Texas Cooperative Extension
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Grain Sorghum Production in West Central Texas

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CONTENTS

Introduction

Grain sorghum is grown on about 225,000 acres in West Central Texas. Soils suitable for the crop range from loamy sands to clay and most sorghum in the area is produced without irrigation. Annually, rainfall varies greatly and averages about 18 inches. This variability in rainfall accounts for most of the differences that occur in grain yields.

Management practices used by producers prior to planting until harvest are the focus

of this publication. Linked to this publication are other sources of information that cover grain sorghum production outside the region; they include: "*Irrigated and Dryland Grain Sorghum Production; South and Southwest Texas*" (B-6048), "*Managing Grain Sorghum for Maximum Profitability in the Texas High Plains*" (SCS-2000-26) and "*Grain Sorghum Production Handbook*" from Kansas State University (C-687).

In general, producers select sorghum hybrids that have been shown to be adapted to local soils and growing conditions and provide consistently higher yields. Sorghum hybrids vary in many traits including: plant height, drought resistance, days-to-bloom, insect resistance, openness of head and color of grain.

Consult county Extension agents about hybrids variety tests conducted in county or regional Extension demonstrations and Texas Agricultural Experiment Station performance tests. Factors such as yield, standability, tolerance to important area diseases and maturity requirements weigh heavily in planting decisions. Generally, under favorable moisture and fertility conditions, medium or medium-late (bloom period) maturing hybrids have consistently produced the highest yields in West Central Texas.

Seedbed Preparation

Grain sorghum needs a warm, moist and firm seedbed that provides good seed-to-soil contact. An ideal seedbed would be weed free, have adequate moisture, be shaped and designed to minimize wind and water erosion, and have been prepared early enough to catch precipitation to fill the soil profile and allow the soil to firm before planting.

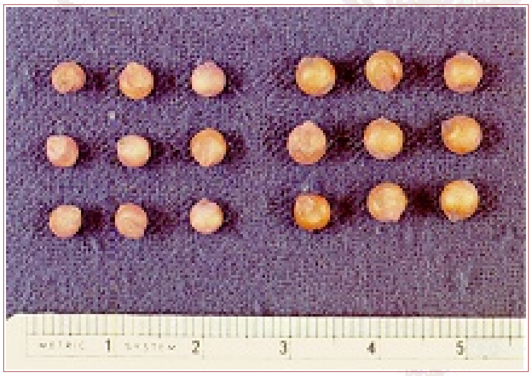
The biggest annual challenge to this region is building up a sufficient soil moisture reserve to a level suitable for profitable grain production. To accomplish this, producers should establish their seedbeds early. All tillage practices for the sorghum crop should be completed 4 to 5 months prior to seeding. Once the seedbeds are formed, consider establishing furrow dikes in order to capture precipitation and build up soil moisture.

Adequate surface residue is not provided by many of the crops produced within this region, so terracing, contouring, strip cropping, and windbreaks are generally used to prevent erosion. Of the crops grown in the area wheat produces the most residue, however, double cropping with sorghum is generally not successful, so a fallow period is needed.

Planting Information

Production practices such as planting rates and dates, selecting properly maturing hybrids, and row spacing are of utmost importance for profitable production. Select planting seed from a reliable seed dealer. To improve emergence, use seed treated with both an insecticide and fungicide.

Planting rates



Avoid excessive planting rates on both dryland and irrigated grain sorghum. Sorghum seed varies greatly in size and are small when compared to corn and soybeans. Shown in the photograph to the right are seed from two different hybrids. If these two hybrids were planted by weight of seed per acre, the smaller seed would provide a much thicker stand than the other. For example, Table 1. shows what would happen if both hybrids were planted at 4 pounds per acre and each had 75 percent field establishment. To obtain the desired plant population it is necessary to know more than how many pounds per acre to plant.

Table 1. Effect of seed size on planting rate and plant population when planting is based on pounds per acre.

Example	Weight of 1,000 seeds (grams)	Number of seed per acre planting 4 pounds	Number of plants per acre with 75% emergence
Hybrid #1	19.0	95,500	71,600
Hybrid #2	34.3	52,900	39,700

Under dryland conditions, planting rates on 40-inch rows should not exceed 2 to 3 seeds per foot (26,000 to 39,000 seed per acre). Dryland production using a "skip row" planting pattern should use about the same number of seed per row foot. When narrow rows are used under adequate irrigation, you would still have the same seed population per acre; however, the number of seed per foot of row should be adjusted accordingly. On 40-inch rows with limited irrigation, 5 to 6 seeds per foot are sufficient, and to produce maximum yields with full irrigation 8 seeds per row foot.

Planting dates

For highest yields, and to avoid possible sorghum midge damage, plant as soon as soil temperatures reach a minimum of 60 degrees F at planting depth (reading should be made between 7:00 and 8:00 a.m.). Optimum planting dates begin around April 15. Yield reductions can be expected from plantings made after June 15 due to sorghum midge damage, inadequate precipitation, heat stress and other climatic events.

Fertilization

Consider residual soil fertility and moisture before applying fertilizer. Balanced fertility (N, P, K) increases yield, improves water use efficiency, and insures an early harvest of a mature crop that is uniform in height.

Under non-irrigated conditions, sandy loam and other coarse-textured soils more frequently require fertilizer applications to improve the balance and level of plant nutrients than clay and clay loam soils. However, soils are not uniform and soil tests are the only way to determine the nutrients required for proper balance. When rainfall is low, existing soil moisture reserves influence the nutrient amounts required for an economical response. Refer to the fertility section of "*Irrigated and Dryland Grain Sorghum Production; South and Southwest Texas*" (B-6048) for additional information on nutrients needed by grain sorghum.

Nitrogen applications should be increased when grain sorghum follows grain sorghum or other high residue crops, particularly if seedbed preparation has been delayed and considerable residue has to be decomposed. If nitrogen is applied in bands at planting, avoid placing the seed in contact with the fertilizer. The nitrogen should be placed 2 to 4 inches to the side and 2 to 4 inches below the seed. Nitrogen may be chiseled into the side of the seedbed, as a second choice. Sidedressing part of the nitrogen after planting may be desirable in some areas. This allows time to evaluate the soil moisture reserve and estimate yield potential and fertility requirements. On sands, loams and other permeable soils, sidedressing also may minimize leaching losses from rainfall or irrigation.

Other Nutrients

Two other important nutrients for grain sorghum production in Texas are zinc and iron. Where soil phosphorus levels are "high" or "very high" and zinc levels are "low" to "medium", the application of phosphorus fertilizer may induce a zinc deficiency. If soil test results indicate a possible zinc deficiency, zinc fertilizer should be broadcast and incorporated preplant or banded at planting. Foliar applications of zinc should be used as a preventative measure as damaged to the crop will occur before symptoms are recognized and corrected. For more information refer to "*Zinc Deficiency and Fertilization*" (L-721).

Iron deficiencies occur on some high pH (calcareous) soils in West Central Texas. Soil applied iron compounds have not been effective at economical rates. For more information refer to "*Correcting Iron Deficiency in Grain Sorghum*" (L-5155). An early foliar application of iron will reduce symptoms and encourage normal growth. In most acreage a second application usually is required in 7 to 10 days. In severe situations a third application may be needed to return plants to normal green color. Table 2 suggested foliar treatments to correct iron and/or zinc deficiencies.

Table 2. Suggested sources, rates and timing of iron and zinc foliar sprays.

Deficiency	Product*	Product/ 100 gals water	Product/Acre	Timing
Iron	Iron sulfate (20% Fe)	20 lbs (2.5% solution)	1 lb 2 - 3 lbs	10-14 days after emergence - 5 gals/A over crop row. Follow with 2 apps. @ 10-14 day interval @ 10-15 gals/A
	Iron chelate (10% Fe)	8 lbs (1%)	0.4 - 0.5 lbs	10-14 days after emergence - 5 gals/A over crop row. Follow with 2 apps. @ 10-14 day interval @ 10-15 gals/A
Zinc	Zinc sulfate (30% Zn)	2 lbs (1/2 %)	0.2 - 0.4 lbs	10-20 gals/A in first 30 days
	Zinc chelate (9 to 10% Zn)	2 qts (0.1%)	1 pint	10-20 gals/A in first 30 days
Iron & Zinc	Iron sulfate + Zinc sulfate + urea fertilizer	15 lbs+ 1 lb + 2 lbs	3/4 Iron + 0.1-0.2 Zinc 1.5 lb Iron + 0.2-0.4 Zinc	10-14 days after emergence - 5 gals/A over crop row. Follow with 2 apps. @ 10-14 day interval @ 10-15 gals/A

	Iron sulfate + Zinc chelate	15 lbs 3 pints	3/4 Iron + 2.4 fl oz. 1.5 lb Iron + 5 fl oz.	10-14 days after emergence - 5 gals/A over crop row. Follow with 2 apps. @ 10-14 day interval @ 10-15 gals/A
	Iron chelate + Zinc chelate	6 lbs 3 pts	follow mfg. directions	10-14 days after emergence - 5 gals/A over crop row. Follow with 2 apps. @ 10-14 day interval @ 10-15 gals/A
*Include a surfactant or other wetting agent. Product composition may vary. Select similar products or adjust mixing ratios to achieve comparable rates of nutrient application.				
Source: Updated information based on research results and recommendations through the Texas Agricultural Extension Service Soil, Water and Forage Testing Laboratory.				

Irrigation

To produce optimum sorghum grain yields, 23 to 25 inches of water are required during the growing season. Adequate soil moisture is particularly important during the critical growth stages of boot, bloom and soft dough.

Sorghum grown on deep, well drained permeable soils usually develops extensive root systems. Mature plant roots may penetrate to depths of 4 to 6 feet in an ideal soil. Root development can be severely restricted by soil conditions such as excessively high or low soil moisture levels, hard pan and compaction.

Adequate soil moisture at planting helps assure uniform stands and contributes to early plant growth. Preplant irrigation can supply this moisture when winter and spring rainfall do not fill the root zone prior to planting. If the seedbed contains sufficient moisture for good germination and early plant growth but subsoil moisture is lacking, water may be supplied by irrigating after emergence. Whether irrigating before or after planting, apply no more water than required to fill the effective root zone.

High sorghum grain yields can be produced maintaining optimum soil moisture throughout the growing season. Irrigate when 50 to 60 percent of the available moisture has been used. Moderate plant moisture stress during early vegetative growth normally does not significantly limit grain yield. However, adequate moisture must be available by the boot stage. Greatest grain yield increases and water use efficiency have been obtained by irrigating so that ample soil moisture is available during the boot and bloom growth stages. Irrigation at the milk to soft dough stage also has consistently maintained high yield potential.

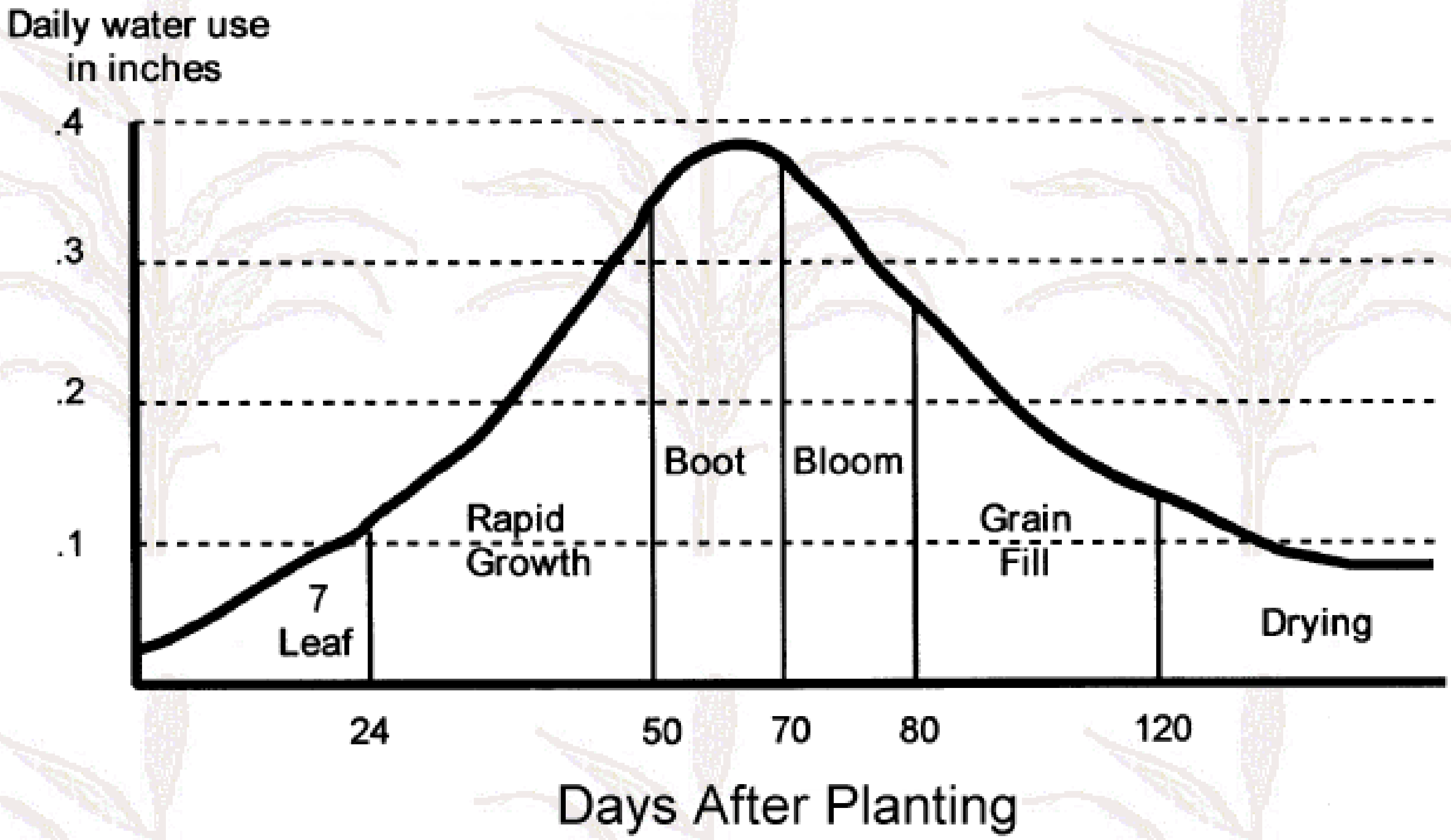
Irrigation intervals and the amount of water to apply is determined by:

- **Rainfall**
- **soil's water-holding characteristics**
- **plant rooting depth**
- **and climatic conditions**

Realizing that sandy soils hold less water than heavier clay soils, apply smaller quantities more frequently to sandy soils. Shallow-rooted crops also require more frequent irrigation. Encourage deep rooting by maintaining only moderate soil moisture

levels during early vegetative growth.

Average Daily Water Use by Grain Sorghum



The average daily water use by grain sorghum is usually less than 0.10 inch until approximately the seven-leaf stage, depending upon climatic conditions. At this stage, water use increases rapidly and is likely to average 0.30 inch per day during the boot, bloom and early grain development stages. Plan irrigations to provide adequate soil moisture during these high water requirement periods.

Weed Control

Weeds and grasses reduce yields and may interfere with harvesting. Satisfactory control can be obtained by combining timely cultivation, crop rotation and herbicide applications. Herbicides should be selected based on specific weed and grass problems encountered in each field and rotational crops to be planted following the sorghum harvest.

It is very difficult to control grass-type weeds with post-emergence herbicides so plan to use a preemergent herbicide if grass-type weeds are expected. Most of the preemergent herbicides used to control grass-type weeds require that the grain sorghum seed be coated with a seed safener which protects the young grain sorghum seedling from the harmful effects of the herbicide. Additional information on the herbicides available can be found in "Suggestions for Weed Control in Sorghum" (B-5045). Product labels should be consulted before applying any herbicide.

Insects

Insects and mites attack grain sorghum from planting until nearly harvest. The ability to identify damaging insect pests and beneficials, and to determine population levels, is a basic requirement for insect pest management. Inspect fields weekly when weather conditions are favorable for rapid pest population development. Information on these and other small grain pests and pesticides suggested for their control is presented in the attached PDF. "*Managing Insect and Mite Pests of Sorghum* " (B-1220).

Diseases and Treatment

Treat grain sorghum with a seed protectant fungicide. Seed treatment helps prevent seedborne diseases, smuts, seed rots and seedling diseases. Reputable seed companies will clean seed before treating to eliminate weed seed and lightweight seed which often contain disease organisms. Identification of Grain Sorghum Diseases (http://sanangelo.tamu.edu/agronomy/sorghum/gsdis.htm) obtained from the Department of Plant Pathology and Microbiology at Texas A&M University should make a good reference for individuals interested in learning more about identifying diseases and determining methods of control.

Desiccants

In some situations, a desiccant to kill leaves on sorghum or grass and certain broad-leaf weeds may allow the grain to dry faster or reduce harvesting problems with vegetation. Sodium chlorate, with urea as a fire retardant, partially kills the plant and allows the head and leaves to dry rapidly for about 10 days after application. Rapid drying will occur only when there is high temperature and low humidity following application. Sodium chlorate may be applied at rates up to 6 pounds of active ingredient per acre when the sorghum is fully mature, or about 7 to 10 days before harvest. Use 5 to 10 gallons of solution per acre for aerial applications. Follow instructions given on the product label.

Harvesting

Harvest when grain moisture has reached the proper level for available handling facilities. Delay means losses. Acceptable long -term storage moisture is 13 percent. Grain with up to 18 percent moisture may be harvested if drying facilities are available.

To avoid waste have the combine operator follow the manufacturer's manual on proper adjustment. Trash and cracked grain favor stored grain insects, moisture accumulation and mold damage. Practice good sanitation with all harvesting and storing. Protect grain from rodents and insects.

Marketing

Grain sorghum producers, individually or as a group, may (1) forward contract a growing crop through mutually agreed upon terms of trade, then deliver the grain at harvest, fulfilling the contract; (2) "hedge" the growing crop through a "cross-hedge" using corn on the futures market, then liquidate the hedge at harvest and deliver the grain to the local buyer for cash; (3) deliver and sell the crop at harvest to a local buyer

for cash; (4) store the harvested crop in either on-farm or commercial storage facilities for cash sale at some later date; or (5) place the harvested crop under loan in an approved facility for later-than-harvest cash sale, or redeem the loan and deliver title to the grain to the government.

Weigh each marketing method carefully. Location in relation to feedlots, poultry and egg producing units, swine or sheep feeding, in addition to export demand, will help determine the most advantageous method during any marketing year.

Acknowledgment

Appreciation is expressed to all the individuals that produced the various factsheets and publications that are linked to in these pages.

Disclaimer

Educational programs conducted by the Texas Agricultural Extension Service are open to all people without regard to race, color, sex, disability, religion, age or national origin.

Suggested pesticides must be registered and labeled for use by the Environmental Protection Agency and the Texas Department of Agriculture. Pesticide label clearances are subject to change.

The pesticide user is responsible for a pesticide's used on his own crop, as well as problems caused by drift or pesticide movement from his property to other properties.

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AGR 2

Top of Page | Soil and Crop Science Homepage

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Billy Warrick received his B.S. in Agriculture and his M.Ag. in Plant Science from West Texas State University in 1975 and 1976 respectively. Dr. Warrick received his Ph.D. in Agronomy from Texas Tech University in 1989. I serve Texas Agricultural Extension Service District 7 as a soil and crop science resource person. Presentations are given at county production meetings, crop tours, field days, turnrow meetings, program area committee meetings, and agent training meetings. My applied research program involves a number of producers and numerous miles of travel. The main objective of these tests is to develop localized information to address producer questions.

My Publications

Dr. Chris Sansone's Biographical Page

- Larger image of Chris Sansone (JPG 78,930 bytes)

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Workplace: Texas A&M University Agricultural Research and Extension Center, San Angelo, Texas

Department: Entomology

Job Tasks: Educational Training in Entomology for the 23 counties that make up TAEX District 7.

Crop Responsibilities include:

Dryland Small Grain Crops	**915,500 acres**
Irrigated Small Grain Crops	**24,500 acres**
Dryland Cotton	**361,000 acres**

Irrigated Cotton	**28,000 acres**
Dryland Grain Sorghum	**214,500 acres**
Irrigated Grain Sorghum	**14,000 acres**
Forage (Hay)	**188,000 acres**
Irrigated Corn	**6,000 acres**

Entomology Information Available

Entomology Information Related to Crop Pests.
Entomology Information Related to Household Pests.
Entomology Information Related to Lawn and Garden Pests.
For Pesticide Labels and MSDS Sheets (CDMS).
For Pesticide Labels and MSDS Sheets (Greenbook).

Chris Sansone's Biographical Page
last modified: April 27, 2001

Dr. Jason Johnson

Dr. Jason Johnson is an Assistant Professor and Extension Economist, Texas Agricultural Extension Service, District 7 stationed at the Texas A&M Research and Extension Center in San Angelo. Jason Johnson received his B.S. in Agricultural Economics from Texas Tech University in 1991. He earned his M.S. in Agricultural Economics from Louisiana State University in 1993 and his Ph.D. in Agricultural Economics with a minor in Consumer Economics from Texas Tech University in 1996.

As an Extension Economist Jason's primary responsibilities include the presentation of economically related information to clientele in the west central region of the state. His interests lie in farm and financial management, production economics, agribusiness management, and marketing. Specific responsibilities include the preparation of regional crop enterprise budgets and assisting with the economic analysis of ongoing state and regional research programs.

SELECTED PUBLICATIONS:

- The Economic Impacts of Agricultural Sustainability: An Application to Irrigated Cotton Production. Johnson, Jason L., and Eduardo Segarra. *Journal of the American Society of Farm Managers and Rural Appraisers*. (19): pp. 93-100. (1996).
- Technical Efficiency in Louisiana Sugar Cane Processing. Johnson, Jason L., Hector O. Zapata, and Arthur M. Heagler. *Journal of Agribusiness*. (13)2: pp. 28-33. (1995).
- The Impact of Succession Planting and a Third Ratoon Crop on Economic Efficiency in Sugarcane Production in Louisiana. Johnson, Jason L., Arthur M. Heagler, Hector O. Zapata, and Ray Ricaud. *Journal of American Society of Sugar Cane Technologists*. (13): pp. 85-98. (1993).
- Demand Relationships for Table Wine in Texas and the Influence of an Emerging Texas Wine Industry. Johnson, Jason L. *American Journal of Agricultural Economics*. (73)5: p. 1570. (1991).

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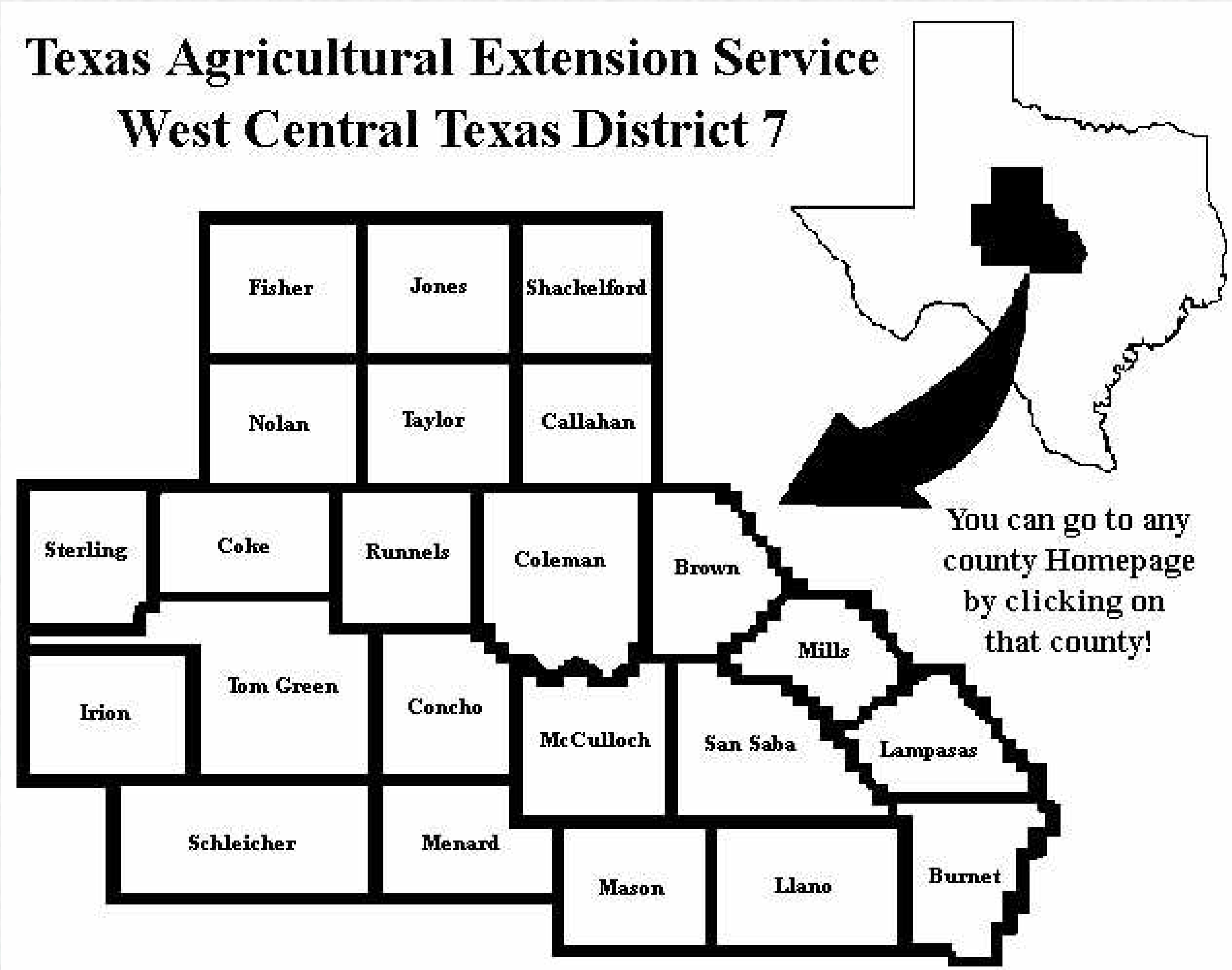
Return to Extension Economics Home Page
Return to Extension Economics Faculty List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Irrigated and Dryland
Grain Sorghum Production
South and Southwest Texas

Charles Stichler, Mark McFarland, and Cloyce Coffman*

Many people try to put the growth, development and eventual yield of the grain sorghum plant into a simple formula, when it is a complex series of many processess and interactions. Only after decades of research, the effects and interactions of fertility, row and plant spacing, planting date, environmental conditions (water, temperature, etc.), insects, diseases and hybrids are better understood. All are important factors in determining crop yield. A brief summary of the basic growth processes and important interactions follows to assist in making better production decisions as conditions in the field change. Information related to weed and insect control is not addressed in this publication, but can be found in ***Suggestions for Weed Control in Sorghum (B-5045)*** and ***Managing Insect and Mite Pests of Sorghum (B-1220)***.

Growth and Development

Like other crops, seed production in sorghum is a one-time event and all root, leaf and stem development is directed toward completion of the reproductive cycle. Since both the number and weight of seed determine yield, it is important to understand the plant processes that influence seed development. Plant growth in each stage of development is dependent on the previous stage. Stress in any stage of development will reduce yield potential.

Many producers falsely believe that sorghum is "tough" and requires little management. Although sorghum can survive and produce seed under adverse conditions, yields can be greatly reduced by environmental stress and poor management. Like any other crop, sorghum responds to optimum growing conditions and good management.

Seedling Development

The seedling development stage begins at germination and ends 30 to 35 days after emergence when plants have five to six mature (fully expanded) leaves. Emergence and early plant growth are highly dependent upon growing conditions. Plant growth requires energy, but it takes time to produce carbohydrates with a few small leaves which are subject to destruction by wind, hail, frost, insects and pests. As plants slowly develop their root systems and absorb water and nutrients, leaf tissue expands and produces carbo-

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hydrate energy for future growth. During this period of development, water and nutrient uptake are low, and only about 25 percent of the total crop nutrient demand will be absorbed.

Rapid Growth

In the rapid growth stage, 40 to 65 days after emergence, growing point differentiation occurs and the panicle or head begins to develop. This stage continues through head exertion. During this period, plants are especially sensitive to any type of stress such as temperature extremes, nutrient deficiencies, or water deficits or excesses, any of which may reduce potential seed numbers. Some herbicides (e.g., phenoxy or atrazine) applied at this time may cause florets to abort resulting in a "blasted" head. The rate of water and nutrient uptake increases rapidly during this period with about 70 percent of the nitrogen, 60 percent of the phosphorus and 80 percent of the potassium being absorbed into the plant. Plants use a portion of these nutrients for growth with the remainder stored in the leaves and stalks for later use. By the time the "flag leaf" is visible in the whorl, 80 percent of the total leaf area is capturing sunlight and converting it into energy. The rapid growth stage is the most critical stage of plant development and the period during which growing conditions have significant impacts upon yield.

