outcomes have been reported for Georgia. Proper crop rotation is critical to maintain optimum sorghum productivity.

Sorghums should be rotated with broad-leaved crops between growing seasons. Examples of broad-leaved crops might include southern peas, cotton, soybean, Irish potatoes, sweet potatoes, cucurbits, and solanaceous crops.

Nematode Name:
Pratylenchus (*Pratylenchus sp*)
Description and Damage:
- Yellowing and stunning of top growth.
- Lesions on roots.
- Loss of primary roots and severe pruning of roots.

Management
- Build up to damaging levels of this pest can be delayed by using varieties with some resistance to these nematodes.
- The use of nematicides also helps in delaying the build-up of nematodes.

Diseases

Forage sorghums in Florida and Georgia can be susceptible to several diseases. Potential diseases include Anthracnose (major leaf disease), Zonate Leaf Spot, Rough Spot, Northern Corn Leaf Blight, Bacterial Leaf Stripe, Rust, Head Mold, and Ergot. Of these, Ergot is the only disease that has caused significant damage on forage sorghum in the southeastern United States in the past few years. In fact, it is a rare occurrence when one or more of the diseases cause severe damage or economic loss in forage sorghum. Moreover, no fungicides are labeled for use on forage sorghum plantings. Disease management in forage sorghum plantings is largely mitigated by proper planting time and crop rotation.

Disease:	**Anthracnose (*Colletotrichum sublineolum)* (Photo 5 and 6)***
Symptoms:	• Elliptical black lesions, larger than 5 mm in diameter that develop circular, straw-colored centers with wide margins that may vary in color from reddish-blackish purple. • On some cultivars disease may defoliate the plant and in severe cases, plants will die before they reach maturity. • May also occur on stalks, where it is known as stalk or red rot, panicles (head rot) and the grain. • Disease favored by frequent rains and warm nights.
Management:	• Crop rotation, • Cultivar resistance (good resistance in forage sorghums) • Suppression of grass weeds and volunteers around field • Adjust planting date (mid-April to early May to avoid late summer disease pressure in North Florida)
Disease:	**Head Mold (Fusarium, Curvularia, Colletotricum, Alternaria, and Bipolaris spp.) (photo 6)***
Symptoms:	• Florida's warm, wet summer weather is conducive to head mold. • Infection by some Fusarium spp. can produce toxins that are poisonous to livestock. • Abnormal colorations and moldy growths on the head. • Fusarium spp. cause white-pink colors on the outside of flowers and seed.

**Photos found in Appendix B, Page 89.*

Management:	• Can be severe in some plantings, especially in varieties with tight heads or panicles or some non-bird resistant types of sorghum. • Red seed coats provide some resistance to this disease complex. • Plant at a time of year when flowering initates during drier months, reduce insects such as sorghum midge, use resistant varieties.
Disease:	**Ergot (*Claviceps africana*) (Photo 8)***
Symptoms:	• Initial symptom is appearance of sphacelia, which is a white swelling of the seed. • Sphacelia produce honey dew and spores. • Black sclerotia develop in place of the seed and give an overall black, sooty appearance to the seed head.
Management:	• Especially problematic on later plantings, or plantings that mature later. • Male sterile forage sorghum is also at heightened risk for Ergot. • An active infection cannot be cured. Avoid late planting and utilize cultivar resistance. • Early-applied fungicides can be effective but may be cost prohibiting
Disease:	**Bacterial Leaf Stripe (*Pseudomonas andropogonis*)(Photo 9)***
Symptoms:	• Reddish-purple to tan-brown somewhat linear spots. • Lesions tend to be interveinal and may attain lengths of 8 inches with lesion color uniform throughout. • Favored by warm, wet weather conditions.

Management:	• Not a major problem in Florida. • Most forage sorghum varieties have tolerance and/or resistance to this bacterial disease. • Crop rotation • Resistant varieties • Plowing down old crop debris • Avoid field operations when the field is wet.

Disease:	**Northern Corn Leaf Blight** (*Exserohilum turcicum*) **(Photo 10)*** Pathogen also known as *Bipolaris spp,* or *Helminthosporium spp*.
Symptoms:	• Lesions are cigar-shaped, tan to brown in the center. • Lesions are sometimes surrounded by a dark brown-reddish purple border or narrow band of water soaking.
Management:	• Rarely seen disease on forage sorghum in Florida. • Resistant varieties • Crop rotation with non grass crops • Bury old sorghum crop debris • Destroy Johnsongrass and volunteers of susceptible crops in the vicinity

