UNITED SORGHUM CHECKOFF PROGRAM

MID-SOUTH PRODUCTION GUIDE

SORGHUM THE SMART CHOICE

Welcome to the United Sorghum Checkoff Program's Mid-South Production Guide. 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 Sorghum Checkoff work will only improve that potential over time. As you manage your sorghum, keep these tips in mind:

- Choose a hybrid appropriate for your region and conditions. Check with your extension service for unbiased data as well as your seed company representative.
- Set a realistic yield goal, and apply the appropriate amount of fertilizer to meet that goal.
- Use an integrated weed management strategy that starts with pre-emergence herbicide, and then apply an appropriate post treatment as needed.

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. 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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United Sorghum Checkoff Program

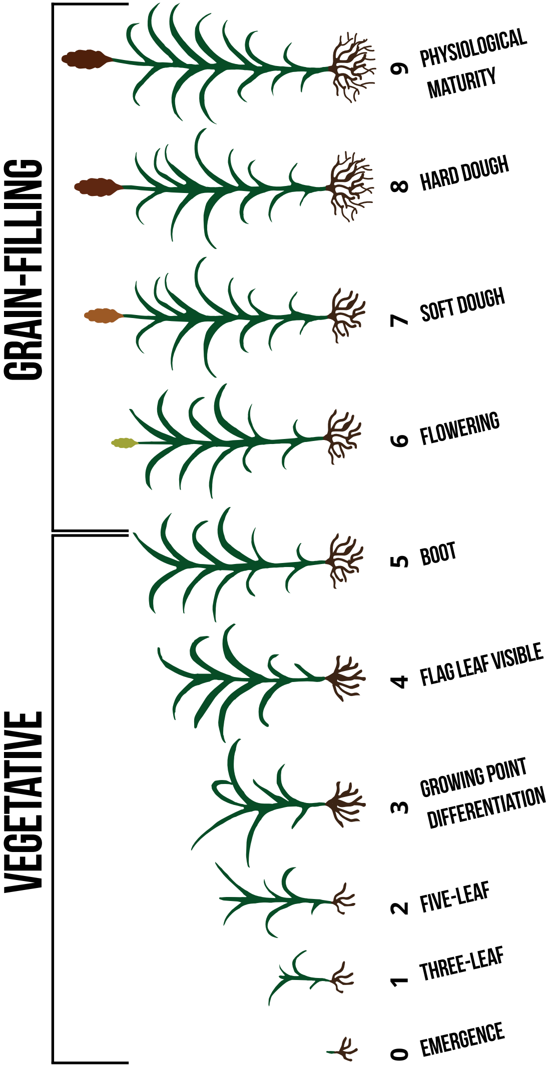
4201 N. Interstate 27
Lubbock, TX 79403
806-687-8727
www.sorghumcheckoff.com

TOPIC PAGE

GROWTH STAGES

It is important to understand the various developmental stages of sorghum to aid in making critical management decisions. The stages are based on key points of sorghum growth used to describe sorghum from planting to maturity. There are 10 recognized stages in sorghum starting with emergence (Stage 0) to physiological maturity (Stage 9).

An excellent publication on sorghum growth and development was published by Kansas State University titled “How a Sorghum Plant Develops." The publication provides excellent pictures of the different growth stages as well as graphs of cumulative nutrient uptake. The 10 crop growth stages are listed on the next few pages along with timely management suggestions for each stage.


GRAIN-FILLING
VEGETATIVE
9 PHYSIOLOGICAL MATURITY
8 HARD DOUGH
7 SOFT DOUGH
6 FLOWERING
5 BOOT
4 FLAG LEAF VISIBLE
3 GROWING POINT DIFFERENTIATION
2 FIVE-LEAF
1 THREE-LEAF
0 EMERGENCE

Emergence (Stage 0)

The plant is visible when the first leaf (coleoptile leaf) breaks through the soil surface. The coleoptile leaf is shorter than the later emerging leaves and has a rounded leaf tip. Emergence time can range from 3-14 days and will depend largely on soil temperature, moisture, seeding depth and seedling vigor.

Three-Leaf (Stage 1)

The collar of the third leaf is visible (once a leaf's collar forms the leaf no longer expands). This stage occurs 10-15 days after emergence, depending on weather conditions. The plant is typically 3-4 inches tall.

Five-Leaf (Stage 2)

The collar of the fifth fully expanded leaf is visible. This stage occurs approximately 20-25 days after emergence and when plants are 7-9 inches tall. The growing point is at or just below the soil surface. Many post herbicides should be applied at or before this time. Side-dress fertilizer applications are best made now or over the next 10-15 days.

Growing Point Differentiation (GPD)(Stage 3)

The growing point can now be found above the ground, and the number of seeds per head will be determined over the next couple of weeks. The plant is now entering a rapid period of growth. This stage typically occurs 30-40 days after emergence and when the plant is 12-15 inches tall.

One or two of the bottom leaves may have been lost, and tillers may now be present originating at the base of the plant. Prior to GPD, the plant can withstand considerable stress with minimum effect on yield. However, stress during GPD can affect the potential number of seeds per head that can be set at flowering. Plants should be adequately fertilized prior to this stage. This is a key stage to apply irrigation if available and if soil moisture conditions are dry.

Flag Leaf Visible (Stage 4)
The final leaf is visible. The last leaf to emerge prior to heading is called the flag leaf. This leaf is shorter than the preceding leaves. The plant is considered to be in the flag leaf stage when the leaf tip is visible in the whorl. The last two or three leaves will fully expand during this period.

Boot (Stage 5)
Leaf collars of all leaves are now visible. The sorghum head or panicle can be located just below the flag leaf collar enclosed in the flag leaf sheath. The sorghum head is now being pushed up through the flag leaf collar by the upper stalk known as the peduncle. The length of the peduncle can be affected by stress at this time and is influenced by hybrid genetics. With most grain sorghum hybrids, the boot stage occurs 50-60 days after emergence. Moisture stress during boot and for the next 14 days will significantly lower yield.

Heading (Not Official Stage)
Sorghum is considered headed when 50 percent of the heads (panicles) in a field are visible

Flowering (Stage 6)
Flowering is the most critical stage in the life of the sorghum plant. A plant begins flowering (blooming) from the top of the panicle and progresses downward. A field of sorghum is considered to be in the flowering stage when blooming has progressed halfway down the panicle in 50 percent of the plants. The peduncle is still elongating, and it typically takes 4-9 days for a single head to complete the flowering process. Hybrids are rated on their maturity largely based on the length of time it takes to reach the flowering stage.

Milk (Not Official Stage)
Grain begins forming as soon as flowering (pollination) is complete. The grain, or kernel, quickly expands and contains a milky fluid. The sorghum is now in what is often referred to as the grain fill period that will not be completed until physiological maturity is reached.

Soft Dough (Stage 7)
The soft dough stage is reached when the grain can still be crushed between the thumb and index finger but no longer contains a milky liquid. Starch is rapidly accumulating, and 50 percent of the grain's final weight has been achieved. Stress at this time can significantly lower yield. Whole

plant moisture is approximately 65-68 percent once the soft dough stage has been reached and is typically when sorghum is harvested for silage. Grain has colored by the end of the soft dough stage.

Hard Dough (Stage 8)

At the hard dough stage grain has reached 75 percent of its final dry weight, and nutrient uptake is almost complete. The grain can no longer be crushed between the thumb and index finger. Water stress during this time tends to promote lodging.

Physiological Maturity (Stage 9)

Grain has now achieved its maximum dry weight. Physiological maturity is recognized by a dark spot or black layer on the bottom of the kernel. Grain moisture content typically ranges 25-35 percent. Dessicants can now be safely used to aid in harvest without reducing grain yield.

Determining Leaf Stage

Grain sorghum leaves are numbered by counting the fully expanded leaves with a developed collar. Once sorghum has produced about five fully expanded leaves counting can become difficult. This is because lower leaves will become crumbled and will start falling off the plant. When counting leaves, keep in mind leaves alternate from one side of the stalk to the other. Also keep in mind the first leaf is a short leaf with a rounded tip that will likely have fallen off the plant within 25 days of emergence.

APPROXIMATE DAYS TO EACH GROWTH STAGE

Boot		Heading		Flowering		Milk		S. Dough		H. Dough		PM
	3-5 →		5 →		5 →		14 →		10 →		10-14	

GRAIN SORGHUM YIELD COMPONENTS

Sorghum yield is based on three factors: number of heads, number of seeds per head, and seed size and test weight. Although these factors may compensate for each other, the number of seeds per head is the greatest component of yield.

FREEZE DAMAGE & HAIL INJURY

Assessment and formulas used by crop insurance adjusters can get complicated, but yield loss predictions are based on the stage of growth and the amount of plant damage. Plant damage includes both direct damage and leaf defoliation. Direct damage is made up of stand reduction and stalk and head injury.

For the first 30 days after emergence, sorghum can withstand significant damage from a late, light freeze or from hail damage and recover without significant yield loss. This is because the growing point is below or very close to the soil surface. Sorghum has surprisingly little loss in yield potential provided the plants remain healthy. For example, 50 percent leaf removal five weeks after germination (near growing point differentiation) reduces yield potential by about 5 percent. Losses are substantially higher for older plants, especially if bruising of the stalk occurs leading to broken stalks or disease infection. Yield loss from leaf defoliation reaches its maximum at the bloom stage (Table 1).