Reproduction

The final growth stage begins with booting or head exertion and ends with mature grain. Water stress during this period reduces the manufacturing of carbohydrates and ultimately reduces yield. Water usage peaks shortly after flowering at 0.30 to 0.35 inches of water per day. The remaining portion of nutrients is absorbed during this high water use period. (R. L. Vanderlop describes in detail nine stages in ***How a Sorghum Plant Develops***, Bulletin No. S-3 Kansas State University.)

Planting

Sorghum seed are small in comparison to the seed of cotton, corn and soybean. Sorghum does not have the large reserves of energy and minerals to withstand as much stress as other crops with larger seeds. About 75 percent of the seeds planted may be expected to survive and produce emerged seedlings. Thus, planting rates should be adjusted according to planting conditions. Relatively slow growth due to cool temperatures, poor soil moisture conditions and competition from weeds may delay development and seriously reduce grain yields. The minimum soil temperature at the desired planting depth for germination and emergence of sorghum is about 55° F.

The size of sorghum planting seed may vary greatly among hybrids; therefore, careful attention should be given to proper equipment calibration during planting to obtain the desired seeding rate. Seeding rate should not be based on pounds of seed per acre, but rather the correct number of seed per acre.

Plant Density

Sorghum plants are very water efficient and have the ability to compensate considerably in grain yield with respect to growing conditions and planting rates. If soil moisture is limiting, grain yield will be greater if plant density is lower. Furthermore, if soil moisture is favorable due to irrigation or adequate rainfall, there is a level of plant density above which no additional grain yield will be achieved from an increase in plant density. If a modest plant density is used for an area typically limited by adequate moisture and above average rainfall is received, sorghum plants can adjust their grain numbers and weight considerably to compensate for the improved growing conditions.

Depending upon soil moisture conditions, recommended seeding rates vary between 30,000 and 100,000 plants per acre for South Texas. Under limited moisture conditions, 2 to 4 plants per foot for 38-inch row spacings will normally use all available soil moisture (Table 1). Irrigated sorghum performs better with about 80,000 plants per acre when planted in wide single or double row configurations or when narrow row patterns are used (Table 2). Sorghum plants are more efficient when each plant is given space to intercept sunlight and competition between plants is minimized. In addition, closer spacing (i.e., double row or narrow rows) will promote shading of the soil surface to reduce evaporation losses and weed competition.

Tests conducted at the North Plains Research Center at Etter demonstrate a similar response to irrigation levels and seeding rates (Figure 1).

Fertility

The concentration of nutrients in different plant parts may

Table 1. Effects of plant density and row spacing on grain yields of dryland sorghum.

Row Width	Plants/Acre 27,000	Plants/Acre 41,000	Plants/Acre 55,000	Plants/Acre 76,000
38	2,358	2,745	2,635	2,567
2 rows/bed 38 in. rows	2,440	2,687	2,415	2,617

Source: Texas Agricultural Experiment Station, Uvalde, Texas (1976 -1980)

Table 2. Effects of plant density and row spacing on grain yields of irrigated sorghum.

Row Width	Plants/Acre 27,000	Plants/Acre 41,000	Plants/Acre 55,000	Plants/Acre 82,000
26	3,564	4,075	4,787	4,815
38	2,906	3,026	3,203	3,726
2 rows/bed 38 in. rows	2,725	3,547	3,976	4,100

Source: Texas Agricultural Experiment Station, Uvalde, Texas (1977 -1981)

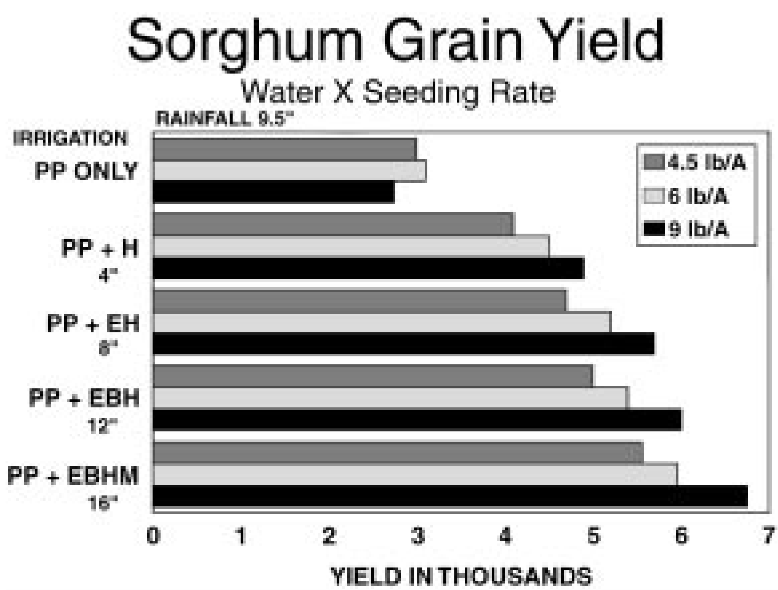


Figure 1. Relationship of seeding rate, water use and yield.

(PP=preplant; E = Early, 6-8 leaf; H = heading, flowering to soft dough; B = boot, flag leaf; M = milk to soft-dough)

Source: Texas Agricultural Experiment Station, Etter, Texas

vary considerably depending upon the conditions under which the crop has been grown. Table 3 gives the approximate nutrient content of sorghum grain and stover where grain yield was 5,600 pounds per acre (100 bu/A).

Table 4 shows the amount of nitrogen, phosphorus and potassium absorbed by grain sorghum plants during various stages of development in the process of producing 7,500 pounds of 14 percent moisture grain per acre. The amounts of secondary and micronutrients used to produce 7,500 pounds of grain per acre are shown in Table 5. Nutrient distribution in dry matter between grain and stover is presented in Table 6. Note the amount of nitrogen and phosphorus in the grain. Conversely, a substantial amount of potassium is contained in sorghum stover relative to nitrogen and phosphorus. If green stover is removed repeatedly, soil phosphorus and potassium levels may be depleted.

Nitrogen

The standard nitrogen (N) recommendation for grain sorghum in Texas is 2 pounds per acre of elemental N for each 100 pounds per acre of grain production expected.

Thus a 5,000-pound grain yield would need about 100 pounds of elemental nitrogen per acre. Nitrogen is by far the most important nutrient for sorghum to maximize production. Nitrogen is normally used by plants for chlorophyll and protein production, which in turn is used in formation of new plant cells. The seed also stores N to enable early growth after germination. Fifty-eight percent of the N absorbed by sorghum plants may be found in the grain at harvest (Table 6). For maximum yields relative to the available water, N should not be lacking or grain development will be reduced.

Side-dress N applications should be made by 20 days after emergence. Later applications may excessively prune feeder roots but more importantly, developmental potential of the grain head is determined 30 to 40 days after emergence. Nitrogen stress during this period will greatly influence yield. Under center pivot irrigation, N fertilizer may be applied several times during the early part of the growing season. Because N is relatively mobile in the soil, fertilizer placement is not as critical for N as it is for most other nutri-

Table 3. Approximate nutrient content of a 5,600 lb/A sorghum crop.

Plant Nutrient	Pounds in Grain	Pounds in Stover
Nitrogen (N)	84	95
Phosphorus (P_2O_5)	42	20
Potassium (K_2O)	22	107
Sulfur (S)	8	13
Magnesium (Mg)	7	10
Calcium (Ca)	1.4	19
Copper (Cu)	0.01	0.02
Manganese (Mn)	0.06	0.11
Zinc (Zn)	0.07	0.14

Source: Kansas State University - Grain Sorghum Production Handbook

Table 4. Approximate amounts of nutrients absorbed during various growth stages by sorghum plants yielding 7,500 lb/A of grain.

Growth Stage	Days after Planting	Nitrogen (N)		Phosphorus (P_2O_5)		Potassium (K_2O)	
		lb/A	% of Total	lb/A	% of Total	lb/A	% of Total
Seedling	0 - 20	9	5	2	3	18	7
Rapid Growth	21 - 40	61	33	18	23	103	40
Early Bloom	41 - 60	60	32	28	33	85	33
Grain Fill	61 - 85	27	15	21	26	39	15
Maturity	86 - 95	28	15	11	14	13	5
Totals	**Harvest**	***185***		***80***		***285***	

Source: Kansas State University - Grain Sorghum Production Handbook

Table 5. Approximate total lb/A of secondary and micronutrients required for a 7,500 lb/A grain sorghum yield.

Sulfur	Magnesium	Calcium	Iron	Zinc	Manganese	Boron	Copper
21	17	20	2.5	.21	0.17	0.1	0.3

Source: Kansas State University - Grain Sorghum Production Handbook

Table 6. Distribution of nutrients removed in sorghum grain and stover.

Crop Dry Matter	Dry Matter distribution	Nitrogen (N)		Phosphorus (P_2O_5)		Potassium (K_2O)	
		lb/A	% of Total	lb/A	% of Total	lb/A	% of Total
Grain 7,500 lbs	56%	107	58	28	35	28	10
Stover 5,280 lbs	44%	78	42	52	65	230	80

Source: Kansas State University - Grain Sorghum Production Handbook

ents. Nonetheless, N must be absorbed into the plant before it is supportive of plant growth and grain production.

Nitrate-nitrogen (NO_3^-, the form most available to plants) dissolves in soil water, but is negatively charged and thus not attracted to negatively-charged clay and organic matter particles. Nitrate-nitrogen will move with water and can be readily brought into contact with crop roots for quick absorption.

Ammonium-nitrogen (NH_4, also available to plants) is positively charged and is held by negatively-charged clay and organic matter particles in the soil until converted by soil bacterial action into the nitrate form. The conversion of N from ammonium form to nitrate form in the soil is referred to as "nitrification," and is most likely to occur when fields are arable. When fields are water-logged, nitrate can be converted to nitrogen gas (referred to as "denitrification") and lost from the soil by volatilization. Whether fertilizer N is applied as liquid or dry, ammonia, urea, ammonium sulfate or N-32, it should be incorporated into the soil as soon as possible to reduce potential loss of N to the atmosphere, especially where soil pH is above 7.

Phosphorus

Phosphorus (P) is the most controversial nutrient. Different soil testing laboratories use different chemical extractants to estimate "available P." As a result, there may be large differences between soil test values for the same soil sample obtained from different laboratories. In addition, fertilizer recommendations from different laboratories may also vary considerably. In most cases, soil P levels are sufficient to meet early season needs of grain sorghum plants. However, grain sorghum seed are small and contain only enough P to nourish young seedlings until emergence. If young seedlings develop under favorable conditions, P-deficiency symptoms often do not occur. However, if growing conditions are unfavorable (i.e., cool and/or wet), seedlings may show temporary P-deficiency symptoms.

In years where the planting environment is unfavorable for rapid growth and development, banding P fertilizer at low rates in the seed row may be beneficial. One key point to remember is that P is less available in cold soils. Most growers plant as early as possible to reduce sorghum midge damage and to minimize the effects of hot, stressful weather normally experienced later in the season. By doing so, sorghum seedlings often must establish and grow in much cooler soils than if planted later in the spring.

Since soil P is relatively immobile, or "fixed" in soils, placement in a concentrated form is particularly important in low to medium testing soils. By banding P near the seed, 2 to 4 inches below and 2 to 4 inches to the side, developing roots contact the fertilizer shortly after emergence. Placing P fertilizer in direct contact with sorghum seed at planting may cause emergence problems due to the salt effects caused by nitrogen in the fertilizer material.

Research has shown that plants obtain a higher proportion of the needed P from soil reserves. Only about 30 percent of applied P is used by the crop following fertilization, even though it may have been banded. Once soils are warm, some of the "reserve" P becomes available for plant use. The rate at which fertilizer P is converted to soil or "reserve" P depends upon several factors, but most important is the fertilizer P-to-soil contact. Confining P fertilizer to a band reduces fertilizer-to-soil contact and slows the rate of conversion, compared to mixing the same amount throughout the soil as with broadcast applications.

Phosphorus can also be applied as a "pop-up" fertilizer, sprayed in the seed furrow at planting. Corn and sorghum usually respond better than cotton to "pop-ups." However, when using a product like 10-34-0 or 11-37-0 as a "pop-up," it is important not to exceed the equivalent of 5 pounds of elemental N per acre in the seed furrow, or salt injury from the N is likely to occur. Under irrigated or high rainfall conditions, up to 10 pounds of N/acre may be applied without injury. A rain following planting will dilute the nitrogen and also lessen the chance of injury. High P to low N ratio specialty fertilizers, such as 4-29-2 or similar products, lend themselves to "pop-up" applications with minimal injury risk.

Potassium

Potassium (K) is needed in all plant parts for maintenance of water balance, disease resistance and stalk strength. However, as indicated in Table 6, very little K is removed from the field if only grain is harvested. If the stover is harvested as green forage, then a much larger amount of potassium is removed. Most medium to fine textured soils in Texas are inherently high in potassium. Soil test levels should be monitored over years to look for any trends of reduced K.

Other Nutrients

Two other important nutrients for grain sorghum production in Texas are zinc and iron. Where soil phosphorus levels are "high" or "very high" and zinc levels are "low" to "medium," application of additional phosphorus may induce a zinc deficiency. If soil test results indicate a possible zinc deficiency, zinc fertilizer should be broadcast and incorporated preplant or banded at planting. Foliar applications of zinc should be used as a salvage measure since this will only prevent symptoms on new growth.

If iron chlorosis has been observed during previous years in a field, iron fertilizer materials should be applied to the foliage through multiple sprayings early in the season. Table 7 gives suggested foliar treatments to correct iron and/or zinc deficiencies.

Organic Fertilizers

In areas where organic fertilizer materials such as feedlot manure, gin trash, poultry litter, or treated municipal sewage are available, producers may choose to use these as a nutrient source for grain sorghum. Since the nutrient content of organic fertilizers can vary greatly, samples of the materials should be tested prior to use to determine proper rates of application. One significant advantage of organic fertilizers is that the nutrients become available over a longer period of time as the material decomposes, compared to the immediate availability of nutrients from inorganic sources.

Some problems in the use of organic fertilizer materials are: 1) obtaining the ratio of nutrients called for in the fertilizer recommendation for the sorghum crop; 2) determining the amount of animal manure to apply to meet crop needs; and 3) minimizing weed seeds or other impurities (from materials such as gin trash).

By understanding the nutritional requirements of sorghum, adequate nutrients can be applied to reach the yield potential of the crop without applying excess nutrients which may reduce profits and/or contribute to excessive nutrient loads in water and soils.

Water

Grain sorghum is a very drought tolerant crop. Sorghum develops a diffuse root system that may extend to a depth of 4 to 6 feet. Table 8 shows the amount of water used by a sorghum crop from various soil depths during a season. Moisture stress early in the season will limit head size (number of seed per head) and delay maturity — more time is required to complete the plant's life cycle. If stress occurs later in the season, the seed size is greatly reduced. The number of heads per acre is not affected by moisture stress unless it is so severe as to prevent head formation.

During the seedling stage, only a small amount of moisture in the soil surface is required to establish the crop. More moisture is lost during this stage through evaporation from the soil surface than through the crop canopy. Water conserving practices such as residue management, timely planting for quick establishment, narrow row spacing and weed control will minimize soil moisture losses.

About 30 to 35 days after emergence, five to six true leaves are visible and the plant begins rapid growth. Nearly half of the total seasonal water will be used during this stage prior to heading. Near the end of this period, daily water use will be near maximum (about 0.35 inches/day/acre).

The most critical period for water availability for a sorghum plant begins about one week before head emergence

Table 7. Suggested sources, rates and timing of iron and zinc foliar sprays.

Deficiency	Product*	Product/100 gals water	Product/Acre	Timing
Iron	Iron sulfate (20% Fe)	20 lbs (2.5% solution)	1 lb 2 - 3 lbs	10-14 days after emergence - 5 gals/A over crop row. Follow with 2 apps. @ 10-14 day interval @ 10-15 gals/A
	Iron chelate (10% Fe)	8 lbs (1%)	0.4 - 0.5 lbs	same as above
Zinc	Zinc sulfate (30% Zn)	2 lbs (1/2 %)	0.2 - 0.4 lbs	10-20 gals/A in first 30 days
	Zinc chelate (9% Zn)	2 qts (0.1%)		10-20 gals/A in first 30 days
Iron & zinc	Iron sulfate + Zinc sulfate + urea fertilizer	15 lbs + 1 lb + 2 lbs	3/4 Iron + 0.1-0.2 Zinc 1.5 lb Iron + 0.2-0.4 Zinc	10-14 days after emergence - 5 gals/A over crop row. Follow with 2 apps. @ 10-14 day interval @ 10-15 gals/A
	Iron sulfate + Zinc chelate	15 lbs 3 pts	3/4 Iron + 2.4 fl oz. 1.5 lb Iron + 5 fl oz.	10-14 days after emergence - 5 gals/A over crop row. Follow with 2 apps. @ 10-14 day interval @ 10-15 gals/A
	Iron chelate + Zinc chelate	6 lbs 3 pts	follow mfg. directions	10-14 days after emergence - 5 gals/A over crop row. Follow with 2 apps. @ 10-14 day interval @ 10-15 gals/A

*Include a surfactant or other wetting agent. Product conposition may vary. Select similar products or adjust mixing ratios to achieve comparable rates of nutrient application.

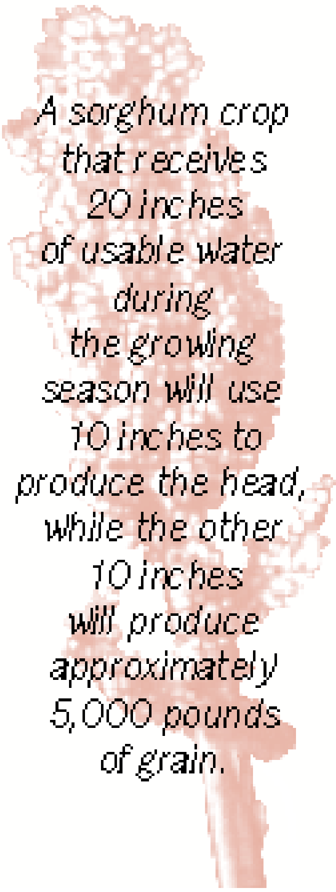
Source: Updated information based on research results and recommendations through the Texas Agricultural Extension Service Soil, Water and Forage Testing Laboratory.

Table 8. Total water absorbed from various depths in a soil profile.

Soil Depth (feet)	Inches of Water Absorbed	Percent of Total
0 - 1	8.9	35
1 - 2	6.6	26
2 - 3	4.0	16
3 - 4	2.8	11
5 - 6	1.3	5

Source: USDA/ARS Report No. 29

or the "boot" stage, and continues through two weeks past flowering (Figure 2). Sorghum plants require good soil moisture during this period for maximum yields. Adequate soil moisture prior to the "boot" stage will assure the highest potential seed set. The actual seed number and seed size will be dependent upon the availability of soil moisture following flowering. Moisture demand drops rapidly after the grain has reached the "soft-dough" stage. The soft-dough stage has occurred when immature seeds squeezed between the thumb-nail and the index finger do not exude a "milk" or white juice. The combined drop in moisture demand, natural drought tolerance in sorghum, and the extensive root system generally make late irrigations unprofitable.



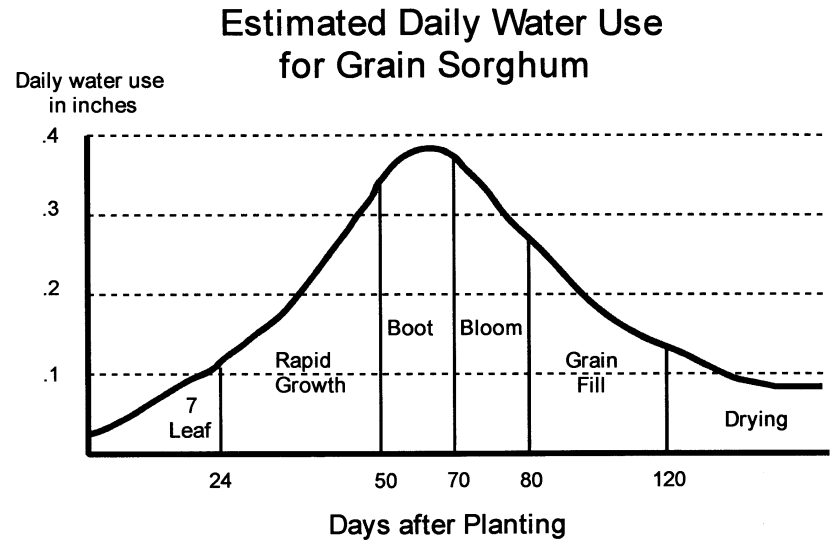


Figure 2. Daily water use in inches.

Since water is the first limiting factor to crop production in South Texas, yield goals should be based upon the amount of water available during the season. Research at Texas Tech University indicates that a minimum of 10 inches of available water is required for sorghum plants to produce a head (D. R. Krieg, personal communication). Each additional inch will yield approximately 385 to 400 pounds of grain. Thus, a sorghum crop that receives 20 inches of usable water during the growing season will use 6 to 8 inches to produce the head, while the other 12 to 14 inches will produce approximately 5,000 pounds of grain.

Maturity selection of hybrids is also important in water management. Table 9 suggests the amount of expected water needed by the crop of different maturity groups.

Besides the total amount of available water, the timing of irrigation (or rainfall) is also important. Research done in the Texas High Plains indicates that as the amount of water received by the crop increases, grain yield/inch of water applied decreases. Results of two years of field studies at the Etter Experiment Station on the High Plains to determine the best combinations for irrigation timing are shown in Table 10. Sixteen irrigation treatments were used. In the first year of the test, 10.5 inches of rain fell in the growing season with 6.1 inches occurring late during bloom and grain fill. During the second year of the test, 8.9 inches fell early in the growing season with 6 inches falling prior to and during bloom.

Average yields for the two years showed increased production with additonal water. The results also show important year-to-year yield differences within the same irrigation timings when rain fell early or late. Irrigation timing is just as important as the amount of water applied. Figure 3 shows the best timing for one, two, three, and four in-season irrigations and the amount of additional grain produced with each subsequent irrigation.

More recently, first year experiments conducted at the Uvalde Research and Extension Center support the Etter findings. At Uvalde in 1996, no

Table 9. Approximate maturity and water use of grain sorghum by seasonal types.

Maturity Range	Days to Bloom	Number of leaves	Plant Height	Days to Maturity*	Inches of Water
Early	55 - 60	6 - 9	30 - 36	90 - 105	10 -15
Medium	65 - 75	9 - 12	36 - 45	110 - 115	15 - 20
Medium late	75 - 85	12 - 16	40 - 50	115 - 120	20 - 25
Full season or late	75 - 85	14 - 18	50 - 60	120 - 125	25+

* Physiological maturity - the point after which there is no increase in seed weight.

Table 10. Two-year sorghum grain yield responses to irrigation at various stages of plant development. Preplant irrigations totalled 4 inches and all post plant irrigations were 4 inches each ('69 late rains, '72 early rains).

Preplant	Early (6-8 leaf)	Mid to Late Boot	Heading/ Flowering	Milk to Dough	1969 Yield	1972 Yield	2 Yr Average
X					1,441	2,786	2,113
X	X				1,799	2,842	1,820
X		X			4,019	4,249	4,134
X			X		3,167	4,908	4,037
X				X	1,141	3,268	2,204
X	X	X			3,659	3,907	3,783
X	X		X		4,181	5,710	4,945
X	X			X	1,260	4,201	2,730
X		X	X		5,237	5,582	5,409
X		X		X	3,677	5,097	4,387
X			X	X	3,954	4,727	4,340
X	X	X	X		6,396	5,990	6,193
X	X	X		X	3,716	5,573	4,644
X	X		X	X	4,417	5,932	5,174
X		X	X	X	5,956	5,960	5,958
X	X	X	X	X	6,800	6,782	6,791

Source: Texas Agricultural Experiment Station, Etter, Texas

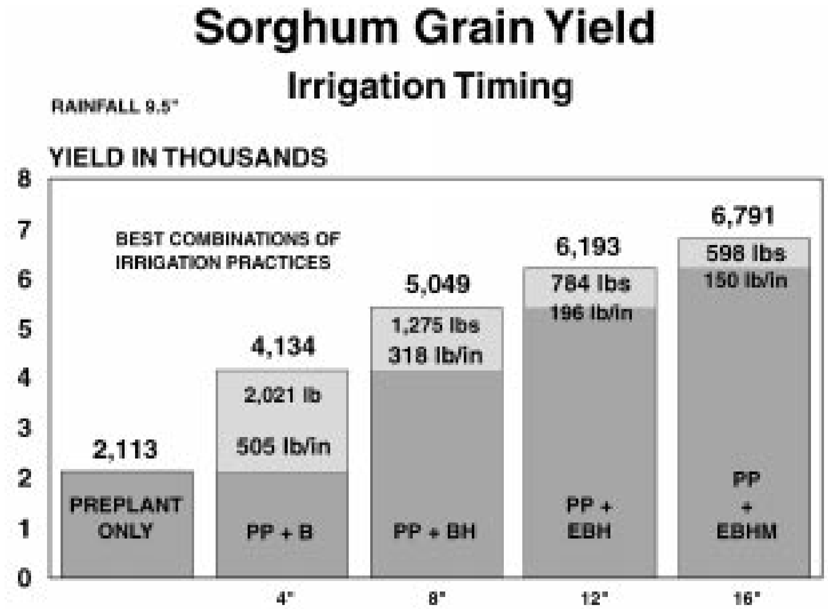


Figure 3. Estimated daily water use for grain sorghum.

Source: Texas Agricultural Experiment Station - Etter, Texas

effective rain fell during the growing season. Results indicate only the effects of irrigation rate and timing. (unpublished data, C. Fernandez).

Not only is the amount of water applied important, but also the timing (Table 11), relative to the developmental stage of the crop. Based on the results of the experiments at Etter and Uvalde, several important conclusions can be drawn.

- Preplant irrigations alone do not produce optimum yield.
- One irrigation at any time prior to dough stage was equal in yield to two irrigations at heading and dough. If an irrigation is missed during head initiation (45 DAE), later irrigations will not increase yields substantially.
- If two in-season irrigations are possible, 45 DAE and heading will produce the greatest yields.
- If three inseason irrigations are possible, 30 DAE, 45 DAE and heading produce greater yields than 45 DAE, heading and dough stage.
- Irrigations at the dough stage failed to substantially increase yields.
- Four irrigations in addition to the preplant watering produced the highest yields.

Table 11. Effects of irrigation timing on grain sorghum yield.

Preplant	30 DAE	45 DAE	Heading	Dough	Grain Yield per Acre	Heads/ Acre	Grains/ Head	Weight/ Grain
X					1,079	31,914	627	22.6
X	X				2,811	48,076	1,277	20.2
X		X			2,890	51,653	1,406	17.5
X			X		3,016	48,283	1,043	26.5
X	X	X			3,387	50,277	1,548	19.1
X		X	X		4,905	53,923	1,560	25.9
X			X	X	2,704	47,663	883	28.9
X	X	X	X		5,404	52,006	1,746	26.2
X		X	X	X	5,116	52,478	1,698	25.4
X	X	X	X	X	5,773	53,028	1,804	27

DAE = days after emergence; 30 DAE = head initiation; 45 DAE = rapid growth; Heading = boot-flowering; Dough = soft dough stage

If the response of sorghum plants to 1 inch of irrigation water is an additional 385 to 400 pounds/acre of grain, every effort should be made to reduce water runoff. Not only do water conservation practices such as furrow diking reduce the chances of erosion and nutrient loss, they also increase grain yields. Three years of research on the Texas Rolling Plains demonstrate the potential for furrow diking to increase sorghum yields (Table 12). The greatest impact from furrow diking was observed in dry years (1980, 1981).

Six years of studies in Uvalde on dryland grain sorghum production produced up to 72 percent higher yields in dry years when fields were diked. Table 13 shows the effects of various tillage systems on average production between 1984 and 1990, which included both wet and dry years.

Table 12. The effects of furrow diking and subsoiling on sorghum grain yields.