Disease:	**Rust (*Puccinia spp.*) (Photo 11)***
Symptoms:	• Pathogen produces elongated raised pustules in leaves and in the outer tissue of the peduncle (head stem). • Pustules in leaves are smaller than 1/8 inches long and often surrounded by a reddish-brown to tan halo. • Pustules in peduncle may be longer and linear or within oval red to brown lesions. Within raised pustule, a red to orange brown mass of spores will be exposed if the pustule covering has ruptured. • Spores are easily dispersed by wind. Pathogen also produces telial lesions which are dark brown to black in color. • Favored by cool, wet conditions.
Management:	• Has not been a major problem in Florida. • Resistant varieties • Management of rust harboring weed species such as red sorrel

Disease	**Zonate Leaf Spot (*Gloeocercospora sorghi*) (Photo 12)***
Symptoms	• Early lesions can be similar to Anthracnose. • Larger lesions have, however, distinctive circular alternating bands of white or tan with bands of reds, purples, or browns. • Disease favored by frequent rains and warm nights.

Management	• Historically, has not been a major problem in Florida. • Management includes crop rotation. • Use resistant varieties. • Bury old crop debris by plowing. • Avoiding field tasks when leaves are wet.

Further information on disease symptoms and management:

- University of Florida has on line information on plant pathology for sorghum crops
- http://plantpath.ifas.ufl.edu/takextpub/FactSheets/circ1073.pdf

- University of Georgia has a plant pathology website that is a disease library and includes information on sorghums about 2/3 of the way down the page.:
-
- http://plantpath.caes.uga.edu/extension/DiseaseLibrary.html

- http://plantpathology.tamu.edu/sergot/default.asp

Harvesting

Preharvest Desiccants for Sorghum

Preharvest desiccants are commonly used in grain sorghum. For forage sorghums, no preharvest desiccants are needed and those that are commonly used in grain sorghum have harvest interval restrictions that make them impractical for forage use (i.e., the feeding restriction after application is too long for these products to be feasible).

The time of harvest can be critical to sorghum yields. Silage sorghums should be harvested at soft-dough stage for maximum dry matter yield and forage quality. Green-chop sorghums should be harvested pre-boot for repeated cuttings. Protein content often decreases in the 18 to 24 inch stage. Ratoon crops of either silage or forage sorghums should leave at least two intact nodes (counting from the soil surface upward, usually over 6 inches) for regrowth, and need an application of nitrogen fertilizer. Grain should dry sufficiently in the field, but if left longer than necessary, bird predation, ergot and other diseases in the seed head can significantly reduce yield. Syrup sorghums should be harvested at peak sugar content (highest °Brix, measured from juice expressed at the fourth node from the soil level).

Drying and Storage of Forage Sorghum

If harvesting sudangrass or sorghum x sudan

hybrids, it is best to use a roller-crimper mower-conditioner. Research in Georgia has indicated that it takes sudangrass or sorghum x sudan hybrids at least 1 to 2 days longer to dry to hay-making moistures than the perennial grasses conventionally used as hay crops in the southeastern United States. Failure to use a roller-crimper mower-conditioner may add 3 to 4 additional days to this drying time.

Sorghum Economics

Marketing Strategies for the Southeastern United States

Sorghum silage hybrids can produce high fresh weight yields of silage. In northeast Florida, on a wet Flatwoods soil site, highest crude protein, total digestible nutrients and fresh weight yields were obtained when the silage hybrids were harvested at the soft-dough stage of maturity with an intermediate nitrogen rate. Custom-chopping silage for local dairies and feed lots is an option. Large enough equipment is now available to cut. Allow wilting to 50 to 60% moisture, rolling, and bagging for ensilaging in 1,000 lb. plastic-wrapped units. The wrapped units can be stored and transported when needed by livestock producers.

The production of sorghum x sudangrass hybrids and sudangrass for grazing is directly tied to beef cattle and dairy production systems. These grasses are efficient users of nutrients, making them adapted to capturing nutrients from lagoon spray fields in the form of forage, which can again be re-cycled through the ruminant animal. Pastures of these grasses could be used to raise replacement beef heifers and dairy cattle. Back-grounding beef calves on a contract basis might be an option. The movement to buy locally-raised beef and pasture-raised beef could be exploited, although this is a small, currently emerging market.