It is best to wait 7-10 days after an early to mid-season hail event to assess damage. Under good growing conditions the sorghum plant will often put on new growth in just a few days. Early in the season even if a few plants are killed, leaving a skip in the row, yield will be compensated for by an increase in tillering or increased head size of the surrounding plants.

An early freeze during grain fill can have a major effect on yield. Grain at the soft dough stage has only accumulated about 50 percent of its final weight and at the hard dough stage about 75 percent of its final weight.

TABLE 1. YIELD LOSS DUE TO LEAF DEFOLIATION (NEB G86-812)

Growth Stage	Percent Defoliation		
	30	**50**	**70**
Boot	18	31	53
Bloom	19	33	57
Milk	13	22	38
Soft Dough	7	12	21

HYBRID SELECTION

The criteria for selecting grain sorghum hybrids are similar to those for selecting corn hybrids. Yield, maturity, stalk strength (standability) and disease resistance are all important. Selecting sorghum hybrids suitable to the climate with excellent yield potential and with tolerance or resistance to certain diseases is critical to high yields. Full season hybrids have yielded better in variety trials than early hybrids when planted in May. An earlier-maturing hybrid may be needed if planting after mid-June or as a double crop after wheat. Because of the limited acreage of grain sorghum in the eastern United States, most hybrids are developed and tested in the Great Plains and may not have been extensively tested under Mid-South conditions.

Commercial seed companies publish more detailed information about the agronomic characteristics and specific disease resistances of their hybrids. An ideal hybrid should have good seedling vigor, some resistance to anthracnose (primary cause of stalk rot), charcoal rot resistance and good stalk strength. Low lodging scores in local test plots are a good indication a hybrid has the potential to stand better when under stress.

Physical characteristics to be considered are head exertion (the distance between the sorghum head and the upper most leaf) and head type (i.e. compact, semi-compact or open). The distance between the head and leaves can be from 0-8 inches and is of major importance when it comes time to harvest. The grain itself may be mature and ready for harvest, but the plant material may still be green. The mature grain needs to be harvested with as little green material as possible because this green material, which can be sticky due to accumulated sugars, can cause problems with harvest and drying. Hybrids with greater head exertion send less foliage into the combine at harvest. A harvest aid or desiccant may be needed to reduce the amount of green material in hybrids with low head exertion.

The head type can affect the amount of pest damage to the seed and the quality of grain drying. Grain insects may be more difficult to scout and treat with the compact head types versus the open head types. The open and semi-compact hybrids will dry quicker in the field and are thought to be less susceptible to damage from head diseases.

Performance testing of commercial grain sorghum hybrids is not currently being done in Illinois or Kentucky, but hybrid test results are available from Tennessee and nearby states such as Missouri. Consult these and other tests to identify hybrids with excellent yield potential across multiple locations or environments. Hybrids are evaluated for yield and lodging in Tennessee in small plot replicated trials and in large strip plot county demonstration trials. Compared to corn, there are fewer commercial grain sorghum hybrids to choose from, so deciding what to plant is less challenging. Visit SorghumCheckoff.com or TennesseeTrials.com for more information on sorghum hybrids.

PLANTING

Site Selection

Grain sorghum is adapted to a wide range of soils throughout the Mid-South region, but it is often placed on less-productive soils. If higher yields are desired, grain sorghum needs to be planted on soils that produce higher corn, cotton or soybean yields. Even though grain sorghum is relatively drought resistant, it produces its best yields on deep, level soils rather than on drought-prone hillsides. It is common to see increased sorghum acreage in years following a drought as producers attempt to avoid two successive years of crop failure. Because chances of dry weather are not above normal the year after a drought year, it makes more sense to plant grain sorghum consistently on those fields with lower productivity for corn than to try to guess what the weather will be like in a given year.

Seedbed Preparation

Seedbeds should have plenty of moisture, be suitable for good seed-to-soil contact and relatively weed free. These conditions can usually be obtained with light tillage or with no-tillage and burndown herbicides. Most planters used to plant grain sorghum are already set up to plant into no-till conditions.

Seed Treatments

When selecting sorghum herbicides, consult the label or contact your seed or herbicide retailer to see if a seed safener, such as Concep® or Screen®, might be needed. Using such herbicides without the safener seed treatment can result in severe crop injury. Insecticide seed treatments should be considered in areas where local university data supports such use.

Planting Date

The optimum planting period for grain sorghum varies some by region. Planting grain sorghum from May 1-June 1 results in highest yields in Kentucky and Tennessee, while in Illinois, the best date to start planting ranges from mid-May in southern Illinois to late May in northern Illinois. Grain sorghum is a warm season plant, and emergence is best when soils are at least 60-65˚F in the upper two inches of soil and warm weather is expected to continue. Grain sorghum prefers soil conditions similar to soybean and germinates rapidly when soil temperatures are near 70° F. Soils in the Mid-South will often reach these temperatures prior to May 1.

Early-planted sorghum usually has less damage from sorghum midge and worm pests. May-planted sorghum will receive adequate rainfall in the spring for vegetative growth and will bloom during July when rainfall amounts are lower, thus reducing occurrence of head diseases.

Later planting results in lower yields and higher moisture grain at harvest. Grain sorghum can be planted after wheat harvest, but soil moisture supply should be adequate to achieve good stands, and double-cropping sorghum will be more successful on soil with better water-holding capacity. Hybrids used in late planting situations should be early maturing in order to reach maturity before frost.

Planting Depth

Sorghum seed is smaller than corn seed and tends to emerge less vigorously. It should be planted shallow enough for easy emergence but deep enough to assure good contact with moist soil. Adequate seed coverage makes plant emergence more uniform in a field. Sorghum should be planted one inch deep under most situations. Seeds should be placed to moisture, but no deeper than about one inch in heavy soils and about two inches in sandy soils. Planting into a moist, warm seedbed allows for quick germination and uniform stands. Planter units should be set to firm the soil around the seed to expedite germination and emergence.

Because sorghum seedlings are slow to emerge, care is needed when using reduced- or no-till planting methods. Surface residue usually keeps the soil cooler and may harbor insects that can attack the crop, causing serious stand losses, especially when the crop is planted early in the season. No-till sorghum may have to be planted slightly deeper to ensure adequate seed coverage. Be sure the planting slot closes well.

Row Spacing

Since grain sorghum is planted on fewer acres than corn or soybean by most producers in the Mid-South, row width is generally that which is used for corn and soybean. Row spacing experiments in Missouri have shown narrow rows produce more than wide rows (Table 1), but recent University of Illinois experiments produced mixed results. In two of eight site-years, both in 2004, yields were significantly higher for the 30-inch row spacing (Table 2). Grain sorghum in 30-inch rows facilitates inter-row cultivation, which can help with weed control.

Narrow rows can make the crop more competitive with weeds, and they work well if weeds can be controlled without cultivation. Narrow rows are suggested for late-planted sorghum if the equipment is available. Grain sorghum in 15- or 7.5-inch rows will usually have less lodging. Using a split-row planter to plant 15-inch rows may be a good option in fields where weeds can be controlled.

Plant Population

Grain sorghum seeding rates depend upon soil type, soil fertility, soil moisture and seasonal rainfall. The number of grain sorghum seeds per pound can vary from 10,000-20,000. Years ago, seeding rate recommendations were expressed as pounds of seed per acre, which caused overplanting with small-seeded hybrids. Too-high plant populations can cause lodging

TABLE 2. YIELD OF GRAIN SORGHUM AS AFFECTED BY ROW SPACING IN MISSOURI (CONLEY ET AL. 2005)

Row Spacing (in.)	Yield
7.5	125.5
15	117.7
30	116.8

Data is set in 2-year averages

problems and yield loss. Targeting a specific plant population and adjusting seed drop rate for the row width used is a much more accurate way to plant sorghum. Most grain sorghum hybrids have about 16,000 seeds per pound.

Seeding rates of 60,000-100,000 viable seeds per acre are sufficient for maximum yields regardless of row spacing. Some nearby states are evaluating twin-row sorghum at seeding rates of 100,000 plants per acre or above, but little data is available at this time. If planting into soils where drought is expected, use the lower population. In irrigated fields, a final population of 75,000 plants per acre is adequate based on University of Arkansas information.

University of Illinois seeding rate experiments conducted from 2003-2005 (Table 3) showed no significant yield increases across the different seeding rates within locations. When averaging the entire study across years and locations, there was only one bushel per acre difference between the

TABLE 3. YIELD OF GRAIN SORGHUM AS AFFECTED BY ROW SPACING IN UNIVERSITY OF ILLINOIS TRIALS (2003-2005)

Row Spacing	2003			2004			2005		Average
	DSAC	BRC	BARC	DSAC	BRC	BARC	DSAC	BRC	
	------	------	------	------	bu/ac	------	------	------	------
15 inches	90	99	39	83	122	117	64	48	83
30 inches	89	101	39	86	136	127	63	50	86
ANOVA*	NS	NS	NS	NS	***	**	NS	NS	---

DSAC = Dixon Springs, BRC= Bellevill, BARC = Brownstown
* NS = Non-Significant
** = Significant at P=0.05
*** = Significant at P=0.01

60,000 and 120,000 seeds per acre planting rate. This shows grain sorghum has an excellent ability to compensate for low plant populations. There is clearly no need to plant more seeds "just to be safe" in full season, conventional tillage sorghum.