Tillage Treatment	1979		1980		1981		Average Yield (Lbs/A)	Percent of Check
	Lbs/A	%	Lbs/A	%	Lbs/A	%		
Undiked	4,353	100	547	100	1,038	100	1,979	100
Subsoiled	4,941	114	580	106	1,116	108	2,212	112
Diked	4,865	112	751	138	2,240	216	2,619	132
Subsoiled and diked	5,136	119	791	145	2,248	217	2,725	138

Source: Texas Agricultural Research Center, Vernon

Table 13. Effect of furrow diking on dryland sorghum production.

Treatment	Average Yield*	Percent of Bedded & no dikes**
Bedded and no dikes	1,747 a	
Flat (no beds formed)	1,821 a	104
Bedded and diked during the growing season	1,826 a	105
Bedded and diked during the fallow season	2,128 b	122
Bedded and diked continuously	2,321 b	133

* Average yields followed by the same letter do not differ statistically.
** Normal land preparation for dryland sorghum in the Wintergarden area.
Source: Texas Agricultural Research Center, Uvalde

Summary

Efficiency is doing the right thing and effectiveness is doing the right thing at the right time. Not only are production inputs important, but proper timing often determines if these inputs are fully utilized. Crop management is effectively managing all aspects of production to enable the crop to produce its best economic yield. Careful management of all aspects of production, from land preparation to harvest, will maximize yields and profits.

References

Fernandez, Carlos. Texas A&M University, Uvalde, Texas. Unpublished data.

Fertilizer Rates for Irrigated Grain Sorghum on the High Plains. Agricultural Experiment Station Bulletin 523. New Mexico State University, Las Cruces, New Mexico.

Grain Sorghum Production Handbook. Cooperative Extension Service, Kansas State University, Manhattan, Kansas.

Grain Sorghum Production with Different Nutrients, Populations, and Irrigation Frequencies. New Mexico Experiment Station. Bulletin 613.

Grimes, D.W. and T.J. Musick. Effect of Plant Spacing, Fertility and Irrigation Management on Grain Sorghum Production. Agronomy Journal.

Krieg, D.R. Texas Tech University. Personal communication.

Musick, T.J. et al. Irrigation Water Management and Nitrogen Fertilization of Grain Sorghum. Agronomy Journal.

Mulkey, J.R. et al. Dryland Sorghum Response to Plant Population and Row Spacing in Southwest Texas. Texas Agricultural Experiment Station. PR-4294.

Phosphorus Fertilization for Grain Sorghum Production in the Texas Blacklands. Texas Agricultural Experiment Station. L-1550.

Profitable Grain Sorghum Production in the Rolling Plains. Texas Agricultural Extension Service. B-1577.

Sorghum for Grain: Production Strategies in the Rolling Plains. Texas Agricultural Experiment Station. B-1428.

Sorghum Takes Up Much Plant Food. Phosphate and Potash Institute of North America.

Tewolde, H. et al. Furrow Diking Effects on Yield of Dryland Grain Sorghum and Winter Wheat. 1993. Agronomy Journal.

Vanderlip, R.L. How a Sorghum Plant Develops. Cooperative Extension Service, Kansas State University, Manhattan, Kansas.

Water Response in the Production of Irrigated Grain Sorghum, High Plains of Texas. Texas Agricultural Experiment Station Report. MP-1202, 1975.

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Managing Grain Sorghum for Maximum Profitability in the Texas High Plains

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Grain sorghum remains one of the most risk free crops that can be grown in the Texas High Plains. Other crops may produce more profits in any given year, but from a risk management standpoint grain sorghum will almost always produce a crop at a lower cost per acre than most other crops. Several cultural and management practices can enhance the potential of producing a successful grain sorghum crop.

Water management is the primary yield detriment for dryland or limited irrigated sorghum on clay loam soils in the Texas High Plains. It is critical that as much water as possible be stored in the soil profile prior to or soon after sorghum planting. A clay loam soil will hold approximately 2 inches of available plant water per foot. With a typical 4-foot soil profile up to 8 inches of water could be available to the crop. A sandy soil will only hold 0.75 to 1 inch of available water per foot, making it a less desirable soil on which to produce sorghum unless the profile can be replenished through timely rainfall or irrigation. It takes approximately 6 inches of water to get a sorghum plant to the point where grain can be produced. If this amount can be stored in the soil prior to planting, the risk associated with growing sorghum successfully is greatly reduced. For every inch of additional water applied through irrigation or rainfall during the growing season, yield will increase 350 to 450 pounds per acre. Study after study has shown that reducing tillage will help maintain crop residues on the surface which results in more water stored in the soil. Each tillage operation will cause approximately one half inch of water loss through evaporation. The actual amount of loss will be dependent on the depth and type of tillage, soil type, and amount of moisture stored at the time of tillage.

Poor weed control will reduce stored soil water. Weeds must be controlled during the fallow period prior to planting sorghum. A severe infestation of weeds can use as much as 3 inches of water in a single month. Weed control is also important during the growing season. Because of the lack of good, safe, post emergence herbicides that are labeled for sorghum, an application of a pre-emergence herbicide is strongly recommended. Broadleaf weeds such as pigweed can usually be controlled with an inexpensive treatment of atrazine at the time of planting. If annual grasses are a problem then more expensive products containing the active ingredients of Dual®, Lasso®, Frontier®, or Harness® will need to be used. Several premixes containing these herbicides combined with atrazine are available. Under dryland conditions, applying the herbicide in a band and cultivating the middles may be an option in order to keep down cost. If possible, avoid the use of 2,4-D or high rates of Banvel®. Even though injury from these herbicides may appear light, yield reductions can and do occur, especially if the herbicides are applied to sorghum past ten inches in height. Peak® plus 0.75 lb. of atrazine is a good alternative for broadleaf weed control if a post-emergence herbicide application is needed. For the irrigated farmer, a post-emergence application of Buctril® + atrazine + 2 oz. Banvel® can be a very effective treatment. Rhizome Johnsongrass in sorghum will greatly reduce yield. Competition from Johnsongrass can be significantly reduced by letting the Johnsongrass emerge prior to planting, and then treating with Roundup® prior to sorghum planting. Since Roundup® has no soil activity, grain sorghum can be safely planted immediately after herbicide application. Research has shown that sorghum yield can be more than doubled by treating Johnsongrass in this manner.

The planting date for dryland or limited irrigated sorghum is dependent on soil moisture and the amount of irrigation capacity that is available. If a full profile of water (wet to 6 feet) is present, a medium-late sorghum can be planted in mid-May. If something less than a full profile of water is present, choose a medium maturity hybrid with good drought tolerance. If need be, wait until at least 3 feet of moisture is present before planting. A good sorghum crop can be planted as late as July. The later you plant, the shorter the maturity of the hybrid will need to be. A good yielding sorghum will require moisture in September. If water is lacking, the plant will translocate water and nutrients from the stalk, which can lead to lodging. For this reason, plant a hybrid with good stalk strength.

Plant density should also be adjusted to soil moisture conditions. A seed drop of 32,000 seed per acre has been shown to provide the best results under a wide range of conditions. This is a high enough density to not limit yield, while under extreme dry conditions the sorghum will be less likely to burn up compared to a higher population. If the variety chosen to plant has a high tillering capacity, seeding rate may be dropped 30 percent. If less than three feet of moisture is present by early July consider lowering the plant density to 20,000 seed per acre and planting a short maturity drought tolerant hybrid.

A strategy that has proved successful for dryland sorghum planted in early July is to plant a very short maturity hybrid on 15 inch centers at a seeding rate of 64,000 seed per acre. This should only be done if 4 to 5 feet of soil moisture is present. The higher seeding rate is necessary because of the lack of tillering that will occur at this late planting date.

Dryland and limited irrigated sorghum seldom has greenbug infestations high enough to warrant insecticide application in the Texas High Plains. For this reason, seed treated with Gaucho® is usually not necessary. Texas A&M research consistently shows in dryland and limited irrigated systems that Gaucho® treated sorghum seed will not pay for itself in the Texas High Plains. This however, is not necessarily true for other parts of the State where soil insect or early season pests are more of a problem. Gaucho® treated seed is more justified under full irrigation conditions.

If only limited irrigation is available, the highest return will usually occur if sorghum is irrigated at heading or milk stage depending on the severity of moisture stress prior to irrigation. For high yield levels, it is important that the sorghum not stress during the mid-vegetative stage. About 30 to 35 days after emergence the potential size of the head and number of seed is being determined. If adequate soil moisture (4 ft.) is present at planting, and any significant rain events occur 2 to 4 weeks after planting, the sorghum is not placed under much stress during this time. If this is the case, the first irrigation can be delayed until boot or heading. Irrigation at the grain milk stage will also improve yield, and is particularly important if sorghum was watered early but not watered at heading.

Maximum sorghum yield can usually be achieved with an irrigation capacity of 3.5 to 4.5 gpm per acre. The actual amount needed will depend on the irrigation system and the field location in the Texas High Plains. Irrigation systems equipped with LEPA or nozzles set low in the canopy will require less irrigation capacity than nozzles placed several feet above the crop canopy or furrow irrigation. Water demand is also generally higher as you move south in the Texas High Plains. Critical irrigation times are during boot, heading, flowering and grain filling stages of plant growth. If little rainfall has occurred shortly after planting, then an irrigation 30 to 35 days after emergence will be necessary to insure the potential for good head size and grain number. For maximum yield under irrigation a seeding rate of 80,000 seed per acre is adequate for most conditions. A medium-late to late maturity hybrid should be planted before June 1. If planting is delayed, then a medium-early to medium maturity hybrid may be better. If so, seeding rate should be increased to 110,000 seed per acre.

In summary, under dryland or limited irrigation, choose your planting date, hybrid, and seeding rate based on stored soil water and irrigation capacity. Under low soil moisture conditions, delay planting and choose a shorter season hybrid and consider planting at a lower seeding rate. If conditions turn favorable after planting, sorghum has the ability to tiller and compensate for low seeding rates. Always choose a hybrid with good standability. Weeds must be controlled prior to planting and a pre-emergence herbicide application is recommended. Do not spend extra for insecticide treated sorghum seed unless you have a history of soil insect or early season pest problems. Under full irrigation where maximum yield is desired, plant early, use a high seeding rate, and keep in mind the critical growth stages of sorghum in irrigation timing for maximum production.

For additional information see our web site at: http://taexsoilcrop.tamu.edu

Grain Sorghum Production Handbook

Kansas State University Agricultural Experiment Station
and Cooperative Extension Service
Manhattan, Kansas

Contents

Growth and Development of the Sorghum Plant

Some may wonder why the recommendation for the use of 2,4-D on sorghum reads, "Apply as a broadcast spray when sorghum plants are from 6 to 8 inches tall." Certainly, broadleaf weed control may be needed at earlier or later times; however, this height represents a particular time in the development of the sorghum plant. Understanding how the sorghum plant grows and develops will help in understanding what will affect its growth. It also will help explain the reasons for specific production practices discussed in this publication.

Sorghum seed is the smallest of the spring-planted crops; therefore, its early growth usually will be slower than that of corn or soybeans. In fact, growth is not very rapid up to the 8-inch height previously mentioned, while the plant establishes a root system and starts to take up nutrients much more rapidly.

Shortly after reaching the 8-inch height, the growing point of the plant—at this time still below or just at the soil surface—changes from producing leaves to producing the head. For a medium-maturity sorghum, this occurs about 30 to 35 days after emergence. This is a critical point in the development of the plant since its total number of leaves will be determined. At this point, when the plant has completed about 5 percent of its growth, it has taken up 10 to 15 percent of the nutrients it will use during the entire season.

During the next 30 to 35 days, until flowering, the plant grows rapidly. It produces much of the leaf area, which will be important during the grain-filling period. During this time, the head develops and the stalk grows rapidly. First, the lower portion of the stalk grows, pushing the head up into the flag leaf sheath into the boot stage.

Later, the upper stalk—the peduncle, which holds the head—grows rapidly, pushing the head out of the flag leaf sheath where flowering and pollination can occur. If something happens during this stage of growth, the head may not fully emerge from the sheath, may not be fully pollinated, or may cause problems at combining. This period, from when the head first starts to form until flowering, is a time for rapid growth and rapid nutrient uptake. At flowering, the plant will have produced about half of its total weight at maturity; however, between 60 and 70 percent of the total nutrient uptake already will have occurred.

The final stage of growth, from flowering to physiological maturity, is the important grain-filling period. During this time, total production of the plant is going into the grain. Materials stored in the stalk are being moved into the grain, and the plant is taking up approximately the final one-third of the nutrients. If drought occurs, both uptake and growth may be limited.

The end of this period occurs when the grain is no longer increasing in dry weight. This physiological maturity is not harvest maturity. At physiological maturity, the grain moisture will be 25 to 40 percent, and it must dry considerably before it can be harvested and placed in conventional storage. For high-moisture grain or early harvest and artificial drying, sorghum can be harvested at any time after physiological maturity.

Returning to the example of 2,4-D application, the 8-inch plant height corresponds to the plant's stage of development (head formation). Similarly, if the following discussions on production practices are related to the crop's stage of development, their effects will be better understood. A more detailed explanation of sorghum-plant growth may be found in *How a Sorghum Plant Develops*, K-State Research and Extension publication S-3.

Selection of Grain Sorghum Hybrids

Veteran sorghum producers remember going from a handful of standard varieties (Midland, Martin, Westland, Redlan) to the confusion of the hundreds of hybrids offered since the late 1950s under many private brands with numbers or names. Growers enjoyed the 20- to 30-percent yield advantage the first hybrids had over varieties and found the effort involved in careful selection among hybrids worthwhile. Careful selection is the key. Simply planting hybrid seed does not ensure good performance.

To help growers identify best-adapted hybrids, the Kansas Agricultural Experiment Station conducts annual performance tests at 13 sites on a voluntary cost-sharing basis with seed companies. Thousands of hybrids have been tested since 1957. During the past several years, more than 100 hybrids submitted by 20 or more private companies were tested annually. About one-third of each year's entries were new hybrids, indicating a rapid turnover rate.

Not all hybrids sold in the state are included in tests, and hybrids are not grown at all test sites because entrants choose the test locations. The annual performance-test bulletins containing current-year data and multiyear averages can provide valuable guidance in hybrid selection. Test results from several years and locations should be examined before making selections. Small differences in yield may not be real. Be sure to look at the measures of variability (C.V.) and significance (L.S.D.) for each test.

Yield

It is not unusual for the best hybrid to out-yield the poorest hybrid on a test or farm plot by 40 bushels or more per acre. Even on a multiyear-test-average basis, hybrid yields may differ by more than 20 bushels. Because yield is the end result of many genetic and environmental influences and interactions, it is useful to study other sorghum characteristics leading to high yields in a specific farm situation.

Maturity and standability (stalk strength) are two major characteristics affecting yield in Kansas that can serve as reliable guides in hybrid selection. Yield components such as number of heads per acre, number of seeds per head, and seed weight are factors in yield, but they tend to compensate for each other. Any one of these components is too inconsistent to serve as a reliable yield predictor.

Diseases and insects often are destructive in specific locations and sometimes cause widespread damage. In terms of hybrid selection, pests should be considered on the basis of probability of a repeat problem, availability of resistance or tolerance in commercially available hybrids, practicality of chemical control, and use of hybrids best adapted to management practices that have been adjusted to avoid or tolerate pest problems.

Recent greenbug and chinch bug infestations serve as examples. Good greenbug-tolerant hybrids were available from 1976 to 1980, and chemical control generally was needed only for heavy seedling infestations and for large, persistent greenbug populations in later plant-growth stages; however, those hybrids had little or no resistance to a new strain of greenbug called Biotype E, so insecticides were the primary control method until newly adapted resistant hybrids became available a few years later. More recent strains, biotypes I and K, have added additional dimensions to the greenbug-resistance picture.

Some hybrids appear to have more tolerance to chinch bugs than others, but chemicals are the major control method. The use of systemic insecticides in the furrow at planting or as seed treatments, planting earlier or later than normal, and avoiding planting sorghum next to small grains can reduce the probability of chinch bug damage to sorghum seedlings.

Maturity

A good full-season hybrid will out-yield a good early-season hybrid every time, other conditions being equal and favorable for sorghum growth. The stalks of full-season hybrids usually are larger and stand better than earlier hybrids. The rule of thumb is to plant the latest-maturing hybrid available within the limitations of projected moisture availability, average length of growing season, and crop sequence. Hybrid selection can then be narrowed to that group of hybrids meeting the maturity criteria.

Maturity is relative in a state that varies from 800 to 4,000 feet in elevation and from nearly 40 to less than 16 inches of annual precipitation. A conservative view is that hybrids should be in the maturity class reaching physiological maturity (maximum dry-matter content of grain at about 30- to 40-percent moisture) a week or two before the average date of the first killing frost.

On nonirrigated acreage in western Kansas or on shallow soils in other areas, moisture exhaustion can be more damaging to late hybrids than frost. Earlier hybrids should be planted on those sites. Moisture stress often causes lodging problems because of incomplete development of stalk-strengthening tissue, invasion by organisms that further weaken stalk tissue, or both. By choosing hybrids that mature early enough to avoid severe moisture stress, lodging risk may be reduced.

Lodging

If a hybrid goes flat after having stood well in previous years, producers may wonder what happened. Lodging inconsistencies are common in research trials, but they usually can be explained. The maturity-moisture situation previously noted is a prime source of lodging variability because timing of moisture exhaustion in relation to the plants' growth stage is important, not only to degree of reduced yield but also to susceptibility to invasion by organisms, such as charcoal rot, that cause lodging.

The interaction of hybrid maturity and environmental stress is important in hybrid selection. Planting two or more hybrids that differ slightly in maturity will help ensure adverse environmental conditions will not affect total grain sorghum production.

As discussed, early hybrids have more lodging problems than late hybrids. If early hybrids must be grown, producers should recognize the risks and harvest as early as possible, using high-moisture grain storage or grain dryers if economically feasible.

In any maturity group—early, medium, or late—there are hybrids that consistently lodge worse than others. They should be avoided, especially on fields with a history of frequent lodging. The best sources of information are seed companies, performance-test results, personal experiences, and Extension agents.

Be willing to …

- spend considerable time searching for improved hybrids. It can pay big dividends.
- look at a broad base of information on hybrids of interest. Avoid reliance on only one source of hybrid-performance information.
- look at hybrids from several companies.
- learn hybrid names or numbers. Each company has only one brand but many hybrids.
- try hybrids on a small scale and keep harvest records.
- plant two or more hybrids of differing maturity to spread out risk of damage from adverse weather conditions.

Keep alert for …

- hybrids with resistance to pests threatening the next crop. New strains of pests, such as greenbugs and maize dwarf mosaic virus, appear from time to time, so it is important to keep up with new developments in both pests and hybrids.
- hybrids with tan plant color. White grain has been around for several years, but new hybrids with white grain and a tan plant may appear on the market soon. These hybrids produce excellent food-quality grain without the discoloration problems that can occur with white grain produced on hybrids with a red or purple plant. White-on-tan (white grain produced on tan plants) sorghum may provide the opportunity for a price premium in some food and poultry-feed markets.
- high-tannin hybrids. Avoid hybrids high in tannin unless severe bird-damage potential exists and the grain can be utilized on-farm. Marketing high-tannin grain through normal channels can be difficult.

Seedbed Preparation and Planting Practices

Grain sorghum needs a warm, moist soil well supplied with air and fine enough to provide good seed-soil contact for rapid germination. A number of different tillage and planting systems can be used to get these conditions. These systems may involve primary or secondary tillage or no tillage operations prior to planting.

An ideal seedbed should accomplish these goals:

- control weeds,
- conserve moisture,
- preserve or improve tilth,
- control wind and water erosion, and
- be suitable for planting and cultivating with available equipment.

One goal of seedbed preparation is to provide a means of profitable crop production while minimizing soil erosion due to wind and water. Tillage and planting systems accomplishing this goal are often referred to as conservation tillage systems. Conservation tillage is an umbrella term including reduced-till, mulch-till, ecofallow, strip-till, ridge-till, zero-till, and no-till. The emphasis in conservation tillage is erosion protection, but moisture, energy, labor, and even equipment conservation may be additional benefits. Conservation tillage will be an integral part of many conservation plans for highly erodible fields as a result of the conservation compliance provisions of the 1985, 1990, and 1996 farm bills.

Table 1. *Soil Losses for Various Tillage Systems in Soybean, Corn, and Wheat Residue*

	Corn residue [1]		Soybean residue [1]		Wheat residue [2]	
Tillage system	Cover %	Soil loss (tons per acre)	Cover %	Soil loss (tons per acre)	Cover %	Soil loss (tons per acre)
Plow, disk, disk, plant	4	10.1	2	14.3	–	–
Chisel, disk, plant	13	18.3	7	9.6	–	–
Disk, disk, plant	–	–	5	14.3	–	–
Disk, plant	15	6.6	9	10.6	–	–
Plow, harrow, rod-weed, drill	–	–	–	–	9	4.2
Blade (three times), rod-weed, drill	–	–	–	–	29	1.2
No-till plant or drill	39	3.2	27	5.0	86	0.2

[1] Silty clay loam, 5-percent slope, 2 inches applied water at 2.5 inches per hour.
[2] Silt loam, 4-percent slope, 3 inches applied water at 2.5 inches per hour.
Source: E.C. Dickey, University of Nebraska-Lincoln

Erosion Protection

In conservation tillage, the soil surface is protected from the erosive effects of wind, rain, and flowing water. Resistance to these erosive agents is achieved either by protecting the soil surface with crop residue or growing plants or by increasing the surface roughness or soil permeability. Soil erosion losses for different tillage systems are shown in Table 1.

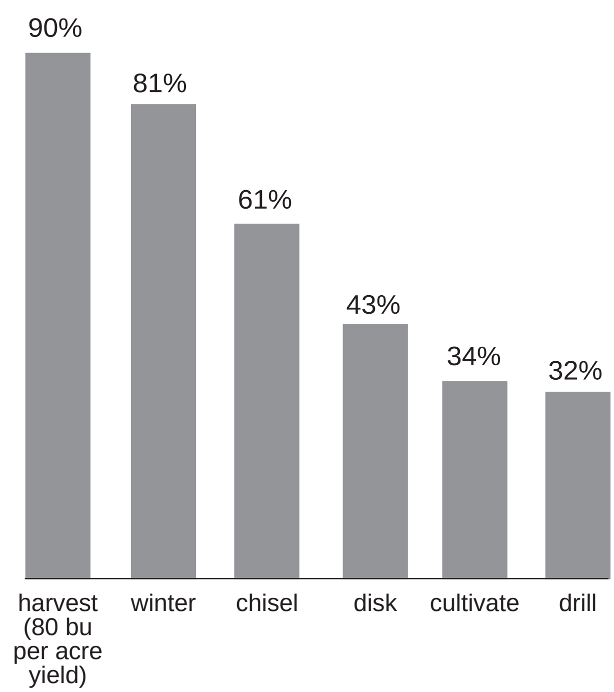
A common goal of conservation tillage systems is to reduce soil erosion losses below the soil-loss-tolerance or "T" value. Soil-loss tolerance is an estimate of the maximum annual rate of soil erosion that can occur without affecting crop productivity during a sustained period. Soil-loss tolerances for Kansas cropland are normally in the range of 4 to 5 tons per acre per year. Soil-loss tolerances for specific soil series can be found in soil surveys or from Natural Resources Conservation Service (NRCS) personnel.

The amount of residue necessary for erosion protection depends on several factors, such as climate, soil erodibility, surface roughness, field length, slope length and steepness, cropping practices, and conservation practices. Generally, leave 30 percent residue cover after planting where water erosion is the primary concern. Where wind erosion is a concern, 1,000 pounds per acre of flat, small grain residue or its equivalent is required during the critical wind-erosion period. It is important to be aware of crop-residue levels to stay in compliance with the conservation provisions of the 1996 farm bill.

It may be helpful to estimate the residue on the surface to evaluate the tillage options available for next year. This calculation is explained on the Residue Fact Sheets (available from K-State Research and Extension offices). A computer program also is available. An example output is shown in Figure 1.

After an 80-bushel-per-acre sorghum yield, the average soil surface will be about 90 percent covered with crop residue. After overwintering and some limited tillage (one chiseling, one disking, and one field cultivation), the soil will still be about 30 percent covered after planting. Results may differ from actual

Figure 1. *Sorghum Residue Cover Reduction with Successive Tillage Operations*



residue levels in the field, depending on initial residue amount after harvest, tillage speed, and soil-moisture content. It is best to estimate residue in the field to check for conservation-compliance. Residue amounts can be estimated by comparison with pictures of various residue covers, line transect method, or stepping out the residue (boot method).

In Kansas, almost 40 percent of the harvested sorghum acres will end with less than 15 percent ground cover before the next crop is planted. Only 25 percent of the sorghum acres is in reduced-till, no-till, or ridge-till, leaving more than 30 percent ground cover at all times. The actual level of residue required to minimize soil loss on fields may vary from these limits. NRCS personnel can provide assistance in determining residue needs.

Conservation tillage alone may not adequately protect the soil from erosion. In these situations, conservation tillage can be integrated with other practices—such as terracing, contouring, strip cropping, and windbreaks—to provide erosion protection.

Long-term research in Kansas has shown grain sorghum can be grown successfully in conservation-tillage systems (Table 2). Careful management and planning are important. Uniform residue distribution, effective weed control, proper seed placement, correct planter adjustment, soil testing, and fertilizer management are important in conservation-tillage grain sorghum production.

No-till grain sorghum planting is best suited to moderately and well-drained soils. Soils often remain cooler and wetter through the growing season under no-till conditions. This is particularly true in heavy residue. While wetter soils are an advantage during dry periods, at planting time they can mean slower germination, delayed maturity, and a longer period when seeds are susceptible to pests. These conditions can result in reduced yields in no-till situations, particularly in cool, wet springs and on poorly drained soils. Other conservation-tillage systems, such as reduced-till or ridge-till, would be better choices.

Many producers trying no-till grain sorghum for the first time do so after soybeans. Fewer planting problems are encountered in this sequence as soybeans produce less residue than other crops, the residue is easily managed, and the soil is generally loose and mellow. Soybeans typically produce 45 pounds of residue per bushel of grain, whereas corn, grain sorghum, and wheat produce 60, 60, and 100 pounds of residue per bushel of grain, respectively.

Planting Practices

Row width. Most grain sorghum is planted in 30-inch rows because other row crops have performed well that way, and that is the row width of most equipment. Historically, 30-inch rows performed better than wider rows, and narrower rows have not consistently yielded better than 30-inch rows. Plants in narrower rows shade the soil quicker, improving weed control and reducing soil erosion.

Seeding rate. Seeding rates or plant populations vary depending on rainfall and growing conditions. In Table 3, recommended plant populations are given for specific rainfall regimes. The within-row seed spacing is given based on 65-percent field emergence. In Figure 2, average annual rainfall regimes are presented to help determine seeding rates.

Two formulas can be used in calculating plant populations and seeding rates.

Formula 1. *Plant population or seeding rate*

$$\frac{43{,}560 \text{ sq.ft.}}{\text{acre}} \times \frac{12 \text{ in.}}{\text{row spacing (in.)}} \times \frac{\text{seeds or plants}}{\text{foot-row}}$$

Example 1.

$$\frac{43{,}560 \text{ sq.ft.}}{\text{acre}} \times \frac{12 \text{ in.}}{30 \text{ in.}} \times \frac{3 \text{ plants}}{\text{foot-row}}$$

$= 52{,}272$ plants per acre

Table 2. *Long-term Yields of Grain Sorghum Grown under Various Tillage Systems* [1]

Location (soil type)	Rotation	No. of years tested	Yield (bushels per acre): No-till	Reduced-till	Conventional-till
Finney County (Santana loam)	WSF	11	65	63	58
Ellis County (Harney sil)	WSF	20	45	51	51
Riley County (Smolan sil)	continuous	8	79	–	80
Franklin County (Woodson silt-clay)	continuous	6	59	64	66
	S-SB	6	70	72	77

[1] Yields averaged across other treatments.

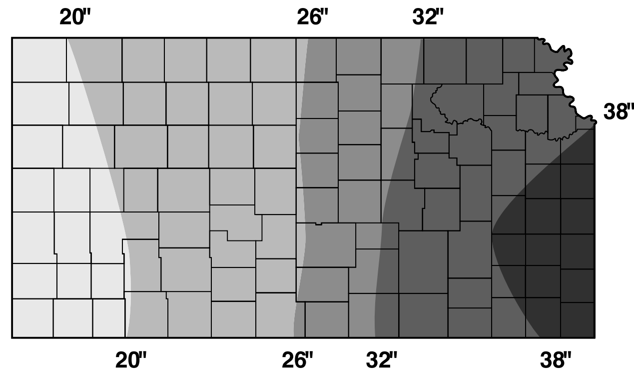
Table 3. *Grain Sorghum — Plant and Seed Spacings*

Recommended population and spacing	Average annual rainfall (in inches) <20	20-26	26-32	>32	Irrigated
Plant population	24,000	35,000	45,000	70,000	100,000
Within-row seed spacing at planting: [2]					
15-inches	11.3	7.8	6.0	3.9	2.7
30-inches	5.7	3.7	3.0	1.9	1.4

[1] In plants per acre. Plant populations may be increased or decreased by at least 25 percent from the values given, depending upon the expected growing conditions, without significantly affecting yields.