Table 11. Economic Worksheet adapted to Southeast conditions ($ figures will be blank to be used as a template for farmers to utilize in working up their cost of production)

Irrigated forage sorghum harvested one time per year for silage.	**Unit**	**Number of Units**	**$/Unit**	**Cost/Acre**	**Your Farm**
Variable Costs (VC):					
Seed	Thous.	150.00	$ 0.09	$ 13.80	
Lime	Tons	0.50	$ 35.00	$ 17.50	
Fertilizer					
Nitrogen	Lbs	150.00	$ 0.75	$ 150.00	
Phospate (P_2O_5)	Lbs	60.00	$ 0.90	$ 81.00	
Potash (K_2O)	Lbs	120.00	$ 0.60	$ 75.00	
Weed Control	Acre	1.00	$ 14.59	$ 14.59	
Insect Control	Acre	1.00	$ 6.53	$ 6.53	
Machinery: Preharvest					
Fuel	Gallon	3.73	$ 4.00	$ 14.93	
Repairs & Maintenance	Acre	1.00	$ 6.48	$ 6.48	
Irrigation*	Inch	5.00	$ 16.50	$ 82.50	
Labor	Hrs	0.56	$ 10.00	$ 5.64	
Crop Insurance	Acre	1.00	$ 9.00	$ 9.00	
Land Rental	Acre	1.00	$ -	$ -	
Interest on Operating capital	Percent	$ 238.49	8.00%	$ 19.08	
Total Pre-harvest Costs				$ 496.05	
Harvesting Costs					
Custom Harvesting	Tons	20.00	$ 10.50	$ 210.00	
Custom Bagging	Tons	20.00	$ 8.00	$ 160.00	
Total Harvesting Costs				$ 370.00	
Total Variable Costs				$ 866.05	

Fixed Costs:						
Machinery: Depreciation, Taxes, Insurance, and Housing						
Preharvest	Acre	1.00	$ 17.60	$ 17.60		
Harvest	Acre	1.00	$ -	$ -		
Management	% of VC	$ 866.05	5.00%	$ 43.30		
Irrigation	Acre	1.00	90.00	$ 90.00		
Owned Land Costs; Taxes, Cash Payment, Etc.	Acre	1.00	$ -	$ -		
Other: _____	Acre	1.00	$ -	$ -		
Total Fixed Costs				$ 150.90		
TOTAL COSTS						
Total Costs Excluding Land				$ 1,016.95		

Toxicity Concerns

When considering possible toxic instances, prussic acid poisoning and nitrate poisoning are two common concerns. If not properly managed, sorghum containing these acids may be toxic to livestock. Careful management is required to avoid these toxic instances. Generally speaking, poisoning can be avoided if time is allowed for moisture to dry from forage.

Prussic acid or hydrocyanic acid (HCN), most prevalent in young leaves, can factor into the grazing of cattle, sheep and goat. Once the forage reaches 18 inches in height, prussic acid is dissipated. HCNs decrease as plants age, however hybrids have also been selected to achieve a low amount of HCN. An animal that has been poisoned will start to show symptoms about 15-20 minutes after consumption of the forage. The animal can show signs of poisoning by staggering, exhibiting labored breathing, foaming at the mouth and having spasms. The blood of the affected animal will become cherry red. Animals can be treated if caught early and administered sodium thiosulfate and sodium nitrate.

Suggestion for optimal grazing are as follows:
1. Do not allow livestock to graze a crop lower than 18 inches tall. This is applicable for new growth or regrowth of the forage.
2. After a frost that damages the crop, avoiding grazing the forage for an entire week.

3. Do not give livestock access to forage with new, highly palatable regrowth- commonly after a drought ending rain or frost which was not forage damaging. As suggestion above, allow forage to regrow to 18 inches in height in this instance as well.

Sorghum silage is generally safe to be fed, due to a portion of prussic acid becoming dissipate during ensilling. For best results, hold sorghum silage for three to four weeks before feeding in order to give prussic acid enough time to dissipate. It is uncommon for dry sorghum to be hazardous to livestock, as the curing process extracts the major of HCN.

Nitrate poisoning is more common in corn than sorghum, high amounts of nitrogen fertilizer is the most common cause of nitrate poisoning. A high amount of nitrate in forage is most common when plants are close to flowering. Nitrogen is utilized, reducing chances of poisoning, as maturity approaches.

The most accurate way to determine if an animal has been nitrate poisoned is determining the change in blood color. A poisoned animal's blood color will change to a chocolate brown color.

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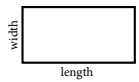
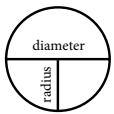
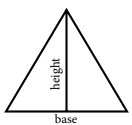
Calculations & Conversions



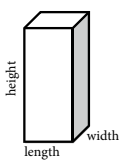
Area of a rectangle or square = length x width



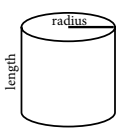
Area of a circle = 3.1416 x radius squared; or 0.7854 x diameter squared
Circumference of a circle = 3.1416 x diameter; or 6.2832 x radius



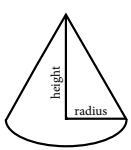
Area of triangle = base x height ÷ 2



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

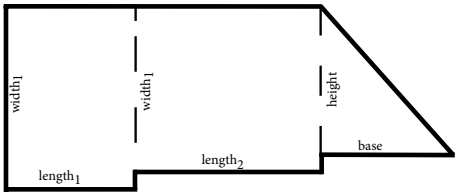


Volume of a cylinder = 3.1416 x radius squared x length



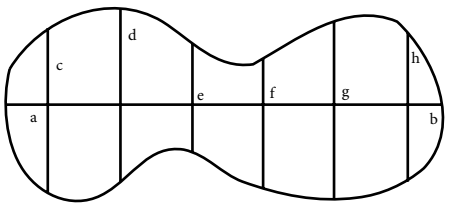
Volume of cone = 1.0472 x radius squared x height

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.