Divide the desired plant stand by the germination given on the seed tag to determine the actual seeding rate. For example, if a seed tag says 85 percent germination and you want to establish 90,000 plants per acre, divide 90,000 by 0.85 to get 105,882 planted seeds per acre. If there is reason to believe emergence percentage may be less than the germination, divide by expected establishment percentage instead of germination. When planting into no-till, especially as a double crop, it is best to assume only 65-75 percent of what is planted will become a viable plant so divide by that percentage.

Seeding rates are independent of row width. Table 4 illustrates seed number per foot of row that is needed to achieve a desired population of sorghum for a specific row width. Pounds of seed per acre based on seed size are indicated for desired populations (example: if you desire to plant 80,000 seeds per acre and a hybrid has 15,000 seeds per pound, this is equivalent to 5.3 pounds of seed/acre).

TABLE 4. SEEDING INFORMATION FOR GRAIN SORGHUM

Row Width (inches)	Desired Seeds per Acre					
	60,000	70,000	80,000	90,000	100,000	110,000
	Seeds per Foot of Row					
40	4.6	5.4	6.1	6.9	7.7	8.4
38	4.4	5.4	5.8	6.35	7.3	8.0
30	3.4	4.0	4.6	5.2	5.7	6.3
20	2.3	2.7	3.1	3.4	3.8	4.2
15	1.7	2.0	2.3	2.6	2.9	3.2
7.5	0.8	1.0	1.2	1.3	1.5	1.6

TABLE 4 CONTINUED

Row Width (inches)	Desired Seeds per Acre					
	60,000	70,000	80,000	90,000	100,000	110,000
Seeds/ Pound	Pounds of Seed per Acre					
11,000	5.5	6.4	7.3	8.2	9.1	10.0
12,000	5.0	5.8	6.7	7.5	8.3	9.2
13,000	4.6	5.4	6.2	6.9	7.7	8.5
14,000	4.3	5.0	5.7	6.4	7.1	7.9
15,000	4.0	4.7	5.3	6.0	6.7	7.3
16,000	3.8	4.4	5.0	5.6	6.3	6.9
17,000	3.5	4.1	4.7	5.3	5.9	6.3

NUTRIENT MANAGEMENT

The philosophy of fertilizer recommendations differ by state, but there are several similarities. Consult state fertilizer guides for specific guidelines.

Soil Test

Although grain sorghum is not an extremely heavy user of nutrients, it does require proper fertilization for optimum production. Be sure to include regular soil testing to aid in determining lime, phosphorus and potassium requirements. Soil tests are recommended every 2-4 years, and each soil sample should represent no more than 20 acres (5 acres in Illinois).

Lime

Lime rates are generally tied to the soil test pH values. In Tennessee, lime is recommended when water pH is below 6.0. If lime is needed, it can be applied any time before planting. In Kentucky, agricultural lime applications are triggered when water pH is 6.2 or less.

Phosphorous (P) and Potassium (K)

While potassium is required in relatively smaller amounts than phosphorus, potassium is the primary nutrient that helps regulate stomatal control in leaf tissue and promotes stalk strength.

The regulation of stomata helps the plant take in CO_2 and release O_2 in reducing lodging losses at harvest. Specific recommendations for P and K fertilizers follow.

Illinois: Farmers are encouraged to build soil test P levels to 40-50 pounds per acre depending upon the supplying power of the soil and to build soil test K levels to 260-300 pounds per acre. Once these levels are reached, they are maintained by applying crop removal rates of nutrients. Grain sorghum yields of 80, 100 and 120 bushels per acre would remove 34, 42 and 50 pounds P_2O_5 per acre and 17, 21 and 25 pounds K_2O per acre, respectively.

Kentucky: Fertilizer phosphorus is recommended when soil test levels drop below 60 pounds of P_2O_5 per acre (30 ppm using a 6-inch soil test, 20 ppm using a 10-inch soil test) and fertilizer potassium is recommended when soil test levels drop below 300 pounds of K_2O per acre (150 ppm using a 6-inch soil test, 20 ppm using a 10-inch soil test). Rates are tied to soil test results.

Tennessee: Recommended amounts of K_20 and P_20_5 range from 30 pounds per acre for both nutrients on medium testing soils to 60 pounds per acre for low testing soils and are usually applied immediately before or at planting time. For soils testing high in phosphate and potassium, no additional fertilizer is recommended. Fertilizer may be effectively applied in the fall if fields are not subject to severe erosion or flooding.

Nitrogen (N)

In general, sorghum production needs an application of one pound of nitrogen per bushel of expected yield. This amount needs to be adjusted for soil test results as well as nitrogen credit from legumes. If beginning a no-till program, an additional 20-30 pounds of nitrogen needs to be applied to account for nitrogen immobilization due to the increased residue with no-till. This immobilization effect should disappear by the third year into the no-till program.

Illinois: The response to nitrogen is somewhat erratic, due largely to the extensive root system's efficiency in taking up soil nutrients. For this reason, and because of the lower yield potential, in the past the maximum rate of total nitrogen suggested was about 125 pounds per acre. For sorghum following a legume such as soybean or clover, the nitrogen rate may be reduced by 20-40 pounds per acre. More recent research data conducted by the University of Illinois from 2003-2005 at Brownstown, Dixon Springs and Belleville (8 site-years) suggests an economic approach using the price of nitrogen per pound and the price per bushel of grain sorghum (Tables 5 and 6).

Kentucky: About 100-125 pounds of N per acre are recommended for sorghum in most crop rotation systems. The higher rate would be used on soils that are poorly drained. When grain sorghum follows a field that has been in pasture for four years or less, the nitrogen rate can be reduced to 75-100 pounds of N per acre and if sorghum follows a field that has been in pasture for five years or more, then nitrogen rates can be dropped to 50-75 pounds of N per acre.

Tennessee: Near 60-90 pounds of nitrogen per acre should be applied to grain sorghum immediately before planting, at planting or side-dressed within four weeks after planting. Response to the higher rate would most likely occur when grain sorghum follows a non-legume, is grown no-till, or is grown on soils with restricted drainage or which have textures with more clay than silty clay loam. Nitrogen sources containing urea are more susceptible to losses when surface applied to moist soils followed by three or more days of rapidly drying conditions without rainfall.

Adequate nitrogen, potassium and phosphorus are needed for excellent sorghum yields. However, grain sorghum typically does not respond to the addition of nutrients other than N, P and K.

Table 5 shows recommended N application rates (lb/acre) for grain sorghum based on grain sorghum price and N fertilizer price following soybeans. An extra 20-40 pounds of N may be warranted when sorghum follows corn or a grass crop.

Table 5. Recommended nitrogen application rates (lb/A) for grain sorghum based on grain sorghum price and N fertilizer price

N Price ($/lb)	Grain Sorghum Value ($/bu)									
	$2.50	$3.00	$3.50	$4.00	$4.50	$5.00	$5.50	$6.00	$6.50	$7.00
$0.25	78	84	88	91	93	95	97	98	99	100
0.30	72	78	83	87	90	92	94	96	97	98
0.35	65	73	78	83	86	89	91	93	94	95
0.40	58	67	74	78	82	85	88	91	92	93
0.45	51	61	69	74	78	82	85	87	89	90
0.50	45	56	64	70	75	78	91	84	86	88
0.55	38	50	59	66	71	75	78	81	84	86
0.60	31	45	54	61	67	72	75	78	81	83
0.65	24	39	49	57	63	68	72	76	78	81
0.70	18	33	45	53	60	65	69	73	76	78

Note: Rates are based on grain sorghum following a previous crop of soybean. Using 20-40 pounds per acre, more nitrogen may be warranted when sorghum follows a previous corn or grass crop.

TABLE 6. PRICE OF COMMON NITROGEN FERTILIZERS IN DOLLARS PER POUND OF NITROGEN FOR VARIOUS AMOUNTS OF NITROGEN

Cost per Ton												
Nitrogen Fertilizer	**Percent Nitrogen**	$250	$300	$350	$400	$450	$500	$550	$600	$650	$700	$750
Ahydrous 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 should not be allowed to compete with grain sorghum. Normally, all weeds should be controlled with tillage and/or herbicides prior to planting grain sorghum. Most herbicides used in grain sorghum are selective, meaning they kill certain weed species and do not harm the crop or certain other weed species. In addition, many herbicides require applications on small weeds. Grain sorghum producers need to pay close attention to weeds that emerge in a sorghum field and to try to control them before they get too large.

Do not plant grain sorghum into fields heavily infested with Johnsongrass (Sorghum halapense). Johnsongrass is a very close relative to grain sorghum (Sorghum bicolor) making chemical control of Johnsongrass in grain sorghum extremely difficult. In addition, Johnsongrass is extremely competitive, and it harbors several diseases and insects that attack grain sorghum.

In general, grain sorghum should be planted in fields with relatively low weed pressure. The lower weed pressure can be achieved with aggressive weed management in the preceding crops (i.e. soybean). Grasses are typically more challenging than broadleaves to control with herbicides in grain sorghum.