[2] Assuming 65-percent field emergence. Calibration of planters should be based on seed spacing. Seeding rates based on pounds per acre have little meaning since seed size commonly varies from 13,000 to 24,000 seeds per pound.

Figure 2. *Average Annual Rainfall for Kansas*



Formula 2. *Seeds or plants per foot-row*

$$\frac{\text{seeding rate or plant population}}{\text{43,560 sq. ft./acre}} \times \frac{\text{12 in.}}{\text{row spacing}}$$

Example 2.

$$\frac{\text{70,000 seeds or plants}}{\text{43,560 sq. ft./acre}} \times \frac{\text{12 in.}}{\text{30 in.}}$$

= 4 seeds or plants per foot-row

If the optimum plant population for a particular field is 45,000 plants per acre, the seeding rate needs to be adjusted to reflect expected field emergence. Only 65 to 70 percent of planted seeds will emerge, and those figures should be used to estimate field emergence.

To calculate the seeding rate follow this formula:

$$\frac{\text{desired plant population per acre}}{\text{percent field emergence}} = \text{seedling rate per acre}$$

Example:

$$\frac{\text{45,000 plants per acre}}{0.65} = \text{69,000 seeds per acre}$$

Hybrid seed size varies, so planting in terms of pounds of seed per acre results in large differences in plant population and wastes money. Although there may be emergence differences due to seed size, generally no yield differences are found.

Sorghum plants may tiller and compensate for thin stands. Large heads (more seeds per head) can compensate for thin stands. Heads produced by late tillers may be immature when the head on the main stem is mature, resulting in harvest and storage problems. Seed weight can compensate for reduced seed number to a limited extent.

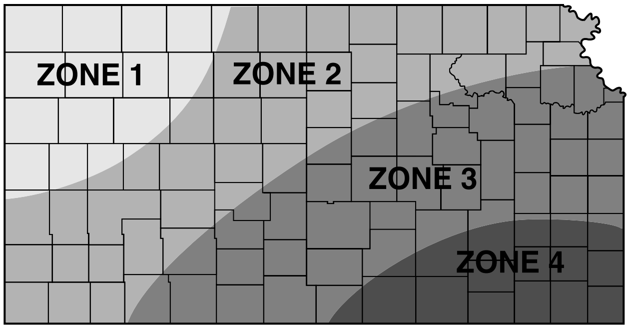
High plant populations result in fewer tillers and are necessary under irrigation and in higher-rainfall areas. Excessive stands produce plants with smaller stems and are more susceptible to moisture stress and lodging.

Seeding date. There is a wide range in planting dates for grain sorghum. Planting should be timed so flowering avoids the hottest, driest period of summer. Suggested planting dates are given in Figure 3. Utilizing several planting dates is suggested to spread the risk of one planting date flowering during a stress period.

Quick germination and emergence occur when the soil temperature is 70 degrees Fahrenheit. Planting too early results in delayed emergence and reduced stands. Plants from early plantings may be taller and more vegetative than later plantings. Late plantings may not allow the crop to mature before a damaging fall freeze. Based on the time grain sorghum blooms, probabilities of sorghum maturing before a freeze can be calculated. Figure 4 shows those probabilities for bloom dates from August 4 to August 29. With late plantings, earlier-maturing hybrids should be used.

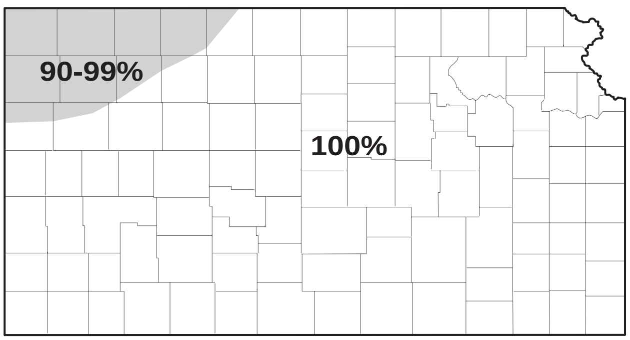
Seeding depth. The optimum planting depth differs with soil types and moisture conditions. In heavier soils, a planting depth of l inch is satisfactory. In sandy soils, seeds can be placed 2 inches deep without problems. Sorghum seeds can emerge from plantings deeper than 2 inches, but seedlings are slow to emerge, and final stand numbers may be reduced. The seed should be well covered with soil for excellent seed-soil contact to aid germination.

Figure 3. *Suggested Grain Sorghum Plating Dates*

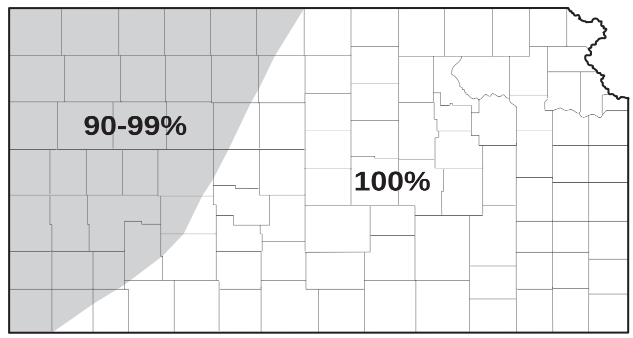


Zone 1: May 15 to June 10
Zone 2: May 15 to June 20
Zone 3: May 15 to June 20
Zone 4: May 1 to May 15, June 5 to June 25

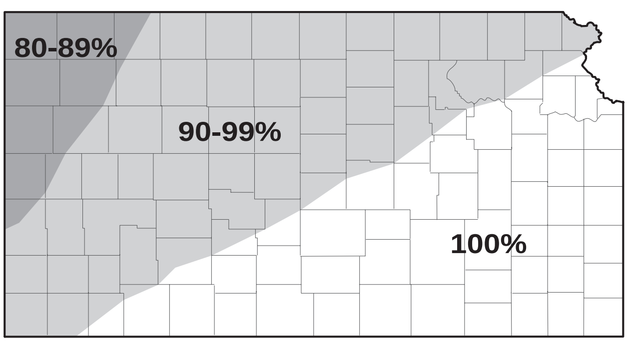
Figure 4. *Probability of Sorghum Maturing before Freeze for Flowering Dates from August 4 through August 29*



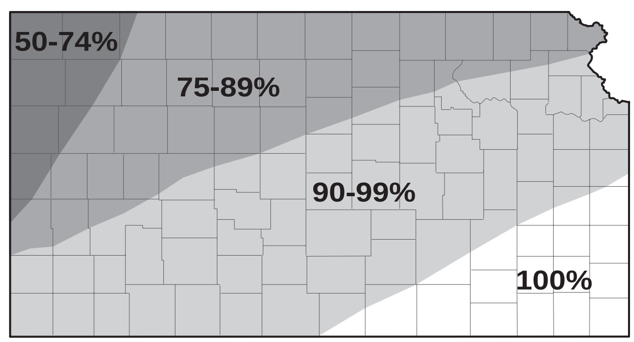
Bloom on August 4



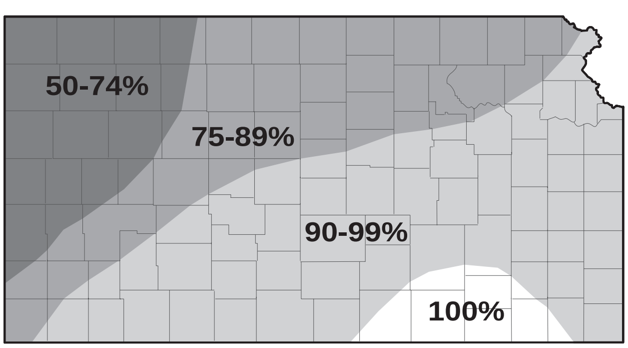
Bloom on August 9



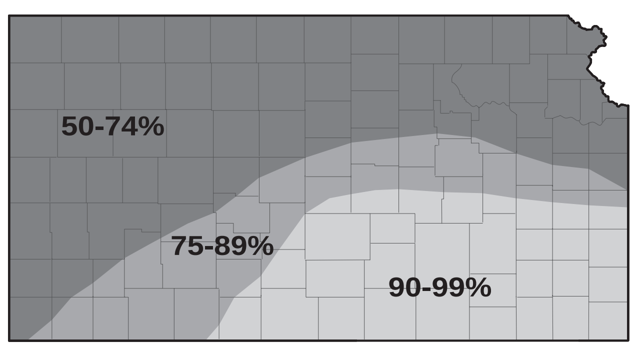
Bloom on August 14



Bloom on August 19



Bloom on August 24



Bloom on August 29

Weed Control

Weed control in grain sorghum is best achieved with an integrated approach based on crop rotations and herbicides or tillage, which enhances the ability of sorghum to compete with weeds.

Integrated Weed Management

Before planting grain sorghum, fields should be evaluated for annual and perennial weeds. The current year's weed-management program should be based on field notes from previous years that show weed species present, their relative abundance, and locations of perennial-weed infestations.

Common grassy weeds in Kansas include crabgrass, foxtails, shattercane, longspine sandbur, and panicums such as fall panicum and witchgrass. Common annual broadleaf weeds include kochia, the pigweeds, venice mallow, velvetleaf, cocklebur, devilsclaw, and sunflower. Successful control of annual weeds requires planting the crop into a weed-free environment and other management practices designed to get the crop up before the weeds.

Perennial weeds such as field bindweed, common milkweed, hemp dogbane, bur ragweed, and Johnsongrass also may infest sorghum fields. Perennial weeds can be suppressed, but they are difficult to kill. Cultivation between the rows, directed herbicide applications with drop nozzles, and certain broadcast herbicides are helpful in suppressing perennial weeds.

Crop rotation reduces weed pressure by varying the timing and types of tillage and herbicides. This is the most effective control for shattercane and Johnsongrass in sorghum. Fallow periods and rotation with summer crops such as soybeans, or winter crops such as wheat, will greatly reduce weed numbers, provided weed control is adequate to prevent seed production.

Delayed sorghum planting provides opportunities for effective weed control. In tilled seedbeds, field cultivation prior to planting will control emerged weeds, reducing weed-seed stocks in the soil. The last tillage before planting should be very shallow to avoid bringing new weed seed to the soil surface. In no-till seedbeds, herbicides are used to control emerged weed seedlings. Once several flushes of weed seedlings have been killed without further soil disturbance, weed pressure is decreased because few weed seeds remain in the favorable germination zone near the soil surface. Such "stale seedbed" techniques are especially effective in late-seeded crops.

Weed Control Strategies Prior to Planting

Repeated tillage before sorghum planting can effectively control weeds, but it is not likely to provide adequate protection from soil erosion by wind and water. Herbicides may substitute for some or all preplant tillage.

One strategy, where sorghum follows the previous year's wheat, is to control weeds in wheat stubble with Roundup and 2,4-D or dicamba then follow with an atrazine application in late summer. Atrazine controls volunteer wheat and other winter weeds and should keep the field relatively weed-free for a no-till sorghum planting the next spring. In central and eastern Kansas, atrazine should be applied after the end of August to reduce the potential for atrazine loss in surface runoff.

On the fine-textured soils of central and eastern Kansas, no-till planting of sorghum into standing wheat stubble may be hindered by wet soils. An alternative to no-till planting is to chisel the stubble after wheat harvest, leaving a rough but protected and porous surface. Apply atrazine and crop-oil concentrate to volunteer wheat and other winter weeds. A single pass with a field cultivator in spring is usually sufficient to assure a weed-free seedbed for sorghum planting.

Sorghum planted into soybean or row-crop stubble normally requires no seedbed preparation other than weed control. Where weed pressure is light and consists mainly of broadleaf weeds, a March or early-April application of atrazine with crop-oil concentrate and 2,4-D can control winter weeds, such as mustards and marestail, and most germinating weeds through planting. Early-spring-applied atrazine is a best management practice (BMP) as there is little potential for loss in surface-water runoff compared to later planting-time applications.

If annual grasses and tough broadleaf weeds like velvetleaf are emerged as planting time nears, Roundup and 2,4-D ester should be applied about a week before planting. In addition to killing all emerged annual weeds, this treatment can be very effective on established perennials such as field bindweed and hemp dogbane. Soil-residual grass herbicides are often added to these foliar-applied treatments for extended control.

Herbicides Applied at Planting

It is critical that fields be weed-free at planting time. Soil-applied herbicides for grass and pigweed control in the growing crop include Dual, Frontier, Partner, and Ramrod. Dual, Partner, and Frontier may be shallowly incorporated or surface applied, and they require the use of seed treated with Concep safener. These soil-applied herbicides do not control shattercane or large-seeded broadleaf weeds such as cocklebur, velvetleaf, venice mallow, devilsclaw, and sunflower.

The rate of atrazine applied to the soil surface at planting should not exceed 1 pound per acre because surface-applied atrazine is especially vulnerable to loss in surface-water runoff during May and June. Alternatives for using higher rates of atrazine at planting time include surface application before April 15, preplant incorporation, or application in bands over the sorghum row.

Herbicides Applied Postemergence

The only foliar-applied herbicide that controls annual grasses in sorghum is atrazine with crop-oil concentrate, and this must be applied to very small grass seedlings. Application rates of more than 1 pound per acre are not considered best management practices because of high potential for atrazine loss in surface-water runoff.

Several foliar-applied herbicides are available for broadleaf-weed control. Products such as bromoxynil plus atrazine, Laddok S-12, Marksman, and Shotgun all contain about 0.5 pound atrazine along with other herbicides. They should be applied when sorghum is in the three- to six-leaf stage and weed sizes conform to label guidelines.

Peak and Permit are two recently developed sulfonylurea herbicides for sorghum that work by inhibiting the function of the acetolactate synthase (ALS) enzyme. They are often tank-mixed with dicamba or atrazine to control a broader spectrum of weeds and to help control ALS-resistant species, which are immune to those types of herbicides.

A common mistake is applying postemergence herbicides too late for optimum weed control. Bromoxynil (Buctril and Moxy), bentazon (in Laddok), and atrazine all kill weeds through foliar contact and do not move through the plant; therefore, weeds may recover even after having lost their leaves. Systemic herbicides are translocated from the foliage throughout the plant and are more effective on larger annual weeds and may help control perennial weeds such as field bindweed.

Dicamba (Banvel or Clarity) and 2,4-D are among the least expensive herbicides for broadleaf-weed control in sorghum. These herbicides act as growth regulators, often causing temporary leaning and brittleness in sorghum plants. Such plants are more vulnerable to wind and cultivator damage. Application to sorghum more than 8 inches tall should be made with drop nozzles to reduce potential for sorghum injury.

Cultivation of Sorghum Rows

Cultivation remains an option for control of weeds between bands of herbicides and for later-emerging weeds. Heavy, high-residue cultivators can be effective even in no-till planted sorghum. They also can be used as backup where herbicides have performed poorly and where perennial weeds have not been controlled. Electronic guidance systems can increase cultivating speed and efficiency by reducing operator fatigue and cultivator blight.

Fertilizer Requirements

Grain sorghum is grown throughout Kansas under a wide range of climatic conditions. Sorghum is considered very efficient in utilizing nutrients from the soil because of a large fibrous root system; however, profitable responses to fertilization can be expected on many Kansas soils. Total nutrient uptake by sorghum is similar to that of corn and wheat at comparable yields.

Nutrient content of the grain and stover for a sorghum crop of 100 bushels per acre is shown in Table 4. The data show that harvesting only the grain removes considerably less nutrients than if the entire crop is harvested for silage.

Fertilizer and lime needs can best be determined by soil tests with supporting experience and field-history information. Soil tests are, however, no better than the sample collected in the field. Interpretations of soil tests and resulting fertilization recommendations are made based on many years of research conducted across the state. Fertilizer rates are targeted for optimum yields assuming yield potential is not restricted by other growth-limiting factors.

Nitrogen

Nitrogen is the element most frequently lacking for optimum sorghum production. Nitrogen recommendations will vary with expected yield, soil texture, and cropping sequence.

A soil test for available nitrogen in the soil profile is encouraged where nitrogen or manure applications have been excessive relative to yields. The profile nitrogen soil test is used to reduce nitrogen application so accumulated available nitrogen is utilized. Consult *Soil Testing Laboratory,* MF-734 for instructions on proper soil sampling and handling. Samples should be taken to a depth of 2 feet and must be air-dried after collection to minimize mineralization in handling and shipping.

Another important consideration in determining the optimum nitrogen rate is cropping sequence. Research in Kansas and adjoining states shows nitrogen credits for legumes grown in rotation with sorghum can be substantial. Table 5 summarizes nitrogen credits for legumes in rotation with sorghum and the basic nitrogen-recommendation adjustment for these credits.

Nitrogen recommendations can be calculated by using these factors:

N_{rec} = [YG × 1.25] STA – PCA – PYM – PNST

where

N_{rec}: nitrogen recommended in pounds per acre

YG: a realistic yield goal in bushels per acre

STA: soil texture adjustment (1.1 for sandy soils and 1.0 for medium and fine textures)

PCA: previous crop adjustment [use Table 5 for previous legumes, 20 pounds for fallow (if no profile nitrogen test) and zero for all other previous crops]

PYM: previous year's manure (50 pounds for last year, 20 pounds for 2 years ago, and zero for no manure history)

PNST: profile nitrogen soil test results —

surface: ___ ppm N × .3 × ___ depth (in) = ___ lbs/acre
subsoil: ___ ppm N × .3 × ___ depth (in) = ___ lbs/acre
profile N = ___ lbs/acre

Note: If no available nitrogen test is run, then use default value of 30 for PNST.

Table 4. *Approximate Amount of Nutrients in a 100-bushel-per-acre Sorghum Crop*

	Quantity in pounds	
Element	Grain	Stover
Nitrogen (N)	84	95
Phosphorus (P_2O_5)	42	20
Potassium (K_2O)	22	107
Sulfur (S)	8	13
Magnesium (Mg)	7	10
Calcium (Ca)	1.4	19
Copper (Cu)	0.01	0.02
Manganese (Mn)	0.06	0.11
Zinc (Zn)	0.07	0.14

Source: Adapted from the National Plant Food Institute.

Table 5. *Nitrogen Credit for Legumes in Rotations*

Previous legume	Nitrogen credit (pounds per acre)
Alfalfa	
>80% stand	100 to 140
60-80% stand	60 to 100
< 60 % stand	0 to 60
Second year	½ of first-year credit
Red clover	40 to 80
Sweet clover	100 to 120
Soybeans	30 to 60

Example:

Expected yield = 100 bushels per acre
Soil texture = silt loam
Previous crop = sorghum
Previous manure = none
Soil test = 15 ppm for top 6 inches
10 ppm for 6 to 24 inches

N_{rec} = (100 bu/acre × 1.25 lbs/bu) 1.0 – 0 – 0 – 81[a]
= 44 lbs/acre

[a] [15 ppm × 0.3 × 6 in] + [10 ppm × 0.3 × 18 in] = 81 lbs/acre

Field comparisons of nitrogen sources conducted by K-State researchers indicate little agronomic difference between sources when properly applied. For no-till or reduced-till systems that leave almost a complete residue cover, materials containing urea should be injected below the residue to minimize volatilization and immobilization losses. Source selection should be based on cost (applied), availability, adaptability to farm operation, and dealer services.

Nitrogen application for grain sorghum can be made at various times with equal results on most soils. Nitrogen utilization is quite rapid after the plants reach the five-leaf stage; by boot stage, 65 to 70 percent of the total nitrogen has been taken into the plant. Nitrogen applications should be timed so nitrogen is available when needed for this rapid growth. Preplant nitrogen applications can be made in late fall or spring (except on sandy soils) with little concern for leaching loss. On sandy soils, preplant nitrogen applications should be delayed until spring, sidedressed, or split with part in the spring and part sidedressed. If nitrogen is applied sidedress, the applications should be made by shortly after the five-leaf stage.

Application of nitrogen through the irrigation system has been quite satisfactory on sandy soils. Application of nitrogen through irrigation systems under other soil conditions is possible, but the fertilizer distribution is no better than the water distribution. No nitrogen material that contains free ammonia should be used when applying through a sprinkler system unless special precautions are taken. A small amount of nitrogen also may be applied in starter fertilizer.

Phosphorus

Phosphorus application should be based on a soil test. Consistent responses to phosphorus fertilization have generally occurred on soils testing very low or low in available phosphorus where yield potential is not restricted by low rainfall. With medium-testing soils, responses have been erratic and normally quite small. Phosphorus applications are recommended on medium-testing soils for their potential yield response and to maintain the soil in a highly productive condition. Phosphorus recommendations are shown in Table 6.

Phosphorus can be applied preplant-broadcast, preplant-knifed, or banded at seeding. If a difference among methods is found, broadcast is normally inferior. Starter applications are most efficient when small amounts are applied on acidic soils low in available phosphorus. Starter applications can be placed in direct contact with the seed or placed to the side and below the seed. If placed in contact, the starter material should contain no more than 10 pounds of nitrogen plus potash per acre. The nitrogen and potash can cause germination damage with their high salt index. No urea or ammonium thiosulfate should be placed in direct seed contact.

Preplant applications can be made in the fall or spring and should be thoroughly incorporated because phosphorus does not move appreciably in the soil. With no-till or reduced-till seedbed preparation, preplant-knifed or banded at seeding are preferred over broadcast.

Liquids, solids, and varying chemical forms of phosphorus (ortho- and polyphosphates) are available. K-State research indicates, in general, all are agronomically equal. Selection of a phosphorus source should be made on the basis of cost, availability, and adaptability to the operation.

Potassium

As with phosphorus, a soil test is the best guide to potassium need (Table 7). Potassium removal is much greater with silage than with grain production. Additional potassium should be considered in cropping sequences including forage sorghum because of the greater potassium removal. Potassium deficiencies are most likely to be found in southeastern Kansas and on sandy soils in other areas of the state.

Table 6. *Phosphorus Recommendations for Sorghum*

	Soil test for phosphorous (ppm)				
	Very low	Low	Medium	High	Very high
	<5	5-12	13-25	26-50	>50
	pounds per acre of P_2O_5				
Irrigated	50-70	30-50	20-30	0-20	none
Nonirrigated	40-60	30-40	20-30	none	none

*__Table 7.__ Potassium Recommendations for Sorghum **

	Soil test for potassium (pp2m or lbs/acre)				
	Very low <40	Low 40-80	Medium 81-120	High 121-160	Very high >160
	pounds per acre of K_2O				
Irrigated	80-100	60-80	40-60	20-40	none
Nonirrigated	60-80	40-60	20-40	0-20	none

* If silage is produced, add 40 K_2O to the recommendation.

Potassium should be applied preplant-broadcast, preplant-knifed, or banded at seeding. Broadcast applications should be thoroughly incorporated to get the potassium in the root zone. The most common potassium source is muriate of potash (potassium chloride); however, potassium sulfate, potassium nitrate, potassium-magnesium sulfate, and mixed fertilizers are good potassium sources. Little difference in potassium availability exists among them. Selection should be based on cost, availability, and adaptability to the farm operation.

Lodging of grain sorghum at maturity can be a problem in many areas of Kansas and can result in considerable harvest loss. Research has shown lodging occurs due to many factors—weather stress, insect and disease damage, hybrids, date and rate of planting, and nutrient imbalance. Adequate potassium is essential for sturdy stalks, and research has shown potassium fertilization can reduce lodging on medium- to low-testing soils. Recent research has shown adequate chloride may be as important as potassium in stalk strength. Potassium chloride at 40 to 50 pounds per acre supplies adequate chloride.

High application rates of potassium fertilizer for insurance against lodging is not recommended. Fertilization with proper levels of all nutrients plus good crop-management practices in general is the best way to minimize lodging. Weather conditions play a major role in lodging, and they cannot be controlled.

Liming

Lime recommendations are intended to maintain productive soils. Sorghum is not the most responsive crop to lime, but liming of acidic soils should not be ignored. Although yield increases may be small, liming is a sound farming practice. In the eastern third of Kansas, lime is recommended for sorghum on soils with a pH of 6.0 or less. For the rest of Kansas, lime is recommended for sorghum on soils of pH 5.5 or less. If sorghum is grown in a cropping system that includes legumes, the pH should be maintained at the optimum pH for the legume.

Other Elements

Secondary and micronutrient research has demonstrated a need for zinc and iron in some situations. Calcium and magnesium are relatively abundant in most Kansas soils. Liming of acidic soils supplies sufficient calcium, and a deficiency of this element would not be expected. Research with boron, copper, and manganese has not revealed any consistent responses, and these elements should not be a problem for optimum sorghum yields.

Sulfur may be lacking on sandy soils low in organic matter (less than 1.5 percent). On irrigated sandy soils, sulfur would only be of concern when sulfur levels in the irrigation water are low. Much of the irrigation water in Kansas contains an appreciable amount of sulfur. Current sulfur soil tests, when used alone, are poor predictors of sulfur deficiency. Farmers with sandy soils low in organic matter and a low sulfate soil test should try sulfur to ascertain the likelihood of a sulfur response.

The need for zinc (Table 8) and iron can be predicted by soil tests. Zinc is most likely deficient on areas where the topsoil has been removed and under high-yield conditions. Iron deficiency is most likely to occur in the western half of Kansas on soils where erosion or leveling has exposed highly calcareous subsoil, which also is low in organic matter and has a high pH.

Zinc usually is applied in conjunction with phosphorus and potassium, and time and method of application discussed in those sections are applicable to zinc. Inorganic and organic (chelate) sources of zinc are available for application with the chelates generally being three to five times more effective per pound of metal. Remember, however, small application rates are more effective if banded close to the seed.

No economical source of iron for soil application is currently available for correction of iron deficiency in sorghum. Foliar sprays of iron and manure application are the most effective methods of correcting iron chlorosis.

__Table 8.__ Zinc Recommendations for Sorghum

	DTPA-extractable zinc (ppm)		
	Low <0.5	Medium 0.5-1.0	High >1.0
	pounds per acre of zinc *		
Irrigated	8-10	2-5	none
Nonirrigated	2-5	none	none

* Based on the use of zinc sulfate as the source of zinc.

Irrigation

Grain sorghum peaked in popularity as an irrigated crop in the early to mid-1980s (Figure 5) and remains one of the top five irrigated crops in the state. Corn, wheat, soybeans, and alfalfa are the other four. Currently, about 250,000 acres of the 3 million irrigated acres in Kansas are planted to grain sorghum.

Grain sorghum has a drought-tolerant reputation; therefore, it is a choice for some irrigators with low-capacity wells and limited water. Good yield response to limited water applications are possible. Under full irrigation, corn generally becomes the preferred feed-grain crop due to increased yield potential.

Water-use Requirements

Grain sorghum will use about 18 to 22 inches of water to produce a normal yield in the western part of Kansas. Its use requirements will be 1 to 2 inches less in the eastern part of the state. The total amount of irrigation water needed depends on the season and the amount of soil water stored in the root zone.

Figure 5. *Kansas Acreage Trends for Irrigated Corn, Grain Sorghum, and Wheat*

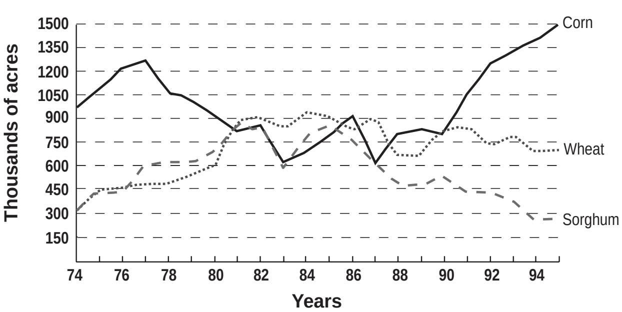
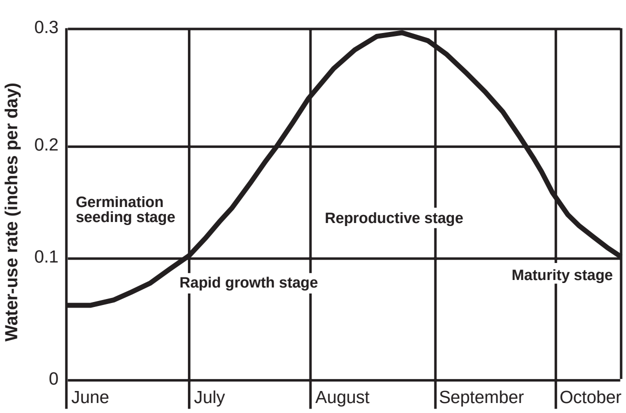


Figure 6. *Characteristic Water-use Pattern of Grain Sorghum*



Dry-year-irrigation estimates (*NRCS Irrigation Guide*) for grain sorghum range from about 15 inches in southwest Kansas to less than 7 inches in southeast Kansas. Irrigation estimates for years with average rainfall are from about 13 inches in the west to 4 inches in the east. These range estimates are for well-watered conditions.