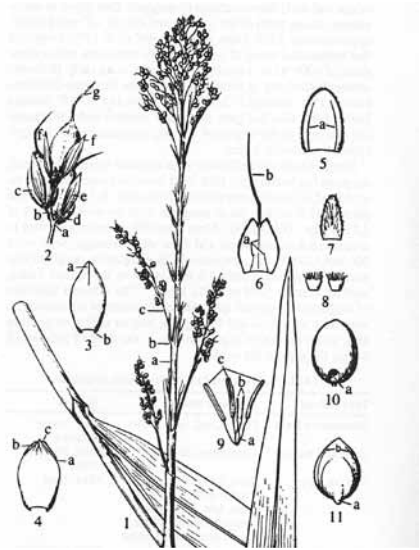


Fig. 3. The panicle of *Sorghum bicolor* subsp. *bicolor* which consists of the inflorescence and spikelets. 1. Part of panicle: a = internode of rachis; b = node with branches; c = branch with several racemes. 2. Raceme: a = node; b = internode; c = sessile spikelet; d = pedicel; e = pedicelled spikelet; 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.

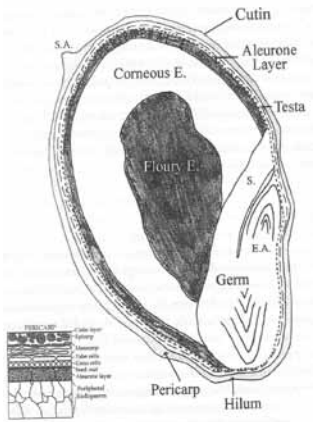


Fig. 4. Sorghum grain, showing the pericarp (cutin, epicarp, mesocarp, cross cells, tube cells, testa, pedicel, and stylar area (SA)), endosperm (aleurone layer, corneous and floury), and the germ (scutellum (S) and embryonic axis (EA). Adapted from L. W. Rooney and Miller, 1982).

b. Photos

Photo 1. *Sorghum Midge*

Photos from: http://www.ipmimages.org/browse/detail.cfm?imgnum=1327122

Photo 2. *Greenbug*

Photos by: Guy Bishop and Susan Halbert, respectively, University of Idaho and Florida Department of Agriculture & Consumer Services

Photo 3. *A. Adult Chinchbug*

Photo 4. *B. Nymph Chinchbug*

Photos 3 and 4 by: Lyle Buss, University of Florida

Photo 5*. Anthracnose*

Photo 6*. Anthracnose*

Photos 5 and 6 by: John Erickson, Agronomy, University of Florida

Photo 7. *Head Mold*

Photo by John Erickson, Agronomy, University of Florida

Photo 8. *Egrot*

Photo by Curtis Rainbolt, Agronomy, Univ. of Florida

Photo 9*. Bacterial Leaf Stripe*

Photo from: http://plantpath.caes.uga.edu/extension/plants/fieldcrops/Bacterialleafstripe.html

Photo 10*. Northern Corn Leaf Blight*

Photo from: http://www.ipmimages.org/browse/subimages.cfm?area=72&sub=16546,

***Photo 11**. Rust*

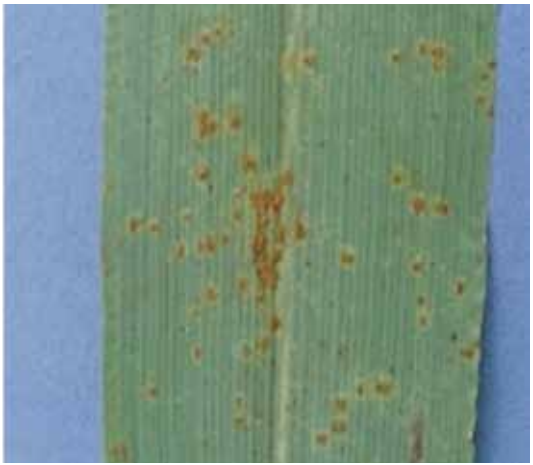


Photo from: http://plantpath.caes.uga.edu/extension/Fungi/puccinia.html

***Photo 12**. Zonate Leaf Spot*

Photo from: http://plantpath.caes.uga.edu/extension/plants/fieldcrops/Bacterialleafstripe.html

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.

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