Prior to Planting

Weeds can be removed prior to planting grain sorghum either by tillage or with herbicides. A field cultivator or chisel plow are probably the best options for tillage.

In no-till situations, herbicide programs involving glyphosate or paraquat plus 2,4-D and atrazine are usually very good options. Expert® (S-metolachlor + atrazine + glyphosate) and Sequence® (S-metolachlor + glyphosate) are premixes containing glyphosate and are suitable for killing vegetation before planting in no-till fields.

At Planting

Several herbicides can be applied at planting for grain sorghum. Dual II Magnum® (S-metolachlor), Micro-Tech® (alachlor) and Outlook® 6E (dimethenamid-P) or premixes of these herbicides with atrazine can all be applied at planting as long as seed is treated with either Concep® or Screen® safener. Atrazine alone (up to 1.2 pounds active ingredient per acre) can be applied at planting without a safener. Milo-Pro® 4L (propazine) can be applied without a safener.

Postemergence or Foliar

Herbicides that can be applied after grain sorghum has emerged include Aim® (carfentrazone), Basagran® (bentazon), Buctril® (bromoxinyl), 2,4-D Amine, Rage

D-Tech® (carfentrazone + 2,4-D), dicamba, Weedmaster® (dicamba + 2,4-D), Starane® (fluroxypyr), Permit® (halosulfuron), Yukon® (halosulfuron + dicamba), and Prowl® (pendimethalin). Prowl® should not make contact with brace roots, and drop nozzles are suggested on larger plants. Paraquat can be applied post emergence if directed with drop nozzles. Most of the foliar herbicides have crop height limitations. Some allow the use of directed spray for later applications.

Interrow cultivation can be conducted in relatively flat soils where grain sorghum is grown in rows wide enough to accommodate the equipment. If interrow cultivation is used, set the shovels only as deep as necessary to remove the weeds.

For more specific information on herbicide options, timings and use rates consult the local state extension weed control publication.

<u>Harvest Aids</u>

Grain sorghum does not dry to safe levels normally in the field. In addition, mature grain sorghum is prone to harvest losses from lodging, birds, insects, molds and poor weather. A chemical desiccant or a killing frost will hasten field drying, and artificial drying is normally required before marketing or storing grain sorghum.

Harvest aids help kill both green weeds and the sorghum plant, thus providing some reduction in moisture from plant matter. Glyphosate (Roundup PowerMax®, Touchdown® and others) used as a harvest aid should be applied after grain moisture has reached 30 percent or less. Glyphosate products are slow acting and may not reduce grain moisture. Desiccants are intended to hasten the drydown of weed and sorghum foliage and may cause small decreases in grain moisture. Sodium chlorate (Defol 6® and others) is a chemical desiccant and should be applied 7-10 days prior to anticipated harvest date.

TABLE 7. POPULAR PRE-EMERGENT HERBICIDES BY ACTIVE INGREDIENT NAME (COMMON TRADE NAMES)

Herbicide	Use
Atrazine (AAtrex, atrazine)	Primarily broadleaf weed control. Long residual.
Propazine (Milo-Pro)	
Metolachlor or S-metolachlor (Dual II Magnum, Cinch, Parallel, Brawl Charger, Medal)	Good annual grass control with some broadleaf activity. Must use Concep III treated sorghum seed.
Dimethenamid (Outlook, Commit, Slider, Sortie)	
Acetochlor (Warrant)	
Atrazine + Metolachlor (Bicep II Magnum, Cinch ATZ, Metal II AT, others)	Broadleaf weed and grass control. Must use Concep III treated sorghum seed.
Saflufenacil + Dimethenamid (Vardict)	
Atrazine + Acetochlor (Degree Xtra, Fultime NXT)	
Atrazine + Metolachlor + Mesotrione (Lumax, Lexar)	Broadleaf weeds including triazine resistant pigweed and kochia in addition to grass control. Must use Concep III treated seed.
Others	See state and local extension service recommendations for other pre emergent herbicides.

TABLE 8. POPULAR BROADLEAF POST EMERGENT HERBICIDES BY ACTIVE INGREDIENT NAME (COMMON TRADE NAMES)

Herbicide	Use
Atrazine (AAtrex, atrazine)	Effective on most broadleaf weeds and will provide soil residual control. Apply with crop oil.
2,4-D (2,4-D, Unison, Barrage, Saber, Weedar 64, others)	Will control most broadleaf weeds, crop injury can be significant and drift to cotton and soybean fields is a concern.
Dicamba (Banvel, Clarity, Rifle, Vision)	Will control most broadleaf weeds, crop injury can be significant and drift to cotton and soybean fields is a concern but safer than 2,4-D.
Prosulfuron (Peak)	Must be applied to small weeds. Best to use with dicamba, 2,4-D or atrazine.
Fluroxypyr (Starane)	Weak on pigweed. Good on kochia, morning glory, and devilsclaw.
Carfentrazone (Aim)	Fast burn down. Effective only on small weeds (<2 inches).
Halosulfuron (Permit)	Best product to use for nutsedge (nutgrass) control. Ineffective when used alone on most broadleaf weeds.
Pyrasulfotole + Bromoxynil (Huskie)	Excellent on many broadleaf weeds but will cause temporary injury to sorghum leaves. Often used as a rescue treatment. Works best with the addition of 0.5 to 1.0 lb atrazine.
Others	See state and local extension service recommendations for other post emergent herbicides.

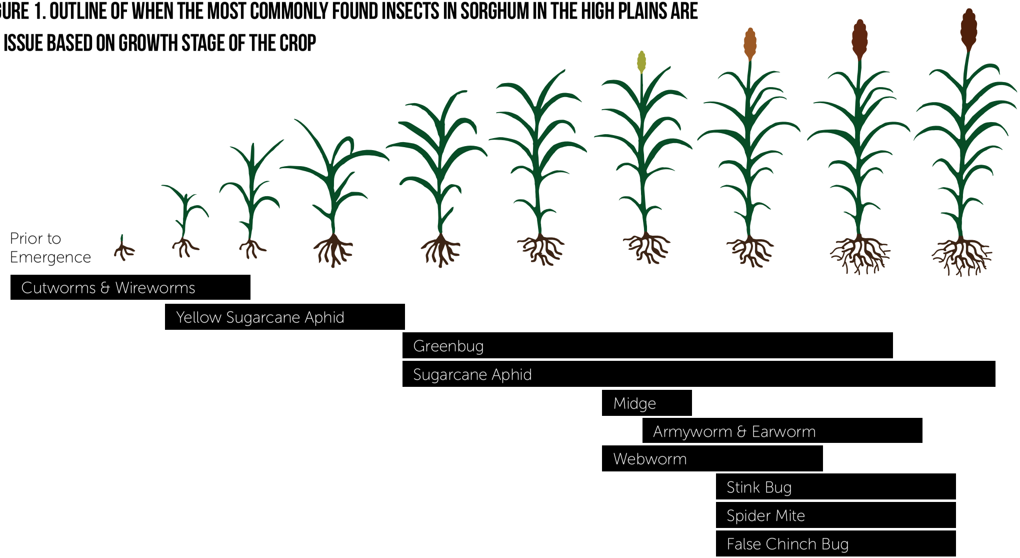
INSECT MANAGEMENT

Figure 1 consists of data compiled by the University of Arkansas Extension Service which outlines the timeframe (shown in darkened line) when common insect pests are more likely to occur during the sorghum growing season.

A number of insects can attack sorghum during the growing season in the Mid-South. The most common insects found at planting are cutworm, wireworm and grubs. Mid- and late-season insects commonly found include greenbugs and other aphids, sorghum midge, flea beetles, grasshoppers, fall armyworm, corn earworm, sorghum webworm and spider mites. T**he extent of damage by insects in grain sorghum is often related to the planting date**. The greenbug is more common in early-planted sorghum, while the sorghum midge, corn earworm, fall armyworm and sorghum webworm are more severe in late-planted sorghum.

Seed insecticide treatments such as clothianidin (Poncho®), thiamethoxam (Cruiser®) and imidicloprid (Gaucho®) are fairly new for use in sorghum and have good efficacy on many below-ground soil pests and early seedling pests of sorghum such as flea beetle, chinch bug or stink bug. Many granular insecticide products for control of rootworm in corn can be used in grain sorghum.

FIGURE 1. OUTLINE OF WHEN THE MOST COMMONLY FOUND INSECTS IN SORGHUM IN THE HIGH PLAINS ARE AN ISSUE BASED ON GROWTH STAGE OF THE CROP



A number of foliar insecticides provide excellent control of sorghum leaf and grain pests. Basic identification and threshold information are included below for some of the most troublesome insect pests in grain sorghum. Refer to the extension publication in your state for specific treatment recommendations for these insects as control options may vary by state. In Kentucky, refer to ENT-24: Insecticide Recommendations for Grain Sorghum (Milo) and IPM-5: Kentucky IPM Manual for Grain Sorghum. In Tennessee, use PB1768 2009 Insect Control Recommendations for Field Crops. In Illinois, refer to IAPM-09 2009 Illinois Agricultural Pest Management Handbook.