Grain sorghum is generally one of the later-planted summer crops. This allows for the soil profile to accumulate water prior to planting and often means the reproductive stage begins after the hottest weather of the summer passes. Water-use rates for the various growth stages are shown in Figure 6. Average peak water-use rates are about 0.3 inch per day, although occasionally a single-day peak use might approach 0.5 inch per day. Table 9 shows estimated water-use rates for various growth periods.

Grain sorghum develops an extensive root system, which can extend to 6 feet in a friable soil. Irrigation scheduling usually accounts for only the upper 3 feet of the root zone since most of the water extraction will occur in this region. About 75 percent of water use will occur in the upper half of the root zone. Under stress conditions, when the upper zone becomes water-limited, the crop will use significant deep water as illustrated in Table 10.

Irrigation Management

Grain sorghum is a crop that lends itself to a limited irrigation-scheduling program. For high-water-holding-capacity soils, like medium-textured silt loams or heavier clay loams, one or two in-season irrigations

Table 9. *Average Daily Water-use Rate by Phenologic Periods for Irrigated Grain Sorghum Grown under Unlimited Soil Moisture for Plant Development, Garden City*

Time	Water use, inches per day
Emergence to 12-inch height	0.16
12-inch height to boot stage	0.27
Boot to heading stage	0.29
Heading to milk stage	0.25
Milk to soft dough stage	0.20
Soft dough to maturity	0.13

Source: Technical Bulletin 113

(6 to 8 inches) will produce 80 to 90 percent of the full yield potential under most circumstances.

Review of research trials in western Kansas demonstrates the utility of grain sorghum as a limited-irrigation crop (Table 11). In general, one or two irrigation applications, which were generally large (4 or 6 inches), provided near-maximum yield potential as compared to treatment with three or four in-season irrigations. These trials were on deep silt loams. Although most of these trials included a preplant irrigation, preplant irrigation is not recommended if any in-season irrigation is planned. In most years, sufficient rainfall is available to recharge the upper root zone, making preplant irrigation an inefficient water-use practice.

In addition to being able to extract water from a great depth within the root zone (Table 10), grain sorghum is able to extract soil water at a lower percentage of available soil water without yield loss when water is limited in the upper root zone. The general irrigation-management recommendation is to maintain soil water at or greater than 50 percent available. For grain sorghum, however, the soil water can be depleted to an average of 30 to 40 percent available water before grain yields are severely reduced (Figure 7). Scheduling based on soil-water depletion or crop-water use (evapotranspiration or "ET") rates would be recommended when full irrigation of grain sorghum is intended.

Full and limited irrigation of grain sorghum on sandy soils require more-frequent and smaller irrigation applications, which matches the capability of center-pivot systems commonly used to irrigate sandy soils. Irrigation scheduling using evapotranspiration or by maintaining a given soil-water-depletion balance may be most useful in this condition where low-water-holding capacity and restricted root zones present challenges to irrigation management. Underirrigation can quickly result in yield-limiting stress. Single, large irrigation can result in nutrient leaching and inefficient water use due to deep percolation.

If water becomes limited at any stage of growth, grain sorghum has the ability to tolerate water stress. Within certain limits, grain sorghum is a drought-resistant crop. One difficulty with a soil-water shortage is a delay in maturity. If plant maturity is delayed due to water stress, the crop may face frost damage in the event of an early freeze. Late-season water stress during grain filling can result in shriveled seeds, which reduces yield.

Irrigation Summary

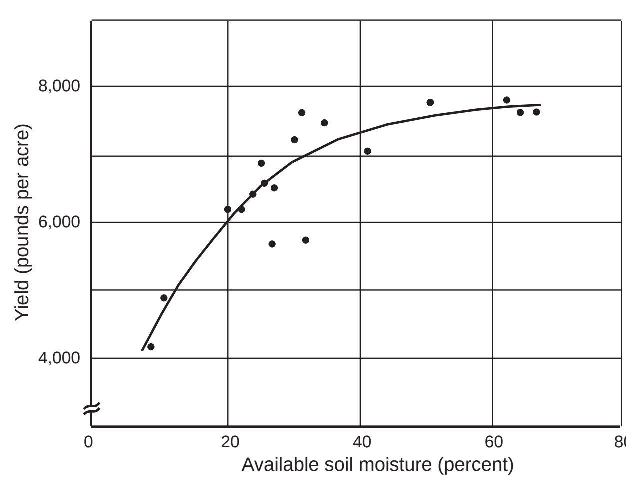
- Grain sorghum's water-use rate is similar to other summer crops and peaks at about 0.3 inch per day. The peak use begins at approximately initiation of the reproductive stage.
- Seasonal water need is 18 to 22 inches.
- Irrigation requirements vary from less than 6 inches in the east to about 15 inches in the west under well-watered conditions in normal years.
- Grain sorghum has an extensive root system, and its drought tolerance makes it suitable for limited irrigation.

Table 10. *Water-extraction Patterns under Different Soil-water Conditions, Garden City*

Depth (feet)	Normal (no stress)	Moderate stress	Moderate to severe stress
0-1	31.4%	25.3%	7.5%
1-2	23.2	18.9	7.3
2-3	18.4	19.9	14.8
3-4	13.4	17.9	24.9
4-5	7.6	11.7	24.4
5-6	6.0	6.3	21.0

Source: Technical Bulletin 113

Figure 7. *Percent Available Soil Water to the 4-foot Depth Prior to Irrigations*



Source: Conservation Research Report #5, 1965

Table 11. *Summary of K-State Irrigated Grain Sorghum Tests in Western Kansas (Bushels per Acre)*

Treatment description	Garden City 1954-59	Colby 1970-72	Tribune 1974-77	Garden City 1976-78	Garden City 1976-82	Colby 1978-79	Colby 1982-85
Nonirrigated	32						
Preplant (pre)	77	101	94	99	110	93	
Pre + early vegetation (ev)	102	107			124		
Pre + ev + boot	112			129	123		
Pre + ev + boot + milk	116	107	106	129		101	
Pre + boot or bloom		102	103	120	118	101, 97	
Pre + boot + head		106	100			105	
Pre + soft dough or milk			104			100	
Pre + boot + milk		105	105				
Pre + head + milk		102	101				
Pre + 50% depletion				128	134		
July		106			105		
August		103					
July & August		112					
Scheduled based on:						Colby (1982-85)	
1.4 × ET (excess irrigation)						105	
1.2 × ET (excess irrigation)						98	
1.0 × ET (normal irrigation)						106	
0.8 × ET (limited irrigation)						99	
0.6 × ET (limited irrigation)						94	
0.4 × ET (limited irrigation)						85	

Major Sorghum Diseases

Diseases of sorghum, like those of other crops, vary in severity from year to year and from one locality or field to another, depending upon environment, causal organisms, and the host plant's resistance. Estimates of annual sorghum yield losses in Kansas average about 5 percent.

The total eradication of disease in sorghum is not economically feasible, so growers must try to minimize their damage through an integrated pest-management system. Planting resistant hybrids; providing optimum growing conditions; rotating with other crops; removing infested debris; planting disease-free seed; proper seedbed preparation; and accurate application of herbicides, insecticides, and fungicides are all methods that can be used to minimize losses from disease.

Although sorghum is susceptible to many diseases, there are only a few that cause or have the immediate potential to cause economic losses in Kansas on a regular basis. They are described in Table 12.

Note: Disease and insects with asterisk (*) are illustrated on the inside back cover.

Table 12. *Sorghum Diseases*

Disease and cause	Symptoms	Occurrence	Control
Seed rot Mostly fungi: *Fusarium* *Rhizopus* *Aspergillus* *Penicillium* *Pythium*	Thin, uneven stands. Weak emergence. Shoots appear yellow. Seeds show general rot, blackened embryos, reddened and necrotic roots.	Most noticeable following prolonged periods of cool, wet weather just after planting. Poorly drained soil.	Captan is routinely used as a seed treatment. Metalaxyl is recommended for Pythium control.
Seedling rot Damping-off Same as for seed rot	Death at or prior to emergence. Rots observed at the soil line. Thin, uneven stands.	Same conditions as for seed rot. Also may occur during hot weather at emergence.	Same as for seed rot.
Seedling blight * *Fusarium* is the principal pathogen	Stunted growth, discolored leaves (reddish), red to black roots with dead areas.	Same as for seed rot. Also may occur in hot weather at time of secondary root development	Avoid acidic soils (pH <5.5). Acid amide herbicides may increase seedling blight severity.
Root rot Soilborne fungi	Plants easily uprooted. Outer portion of roots easily strips off and is red, gray or black. Top growth is stunted.	Generally present every year. Most important under adverse growing conditions.	See Fusarium stalk rot.
Stalk rot Fusarium stalk rot * *Fusarium* spp. See Extension 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 predominating.	Disease is favored by abundant moisture and moderate temperatures following head initiation	Some hybrids are more resistant than others. Continuous cropping, high nitrogen levels, high plant populations and loss of leaf area to insects, disease or hail tends to intensify stalk rots.
Charcoal rot *Macrophomina phaseolina* See Extension Bulletin L-741	Chlorosis of the head stalk is the first symptom. Stalk disintegration 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 stress. Later-maturing hybrids often escape infection.

Table 12. *Sorghum Diseases (continued)*

Disease and cause	Symptoms	Occurrence	Control
Viral diseases			
Maize dwarf mosaic virus * (MDMV-A) Sugarcane mosaic virus (MDMV-B) See Extension Bulletin L-481	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. Seed may be underdeveloped.	Virus is carried by insects, mostly greenbug and corn leaf aphid. MDMV overwinters in Johnson-grass.	Plant tolerant hybrids. Hybrids expressing only the mosaic reaction show less reduction in yield than plants with red leaf symptoms.
Small seed Primarily MDMV	Red to black lesions develop on panicle branches. Often damage is limited to point of seed attachment-appears as a black dot inside floret. As seed shrinks it becomes a dull color	Observed when the crop matures during soft dough. Most common during cool, wet weather.	Hybrids resistant to MDMV are not immune to small seed. No practical controls at present time.
Foliar diseases caused by fungi [1]			
Sorghum ergot *Claviceps africana*	Ovary is converted to a white fungal mass visible between the glumes. Exudation of a sweet, sticky “honeydew” from the infected flowers occurs. Honeydew that drips onto leaves or soil produces a white, powdery mass during moist conditions.	Worldwide wherever sorghum is grown. Male-sterile forage sorghums and hybrid seed production fields are most susceptible.	Avoid planting male-sterile forages or hybrids with cold sterility problems. Avoid late planting. Later plantings should have increased plant populations to discourage secondary tillers.
Northern corn leaf blight *Exserohilum turcicum*	Large (2 inches or more) elliptical spots with gray centers and tan to reddish borders. Very similar to sooty stripe.	Most prevalent during prolonged periods of warm and humid weather.	Crop rotation. Resistant hybrids.
Sooty stripe * *Ramulispora sorghi*	Elongated spots that may extend several inches with broad, yellow to orange margins. A sooty-like growth is generally present on the underside of the lesion.	Oldest leaves usually are attacked first and most extensively. Yield losses of 25% or more have been recorded.	Crop rotation. Full season hybrids appear to be more resistant.
Rust *Puccinia purpurea*	Small brown pustules or blister-like growths on the upper and lower leaf surfaces.	Usually appears late in the growing season. Favored by warm, moist weather. Significant losses can occur if infection occurs early.	Resistant hybrids.
Crazy top downy mildew *Sclerophthora macrospora*	Light colored leaves become stiff, leathery, upright, with roughened, blister-like appearance. If heads appear, glumes are often proliferated to give “crazy top” symptom.	Most severe when flooding occurs on seedbeds or young seedlings. Also, in poorly drained or heavy soils. Many grasses are susceptible including wheat and corn.	Several hybrids are resistant. Avoid areas where the disease is a recurring problem . Seed treatment with metalaxyl.

Table 12. *Sorghum Diseases (continued)*

Disease and cause	Symptoms	Occurrence	Control
Foliar diseases caused by bacteria [2]			
Bacterial stripe *Pseudomonas andropogonis*	Long, narrow, reddish or tan stripes depending upon hybrids. Lesions usually confined between veins. Shiny, crusty spots from exudate generally found on underside of leaves.	Most common bacterial disease. Prevalent during cool, humid weather.	Control measures have not been warranted.
Bacterial streak *Xanthomonas holcicola*	Narrow, water-soaked, translucent streaks about 1/8 inch wide by 1 to 6 inches in length. After several days, lesions turn red.	Very common during warm, humid weather.	Control measures are not warranted
Other sorghum diseases [3]			
Sorghum downy mildew *Peronosclerospora sorghi*	Vivid green and white stripes on leaves in late spring or early summer. Leaves shredded by wind until most leaf veins are separated . Heads partially or completely sterile.	Most noticeable when sorghum is planted after sudan grass. Most common in eastern and south central Kansas.	Do not plant sorghum after sudan grass. Crop rotation. Hybrid differences in susceptibility exist. Ask seed company for list of tolerant hybrids. Seed treatment with metalaxyl.
Gray leaf spot *Cercospora sorghi*	Dark purple spots having a grayish cast during spore production. Rectangular lesions, 1/4 inch and larger.	Usually occurs late in growing season as the crop is maturing. Little, if any, losses occur.	Same as northern corn leaf blight.
Anthracnose *Colletotrichum graminicola*	Small, circular to elliptical spots 1/8 to 1/4 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.	Same as northern corn leaf blight.
Zonate leaf spot *Gloeocercospora sorghi*	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.	Same as northern corn leaf blight.
Head smut *Sporisorium reilianum*	A portion or all of the head replaced by smut galls.	Plants are infected in seedling stage; symptoms are not apparent until boot or heading stage. More severe in south central and southwest Kansas.	Chemical controls are not effective. Utilize resistant hybrids.

1 There are many foliar diseases caused by fungi that can occur on sorghum. Seedling blights, stalk rots, sooty stripe, rust, northern corn leaf blight, and crazy top downy mildew can cause economic losses to occur in some years and on some hybrids. Since fungicide control is not available with the exception of seed treatments, management usually consists of selecting resistant hybrids and cultural practices such as crop rotation and the removal of residue where soil erosion is not a problem.

2 Bacterial leaf spots have not been shown to cause yield losses under Kansas conditions, but they are generally present every year, particularly under wet, humid conditions.

3 The previously described diseases represent those that occasionally cause significant yield losses in Kansas and those that, though not causing economic damage, are present on a regular basis. In addition, there are a number of diseases that occur sporadically in Kansas, only a few of which have the potential to cause economic yield loss. The most notable of these is sorghum downy mildew, which has caused significant yield losses in the past, but it is now effectively controlled using resistant hybrids and chemical seed treatments.

Spray Injury

Red, brown, or black spots or streaks become evident within 7 to 10 days after application. Injury occurs most often after spraying for aphids at the heading stage. Watch for patterns that coincide with application practices. Sorghums vary in sensitivity and expression. In severe cases, elongated streaks may appear as a general blight on leaves, not unlike bacterial streak or maize dwarf mosaic virus (MDMV). Parathion-type insecticides are commonly implicated. Damp mornings and hot days seem to compound the problem. Follow label directions carefully.

Major Sorghum Insects

Insect problems in sorghum vary in different areas of the state, from season to season, and from field to field. The greenbug is generally of primary concern since it occurs statewide and is capable of causing serious damage, and sorghums are susceptible to attack at almost any time during the growing season. Chinch bugs rank high in importance in central and eastern Kansas, particularly during dry seasons. In addition, there is a relatively large group of insects that may, at times, be of local importance. Those of most frequent concern are described in Table 11. Most growers realize that not all insects found in sorghum are destructive; some are beneficial. Among those that are destructive, the amount of economic injury caused will vary according to the species, density of the infestation, the crop growth stage, and sometimes other factors. Economic injury is defined as causing a loss that would be equal to or greater than the cost of control.

For more information on insect problems and their control, obtain a copy of *Sorghum Insect Management Recommendations*, MF-742, for the current year. This publication is available either at county Research and Extension offices or from the Distribution Center, K-State, Umberger Hall, Manhattan, KS 66506. For more information on identification of sorghum insects, ask for sorghum insect picture sheets No. 1 and No. 2, and for more information on scouting techniques and damaging levels of insect populations, request a copy of *Sorghum Insect Scouting Procedures*. These last two publications are available only from Extension Entomology, K-State, Waters Hall, Manhattan, KS 66506.

Table 11. *Insects of Frequent Concern in Sorghum*

Time of year/ crop growth stage	Description	Distribution	Probable insect
1. Planting time; seed-attacking insects	Poor emergence of plants or seeds fail to germinate. Seeds mechanically injured or destroyed.	Statewide	False wireworms, seed corn beetles, kafir ants, wireworms
2. Early season	Plants stunted or lodging early in the season. Occasionally, plants die. Underground portion of stems show signs of tunneling and feeding. Hard-shelled yellowish larvae may be present.	Statewide	Wireworms
3. Early season	Plants stunted or lodged. Roots destroyed or severely pruned. C-shaped whitish grubs present.	Statewide	White grubs
4. Early season	Leaves exhibit moderate to excessive amounts of feeding damage. Some expanded leaves with rows of transverse round to oblong holes. Affected plants may be stunted or dying. Usually found in lower spots within fields corresponding to where yellow nutsedge grew last year.	Statewide	Billbugs

Table 11. *Insects of Frequent Concern in Sorghum (continued)*

Time of year/ crop growth stage	Description	Distribution	Probable insect
5. Seedlings to 6-inch plants	Upper epidermis of leaf tissue chewed away. Pattern shows as a series of streaks or whitish stripes. Definite mechanical destruction of tissue can be observed. Tiny, hard-shelled, shiny beetles, $^1/_{16}$ inch long, jump rapidly when disturbed.	Statewide	Flea beetles
6. Seedlings to 6-inch plants	Similar to flea beetle injury. Small, fine white streaks present on surface of leaf tissue. Small splinter-like insects present on the plants, usually in the whorls. Less than $^1/_{16}$ inch long; color varies from transparent to dark; some winged, some not.	Statewide	Thrips
7. Seedlings to 6-inch plants	Plants partially or totally cut off just above or below the soil surface. Brownish to blackish worms may be present, generally under the soil surface in the vicinity of injured plants.	Statewide	Cutworms
8. May to June on seedling plants	Small seedlings show signs of reddening, sometimes plants dying. Insects present on above-ground portions of the plant. Tiny, light green, soft-bodied insects. Or, sometimes, if insects have disappeared, numerous whitish cast skins present on foliage and soil around affected plants.	Statewide, but more common in central and eastern areas	Greenbugs *
9. May to June on seedling plants	Injury similar to #8, except affected leaves develop distinctive purplish color, older leaves may fire and turn yellow. Insects similar to greenbugs, but somewhat smaller, lemon-yellow color.	More common in eastern areas	Yellow sugarcane aphids
10. May to June; seedlings to 6-inch plants	Medium to dark green sucking insects present, especially in whorls of plants. Prominent cornicles or tail-pipes present on upper side near rear of body. Tail-pipes are darkish in color. Area around base of tail-pipes is also darkish in color. Generally no visible injury associated with these insects, even though they may be quite numerous. Also see #13.	Statewide	Corn leaf aphids *
11. May to June; seedlings to 6-inch plants	Damage generally appearing at the margin of the field and progressing inward. Small plants show signs to 6 inches high of stunting or dying. Occasionally much reddish discoloration on lower portions of plants. Partially grown or full-grown bugs feeding either above or below ground on plants. Immature bugs are reddish to blackish with a white stripe across middle of back. Adults black except for whitish wings. Adult insect about $^1/_8$ inch long or less.	Generally in the eastern half of the state, usually in sorghum fields adjacent to wheat	Chinch bugs *
12. May to June; seedlings to 6-inch plants	Small plants dying, larger plants with the central leaves in the whorl dying. Signs of tunneling present on the underground portion of the stem. Frequently destroys the growing point. Silken tunnels may be attached to the underground portion of the plant. Slender worms up to about $^3/_4$ inch in length may be present. Generally greenish to bluish-green. Very agile, move rapidly when disturbed.	Likely to be present in south central areas of Kansas	Lesser corn stalk borer
13. Early season; 6- to 12-inch plants	Plants lodged. Brace roots absent or appear to have dried up (common during some years). Soil dry in the area where brace roots should be developing. Often mistaken for insect injury.	Statewide	Usually physiological
14. June, July, August; whorl stage	Leaves shiny and syrupy, excessive honeydew present, aphids present in upper portions of the plant. Whitish cast skins also frequently present. Some leaves yellow with reddish blotches.	Statewide	Corn leaf aphids *

Table 11. *Insects of Frequent Concern in Sorghum (continued)*

Time of year/ crop growth stage	Description	Distribution	Probable insect
15. June, July, August; whorl or heading stages	Lower leaves shiny and sticky; excessive honeydew deposit. Light green, soft-bodied insects present on underside of leaves. Reddish areas develop on leaves where colonies are present. Leaves die where heavy infestation develops and is allowed to persist.	Statewide	Greenbugs *
16. June, July, August; whorl stage	Holes in leaves. Occasionally, plants very ragged. Damage often more severe on late-planted fields.	Statewide	Fall armyworms
17. August, September; during bloom stage	Small, light brown, fuzzy striped worms present in heads of sorghum, about 1/2 inch long when full grown.	In eastern areas, usually more common in south-east Kansas	Sorghum webworm
18. August, September; during bloom stage	Seeds fail to develop on part or most of the head Heads appear to be “blasted.” Tiny orange or red maggots occasionally present, but generally not visible except under microscope.	In eastern areas, usually more common in south-east Kansas	Sorghum midge
19. August, September	Destroys grain in the developing head. Infestation usually begins during or shortly after bloom. Worms range in size from 1/4 to 1 1/2 inches in length. Larvae possess a series of stripes on the body. Predominant color may be greenish, pinkish, to almost blackish. Head capsule uniform light brown color.	More common in the southern half of Kansas	Corn earworm
20. July, August	Visible feeding on leaves, particularly around field margins. Occasional signs of feeding on developing seeds in the head.	Statewide	Grasshoppers
21. July, August	Discoloration, browning and yellowing of lower leaves; signs of light webbing on underside of affected leaves. Tiny “crawling specks” may be present. Greenbugs sometimes also present.	More common in western parts of Kansas	Spider mites
22. July, August, September	Plant showing signs of stress; occasional poor filling of heads is visible. Clusters of reddish to blackish insects present on lower portions of the stalk.	Eastern half of Kansas	Chinch bugs *
23. July, August, September	Small, grayish insects, similar in size and shape to chinch bugs, but color is different; feeding in the heads of developing sorghum.	Statewide	False chinch bugs

* See photograph, inside back cover. Information on treatment guidelines and management approaches is available at local Research and Extension offices.

Preharvest Desiccants for Sorghum

Grain sorghum is a perennial species. After producing seed, the plant remains green and alive until killed by tillage or freezing temperatures. This presents management problems for sorghum producers. Grain is often slow drying, and harvest is often delayed until late fall, delaying rotation to a winter crop such as wheat. Harvest delays also increase the risk of damage by wind, snow, and birds. Some Kansas sorghum producers are planting the crop earlier in the spring to spread weather risks; however, this does not guarantee an earlier harvest.

Possible Desiccants

Several chemical desiccants are available for preharvest use on grain sorghum. If applied when the grain is physiologically matured, at 25 to 35 percent moisture, sorghum yields are not adversely affected. Grain is at the correct moisture level when kernels at the bottom of the head (the last to mature) show an abscission layer (black layer) at the tip of the kernel.

Diquat may be used to desiccate sorghum grown for seed, but not for feed. Diquat is much like paraquat. Both produce a rapid foliar burn that bleaches leaves and promotes grain drying.

Foliar application of 28-percent nitrogen urea-ammonium nitrate (UAN) to desiccate sorghum was studied at K-State in the 1970s. UAN caused significant leaf desiccation, but it was not very effective in promoting drier grain unless the application was followed by warm, dry weather. There was low recovery of nitrogen by the succeeding crop, suggesting high volatilization losses following treatment.

In 1997, Roundup Ultra was labeled for use as a defoliant in sorghum grown for feed. It is not recommended for sorghum grown for seed because germination may be reduced. Roundup acts less rapidly than Diquat, or 28-percent urea-ammonium nitrate, but it is more effective in killing the sorghum plant. There is a minimum 7-day waiting period between application and harvest, but a 2- to 3-week wait should be expected for Roundup to completely kill the plant. K-State tests have shown that application of 2 pints per acre of Roundup will achieve about a 10-percent decrease in grain moisture compared to grain dried under natural conditions. Roundup may be applied aerially or on the ground and should be applied at 3 to 10 gallons per acre with water conditioned with ammonium sulfate. Application of Roundup in 28-percent urea-ammonium nitrate did not result in satisfactory desiccation, as the burn from the nitrogen interfered with the activity of the Roundup.

Preharvest desiccation of grain sorghum has several advantages over natural crop drying. For early-planted or early-maturing sorghum, it should permit an earlier harvest of drier grain. Weeds growing in the crop should be killed, and late-summer weed-seed production should be reduced. Killing the sorghum plant will halt further water use by the sorghum and permit faster rotation to the next crop.

Harvesting Grain Sorghum

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.

There are five types of harvest loss:

Preharvest loss is typically weather-related and reduced 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 work days 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 higher 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 cause high 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. K-State 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.

How to Measure Combine Loss

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 to 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. When making ground counts for kernels, look for lost heads. One 10-inch head in a 10-foot-by-10-foot area is approximately 1 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.

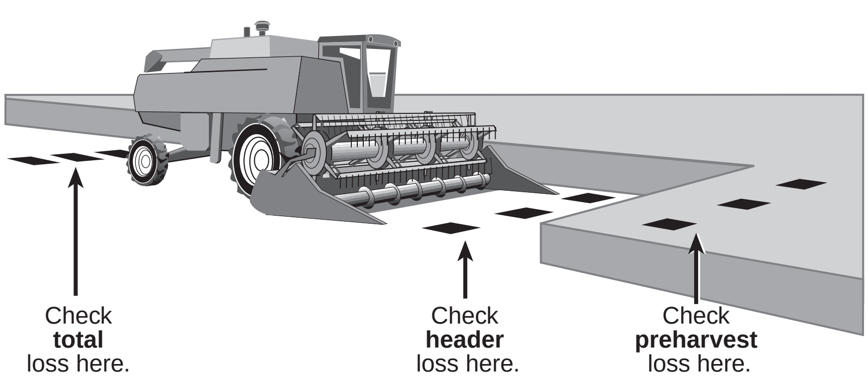
If the total loss was more than 5 percent, the next step is to determine the preharvest loss. Check this in front of the combine in the standing sorghum. Take three counts on 1-square-foot areas, then average them and divide by 20. Subtract the preharvest loss from the total loss to determine the net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

Figure 8. *Determining Harvest Losses*



Drying and Storage

Grain sorghum must be stored at safe moisture and temperature levels to maintain quality prior to marketing. Harvest losses can become excessive if weather conditions do not allow field drying. A low- or high-temperature drying system for handling high-moisture grain sorghum is needed on the farm or at the receiving center.

An individual sorghum seed exposed to air will dry faster than a kernel of corn. The kernel is smaller, and the interior moisture moves a shorter distance. It is harder to move air through a mass of grain sorghum as compared to corn or soybeans. As a result, both the drying and cooling rates of sorghum will be 30 to 50 percent longer as compared to corn, assuming similar grain conditions and drying or storage equipment.

Low-temperature drying systems are affected by weather. During October, the average ambient (outside) air temperature is 55 degrees Fahrenheit with a relative humidity of 65 percent. The temperature and humidity combination limits the natural air's ability to reduce grain moisture content much less than 16 percent in many years. The relative humidity of the outdoor air affects drying potential more in eastern Kansas than western Kansas. If weather conditions do not allow for field drying, low-temperature drying systems using only natural air also will be ineffective. Drying time with a low-temperature system is dependent on weather conditions.