Sugarcane Aphid

Sugarcane aphids are gray, tan or pale yellow, and are sometimes referred to as the white aphid. With the aid of a magnifying glass, a pair of black cornicles or tailpipes can be seen on the aphid's back end. The tips of feet and antennae are black. Colonies or groups of sugarcane aphids are usually clustered around the midrib of the bottom side of the sorghum leaf. The sugarcane aphid has the ability to multiply very quickly in fields depending on weather conditions and the presence of predatory (beneficial) insects that feed on aphids.

Heavy infestations of the sugarcane aphid can cause leaves to be covered with a sticky, shiny substance called honeydew. This honeydew is made up of plant sugars and water, which are harmless to animals. Black, sooty mold will often

TABLE 9. YIELD LOSS IF LEFT UNTREATED

Crop Stage at 20% Infestation	Percent Yield Loss with no Treatment
Pre-boot	81-100%
Boot	52-69%
Heading	67%
Soft Dough	21%

Source: Mississippi State University

begin growing on the honeydew of sorghum leaves. This mold blocks sunlight and eventually leads to yellowing and death of leaf tissue. Loss of plant sap from the sugarcane aphid feeding directly impacts yield. In addition, plant stress caused by the sugarcane aphid can lead to uneven and lack of head emergence, poor grain set, and may contribute to lodging. Actual yield loss will depend on the sugarcane aphid population level and when the infestation occurs (Table 9).

Fields should be scouted once a week for signs of the aphid. Once they are found, begin scouting at least twice a week. To determine if an insecticide treatment is needed, note the presence and number of aphids on leaves in at least four areas of the field. In each area of the field examined, collect a leaf from the bottom and top of 20 plants and observe the presence and number of aphids.

Entomologists with different state extension services vary slightly on their thresholds for when to apply an insecticide application for sugarcane aphid control. **In general, an insecticide application should be made when 25 percent of the plants are infested with 50 aphids per leaf.** Sivanto Prime and Transform WG have proven to be effective in controlling the aphid. Refer to SorghumCheckoff.com or local extension entomologists for updates on threshold levels as well as other available insecticides.

Best Management Practices for Sugarcane Aphid Control

1. Sugarcane aphids can only survive on sorghum-related species. To help reduce local populations, control Johnsongrass, volunteer sorghum and other sorghum species in and around your fields during winter and spring prior to planting.

2. Consider planting a hybrid that has tolerance to the aphid. Tolerance does not mean immunity to the aphid. These hybrids still require monitoring and treating with an insecticide if action thresholds are reached. Be careful in giving up hybrid adaptability, yield potential and other favorable agronomic characteristics. In most cases, these characteristics should not be given up in order to plant a sugarcane aphid tolerant hybrid.

3. Plant seeds treated with an insecticide seed treatment. These seed treatments will protect sorghum from potential early season infestations. Acceptable seed treatments include Cruiser

(thiamethoxam), Poncho and Nipsit (clothianidin), and Gaucho (imidaclorprid).

4. Plant early. Sugarcane aphids tend to infest fields later in the growing season. Early planting may avoid infestation.

5. Scout fields early and often using proper procedures to determine the level of aphid infestation. Once sugarcane aphid infestation occurs in the field, the number of aphids can increase quickly.

6. Apply insecticide as soon as the action threshold is reached. Threshold levels change and vary with individual states. Check with your local experts for current information.

7. Use only recommended insecticides and follow label rates and application instructions. Coverage is critical. Best results are achieved when high volumes of water are used.

8. If aphids are present in the upper canopy or grain panicle in sufficient numbers to produce honeydew, consider applying an insecticide in order to prevent potential issues with harvest. If a harvest-aid product is used, tank mixing with the insecticide has worked well when the sugarcane aphid is present.

9. Avoid use of insecticides, especially pyrethroids, that are harmful to beneficial insects because

they may result in sugarcane aphid numbers increasing rapidly.

Basic identification and threshold information is included for some of the other most troublesome insect pests in grain sorghum. Refer to regional extension publications or visit SorghumCheckoff.com for the most up-to-date recommendations.

Greenbug

(Photo 2*) The greenbug is a small, light green aphid with a dark stripe down its back, usually

TABLE 10. ECONOMIC THRESHOLD LEVELS FOR GREENBUG ON SORGHUM AT DIFFERENT PLANT GROWTH STAGES (TEXAS AGRILIFE RECOMMENDATIONS)

Plant Size	When to Treat
Emergence to 6 Inches	20 percent of plants visibly damaged (beginning to yellow), with greenbugs on plants
Larger Plant	Greenbug colonies causing red spotting or to boot yellowing of leaves and before any entire leaves on 20% of plants are killed
Boot to Heading	At death of one functional leaf on 20 percent of plants
Heading to Hard Dough	When greenbug numbers are sufficient to cause death of two normal-sized leaves on 20 percent of plants

found on the underside of leaves. Early-planted sorghum is more likely to be infested by this pest. The greenbug injects a toxic substance in its saliva that causes red spots on leaves where it feeds. The threshold for when to treat for greenbug varies with growth stage. See Table 10 for when to treat sorghum for greenbug.

Corn Leaf Aphid

(Photo 2) The corn leaf aphid has a bluish-green body about one-sixteenth inch long with black cornicles (tailpipes), legs and antennae. Corn leaf aphids are usually found in sorghum whorls. Corn leaf aphids can transmit viral diseases from weeds like Johnsongrass, but sorghum can tolerate large numbers of these aphids. Treatment is not usually necessary for the corn leaf aphid. Corn leaf aphid populations early in the year can help attract beneficial insects to combat other pests later in the growing season.

Yellow Sugarcane Aphid

(Photo 2) Adults and nymphs are bright yellow to light green in color and covered with small spines with two double rows of darker spots down the top of the abdomen. **Feeding on sorghum causes reddening and yellowing of leaves and may transmit viral diseases.** Early infestations of yellow sugarcane aphid can quickly reduce stands, but in recent years this aphid tends to be more of an issue in the mid to late season. The yellow sugarcane aphid feeds on the underside of sorghum leaves and can reach numbers large enough to require treatment. Threshold levels on when to treat are based on the size of the sorghum and percent of plants infested. See the TexasAgrilfe Extension insecticide guide for specific guidelines on when to treat for yellow sugarcane aphid.

Corn Earworm

(Photo 3) The corn earworm larva has alternating light and dark strips down its body. The color varies from green to pink. The head capsule is a creamy yellow. Larvae feed on whorl tissue of young sorghum plants and on developing grain in maturing plants. Full-grown larvae are about 1½ inches long and feed on grain heads. **In general, treatments should be applied when two or more small larvae or one large (greater than half an inch) larva is found per head.**

Fall Armyworm

(Photo 4) Fall armyworm larvae have a dark head capsule and a prominent inverted Y on the front of the head. Body color is green to brown with brown to black stripes on the sides of the body. Check whorls of young, late-planted sorghum and inside grain heads of more mature plants for fall armyworms. **In general, treat when an average of two or more small larvae or one large (greater than half an inch) larva is found per head.**

Sorghum Webworm

(Photo 5) These are small, greenish, hairy caterpillars with four reddish brown stripes down the back. Full-grown larvae are about half an inch long and are usually associated with sticky webbing in the area of their feeding. Check inside grain heads for worms and on leaves under grain heads for white fecal droppings. Treat when an average of 3-4 or more larvae are found on a grain head.

Sorghum Midge

(Photo 6) The sorghum midge is one of the most damaging insects to sorghum. The adult sorghum midge is a small, fragile-looking, orange-red fly with a yellow head, brown antennae and legs, and gray, membranous wings. **Fortunately, it is not a major pest in the High Plains. It is usually only an issue in late planted sorghum.**

The sorghum plant is only susceptible to midge during the flowering stage. A sorghum midge damages sorghum when the larva feeds on a newly fertilized ovary, preventing normal kernel development. Grain loss can be extremely high. Glumes of a sorghum midge-infested spikelet fit tightly together because no kernel develops. Typically, a sorghum grain head infested by sorghum midge has various proportions of normal kernels scattered among non-kernel-bearing spikelets, depending on the degree of damage. Only the portion of the head with yellow anthers is susceptible to midge. This is because when the glume opens and puts the yellow anther out to pollinate, the midge inserts an egg

TABLE 11. ESTIMATED ECONOMIC INJURY LEVELS FOR SORGHUM MIDGE FOR A RANGE OF FACTORS

Control Costs, $/A	Crop Value, $110 lbs	Flowering Heads = 18,000/A	Flowering Heads = 455,000/A	Flowring Heads = 67,500/A
5	6	1.6	0.6	0.4
5	7	1.3	0.5	0.34
5	8	1.2	0.5	0.3
6	6	1.9	0.8	0.5
6	7	1.6	0.7	0.4
6	8	1.4	0.6	0.35
7	6	2.2	0.85	0.6
7	7	1.9	0.75	0.5
7	8	1.6	0.65	0.45

into the open glume. Each female midge lays 30-120 eggs.

Effective control of sorghum midge requires the integration of several practices that reduce sorghum midge abundance and their potential to cause crop damage. The most effective cultural management method for avoiding damage is early, uniform planting of sorghum in an area so flowering occurs before sorghum midges reach damaging levels. Planting hybrids of uniform maturity early enough to avoid late flowering of grain heads is extremely important. This practice allows sorghum to complete flowering before sorghum midge increases to damaging levels. Cultural practices that promote uniform heading and flowering in a field are also important.