High-temperature drying systems using artificial heat are not impaired by outdoor air conditions. Drying times will increase when drying sorghum in high-temperature dryers. The main energy source for a high-temperature (HT) dryer is propane or natural gas. Available high-temperature drying systems include layer-in-bin, batch-in-bin, continuous-in-bin, column batch, and column continuous.

Batch-in-bin dries sorghum utilizing grain-storage bins with full perforated floors but limiting the drying depth to 4 feet. The airflow is between 10 and 15 cubic feet per minute per bushel and the maximum drying air temperature is 120 to 140 degrees Fahrenheit for drying feed grain and 110 degrees Fahrenheit for drying seed. The higher air temperature (140 degrees Fahrenheit) can be used if the bin has a stirrer or recirculator. After the batch has dried, it is moved to another storage bin with an aeration system. The sorghum must be cooled immediately to avoid storage problems. Layer drying is similar, but the bin is filled in 3- to 4-foot increments. One layer dries before another layer is added.

Column drying (batch or continuous-flow) grain sorghum requires slightly lower air temperatures than with corn because of longer exposure to the high temperatures and the potential fire hazard. The drying air temperature should be 160 to 200 degrees Fahrenheit when using airflows of 100 to 200 cubic feet per minute per bushel. Measuring the grain temperature as it leaves the dryer may be desirable to avoid high-temperature damage.

If the sorghum is not cooled in the column drying, the kernels need to be cooled prior to storage. Column-dryer capacity can be increased by using dyeration or combination drying. Both processes involve moving hot grain 1 to 3 points greater than the desired storage moisture content out of the high-temperature dryer into a storage bin. With dryeration, the grain goes through a sweating process for 8 to 12 hours before fan operation. Combination drying uses a low-temperature drying system to remove the final 1 to 3 points of moisture.

The reduced drying capacity of systems with grain sorghum as compared to corn may encourage the use of higher temperatures or underdrying. Overdried grain may cause a fire and quality problems, and underdried grain may cause storage problems.

Low-temperature (LT) grain dryers are similar to layer-in-bin dryers, but the bin is filled. The fan and motor are designed to move a specified volume of air, varying from 1 to 3 cubic feet per minute per bushel of grain. These units use enough heat to warm the air 5 to 8 degrees Fahrenheit. This increases the moisture-holding capacity of the air. These units should not be operated at ambient temperatures less than 35 degrees Fahrenheit.

At ambient temperatures greater than 60 degrees Fahrenheit, there is potential for increased mold development when using low-temperature drying systems. Low-temperature drying is a slow process and may involve weeks or months, but drying costs have been comparable to high-temperature drying with good management. Typically, these systems work best for sorghum harvested at less than 17-percent moisture.

Farmers should not depend on an aeration systems to dry grain sorghum. Approximately one to two points of moisture is the maximum amount of drying that can be accomplished with an aeration system. With the low airflow rates and minimum drying capability of natural air during the fall, the drying process will be slow.

Holding Wet Sorghum

Wet sorghum cannot be stored as long as corn before spoiling and sprouting. Present recommendations regarding storing wet sorghum follow:

1. Be cautious about storing for more than a day before drying. Longer storage periods require aeration fans on the holding bins and outdoor air temperatures less than 70 degrees Fahrenheit. Wet grain should be removed from the holding bin before refilling.
2. Recognize conditions of 23- to 25-percent grain moisture and grain temperatures of 80 to 90 degrees Fahrenheit are ideal for heating, molding, and sprouting. Safety margins are narrow.
3. Consider adding aeration of 0.5 cubic foot per minute per bushel to the wet holding tank to reduce grain-heating problems. If night temperatures go between 10 and 20 degrees Fahrenheit less than day averages, aeration will be beneficial.

Storing Dry Grain Sorghum

Sorghum producers considering on-farm storage can develop a grain-storage system to store the grain for extended periods without appreciable losses in grain quality or quantity. This requires a working knowledge of what causes storage losses and how to prevent them; a storage system that will hold grain and protect it from weather, insects, birds, and rodents; an efficient, low-labor system for handling and treating the grain; and a planned program of storage management and inspection.

Prior to storage, clean bins thoroughly, treat for insect control, make sure birds and rodents can be controlled, and perform any needed repairs or maintenance to control water or grain leaks. Make sure all handling equipment, conveyors, aeration fans, drying equipment, and other items are in working condition. The bin should be treated with an approved bin-wall spray for grain sorghum.

Grain sorghum should be placed in storage when moisture content is 14 percent or less. The temperature of the kernels should be reduced to 40 to 45 degrees Fahrenheit by aeration as quickly as possible. Insect and mold growth is minimal at these temperatures. Grain sorghum that will be stored for more than 9 months should be treated with a grain protectant. Contact any county Research and Extension office for information on protectants registered for grain sorghum.

Recording the moisture and temperature of loads entering storage is helpful in managing the grain. Temperature and moisture data from the grain mass should be taken on a regular basis. It is recommended that sampling occur once a week during the first month and monthly thereafter. Visual and physical checks of grain sorghum in storage also are helpful. A grain probe may be needed to collect samples in deep bins. Any sudden increase in the temperature of the grain mass is a danger sign. If a temperature increase of 3 to 5 degrees Fahrenheit is recorded in a 1- to 2-week period, immediate corrective action is required to minimize losses. Moisture and temperature readings should be recorded for making management decisions during the storage period.

Round-storage bins are best for long-term storage, easy grain movement, management in storage, and grain-processing systems. Large bins cost less than small ones on a cost-per-bushel basis; however, multiple bins provide flexibility in storing different grains or storage based on quality. Flat storage structures can be converted to other farm uses easily at little cost. It is more difficult to mechanize flat storage for grain handling with stationary equipment, install drying or aeration systems, treat grain, and control rodents or birds. Flat storage is acceptable for short-term storage (6 months or less) or large volumes of one grain.

Storing High-moisture Grain Sorghum

Wet-grain storage accommodates the grain sorghum producer who feeds the grain or has a dependable market agreement with a feeder. It allows early harvest without drying. Structures for high-moisture grain can be either the sealed, “oxygen-free” system or open unsealed storage, such as bunker or trench silos. Sealed systems store the grain whole and process it as removed. Unsealed systems process the grain as it goes into storage.

The recommended moisture level for wet-grain storage is 25 to 30 percent. Grain-preserving acids offer a third option for storing wet grain in conventional bins. When applied as recommended, they provide good protection from spoilage. Bin walls must be protected to prevent corrosion when acids are used. The cost of acid treatment will usually equal or exceed drying costs. Both acid-treated and ensiled grains are limited to use in livestock feeding.

Profit Prospects

Total acres of grain sorghum for grain Kansas averaged almost 3.38 million acres from 1993 to 1996, or 10.8 percent of the state's crop acres. In 1996, Kansas ranked first in the United States in the production of grain sorghum for grain with 354.2 million bushels or 44.1 percent of the total U.S. production. Grain sorghum produced under irrigation represented 7.2 percent of the total grain sorghum acres from 1993 to 1996 and 10 percent of the total production.

Each producer must answer two questions when selecting crops and the acreage of each crop to produce: (1) will this choice be profitable and (2) will this add more to the total net income of the farm operation than other choices? That is, is this the most profitable choice?

The fixed or overhead costs of land and machinery ownership for grain sorghum, soybeans, corn, and wheat will be basically equal for the production period under consideration. Therefore, the variable costs associated with each crop are the costs that need to be considered when selecting a given crop. Variable costs include labor, seed, herbicide, insecticide, fertilizer, fuel, oil, repairs, crop insurance, drying, custom work, crop consulting, and miscellaneous.

Variable costs depend on the management practices used, tillage operations, labor efficiency, and type and fertility of the land. Each producer should develop the variable costs of production for grain sorghum and any other crop alternatives. Expected yield and selling price need to be determined for each crop alternative.

Budgeted variable costs by item are shown for nonirrigated grain sorghum production in western, south central, north central, northeast, and southeast Kansas and for irrigated grain sorghum production. A producer may have higher or lower costs than presented in these budgets.

The prices used in these tables are NOT price forecasts. They are used to indicate the method of computing expected returns above variable costs. These projections should be considered valid only under the costs, production levels, and prices specified. Individuals or groups using the information provided should substitute costs, production levels, and prices valid for the locality, management level to be adopted, marketing circumstances for the location, and time period involved.

The decision to plant grain sorghum or another crop alternative can be made by comparing the expected returns above variable costs for each crop. Returns above variable costs will depend on yields and prices. Each producer should use yields that are reasonable for the land or classes of land operated.

The decision to produce grain sorghum will depend primarily on the costs and expected returns for grain sorghum in comparison with other crop alternatives. However, the producer should take into account other variables such as previous crop rotation, livestock operation, and the machinery and labor requirements of each crop.

The type and amount of equipment, crop rotations, and farm size all affect the cost of producing crops. The tillage practices used and their timing also affect yields and production costs. Each producer should compute the expected returns above variable costs for the farm operation as a means of selecting the crops and acreage of each crop to produce. When computing expected returns above variable costs, consider a number of price alternatives.

Table 13. *Expected Returns above Variable Costs for Grain Sorghum*

	Southeast	Northeast	South central	North central	Western	*Irrigated	My farm
Yield per acre	80	75	65	70	75	110	______
Returns:							
Yield per acre × $2.35	$188.00	$176.25	$152.75	$164.50	$176.25	$258.50	______
Government payments	8.20	9.34	14.79	12.78	13.23	13.23	______
Total returns	**$196.20**	**$185.59**	**$167.54**	**$177.28**	**$189.48**	**$271.73**	______
Variable costs:							
Labor	$23.22	$23.22	$20.52	$23.22	$12.96	$21.33	______
Seed	4.73	4.73	3.15	3.15	2.63	8.40	______
Herbicide	20.30	20.70	20.10	20.15	15.90	20.35	______
Insecticide	0.00	6.53	4.35	4.35	10.44	10.44	______
Fertilizer and lime	28.78	27.55	23.65	23.10	18.35	29.90	______
Fuel and oil (crop)	6.80	6.65	6.35	7.11	6.47	7.84	______
Fuel and oil (pumping)	0.00	0.00	0.00	0.00	0.00	31.77	______
Machinery repairs	14.20	15.87	13.75	15.47	12.40	16.30	______
Irrigation repairs	0.00	0.00	0.00	0.00	0.00	3.70	______
Crop insurance	0.00	0.00	0.00	0.00	0.00	0.00	______
Drying	8.00	7.50	6.50	7.00	7.50	11.00	______
Custom hire	0.00	0.00	0.00	0.00	0.00	0.00	______
Crop consulting	0.00	0.00	0.00	0.00	0.00	6.25	______
Miscellaneous	5.25	5.25	5.00	5.00	5.00	7.00	______
Interest on 1/2 variable costs (10 percent)	5.56	5.90	5.17	5.43	4.58	8.71	______
Total variable costs	**$116.84**	**$123.90**	**$108.54**	**$113.98**	**$ 96.23**	**$182.99**	______
Expected returns above variable costs	$ 79.36	$ 61.69	$ 59.00	$ 63.30	$ 93.25	$ 88.74	______

* The irrigated grain sorghum budget represents an average of the variable costs for flood and center pivot irrigation practices. Fuel-oil and irrigation repair costs will vary slightly between flood and center pivot irrigation.

Table 14. *Estimated Variable Costs of Production*

	Southeast	Northeast	South central	North central	Western	Irrigated *	My farm
Grain sorghum	$117.00	$124.00	$109.00	$114.00	$96.00	$183.00	______
Soybeans	107.00	118.00	114.00	106.00	—	165.00	______
Corn	167.00	177.00	172.00	169.00	121.00	329.00	______
Wheat	94.00	92.00	86.00	88.00	84.00	133.00	______

* For each crop, the values represent an average of the variable costs for flood and center-pivot irrigation practices.

Table 15. Estimated Costs and Returns for Sorghum Compared with Other Crops for Kansas

	Yield	Price	Gov't payments	Gross/ acre	Variable costs	Return above variable costs	Fixed costs *	Return above all costs
Southeast Kansas								
Grain sorghum	80	$2.35	$8.20	$196	$117	$79	$75	$4
Soybeans	28	6.00	8.20	176	107	69	75	– 6
Corn	90	2.60	8.20	242	167	75	75	0
Wheat	35	3.90	8.20	145	94	51	75	– 24

* Based on $625 per acre land at 6 percent; $3.13 per acre taxes. Depreciation, interest, and insurance on $255 per acre machinery investment equals $34.

	Yield	Price	Gov't payments	Gross/ acre	Variable costs	Return above variable costs	Fixed costs *	Return above all costs
Northeast Kansas								
Grain sorghum	75	$2.35	$9.34	$186	$124	$62	$86	– $24
Soybeans	35	6.00	9.34	219	118	101	86	15
Corn	100	2.60	9.34	269	177	92	86	6
Wheat	35	3.90	9.34	146	92	54	86	– 32

* Based on $800 per acre land at 6 percent; $4 per acre taxes. Depreciation, interest, and insurance on $255 per acre machinery investment equals $34.

	Yield	Price	Gov't payments	Gross/ acre	Variable costs	Return above variable costs	Fixed costs *	Return above all costs
South Central Kansas								
Grain sorghum	65	$2.35	$14.79	$168	$109	$59	$78	– $19
Soybeans	28	6.00	14.79	183	114	69	78	– 9
Corn	85	2.60	14.79	236	172	64	78	– 14
Wheat	35	3.90	14.79	151	86	65	78	– 13

* Based on $700 per acre land at 6 percent; $3.50 per acre taxes. Depreciation, interest, and insurance on $240 per acre machinery investment equals $32.

	Yield	Price	Gov't payments	Gross/ acre	Variable costs	Return above variable costs	Fixed costs *	Return above all costs
North Central Kansas								
Grain sorghum	70	$2.35	$12.78	$177	$114	$63	$75	– $12
Soybeans	28	6.00	12.78	181	106	75	75	0
Corn	80	2.60	12.78	221	169	52	75	– 23
Wheat	35	3.90	12.78	149	88	61	75	– 14

* Based on $650 per acre land at 6 percent; $3.25 per acre taxes. Depreciation, interest, and insurance on $245 per acre machinery investment equals $33.

	Yield	Price	Gov't payments	Gross/ acre	Variable costs	Return above variable costs	Fixed costs *	Return above all costs
Western Kansas								
Grain sorghum	75	$2.35	$13.23	$189	$96	$93	$77	$16
Corn	75	2.60	13.23	208	121	87	77	10
Wheat	40	3.90	13.23	189	84	105	77	28

* Based on 1.5 acres of land for each acre harvested. $525 per acre land at 6 percent; $3.94 per acre taxes. Depreciation, interest, and insurance on $190 per acre machinery investment equals $26.

	Yield	Price	Gov't payments	Gross/ acre	Variable costs	Return above variable costs	Fixed costs *	Return above all costs
Irrigated Crops								
Grain sorghum	110	$2.35	$13.23	$272	$183	$89	$143	– $54
Soybeans	50	6.00	13.23	313	165	148	143	5
Corn	190	2.60	13.23	507	329	178	143	35
Wheat	70	3.90	13.23	286	133	153	143	10

* Represents an average of flood and center-pivot irrigation practices and was based on $895 per acre land at 6 percent; $4.48 per acre taxes. Depreciation, interest, and insurance on $715 machinery and irrigation equipment investment equals $85. Center-pivot irrigation would have depreciation, interest, and insurance expenses of $116 on a machinery and irrigation equipment investment of $930. Flood irrigation would have depreciation, interest, and insurance expenses of $56 on a machinery and irrigation equipment investment of $505.

	Yield	Price	Gov't payments	Gross/ acre	Variable costs	Return above variable costs	Fixed costs *	Return above all costs
My Farm								
Grain sorghum	____	____	____	____	____	____	____	____
Soybeans	____	____	____	____	____	____	____	____
Corn	____	____	____	____	____	____	____	____
Wheat	____	____	____	____	____	____	____	____

a. Seedling Blight

b. Fusarium Stalk Rot

c. Sooty Stripe

Major Sorghum Diseases and Insects

d. Maize Dwarf Mosaic Virus (MDMV)

e. European Corn Borer (typical breakage)

f. Greenbug Leaf Damage

g. Corn Leaf Aphids

h. Chinch Bugs

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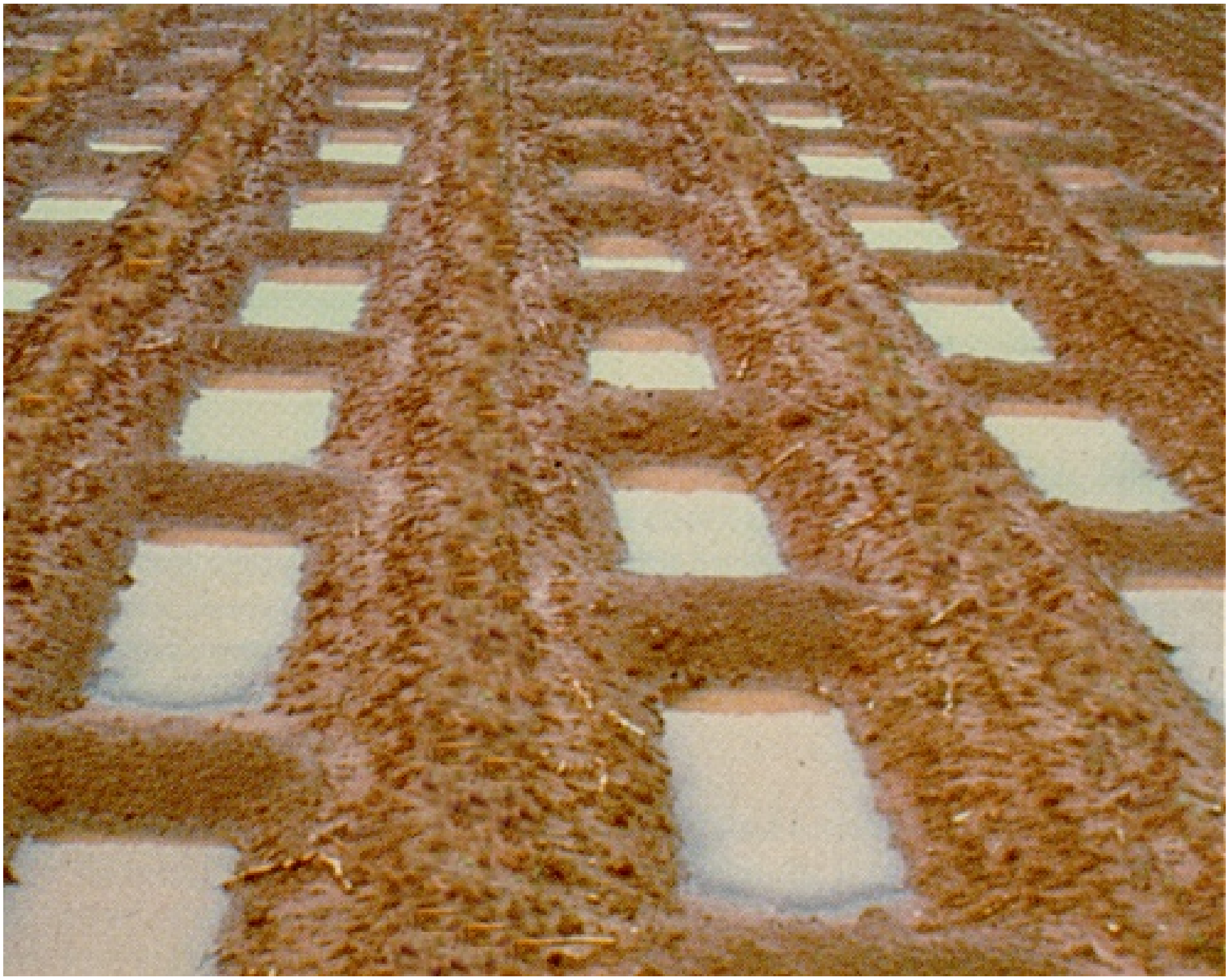

Recommended Last Planting Date for Grain Sorghum in the Texas Low Rolling Plains

Jim Barber, Calvin Trostle and Billy E. Warrick,

Research & Extension Assistant, Extension Agronomist and Extension Agronomist

Sorghum producers in the Texas Low Rolling Plains have many good sorghum hybrids to choose from. The range of planting dates, however, occurs from late April to mid July. Many producers may not readily understand the different sorghum maturity classes or when they should or shouldn't be planted (i.e., what is a 110-day sorghum, and how may it vary?). In addition, early season cold tolerance is an attribute, which may be important particularly for early season plantings when good soil moisture is available. Likewise, tillering and its control may strongly influence the success of sorghum cropping particularly as planting date affects tillering (cool temperatures favor tillering). Hybrids that tiller have the ability to compensate upward if production conditions are favorable relative to the established plant population, but tillering hybrids also erode the ability to manage targeted plant populations and timely harvest.

These are general guidelines and are not an endorsement of any one hybrid or company by Texas Cooperative Extension. Suggested last planting dates for each hybrid are intended to be conservative in order to protect the producer. In northern locations of the Rolling Plains, move toward the earlier portion of the range of last planting dates for a particular hybrid. Check with the seed company representative in your area for specifics. Please report discrepancies in growth and maturity for your particular hybrid and suggested planting date to Jim Barber as well as the company representative.

Keep in mind that in terms of historical averages flowering is most harmed by hot weather even when moisture is adequate. Many producers err on the side of planting too much seed per acre. As a result in droughty conditions producers are at risk of inadequate moisture per plant during flowering and grain fill to produce grain. In managing risk, know that most grain sorghum hybrids at modest plant populations are better able to flex upward to meet the yield potential of favorable conditions. This is less risky agronomically and economically than having a high plant population crop under droughty conditions.

Managing Risk Balancing Seeding Rate vs. Available Soil Moisture: Suggested sorghum seeding rates are influenced by the available soil moisture in soils of different textures. Generally, sandy to sandy loam soil can store about 1" of available soil water per foot; a silty loam to clay loam soil can store about 1.5" inches per foot; and a clayey soil can store about 2" per foot. Typically, it takes 6-8" inches of available moisture (rainfall or in the soil) to bring a sorghum crop to the point of grain production, and each additional 1" of water should produce 350-425 lbs. of grain.

For most dryland sorghum production in the Texas Low Rolling Plains, when soil profile moisture is adequate (>4" of available soil moisture), a good target is 30,000-35,000 seeds/A. If soil moisture is low (2-4"), a seed drop of 25,000-30,000/A is advised. For any condition with poor soil moisture, especially as plantings approach July 1, consider 20,000 seeds/A. For limited irrigation (6-10") with low soil profile moisture conditions, target 40,000-45,000 seeds/A, but if soil moisture is good, consider 50,000-55,000 seeds/A. For full irrigation levels, target 80,000 seeds/A on June 1, but by July consider 100,000-110,000 seeds/A for non-tillering hybrids and 80,000-90,000 seeds/A for tillering hybrids.

Because seed costs are relatively low for sorghum ($1.00-1.20 cents per pound), growers too easily increase seeding rates as it doesn't much affect production costs. Seeding rates occasionally are altered to reflect planting conditions. In general for high quality seed under favorable conditions, expect germination 90%, and stand establishment of 80-90% for germinated seeds. If difficult germination or stand establishment is expected, seeding rates may edge back up slightly. If a rain germinates all seed and high establishment occurs, but overall growing conditions remain poor, plant population will be too high.

In general, Texas Cooperative Extension suggests the following guidelines as a criteria for the last recommended planting date based on the sorghum's maturity class:		
Counties	**Medium Maturity**	**Early Maturity**
Borden, Scurry, Jones, Fisher, Howard,Mitchell, Nolan, Taylor, Callahan, and Counties North of the line from Schleicher to McCulloch	**June 30**	**July 15**
These suggested dates consider the length of sorghum maturity vs. historical averages for cool fall weather, which can be expected ahead of frost. Although these sorghum maturity classes may be planted later and be successful in many years, these guidelines should help producers understand when risk increases relative to achieving grain yield potential. If you must consider a very late sorghum planting, choose among hybrids that have estimated 'days to maturity' of less than 90 days. Check among seed dealers for suggestions.		

In the accompanying table, company representatives have provided estimates of the 'last recommended planted date' for their hybrids. For table headings from left to right, the hybrids below for the Rolling Plains are arranged by date into four general groups for 'last planting date.' Hybrids with a last recommended planting date of June 10-20 are long maturity. In addition, late June hybrids are generally medium long; early July hybrids are medium; and the hybrids suggested for July 8-15 are early.

Participating Companies Recommendations
for Last Planting Dates of Selected Hybrids
(listed alphabetically)

COMPANY: AgriPro Seeds							
June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**

2949* Wings 9850*	**2** **2** **3**	Honcho* 2731 2838 2800 2660* Cherokee*	**3** **2** **2** **3** **3** **3**	2468* 2440 9210	**2** **2** **3**	9135 2140 2233*	**2** **2** **2**
*Good early season vigor ratings, adapted to early plantings at cooler temperatures. NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High							

COMPANY: Asgrow (owned by Monsanto)							
June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**
A603	**3**	A570* A571* A581 MISSILE	**2** **3** **3** **2**	A459* A504	**2** **3**	A201 A298 LASER SENECA*	**3** **3** **3** **3**
*Good early season vigor ratings, adapted to early plantings at cooler temperatures. NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High							

COMPANY: Cargill (owned by Dow AgroSciences)							
June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**
833	**2**	837* 737* 770Y 775Y 697	**3** **3** **3** **3** **2**	627 647*	**2** **3**	606 576	**2** **2**
*Good early season vigor ratings, adapted to early plantings at cooler temperatures. NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High							

COMPANY: Crosbyton Seed Co.							
June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**

9080 9060	**2** **3**	6080 7050 8080* 1489* 6092 6 Row Y 6 Row GBT 6 Row R	**3** **3** **3** **2** **3** **3** **3** **3**	380 5050 5914*	**2** **2** **2**	6035 7031 4 Row Y	**2** **2** **3**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: DEKALB (owned by Monsanto)

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**
DK66*	**3**	DK65 DK56 DK55 DK54* DK53	**4** **1** **3** **3** **2**	DK47* DK45* DK44 DK43A(1) DK41Y (1) DK40Y DK38Y	**3** **3** **1** **3** **4** **3** **3**	DK28E DK36* DK39Y	**2** **3** **2**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
(1) Do not plant later than July 1.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: Frontier Hybrids

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**
F-647E* F-700E*	**3** **3**	F-457E	**4**	F-270E* F-303C* F-501E	**4** **3** **3**	F-227E F-200E	**2** **2**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: Garrison & Townsend--Bill Townsend, (806) 364-0560

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**

SG-822 SG-94249* SG-97157 SG-925	**3** **2** **3** **3**	SG-753 SG-95512 SG-677	**3** **2** **3**	SG-95207 SG-96258	**2** **2**	SG-96275 SG-95392	**2** **2**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: Garst Seed

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**
5319	**2**	5522Y 5429 5440* 5503*	**3** **2** **2** **3**	5631Y 5664* 5515	**3** **2** **3**	5727 5715 5616	**2** **2** **3**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: Golden Harvest (merged with J.C. Robinson Seed Co.)

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**
H-512	**2**	H-502 H-505BW	**2** **2**	H-430Y H-471* H-495W H-499Y	**3** **2** **2** **2**	H-296W* H-388W H-403*	**2** **2** **2**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: Mycogen (owned by Dow AgroSciences)

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**
444E 3696 3700 ORO G XTRA	**3** **3** **2** **2**	ORO XTRA T-E Y-101G T-E Prosper 522 DR T-E Y-75 1506* 1552 3694	**3** **2** **2** **3** **1** **2** **1** **3**	M 3838 T-E Eden 411	**2** **1** **2**	ORO ALPHA 3595* 3636 1482 1498E	**1** **1** **2** **2** **2**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: NC+ Hybrids--Ronnie Morris, (512) 321-1239

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**
		NC+7R83* NC+7W97 NC+8R18	**2** **3** **3**	NC+ 7B29* NC+ 271 NC+ 371 NC+ 7C49 NC+ 7R37E NC+ 7B47* NC+ 7Y57-K	**2** **3** **3** **3** **3** **3** **3**	NC+ 4R48 NC+ 5C35 NC+ 5B74E* NC+ 6B50* NC+ 6C21 NC+ 6R30* NC+ 262 NC+ 6B70 NC+ 6B67* NC+ Y363 NC+ 6C69	**4** **3** **2** **4** **3** **3** **2** **4** **3** **2** **3**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: NK (now goes by the name of Sorghum Partners)

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**
KS560Y* K73-J6	**2** **3**	KS710 KS59-Y2 KS711Y	**2** **3** **2**	KS524	**2**	2030 KS310* KS585*	**2** **2** **2**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: Pioneer--David Peterson, (806) 789-8326

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**

		8212Y 8414 84G62* 8522Y 85G85 84G82 83G66 8310 8505	**3** **2** **3** **3** **3** **3** **3** **3** **2**	85Y34 8699 86G71 8500*	**3** **3** **2** **2**	8950 8925 8875 87G57	**3** **3** **3** **3**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: Richardson Seeds, Inc.