To determine if adult sorghum midges are in a sorghum field, check at mid-morning when the temperature warms to approximately 85°F. Sorghum midge adults on flowering sorghum grain heads are most abundant at that time. Because adult sorghum midges live less than one day, each day a new brood of adults emerges. Sampling must be done almost daily during the time sorghum grain heads are flowering. Sorghum midge adults can be seen crawling on or flying around flowering sorghum grain heads.

The most simple and efficient way to detect and count sorghum midges is to inspect carefully and at close range all sides of randomly selected flowering grain heads. Handle grain heads carefully during inspection to avoid disturbing adult sorghum midges. Other sampling methods can be used, such as placing a clear plastic bag or jar over the sorghum grain head to trap adults. Since they are relatively weak fliers and rely on wind currents to aid their dispersal, adult sorghum midges are usually most abundant along edges of sorghum fields. For this reason, inspect plants along field borders first, particularly those downwind of earlier flowering sorghum or Johnsongrass. If no or few sorghum midges are found on sorghum grain heads along field edges, there should be little need to sample the entire field.

The threshold for midge depends on yield potential and crop value but is generally one midge per head. Fields vulnerable to midge infestation should be scouted daily until flowering is complete. See extension service recommendations for scouting and control options for midge.

*Photos are located in Appendix B on page 84.

TABLE 12. SUGGESTED INSECTICIDES FOR CONTROLLING SORGHUM MIDGE

		Days from Last Application To:	
Insecticide	Application Rate	Harvest	Graze
Chlorpyrifos (Lorsban® 4E)	8 oz	30	30
Cyfluthrin (Baythroid® 2E)	1.0-1.3 oz	---	14*
Cyhalothrin	---	---	**
Karate® IE, Warrior® IE	1.92-2.56 oz	---	---
Esfenvalerate (Asana® XL)	2.95-5.8 fl oz	21	---
Malathion (Flyanon® ULV)	8-12 oz	7	7
Methomyl (Lannate®)	12-24 oz	14	14
2.4LV, 90WSP	4-8 oz	14	14
Zeta-cypermethrin (Mustang Max®)	1.28-4.0 fl oz	14	45

*If one or two applications are made, green forage may be fed or grazed on the day of treatment. If three applications are made, allow at least 14 days between last application and grazing.
**Do not graze livestock in treated area or harvest for fodeder, silage or hay.

DISEASES

Although sorghum is susceptible to many diseases, there are only a few which cause or have the immediate potential to cause economic losses in the Mid-Atlantic on a regular basis. Sorghum is also susceptible to many physiological leaf spots. These can be easily confused with a number of commonly occurring foliar diseases so caution should be taken in making a diagnosis. University plant disease diagnostic laboratories are available to assist in making positive disease identifications.

The total eradication of disease in sorghum is not economically feasible, so growers must try to minimize losses using an integrated pest management system. Planting resistant hybrids, providing optimum growing conditions, rotating with other crops, burying infested debris, proper seedbed preparation and seed placement, and accurate application of herbicides and insecticides are all practices that can be used to minimize disease losses.

The most common diseases in the Mid-South are stalk rots, primarily fusarium stalk rot and charcoal rot. Seedling blights can also occasionally be an issue. **Although foliar diseases are often present in low levels, they seldom cause a reduction in yield.**

Diseases found in sorghum fields in various regions are described in Table 13.

TABLE 13. SORGHUM DISEASES

Disease / Cause	Symptoms	Occurrence	Management
Seed Rots and Seedling Blights			
Pythium Blight Fusarium Blight	• Thin uneven stands • Seeds may rot prior to emergence or plants may die back after emergence • Plants may show stunted growth with red to black roots	• Most noticeable following prolonged periods of cool, wet weather just after planting and in poorly drained soil • Fusarium may be a problem in droughty, sandy soils	• All sorghum comes pretreated with fungicides that aid in management • Efficacy of these chemicals is often decreased by long periods of poor germination and early growth conditions
Stalk Rot			
Fusarium Stalk Rot (See Kansas State University bulletin L-741, "Stalk Rots of Corn and Sorghum")	• Premature death of plants • Roots usually show considerable rot • Infected stalk tissue is discolored with salmon to dark red hues often predominating	• Disease is favored by abundant moisture and moderate temperatures following head initiation	• Select hybrids with good standability ratings • Avoid continous cropping, fertilize adequately and avoid leaf loss to insects or foliar disease • Hail tends to intensify stalk rot

Disease / Cause	Symptoms	Occurrence	Management
Charcoal Rot (See extension bulletin L-741)	• Disintegration of the lower stalk with numerous small, black bodies (sclerotia) scattered throughout	• Most apt to occur in light or shallow, drought-stressed soils • Disease may be present only in scattered areas of the field	• Some hybrids are more resistant than others • Reduce plant populations to avoid drought stress • Later-maturing hybrids often escape infection
Foliar Diseases Caused by Fungi[1]			
Sooty Stripe	• Elongated spots that may extend several inches with broad, yellow to orange margins • A sooty-like growth (sclerotia) is generally present on the underside of the lesion	• Oldest leaves usually are attacked first and most extensively • Yield losses of 30% or more have been recorded	• Crop rotation • Resistant hybrids are available
Gray Leaf Spot	• Dark purple, rectangular lesions one-fourth inch or longer with a grayish cast during spore production	• Same as northern corn leaf blight • Usually occurs late in growing season as the crop matures • Little, if any, losses occur	• Crop rotation • Resistant hybrids are available

Northern Corn Leaf Blight	• Large (two inches or more) elliptical spots with gray centers and reddish-tan borders • Very similar to sooty stripe but without sclerotia	• Most prevalent during prolonged periods of warm, humid weather	• Crop rotation • Resistant hybrids are available
Rust	• Small brown pustules or blister-like growths on the upper and lower leaf surfaces starting on the lowest leaf	• Usually appears late in the growing season (late August or early September) • Favored by warm, moist weather • Significant losses are rare	• Resistant hybrids are available
Anthracnose	• Small, circular to elliptical spots one-eighth to one-fourth inch in diameter • Depending on the hybrid, lesions may be tan, orange, red or blackish-purple	• Most prevalent in areas where periods of high humidity alternate with relatively dry periods	• Crop rotation • Resistant hybrids are available

Disease / Cause	Symptoms	Occurrence	Management
Zonate Leaf Spot	• Circular, reddish-purple bands alternating with tan or straw colored areas which give a concentric zonate or bull's-eye appearance • Lesion diameter may extend several inches	• Most severe during prolonged periods of high humidity	• Crop rotation • Resistant hybrids are available
Foliar Diseases Caused by Bacteria[2]			
Bacteria Stripe	• Long, narrow, reddish or tan stripes depending on hybrids • Lesions usually confined between veins • Shiny, crusty spots from exudates generally found on underside of leaves	• Most common bacterial disease • Prevalent during cool, humid weather	• Crop rotation

Bacterial Streak	• Narrow, water-soaked, translucent streaks about 1-8 inches wide by 1-6 inches in length • Lesions turn red	• Very common during warm, humid weather	• Crop rotation
Virus Diseases			
Maize Dwarf Mosaic Virus (MDMV-A) Sugarcane Mosaic Virus (MDMV-B)	• Mosaic patterns (alternating light and dark green areas) on whorl leaves • Cool nights (below 60° F for Strain A, below 70° F for Strain B) may cause red and necrotic areas resembling a blight • Flowering may be delayed and seed may be underdeveloped	• Virus is carried by insects, mostly greenbug and corn leaf aphid • MDMV overwinters in Johnson grass	• Most current hybrids are resistant to the more severe necrotic symptoms
Other Sorghum Diseases[3]			
Crazy Top Downy Mildew	• Light colored leaves become stiff, rubbery and twisted • If heads appear, glumes are often proliferated to give "crazy top" symptom	• Most severe when flooding occurs on seedbeds or young seedlings, especially in poorly drained or clay soils	• Avoid areas where the disease is a recurring problem

Disease / Cause	Symptoms	Occurrence	Management
Sorghum Downy Mildew	• Vivid green and white stripes on leaves in late spring or early summer • Leaves shredded by wind until only leaf veins are left • Heads partially or completely sterile	• Most common in eastern and southern production areas of the Central Great Plains • Infections generally take place under saturated soil conditions within the first few weeks of emergence	• Crop rotation • Resistant hybrids are available to pathotype 1
Heat Smut	• A portion or all of the head is replaced by smut galls	• Plants are infected at seedling stage, but symptoms are not apparent until boot or heading stage • More severe in south-central and southwest areas of the Central Great Plains	• Chemical controls are not effective • Utilize resistant hybrids

Sorghum Ergot	• Exudation of sweet, sticky "honeydew" from infected flowers occurs • Honeydew drips onto leaves or produces a white, powdery mass during moist conditions • Ovary may be converted to a white fungal mass visible between the glumes	• Occurs only sporadically in the Central Great Plains • The fungus only infects through unfertilized ovaries • It usually only occurs late in the season when colder temperatures affect pollination of late-planted sorghum or late developing tillers	• Fungicide application at pollination can be made but are usually only economical in hybrid seed production fields • Harvesting right after a rain which temporarily washed off the honeydew may prevent the clogging of harvesting equipment

[1]There are many foliar diseases caused by fungi that can occur on sorghum including sooty stripe, rust and northern corn leaf blight. Sooty stripe and rust can cause economic losses to occur in some years and on some hybrids. Management of these diseases should primarily rely on selecting resistant hybrids and cultural practices such as crop rotation and the removal of residue where soil erosion is not a problem. Fungicides should be considered under high-yielding environments.