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**
JOWAR 1	**2**	9200Y 9212Y 9300 9322	**2** **2** **2** **2**	RS200E RS250E 9200Y 202CR	**2** **2** **2** **2**	SPRINT II SPRINT E DASH E	**2** **3** **3**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: Triumph Seed

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**
TR82G TR481 Two 80-D TR474	**3** **2** **3** **3**	TR464 TR65G TR459 TR462 TR60G	**3** **3** **1** **3** **3**	TR438 TR447 TR445	**3** **3** **3**	TR430 TR432*	**3** **2**

*Good early season vigor ratings, adapted to early plantings at cooler temperatures.
NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High

COMPANY: Warner Seeds

June 10-20 Tillering#		**June 21-30 Tillering#**		**July 1-7 Tillering#**		**July 8-15 Tillering#**	
Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**	Hybrid	**Tiller Rating**

W-844E	**2**	W-528W	**3**	W-528W	**3**	W-494	**2**
W-851DR*	**3**	W-625Y	**2**	W-560T	**3**		
W-965E*	**2**	W-560T	**3**	W-622E	**2**		
W-839A	**2**	W-622E	**2**				
W-818E	**2**						
*Good early season vigor ratings, adapted to early plantings at cooler temperatures. NOTE: Tiller Rating 1 = None, 2 = Little, 3 = Moderate, 4 = High							

This publication is made possible through Sorghum PROFIT, an initiative of the State of Texas as developed by the Texas Grain Sorghum Association in conjunction with the Texas A&M University Agriculture Program and Texas Tech University.

For producer questions contact any author. For company updates or additions to this list please call Jim Barber or look for any recent updates via the Internet at http://lubbock.tamu.edu and click on crops then sorghum. You may also obtain a copy through your local county extension office. This document will be updated each year by March 1.

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Top of Page

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Things are quiet outside, and brown and cold. Yet the holidays demand color and light. We are pleased to be able to provide a little cheer through some of our Lubbock roses of summer.

Jude the Obscure

Zepherine Drouhin

Upcoming Events

Southern High Plains Calendar

Parenting Coalition

February 06, 2002 at City Health Dept., 1902 Texas Ave. in Lubbock, 12:00 pm. Click here for more information

Last Minute CEU Meeting

February 19, 2002 at KoKo Palace, 5101 Ave. Q in Lubbock, 08:30 am. Click here for more information

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The Lubbock Research & Extension Center
Soil & Crop Sciences

I began my service in the 20-county Lubbock region and the Texas South Plains in January 1999. My responsibilities as a Lubbock region district (D-2) extension agronomist include assisting farmer inquiries and extension education programming, often in conjunction with county agriculture extension agents, for all crops but cotton, applied research, and precision agriculture applications. Programming compliments Dr. Randy Boman's extension responsibilities for cotton in the Texas South Plains. Currently crop demonstration and applied research projects include work with peanuts, sorghum, corn, wheat, sunflower, soybeans, guar, black-eyed peas, and summer sorghum-based forages (photoperiod sensitive and brown mid-rib). Emphases within these crops include fertility and crop rotation with cotton. I also serve as a regional co-coordinator of the South Plains component of the statewide Sorghum PROFIT program investigating means to stabilize crop production systems by using sorghum in rotation with other crops. Precision agriculture is also part of my efforts on behalf of South Plains producers. My particular interest is helping producers determine what level of or what components of precision agriculture may be appropriate for their operation. Precision agriculture efforts currently focus on peanuts and corn. I actively participate in several projects with faculty from Texas Tech University where I am also an adjunct professor in the Plant and Soil Sciences department. Prior to Lubbock I worked at the Texas Ag. Experiment Station in Beaumont. There I worked as a post-doc then assistant research scientist working primarily with nitrogen soil chemistry and fertility in rice. Prior experience also includes growing up and working on a diversified crop-and-livestock family farm in Eastern Kansas (sorghum, wheat, soybeans, corn). My academic training includes time at Kansas State (B.S., agronomy), Texas A&M (M.S., soil science), the University of Minnesota (Ph.D., soil science).

My Publications

products

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All Technologies
Roundup Ready
Residue Proven
Roundup Ready/STS
Conventional

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Seed Catalog Legal Information

MONSANTO

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

 | TERMS AND CONDITIONS | PRIVACY POLICY

MONSANTO

A603

Product Characteristics

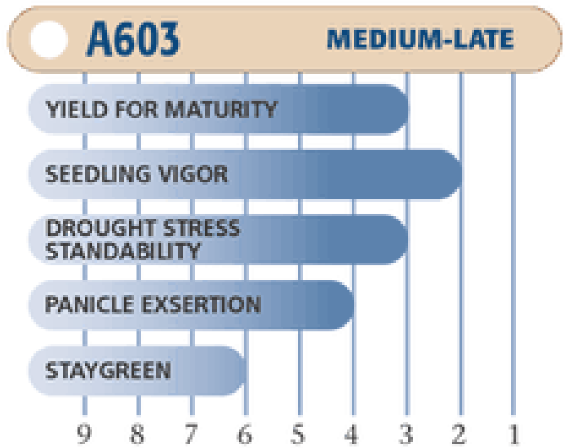
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
medium/late	72-79	bronze	purple	open	4

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
16-18K	3	2	42-48	3	3

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
3	3	3	3	6	3

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
4	no	3	6	3



- Excellent stalk strength with high yield potential for greater profit opportunities
- Proven hybrid has an open head for excellent drydown of the grain
- Uniform hybrid with bronze grain
- Resistant to downy mildew, pathotype I
- Smaller planting seed gives an excellent value

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

 | TERMS AND CONDITIONS | PRIVACY POLICY

MONSANTO

MISSILE

Product Characteristics

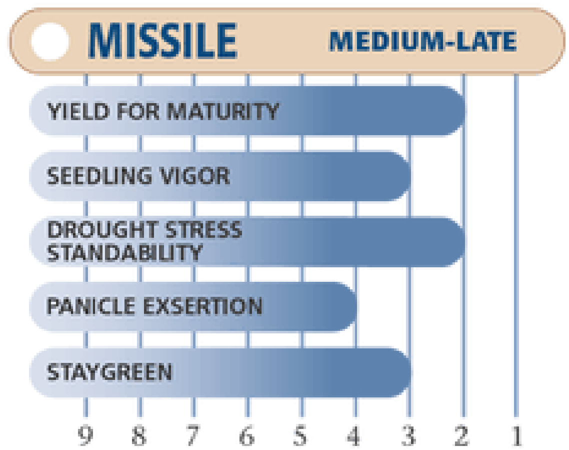
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
medium/late	70-80	bronze	purple	semi-compact	4

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
12-14 K	2	3	40-50	2	2

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
2	4	3	5	5	3

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
3	E	3	3	2



- High yield potential
- Very good seedling vigor
- Excellent drought tolerance
- Resistance to biotype E greenbug
- Very good staygreen rating

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

MONSANTO

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

A459

Product Characteristics

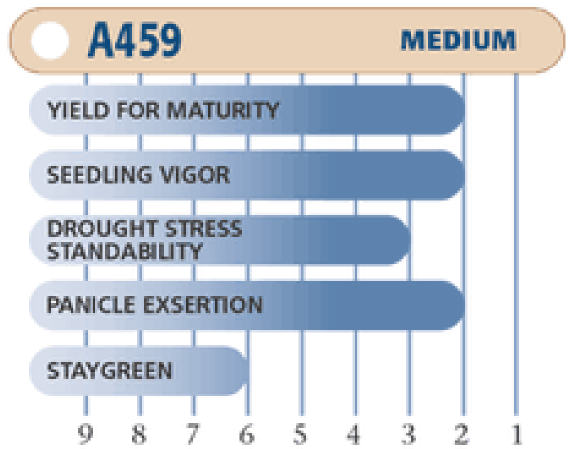
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
medium	64-68	bronze	purple	open	2

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
12-14K	3	2	44-50	3	4

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
3	3	4	3	1	3

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
4	E	3	6	2



- High yield potential
- Excellent emergence and top-rated seedling vigor
- Fast drydown
- Resistant to downy mildew, pathotypes I
- Resistance to biotype E greenbug
- Keep populations on the low side to maximize agronomic performance

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

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 | TERMS AND CONDITIONS | PRIVACY POLICY

MONSANTO

ASGROW

LASER
Product Characteristics

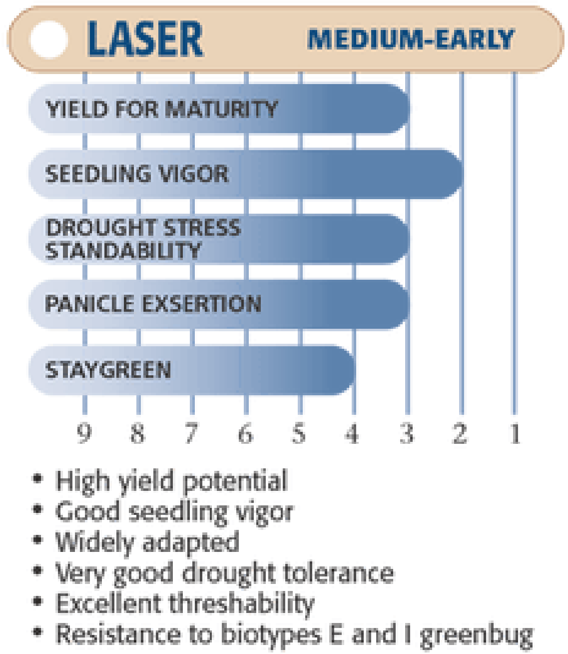
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
med/early	65-70	bronze	purple	semi-open	3

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
13-15 K	3	2	36-44	3	2

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
3	2	3	9	2	2

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
4	E & I	3	4	3



Rating Scale:
1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:
Y = Yellow Grain

Greenbug Resistance:
E = Biotype "E"
I = Biotype "E"

MDMV:
MDMV= Maize dwarf mosaic virus

Notes:
1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

 | TERMS AND CONDITIONS | PRIVACY POLICY

MONSANTO

SENECA
Product Characteristics

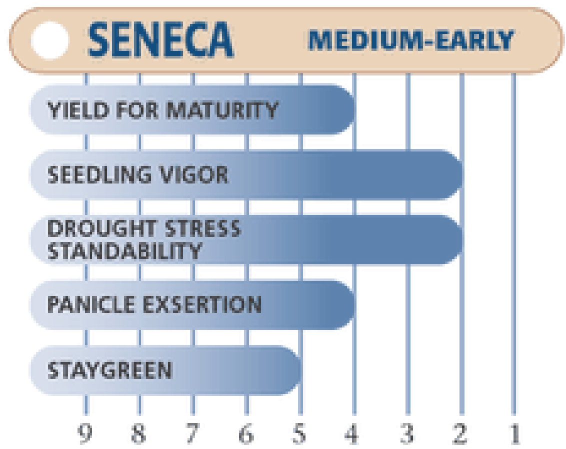
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
med/early	64-66	bronze	purple	semi-open	4

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
13-15K	2	2	37-42	4	3

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
2	2	2	6	2	3

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
4	no	3	5	4



- Bronze-colored grain on semi-open heads
- Excellent stalk quality and short plant height
- Excellent seedling vigor for rapid stand establishment
- High test weight and outstanding yield for maturity
- Superior post-freeze stalk lodging resistance
- Use where emergence in cool conditions is needed
- If planting late, increase planting rate

Rating Scale:
1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:
Y = Yellow Grain

Greenbug Resistance:
E = Biotype "E"
I = Biotype "E"

MDMV:
MDMV= Maize dwarf mosaic virus

Notes:
1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

MONSANTO

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

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- Hybrid pearl millet
- Hybrid sunflowers
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Crosbyton, Texas 79322

Ph: (806) 675-2308
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MONSANTO

2002 Seed Catalog

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Soybean

Technologies:

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Seed Catalog Legal Information

MONSANTO

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

 | TERMS AND CONDITIONS | PRIVACY POLICY

MONSANTO

DK54

Product Characteristics

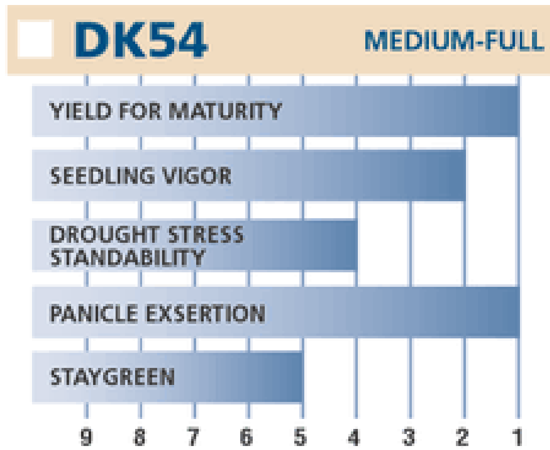
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
medium/late	66-78	bronze	purple	semi-compact	1

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
15-16K	3	2	42-54	2	3

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
4	5	5	7	2	3

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
4	E	3	5	1



- Excellent seedling vigor allows top performance even when planting in cool soils
- Tolerates maize dwarf mosaic virus (MDMV)
- Avoid areas prone to charcoal rot
- High yield potential

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

 | TERMS AND CONDITIONS | PRIVACY POLICY

MONSANTO

DK53

Product Characteristics

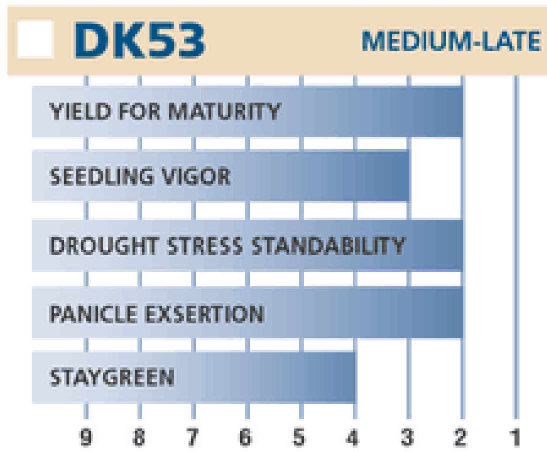
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
med/late	70-80	bronze	purple	semi-compact	2

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
14-15K	3	3	41-51	4	4

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
2	5	4	3	4	3

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
3	E	7	4	2



- Resistance to biotype E greenbug
- Resistance to downy mildew (races 1 and 2)
- High test weight and good stalk quality
- Excellent threshability
- Adapted to a wide range of growing conditions

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

 | TERMS AND CONDITIONS | PRIVACY POLICY

MONSANTO

DK47

Product Characteristics

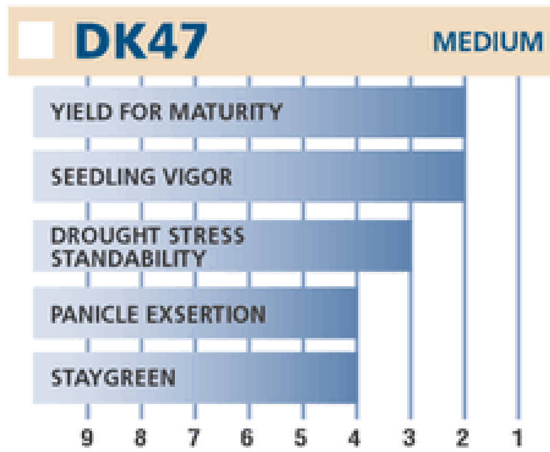
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
medium	63-73	bronze	purple	compact	4

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
14-15K	4	2	45-53	4	3

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
3	3	4	7	4	2

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
6	E	3	4	2



- Excellent emergence
- Performs best on favorable dryland or under irrigation
- Resistance to biotype E greenbug
- Medium maturity bronze hybrid

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

DK45

Product Characteristics

Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
medium	63-73	bronze	purple	semi-open	2

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
14-16K	4	2	43-52	4	3

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
4	4	5	3	3	4

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
5	E	3	3	2

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

 | TERMS AND CONDITIONS | PRIVACY POLICY

DK44

Product Characteristics

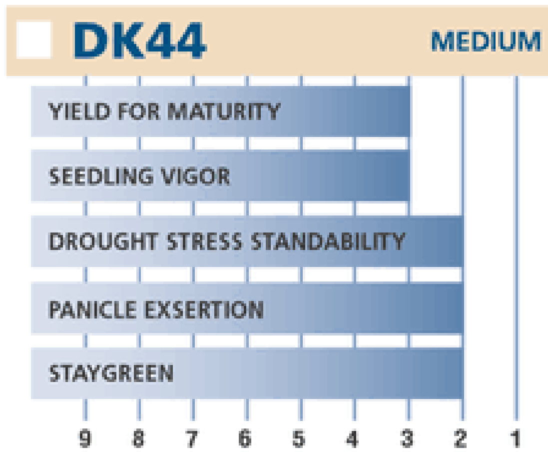
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
medium	65-72	bronze	purple	semi-open	2

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
18-20K	5	3	35-50	4	3

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
2	3	4	7	2	4

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
6	E	3	2	3



- Medium maturity bronze hybrid
- Strong drought tolerance
- Excellent staygreen ability and reduced tillering
- Resistance to biotype E greenbug
- Adapted to a wide range of growing conditions

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

 | TERMS AND CONDITIONS | PRIVACY POLICY

DK43A

Product Characteristics

Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
medium	62-72	bronze	purple	semi-open	3

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
16-17K	4	3	35-40	3	3

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
4	3	4	8	4	3

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
4	E	3	6	4

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

MONSANTO

DK41Y

Product Characteristics

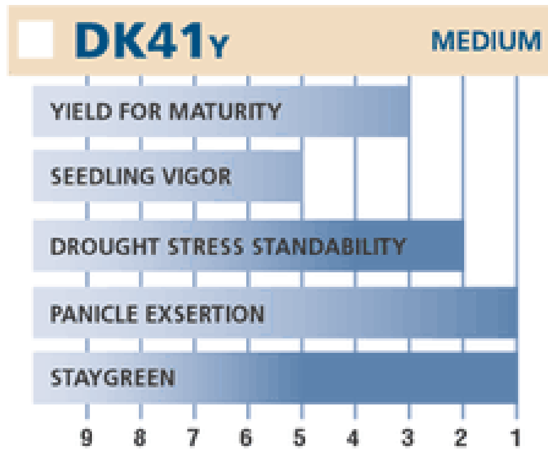
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
medium	63-73	yellow	purple	semi-open	1

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
17-19K	4	5	42-54	3	3

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
2	5	3	7	2	6

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
6	E	4	1	3



- Adapted to dryland and irrigation
- Takes advantage of available moisture
- For optimum stand establishment, soil temperature should be at least 65° F at seeding depth
- Provides strong stalks and resistance to biotype E greenbug

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

DK40Y

Product Characteristics

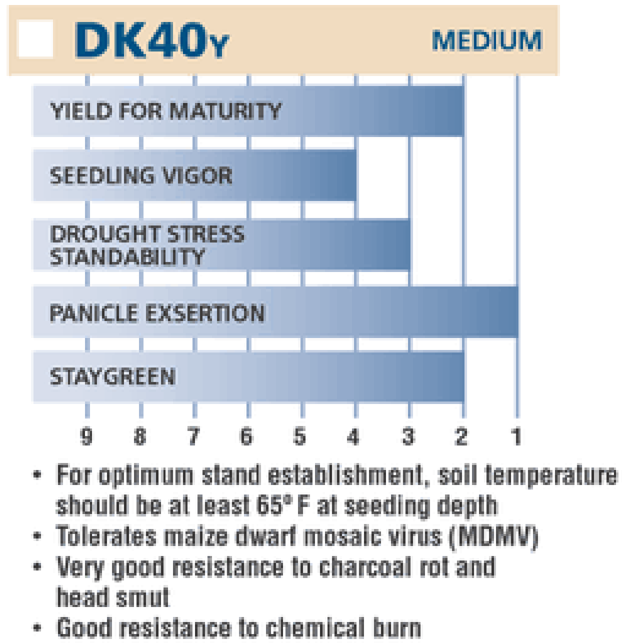
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
medium	61-71	yellow	purple	semi-open	1

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
16-17K	5	4	35-48	4	3

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
3	3	4	3	3	6

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
6	E	4	2	2



Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

MONSANTO

DK38Y

Product Characteristics

Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
medium	62-68	yellow	purple	semi-open	2

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
16-18K	5	6	34-40	2	1

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
1	2	2	9	2	6

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
4	E	6	2	3

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

DK28E

Product Characteristics

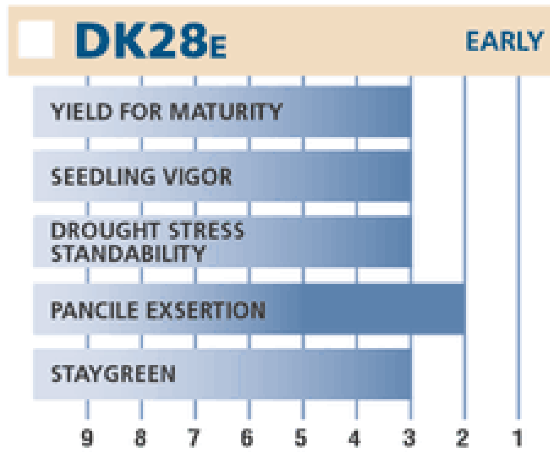
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
early	52-62	bronze	purple	semi-open	2

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
16-18K	4	3	32-44	4	2

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
3	1	6	9	3	3

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
6	E	7	3	3



- Flowers early and has very good drought tolerance
- Shorter plant type for better harvestability
- Increase populations when using in double-crop situations

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Seed Catalog Legal Information

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

 | TERMS AND CONDITIONS | PRIVACY POLICY

DK36

Product Characteristics

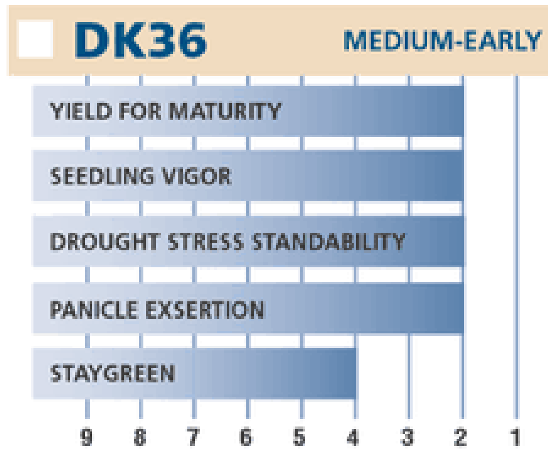
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
med/early	65-70	bronze	purple	semi-open	2

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
14-15K	4	2	35-43	3	2

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
2	2	3	9	2	2

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
4	E	3	4	2



- Flowers early to avoid heat stress and midge pressure
- Performs well when drought stress conditions prevail
- Excellent resistance to head smut
- Adapted to a wide range of growing conditions

Rating Scale:

1-2 = Excellent
3-4 = Very Good
5-6 = Good
7-8 = Fair
9 = Poor

The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

MONSANTO

DK39Y

Product Characteristics

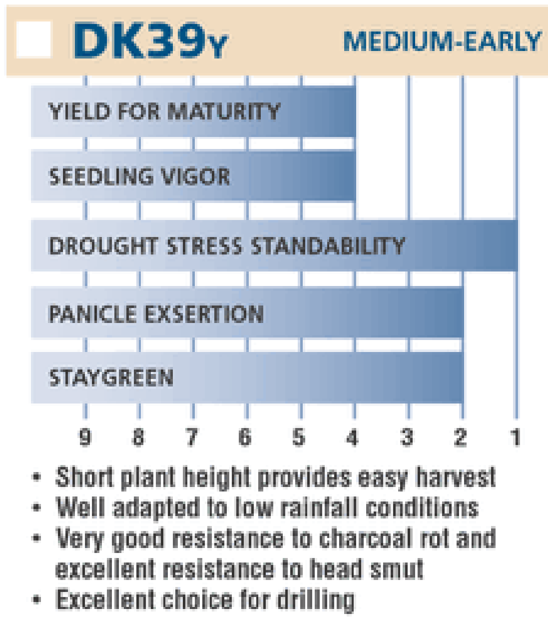
Return to Previous Page

Maturity Group	Days to Flower	Grain Color	Plant Color	Panicle Type	Panicle Exertion
med/early	59-69	yellow	purple	semi-open	2

Seeds per lb.	Test Weight	Seedling Vigor	Height	Uniformity	Root Lodging
13-15K	5	4	34-44	3	1

Drought Stress Lodging	Post Freeze Lodging	Charcoal Rot	Downy Mildew	Head Smut	Grain Weathering
1	1	3	9	2	6

Chemical Burn	Greenbug Resistance	MDMV-A	StayGreen	Yield for Maturity
4	E	9	2	4



Rating Scale:

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The ratings are approximate and should not be considered as absolute.

Hybrid:

Y = Yellow Grain

Greenbug Resistance:

E = Biotype "E"
I = Biotype "E"

MDMV:

MDMV= Maize dwarf mosaic virus

Notes:

1. Plant pigmentation is the color exhibited by plants when damaged from diseases, insects or chemicals. There are three primary colors: purple, red and tan. Food - type sorghum must have tan pigmentation.

MONSANTO

Monsanto Company, DEKALB Genetics Corporation, Asgrow Seed Company LLC, Hartz Seed Company

FRONTIER Sorghum Seed

F-222E

Matures fast without sacrificing yield. This quick hybrid matures in 90 to 100 days with yields of 4,000 to 7,000 pounds under good conditions. An outstanding specialty hybrid. Dryland or irrigated. 12,000-13,000 seed per lb.

F-303C

This cream hybrid is a top yielding sorghum in the medium maturity range. Excellent standability and threshability. Dryland or irrigated. 12,000-13,000 seed per lb.

F-647E

A full season, high yielding, bronze grain sorghum that can top 10,000 pounds per acre under the right conditions. An excellent irrigated variety. 13,500-14,000 seed per lb.

Agronomic Characteristics

	F-222E	F-303C	F-647E
Days to bloom	50-55	55-59	62-68
Plant height (inches)	38-44	40-46	38-40
Yield for maturity	10	10	10
Yield under stress	10	10	9
Standability	10	10	10
Early vigor	10	10	10
Threshability	9	10	10
Head type (1=comp. 9=open)	4	5	4
Color of grain	RED	CREAM	BRONZE

Color of endosperm	RED	YELLOW	YELLOW
MDMV Resistance	YES	YES	YES
Head smut resistance	YES	YES	YES
Anthracnose resistance	YES	YES	YES
Greenbug resistance	C&E	C	C
Downy mildew resistance	NO	NO	NO

Rating: 10 = excellent   1 = poor

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- [ ] Have a salesperson contact me

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Title ______

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Phone ______

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products

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- **Corn**
- **Soybeans**
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- **Sorghum**
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THE J.C. ROBINSON SEED COMPANY

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Sorghum hybrids

Few seed companies offer a better selection of high-yielding grain sorghum than NC+. Available with Gaucho® and Concep®, many offer genetic resistance to disease and greenbugs. See Our Advice section for grain sorghum articles.

Click on a hybrid number for additional information, or select the Map button for the regional picks in your area.

NC+ 4R48	NC+ 6B67	NC+ 7B47
NC+ 5C35	NC+ 6B70	NC+ 7Y57-K
NC+ 5B74E	NC+ 6C69	NC+ 7W51 (New)
NC+ 5B89 (New)	NC+ 7B29	NC+ 272
NC+ 6B50	NC+ 271	NC+ 573E
NC+ 6C21	NC+ 371	NC+ 7R83
NC+ 262	NC+ 7C49	NC+ 7W97
NC+ 6R30	NC+ 7R37E	NC+ 8R18
NC+ Y363		

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NC+ 7R83

GRAIN SORGHUM PRODUCT PROFILE

Maturity | Yield | Plant Characteristics | Disease/Pest Reaction | Rating System

Hybrid Positioning and Management Considerations

Red - Medium - 72 Days to Mid-Bloom

The sorghum industry yield leader.