[2]Bacterial leaf diseases have not been shown to cause yield losses under High Plains conditions, but they are generally present in some fields every year, particularly under wet, humid conditions.

[3]In the High Plains, only seedling blights, stalk rots and sooty stripe are likely to cause economic yield losses on a regular basis. Crazy top downy mildew and sorghum downy mildew occasionally cause significant yield loss in individual fields or small areas of a field in years with excessive moisture early in the season, but they are not a widespread problem. Sorghum ergot infection is rare, but when it does occur it can cause significant harvesting problems because the sticky honeydew can bind up combines, forage cutters and augers.

HARVESTING

Sorghum stalks are generally much wetter than corn stalks at harvest, and they may be sticky from sugars. Stalk material mixed in with grain can cause problems with drying and storing. **To avoid problems with green stalks, harvest as little of the stems and leaves as possible.**

Grain sorghum demands the best combine operators. Most crops have a specific problem (such as header loss in soybeans), but grain sorghum can have difficulties at nearly every point in the combining process. These problems are compounded by the fact grain sorghum often ripens unevenly. In good-standing grain sorghum, losses can usually be kept to 5 percent of the yield, but only careful adjustment and operation of the combine makes that possible. Additional time and effort will be required, but expenses are already in the crop, and every extra bushel saved is clear profit.

<u>Five Types of Harvest Loss</u>
Preharvest loss is typically weather related and can be minimized by timely harvesting. Crops left in the field too long can be damaged by birds or field shatter. Severe weather before or during harvest can cause lodging, which makes the crop difficult to harvest.

Combine size, crop acreage and available workdays dictate timeliness. Combines should be large enough to harvest the crop in acceptable time. If this is not economically feasible, custom harvesting is an option. Another option is harvesting earlier, but this must be balanced against greater drying costs. Generally, grain sorghum can be combined whenever the moisture content is less than 30 percent.

Header loss includes shattered kernels, dropped heads and uncut heads. If a conventional reel is used, the speed of the reel bats should be slightly faster than ground speed. Operating the reel too fast will increase shatter losses while operating too slow will cause dropped heads. Several attachments are available to improve gathering efficiency. Flexible guard extensions on grain platforms substantially reduce gathering losses in standing crop conditions. Row attachments on grain platforms, or using a row-crop head, reduces losses in both standing and lodged conditions.

Cylinder loss, or unthreshed grain, can be a major problem with grain sorghum. It is often necessary to compromise between adequate threshing and excessive kernel cracking. **Cracking can be caused by either too little clearance or too fast cylinder speed, but speed is usually the cause.** Severe threshing action can pulverize the stalks and overload the cleaning shoe and walker. It is often necessary to leave up to 2 percent of the grain in the head to achieve the best overall harvesting results.

In high-moisture grain sorghum, cylinder speed and concave-clearance adjustments are critical. As the head passes through the cylinder area, rolling it (rather than a shearing) provides maximum threshing with minimum kernel and stalk damage. The cylinder concave clearance should be set so the stalks are not crushed, and cylinder speed should be increased until thorough threshing occurs. This often requires wider cylinder-concave clearance than harvesting sorghum at lower moisture contents.

Shoe loss is grain carried or blown across the shoe. Kansas State University research indicates it may be the most serious and most overlooked source of harvesting loss in grain sorghum. In most modern combines, the shoe (and not the cylinder) is the first component of the combine to overload in grain sorghum. If the combine operator pushes the machine as fast as the cylinder can go, the shoe is usually losing large quantities of grain. In one series of tests, a 33-percent increase in ground speed caused shoe loss to increase by more than 4 percent of the total yield. Shoe losses also are increased when operating on hillsides. The amount of air blown on the shoe is important, as is the opening of the louvers. Closing the chaffer louvers will increase the air velocity through the opening; air opening (or fan speed) should be reduced as the louver opening is closed.

Walker loss can be caused by excessive speed also, but in most combines the walkers overload after the shoe; therefore, walker overloading is of secondary importance when combining grain sorghum.

<u>How to Measure Combine Loss</u>
Ground counts are tedious work, especially in grain sorghum. Nevertheless, they offer a reasonably accurate idea of how much grain is being lost. **As a rule of thumb, 17-20 kernels per square foot are equivalent to 1 bushel per acre.**

To accelerate ground counts, a 1-square-foot frame may be constructed from heavy wire. It is best to take at least three ground counts at each location (Figure 4). When making ground counts for kernels, look for lost heads. **One 10-inch head in a 10-foot-by-10-foot area is approximately one bushel per acre.**

Total loss can be checked behind the combine. Make ground counts on 1-square-foot areas in three locations uniformly spaced across the header width, with one count being made in the discharge area of the combine. Average the counts and divide by 20 to get bushels per acre. If the result is 5 percent or less of the total yield, losses are within reasonable limits.

If the total loss was more than 5 percent, the next step is to determine the preharvest loss. Check this in front of the combine in the standing sorghum. Take three counts on 1-square-foot areas, then average them and divide by 20. Subtract the preharvest loss from the total loss to determine the net machine loss. If the net machine loss is more than 5 percent, determine where the loss is occurring.

Header loss can be determined by backing the combine a few feet and taking ground counts between the header and the uncut sorghum. The difference between the header count and preharvest count is the net header loss.

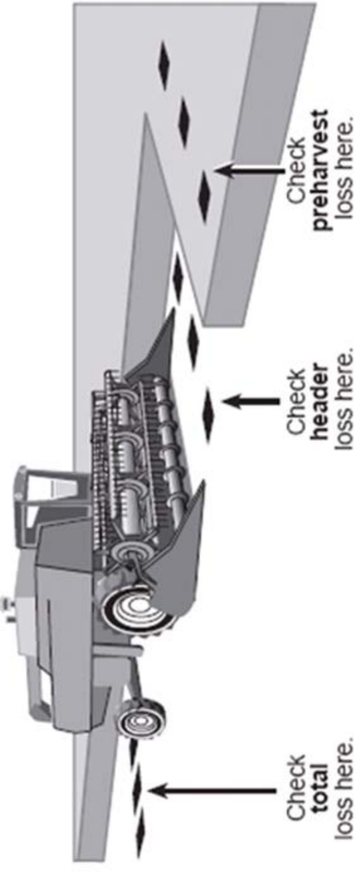
Cylinder and separation loss can be determined by subtracting the header loss from the total machine loss. It is sometimes difficult to determine if the loss is being carried over the walkers or blown across the shoe. Provided the combine does not use a straw chopper, the loss can often be pinpointed by observing the shoe while the combine is operating.

Combine loss monitors can indicate changing harvest conditions. They should be set to indicate a representative loss. If time is not spent setting the monitor, the reading is of little value.

Drying and Storing Grain Sorghum

Grain quality at harvest is influenced by grain variety, weather and combine adjustment.

FIGURE 2. DETERMINING HARVEST LOSSES



Minimizing grain damage in order to maintain quality requires good handling, drying and cooling equipment, and conscientious stored-grain management.

Handling

Grain sorghum may need to be cleaned before being stored in a grain bin, depending on the amount of trash that accompanies the grain. The trash can be reduced by harvesting after a killing frost or after using a desiccant. Excessive trash in the bin can accumulate and become hot spots during drying or can even catch on fire.

Drying

Harvest grain sorghum at 18-22 percent moisture if a suitable heated-air system is available for drying the crop. Harvesting above 22 percent moisture will result in more trash material in the grain.

Producers should be extremely cautious in holding high-moisture grain sorghum prior to drying. High-moisture grain sorghum packs much tighter than high-moisture corn. This inhibits air circulation within the grain and can result in heating, molding and sprouting problems. Never hold wet sorghum longer than 2-4 hours unless aeration is provided.

Grain sorghum is much harder to dry than corn because the seed is small and round, and it is harder to force air through it. Actual drying capacity will be about two-thirds to three-fourths as fast as corn for the same grain depth and air temperature.

Continuous flow or batch dryers are the preferred methods for drying grain sorghum. If it must be dried in a bin, the bin should be used as a batch-in bin dryer, limiting the drying depth of each batch to 4 feet. After drying, cool the grain and move it to another storage bin before the next day's harvest. A 3-foot depth of sorghum is equivalent in resistance to a four-foot depth of corn at an airflow rate of 10 cfm (moving capacity of fan). An individual seed of grain sorghum will dry faster than an individual seed of corn, but greater flow resistance from a bin of sorghum will reduce the airflow. As a result, drying time for grain sorghum is longer than for corn. Cooling time is also longer.

Optimum drying temperature depends on the type of dryer, airflow rate, end use (feed, market, seed), and initial and final moisture contents. Maximum temperature for drying grain sorghum for use as seed should not exceed 110°F. Dry for milling below 140°F in high airflow batch and continuous flow dryers and 120°F in bin dryers. If used for feed, drying temperatures can be up to 180°F. Always cool grain to within 5-10 degrees of the average outside air temperature after drying. Natural, unheated air may be used when the relative humidity is 55 percent or less and the grain moisture is 15 percent or less.

Natural, unheated air drying can be used to dry grain sorghum if the moisture content is 16 percent or below and the drying depth is less than 10 feet. Drying fans must be capable of delivering at least 1-2 cfm/bushel. Because the drying process is slow, it is important to start the fans immediately after the floor is covered.

Storage Moisture Content

The final storage moisture for grain sorghum depends on the expected length of the storage period and whether the grain sorghum is to be fed out to the bin continuously or is allowed to remain undisturbed in the bin until it is sold.

- To sell at harvest: 14 percent moisture
- Short term storage (less than six months): 13 percent moisture
- Long term storage (six months or longer): 11-12 percent moisture

Storing Grain Sorghum

Aeration is one of the most important management tools available to producers for maintaining grain quality in sorghum storage. Aeration extends the storage life of grain by removing odors, preventing moisture accumulation and controlling conditions conducive to mold growth and insect activity.

Grain should be aerated after it is dried and in the fall, winter and spring. Begin aeration when the average outdoor temperature is 10-15°F lower than the grain temperature. Average outside temperature can be taken as the average of the high and low temperatures over a 3-5 day period. Check grain temperatures at various locations in the bin with a probe and thermometer.

Inspect all grain in storage at least once a week. Check for indications of moisture such as crusting or condensation on the bin roof. Check and record the temperature at several points in the stored grain. Any increase in temperature indicates a problem unless outside temperatures are warmer than the grain. Probe the grain to check for insects or other problems. If problems are noticed, run the aeration fans.

Grain Quality

Sorghum grain is placed into U.S. Grade Numbers 1, 2, 3, 4 or is classified as Sample Grade, and U.S. No. 1 is the highest quality (Table 9). Value of grain sorghum follows this grading system. Proper harvesting, drying and storage practices are important to achieving the higher grades.

TABLE 9. SORGHUM GRADES AND GRADE REQUIREMENTS, FROM THE UNITED STATES STANDARDS FOR SORGHUM

Grading Factors	Grades U.S. No.[1]			
	1	2	3	4
Minimum Pound Limits				
Tested Weight per Bushel	57.0	55.0	53.0	51.0
Maximum Percent Limits				
Damaged Kernels:				
Heat (part of total)	0.2	0.5	1.0	3.0
Total	2.0	5.0	10.0	15.0
Broken Kernels and Foreign Material:				
Heat (part of total)	1.0	2.0	3.0	4.0
Total	3.0	6.0	8.0	10.0

Maximum Count Limits (Other Material)				
Animal Filth	9	9	9	9
Castor Beans	1	1	1	1
Crotalaria Seeds	2	2	2	2
Glass	1	1	1	1
Stones[2]	7	7	7	7
Unknown Foreign Substance	3	3	3	3
Cockleburs	7	7	7	7
Total[3]	10	10	10	10

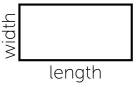
[1] Sorghum which is distinctly discolored shall not grade higher than U.S. No. 3.
[2] Aggregate weight of stones must also exceed 0.2 percent of the sample weight.
[3] Includes any combination of animal filth, castor beans, crotalaria seeds, glass, stones, unknown foreign substances or cockleburs.

U.S. Sample Grade sorghum:
(a) Does not meet the requirements for U.S. No. 1, 2, 3 or 4; or
(b) Has a musty, sour or commercially objectionable foreign odor (except smut order); or
(c) Is badly weathered, heating or distinctly low quality.

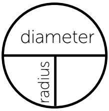
Sorghum Facts

- 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.

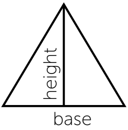
CALCULATIONS & CONVERSIONS



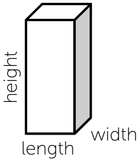
Area of a rectangle or square = length x width



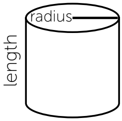
Area of a circle = 3.1416 x radius squared; or 0.7854 x diameter squared
Circumference of a circle = 3.1416 x diameter; or 6.2832 x radius



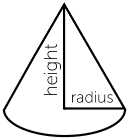
Area of triangle = base x height ÷ 2



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

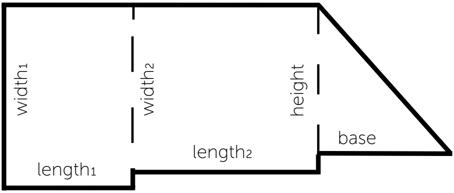


Volume of a cylinder = 3.1416 x radius squared x length



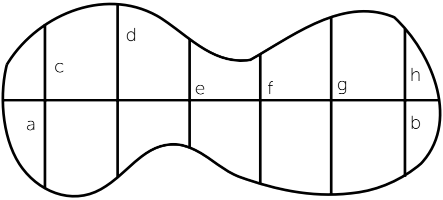
Volume of cone = 1.0472 x radius squared x height

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
Cubic 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
ºCelsius (ºC)	(+17.98)x1.8	Fahrenheit
ºFahrenheit (ºF)	(-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.

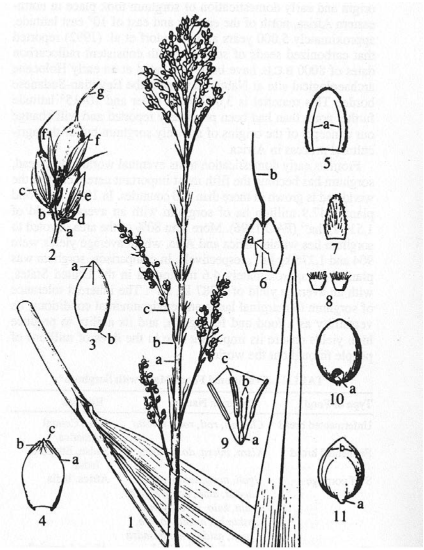


Figure 3. The panicle of Sorghum bicolor subsp. bicolor which consists of the inflorescence and spikelets. 1. Part of panicle: a = internode of rachis; b = node with branches; c = branch with several racemes. 2. Raceme: a = node; b = internode; c = sessile spikelet; d = pedicel; e = pedicelled spikelet; 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 25-40 days after the black layer is formed when moisture content is generally 15 percent or less. Black layer can be seen at the base of the grain where it attaches to the rachis branch and indicates 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 are all said to be free of tannins.

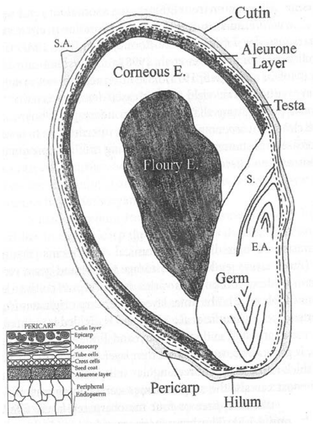


Figure 4. Sorghum grain, showing the pericarp (cutin, epicarp, mesocarp, cross cells, tube cells, testa, pedicel, and stylar area (SA)), endosperm (aleurone layer, corneous and floury), and the germ (scutellum (S) and embryonic axis (EA). Adapted from L. W. Rooney and Miller, 1982).

b. Photos

Photo 1. Iron Deficiency

Courtesy of International Plant Nutrition Institute

Photo 2. Corn Leaf Aphid, Yellow Sugarcane Aphid, Sugarcane Aphid, Greenbug Aphid

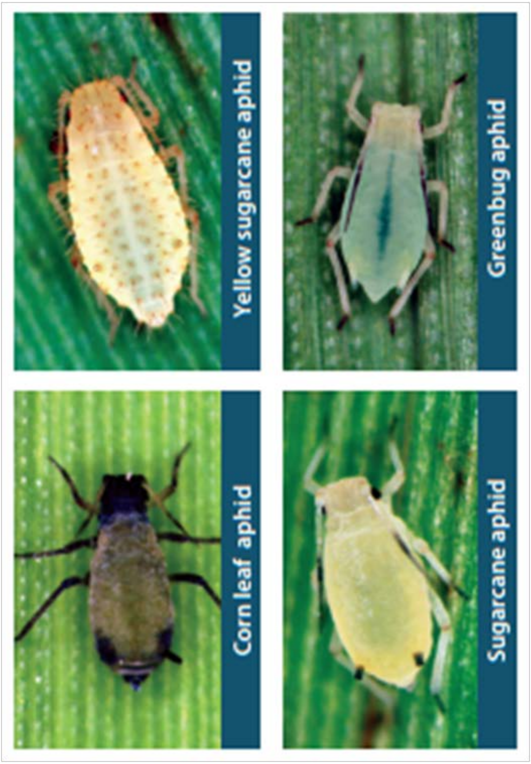


Photo 3. Corn Earworm**

Photo 4. Fall Armyworm*

***Used with permission of USDA-ARS*

Photo 5. Sorghum Webworm*

Photo 6. Sorghum Midge*

Used with permission of Dr. Pendelton, West Texas A&M University

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DISCLAIMER

Some of the information presented in this handbook is specific to the High Plains. 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.

SORGHUM THE SMART CHOICE

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