- Consistent winner in NGSPA Yield Contest.
- Huge yields under aggressive management.
- Strong yields and standability under dryland conditions.
- Excellent choice where water availability limits high-management corn production.
- Sturdy, robust plants with good head exsertion and excellent uniformity.
- Large seed for accurate planting.
- Exceptional seedling vigor.
- Highly resistant to head smut with very good field tolerance to downy mildew.
- Good stalk quality.

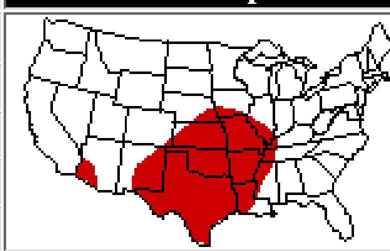
Maturity

Maturity Group	Days to Half Bloom [1]
Medium	72

Yield

For Maturity	Nonirrigated	Irrigated
1	1	1

Area of Adaptation



Plant Characteristics

Grain Color	Seedling Vigor	Drill Culture	Plant Height	Root Development	Standability	Threshability	Head Exertion
Red	1	5	42-51"	2	3	3	2

Head Type[2]	Head Uniformity	Stay Green	DryDown	Test Weight	Post-Freeze Stalk Quality
SC	3	3	3	3	2

Disease and Pest Reaction

Head Smut	Fusarium	MDMV-A	Downy Mildew	Greenbug Biotype Resistance	Sooty Stripe

1	2	3	4	-	2

DEFINITIONS OF TERMS USED TO DESCRIBE NC+ GRAIN SORGHUM HYBRIDS

Standard Rating

A standard nine-point rating system is used unless otherwise indicated. Ratings are based on comparison with other NC+ grain sorghum hybrids of like maturity.
1........................Excellent
9.............................Poor
** = Agronomic data is insufficient to make a rating at this time.
-----

(1) Days to Half Bloom
Days are approximate. Individual hybrid maturities may vary due to sorghum growth characteristics, planting dates, elevation and other environmental conditions.

(2) Head Type
SO = Semi-Open SC = Semi-Compact

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NC+ 7B29

GRAIN SORGHUM PRODUCT PROFILE

Maturity | Yield | Plant Characteristics | Disease/Pest Reaction | Rating System

Hybrid Positioning and Management Considerations

Bronze - Medium - 69 Days to Mid-Bloom

Strong agronomic traits for exceptional performance.

- Consistent NGSPA yield contest winner.
- Good seedling vigor for early stand establishment in minimum-till and no-till.
- Excellent disease package, including tolerance to head smut and pathotype I downy mildew.
- Good field tolerance to iron chlorosis.
- Large seed for uniform planting.
- Good companion to NC+ 7R37E and NC+ 7B47.
- Moderate height with outstanding uniformity; bronze grain on semi-open heads with good test weight and threshability.
- Exceptional post-flowering stress tolerance and standability.

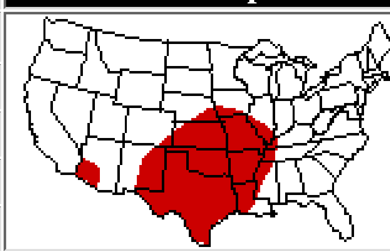
Maturity

Maturity Group	Days to Half Bloom [1]
Medium	69

Yield

For Maturity	Nonirrigated	Irrigated
1	1	2

Area of Adaptation



Plant Characteristics

Grain Color	Seedling Vigor	Drill Culture	Plant Height	Root Development	Standability	Threshability	Head Exertion
Bronze	1	2	39-48"	1	2	3	4

Head Type[2]	Head Uniformity	Stay Green	DryDown	Test Weight	Post-Freeze Stalk Quality
SC	2	2	3	2	1

Disease and Pest Reaction

Head Smut	Fusarium	MDMV-A	Downy Mildew	Greenbug Biotype Resistance	Sooty Stripe

2	2	5	3	-	3

DEFINITIONS OF TERMS USED TO DESCRIBE NC+ GRAIN SORGHUM HYBRIDS

Standard Rating

A standard nine-point rating system is used unless otherwise indicated. Ratings are based on comparison with other NC+ grain sorghum hybrids of like maturity.
1........................Excellent
9.............................Poor
** = Agronomic data is insufficient to make a rating at this time.
-----

(1) Days to Half Bloom
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(2) Head Type
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NC+ 7B47

GRAIN SORGHUM PRODUCT PROFILE

Maturity | Yield | Plant Characteristics | Disease/Pest Reaction | Rating System

Hybrid Positioning and Management Considerations

Bronze - Medium - 70 Days to Mid-Bloom

Top-selling bronze in this maturity.

- Excellent combination of high yield and strong standability.
- Performs well in all but the most severe dryland stress environments, from southern Nebraska to the Rio Grande.
- Very uniform, moderate-height plants.
- Bronze grain with good threshability and very good test-weight.
- Excellent tolerance to pathotype I downy mildew and head smut.

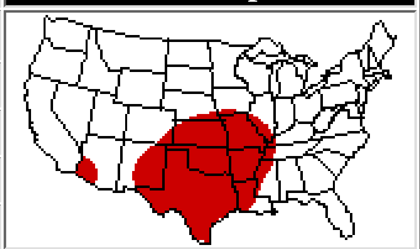
Maturity

Maturity Group	Days to Half Bloom [1]
Medium	70

Yield

For Maturity	Nonirrigated	Irrigated
1	2	2

Area of Adaptation



Plant Characteristics

Grain Color	Seedling Vigor	Drill Culture	Plant Height	Root Development	Standability	Threshability	Head Exsertion
Bronze	1	2	41-49"	2	2	3	4

Head Type[2]	Head Uniformity	Stay Green	DryDown	Test Weight	Post-Freeze Stalk Quality
SO	2	3	3	2	2

Disease and Pest Reaction

Head Smut	Fusarium	MDMV-A	Downy Mildew	Greenbug Biotype Resistance	Sooty Stripe
2	5	4	1	C-E	4

DEFINITIONS OF TERMS USED TO DESCRIBE NC+ GRAIN SORGHUM HYBRIDS

Standard Rating

A standard nine-point rating system is used unless otherwise indicated. Ratings are based on comparison with other NC+ grain sorghum hybrids of like maturity.
1........................Excellent
9.............................Poor
** = Agronomic data is insufficient to make a rating at this time.
-----

(1) Days to Half Bloom
Days are approximate. Individual hybrid maturities may vary due to sorghum growth characteristics, planting dates, elevation and other environmental conditions.

(2) Head Type
SO = Semi-Open SC = Semi-Compact

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NC+ 5B74E

GRAIN SORGHUM PRODUCT PROFILE

Maturity | Yield | Plant Characteristics | Disease/Pest Reaction | Rating System

Hybrid Positioning and Management Considerations

Bronze - Early - 60 Days to Mid-Bloom

High-yielding, 60-day hybrid with excellent post-flower drouth tolerance.

- Sturdy, moderately short plant with excellent uniformity and outstanding stalk quality.
- Takes advantage of early-season moisture and/or limited irrigation; excellent for late-season, high-stress dryland environments.
- Adapts to double-crop after wheat, as well as drill culture.
- Good fusarium head blight tolerance; resistant to pathotype I downy mildew.
- Maturity will lengthen with cooler temperatures, normally associated with higher altitude environments and shorter season areas.

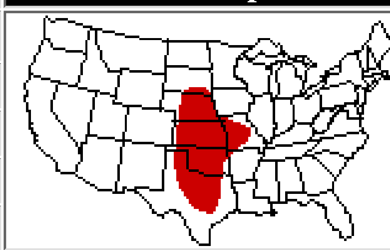
Maturity

Maturity Group	Days to Half Bloom [1]
Early	60

Yield

For Maturity	Nonirrigated	Irrigated
1	1	1

Area of Adaptation



Plant Characteristics

Grain Color	Seedling Vigor	Drill Culture	Plant Height	Root Development	Standability	Threshability	Head Exertion
Bronze	1	1	39-45"	2	2	2	4

Head Type[2]	Head Uniformity	Stay Green	DryDown	Test Weight	Post-Freeze Stalk Quality
SC	2	3	4	2	2

Disease and Pest Reaction

Head Smut	Fusarium	MDMV-A	Downy Mildew	Greenbug Biotype Resistance	Sooty Stripe
2	5	3	2	C-E	4

DEFINITIONS OF TERMS USED TO DESCRIBE NC+ GRAIN SORGHUM HYBRIDS

Standard Rating

A standard nine-point rating system is used unless otherwise indicated. Ratings are based on comparison with other NC+ grain sorghum hybrids of like maturity.
1........................Excellent
9.............................Poor
** = Agronomic data is insufficient to make a rating at this time.
-----

(1) Days to Half Bloom
Days are approximate. Individual hybrid maturities may vary due to sorghum growth characteristics, planting dates, elevation and other environmental conditions.

(2) Head Type
SO = Semi-Open SC = Semi-Compact

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NC+ 6B50

GRAIN SORGHUM PRODUCT PROFILE

Maturity | Yield | Plant Characteristics | Disease/Pest Reaction | Rating System

Hybrid Positioning and Management Considerations

Bronze - Med-Early - 62 Days to Mid-Bloom

#1 selling bronze in this maturity.

- Outstanding yield punch from Nebraska to south Texas; consistent NGSPA yield contest winner.
- Very uniform height, semi-sparse canopy.
- Consistent high yields under dryland conditions; also responds well to limited or full irrigation.
- Good head exsertion under stress.
- Agronomic performance can be maximized at moderate populations.
- Large planting seed with good early vigor.
- Shows tolerance to head smut and resistance to pathotype I downy mildew.

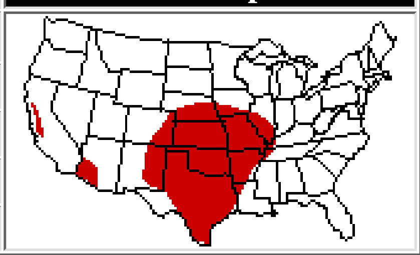
Maturity

Maturity Group	Days to Half Bloom [1]
Med-Early	62

Yield

For Maturity	Nonirrigated	Irrigated
1	1	1

Area of Adaptation



Plant Characteristics

Grain Color	Seedling Vigor	Drill Culture	Plant Height	Root Development	Standability	Threshability	Head Exsertion
Bronze	1	5	36-44"	3	3	3	3

Head Type[2]	Head Uniformity	Stay Green	DryDown	Test Weight	Post-Freeze Stalk Quality
SO	4	4	3	3	3

Disease and Pest Reaction

Head Smut	Fusarium	MDMV-A	Downy Mildew	Greenbug Biotype Resistance	Sooty Stripe
4	4	3	2	-	3

DEFINITIONS OF TERMS USED TO DESCRIBE NC+ GRAIN SORGHUM HYBRIDS

Standard Rating

A standard nine-point rating system is used unless otherwise indicated. Ratings are based on comparison with other NC+ grain sorghum hybrids of like maturity.

1........................Excellent

9.............................Poor

** = Agronomic data is insufficient to make a rating at this time.

-----

(1) Days to Half Bloom

Days are approximate. Individual hybrid maturities may vary due to sorghum growth characteristics, planting dates, elevation and other environmental conditions.

(2) Head Type

SO = Semi-Open SC = Semi-Compact

NC+ 6R30

GRAIN SORGHUM PRODUCT PROFILE

Maturity | Yield | Plant Characteristics | Disease/Pest Reaction | Rating System

Hybrid Positioning and Management Considerations

Red - Med-Early - 63 Days to Mid-Bloom

Good-looking red hybrid with excellent standability.

- One day later than NC+ 6B50 — excellent companion hybrid.
- Outstanding seedling vigor and stand establishment for early planting, no-till and heavy trash situations.
- Ranks near the top for standability.
- Strong stalks hold together under extreme post-flowering stress.
- Moderate height and good uniformity. Large, bright red berries on semi-open heads.
- Excellent canopy and standability for high populations and drill cultures.

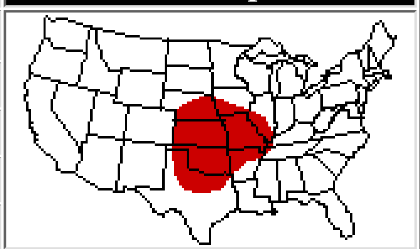
Maturity

Maturity Group	Days to Half Bloom [1]
Med-Early	63

Yield

For Maturity	Nonirrigated	Irrigated
2	1	2

Area of Adaptation



Plant Characteristics

Grain Color	Seedling Vigor	Drill Culture	Plant Height	Root Development	Standability	Threshability	Head Exsertion
Red	1	1	36-45"	2	1	3	4

Head Type[2]	Head Uniformity	Stay Green	DryDown	Test Weight	Post-Freeze Stalk Quality
SO	2	3	3	2	2

Disease and Pest Reaction

Head Smut	Fusarium	MDMV-A	Downy Mildew	Greenbug Biotype Resistance	Sooty Stripe
3	3	**	2	-	3

DEFINITIONS OF TERMS USED TO DESCRIBE NC+ GRAIN SORGHUM HYBRIDS

Standard Rating

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1........................Excellent
9.............................Poor
** = Agronomic data is insufficient to make a rating at this time.
-----

(1) Days to Half Bloom
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(2) Head Type
SO = Semi-Open SC = Semi-Compact

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NC+ 6B67

GRAIN SORGHUM PRODUCT PROFILE

Maturity | Yield | Plant Characteristics | Disease/Pest Reaction | Rating System

Hybrid Positioning and Management Considerations

Bronze - Med-Early - 64 Days to Mid-Bloom

The cornerpost of standability.

- Stable performer in a wide range of nonirrigated environments.
- Outstanding adaptation to all soil types, including low- and high-pH.
- Excellent companion to NC+ 6B50.
- Strong post-flower drouth tolerance; excellent adaptation to limited irrigation.
- Large seed for uniform planting; good seedling vigor for early planting, no-till and drill culture.
- Shows superior tolerance to herbicide carryover, when compared to other NC+ hybrids in NC+ herbicide sensitivity trials.

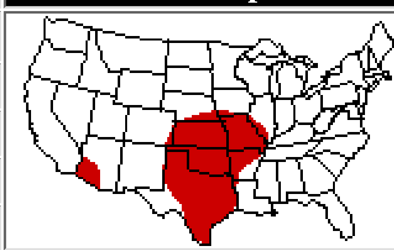
Maturity

Maturity Group	Days to Half Bloom [1]
Med-Early	64

Yield

For Maturity	Nonirrigated	Irrigated
3	2	3

Area of Adaptation



Plant Characteristics

Grain Color	Seedling Vigor	Drill Culture	Plant Height	Root Development	Standability	Threshability	Head Exertion
Bronze	1	1	39-46"	2	1	3	4

Head Type[2]	Head Uniformity	Stay Green	DryDown	Test Weight	Post-Freeze Stalk Quality
SO	3	3	2	4	2

Disease and Pest Reaction

Head Smut	Fusarium	MDMV-A	Downy Mildew	Greenbug Biotype Resistance	Sooty Stripe
3	4	5	1	C	4

DEFINITIONS OF TERMS USED TO DESCRIBE NC+ GRAIN SORGHUM HYBRIDS

Standard Rating

A standard nine-point rating system is used unless otherwise indicated. Ratings are based on comparison with other NC+ grain sorghum hybrids of like maturity.
1.......................Excellent
9............................Poor
** = Agronomic data is insufficient to make a rating at this time.
-----

(1) Days to Half Bloom
Days are approximate. Individual hybrid maturities may vary due to sorghum growth characteristics, planting dates, elevation and other environmental conditions.

(2) Head Type
SO = Semi-Open SC = Semi-Compact

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Sorghum Partners, Inc.

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KS 310

SORGHUM PARTNERS™ TECHNICAL INFORMATION

Hybrid Grain Sorghum — High Plains 2001-2002

Key Positioning / Benefits

Ö Higher Yield than 1210 & 2030

Ö For Western High Plains & Great Plains

Ö Good Choice for Shorter Growing Seasons

Ö Very Good for Doublecrop & Late Planting

Ö Improved Standability over 1210

Ö Very Good Drought Tolerance for Consistance Performance

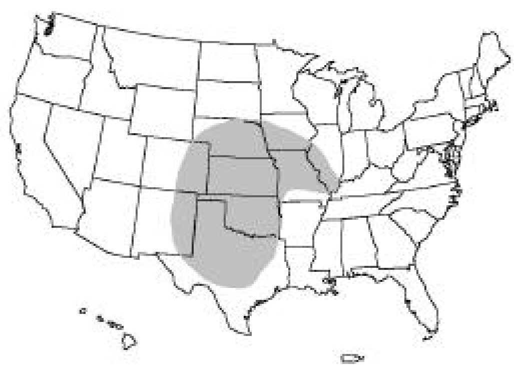
Ö No Delay in Maturity at Higher Elevations

Ö Very Good Threshability for Easier Harvest

Relative Maturity (RM)

Relative Maturity	Early
Avg. Days to 50% Bloom	55-61
Avg. Days Compared to:	251 +5

Area of Adaptation



Planting Rate Guide / Acre

	Environments		
	Stress	**Favorable**	**Irrigated**
Seeds (X1000)	45-60	60-100	100-150
Lbs.	4-5	5-8	8-12

Positioning / Management

KS 310 is higher yielding than 1210 and 2030 in adapted areas. It is well-suited where an early maturity is needed for shorter growing areas in the sorghum growing areas in the western High Plains. Also very good for doublecrop after wheat, late planting, and replant. KS 310 has improved plant health with better standability than 1210. In addition, very good drought tolerance through the vegetative and grainfill stages helps this hybrid provide more consistent performance. There is no delay in maturity at higher elevations and with cooler temperatures. Above average head exsertion and very good threshability allow easier harvest.

Agronomic Traits[1]

Yield for Maturity		1
Yield Stability		2
Standability		3
Drought Tolerance		3
Threshability		3
Avg. Seed Size/Lb.	(X1000)	12-14

Descriptive Characteristics

Relative Height	Medium
Head Exsertion	5-7"
Head Type	Semi-Open
Harvest Grain Color	Bronze
Endosperm	Hetero-Yellow

Disease Resistance[2]

MDMV Tolerance	4
Downy Mildew:	
Pathotype 1	R
Pathotype 3	S
Head Smut	5

Insect Resistance[3]

Greenbug:	
Biotype C	R
Biotype E	R
Biotype I	S

Competitive Reference

	SORGHUM PARTNERS	DeKalb Genetics	Pioneer Brand
Earlier Maturing Products			
KS 310	251 KS 310	DK18 DK27 DK28E	8855 87G57 8950 8925 8875
Later Maturing Products	K35-Y5 1486 2030 1580	DK35 DK36 DK39Y	8699 86G71 8601

Footnotes

1 - Numerical Rating: 1 to 9 (1 = Excellent, 5 = Average, 9 = Poor)

2 - Disease Rating: 1 to 9 (1 = Highly Resistant, 4 & 5 = Moderate Resistance, 9 = Highly Susceptible)

Downy Mildew, Anthracnose: R = Resistant, S = Susceptible

3 - Insect Rating: R = Resistant, S = Susceptible

* = Limited Information / Data

Ratings and descriptions are based on research and field observations compared with NK® Brand products from multiple locations and years.

KS 585

SORGHUM PARTNERS™ TECHNICAL INFORMATION

Hybrid Grain Sorghum | High Plains 2001-2002

Key Positioning / Benefits

Ö High Yield with More Consistency

Ö Favorable to Stress Environments

Ö For the Great Plains, Midwest & Mid-South

Ö Very Good Early Growth in Cooler Soils

Ö Better Standability & Uniformity than 2656

Ö Very Good Drought Tolerance

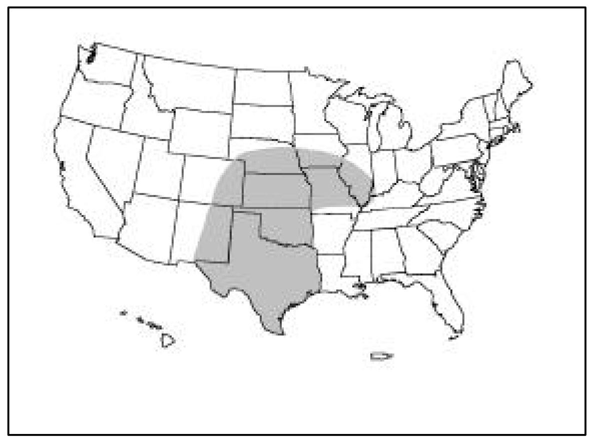
Ö Easy Harvesting, Very Good Threshability

Ö Excellent Compliment with KS 710

Relative Maturity (RM)

Relative Maturity	Medium
Avg. Days to 50% Bloom	65-69
Avg. Days Compared to:	KS 555Y -1

Area of Adaptation



Planting Rate Guide / Acre

	Environments		
	Stress	**Favorable**	**Irrigated**
Seeds (X1000)	45-60	60-100	100-150
Lbs.	4-5	5-8	8-12

Positioning / Management

KS 585 is a very high yielding medium maturing grain hybrid supported by a strong agronomic package. It provides very good yield stability over a wide range of conditions with favorable to more limited moisture. It is very well adapted for sorghum growing areas in the High Plains. This hybrid has better early growth in cooler soils than most grain sorghums. It is medium in height with improved standability and field uniformity over 2656. Very good drought tolerance, particularly in the vegetative growth stage which helps KS 585 to withstand stress better and provide more consistent performance. Above average head exsertion and very good threshability, helps to maximize easier harvesting.

Agronomic Traits[1]

Yield for Maturity		1
Yield Stability		2
Standability		3
Drought Tolerance		3
Threshability		3
Avg. Seed Size/Lb.	(X1000)	12-14

Descriptive Characteristics

Relative Height	Medium
Head Exsertion	5-7"
Head Type	Semi-Open
Harvest Grain Color	Bronze
Endosperm	Hetero-Yellow

Disease Resistance[2]

MDMV Tolerance	4
Downy Mildew:	
Pathotype 1	R
Pathotype 3	S
Head Smut	5

Competitive Reference

	SORGHUM PARTNERS	DeKalb Genetics	Pioneer Brand
Earlier Maturing Products	K35-Y5 1486 2030 1580	DK35 DK36 DK39Y	8699 86G71 8601
KS 585	K59-Y2 KS 585 KS 524 KS 555Y KS 560Y	DK40Y DK41Y DK44 DK45 DK47	85Y34 85G85 85G55 8522Y 8505 8500 8414
Later Maturing Products	K73-J6 KS 711Y KS710 KS 735 1606	DK54 DK55 DK56	84G62 83G66 8313 8310 8212Y 8282

Insect Resistance[3]

Greenbug:	
Biotype C	R
Biotype E	R
Biotype I	S

Footnotes

1 - Numerical Rating: 1 to 9 (1 = Excellent, 5 = Average, 9 = Poor)

2 - Disease Rating: 1 to 9 (1 = Highly Resistant, 4 & 5 = Moderate Resistance, 9 = Highly Susceptible)

Downy Mildew, Anthracnose: R = Resistant, S = Susceptible

3 - Insect Rating: R = Resistant, S = Susceptible

* = Limited Information / Data

Ratings and descriptions are based on research and field observations compared with NK® Brand products from multiple locations and years.

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PRODUCT INFORMATION

84G62

Excellent yields in a wide area of adaptation. Very good stalk and root strength with dependable test weight. Highly resistant to biotype "E" greenbug. Avoid planting in areas where MDMV or pathotype 3 downy mildew are concerns.

For additional information about this product, register with the Pioneer GrowingPoint(sm) Web site.

	HIGH PLAINS & KANSAS CRM	SOUTH TEXAS & DELTA CRM	RM	YIELD FOR MATURITY	YIELD UNDER STRESS	DRYDOWN	STALK STRENGTH	ROOT STRENGTH	POST FREEZE LODGING	HEAD EXSERTION	HEIGHT UNIFORMITY	STAYGREEN	TEST WEIGHT	GREENBUG BIOTYPE E	GREENBUG BIOTYPE I	PLANT HEIGHT (FEET)	GRAIN COLOR
84G62	118-122	122-128	72	9	7	5	7	7	8	5	7	6	7	9	1		BRZ

RATINGS: 9 = Excellent; 1 = Poor; Blank = Insufficient data.

Footnotes (not all traits have footnotes)

Ratings based on period-of-years testing through 2001 harvest and were the latest available at time of printing. Some scores may change after 2002 harvest. Contact your Pioneer sales professional before planting for the latest trait rating information.

RATINGS: 9 = Excellent; 1 = Poor; Blank = Insufficient Data.

IMPORTANT: Ratings based on comparison with other Pioneer® hybrids, not competitive hybrids. Ratings are assigned from research and data over a wide range of both climate and soil types, based on average performance across area of adaptation under normal conditions. Extreme conditions may adversely affect performance. Consult your local Pioneer sales rep/dealer for specific product information in your area.

DISEASE PRECAUTION: Grower should balance hybrid yield potential, hybrid maturity and cultural practice selection against their anticipated risk of a specific disease and need for resistance. In high disease risk conditions, consider planting hybrids with at least moderate resistance ratings of 4 or higher to help reduce risk. When susceptible hybrids with disease ratings of 1 to 3 are planted in conditions of high disease pressure, the grower assumes a higher level of risk. If conditions are severe, even hybrids rated as resistant can be adversely affected. Independent of yield reduction, diseases can predispose plants to secondary diseases such as stalk rots. This requires individual field and hybrid monitoring for stalk stability and timely harvest when warranted.

DISEASE & PEST RATINGS: 8-9 = Highly Resistant; 6-7 = Resistant; 4-5 = Moderately Resistant; 1-3 = Susceptible; Blank = Insufficient Data.

Selected Pioneer® brand grain sorghum hybrids are available with Concep safened seed. Concep is a registered trademark of Syngenta. Gaucho seed treatment is available on select Pioneer® brand grain sorghum hybrids. Gaucho is a registered trademark of Bayer AG, Germany.

GRAIN COLOR: BRZ = Bronze; BWN = Brown; N/A = Non-grain Bearing; RED = RED; RB = Red-brown; WHT = White; YEL = Yellow. Grain color has no influence on feed quality.

CRM [COMPARATIVE RELATIVE MATURITY]: Approximate length of time from emergence to physiological maturity, which will vary depending on planting date, environment and growing conditions.

RM (RELATIVE MATURITY): Approximate length of time in days until flowering.

CRM [COMPARATIVE RELATIVE MATURITY]: Approximate length of time from emergence to physiological maturity, which will vary depending on planting date, environment and growing conditions.

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PRODUCT INFORMATION

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8500

Excellent yields in ideal conditions and under prolonged stress. Good head exsertion. Relatively uniform in height. Avoid planting in fields where downy mildew, greenbugs and anthracnose are concerns.

For additional information about this product, register with the Pioneer GrowingPoint(sm) Web site.

	HIGH PLAINS & KANSAS CRM	SOUTH TEXAS & DELTA CRM	RM	YIELD FOR MATURITY	YIELD UNDER STRESS	DRYDOWN	STALK STRENGTH	ROOT STRENGTH	POST FREEZE LODGING	HEAD EXSERTION	HEIGHT UNIFORMITY	STAYGREEN	TEST WEIGHT	GREENBUG BIOTYPE E	GREENBUG BIOTYPE I	PLANT HEIGHT (FEET)	GRAIN COLOR
8500	110	110	68	8	8	8	6	6	7	6	6	5	7	3	1		RED

RATINGS: 9 = Excellent; 1 = Poor; Blank = Insufficient data.

Footnotes (not all traits have footnotes)

Ratings based on period-of-years testing through 2001 harvest and were the latest available at time of printing. Some scores may change after 2002 harvest. Contact your Pioneer sales professional before planting for the latest trait rating information.

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Richardson Seeds, Inc. is also headquarters for MMR Genetics, LLC, a premier sorghum breeding/research company.

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- Hybrid Sorghum x Sudan
  Foundation Sorghum Seed

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Some sorghum companies are too small while others are way too big. Triumph is just small enough to respond to your individual needs, yet large enough to produce seed on the cutting edge of performance and technology. All Triumph grain sorghum hybrids are carefully evaluated and are held to strict quality and production standards, to ensure that you will be satisfied with our products. All Triumph grain sorghum hybrids are available with Concep and Gaucho seed treatments.

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TR 432 "82-92days"

Our fastest bronze hybrid with outstanding yield potential!

* Quick, vigorous emergence in adverse conditions
* Great performance on dryland and double cropping
* Moderate resistance to smut and good drought tolerance

TR 438 "90-100 days"

Reliably high yields and good grain quality

* Good grain weatherability
* Performs well on dryland or irrigated lands
* Moderate resistance to head smut

TR 461 "95-105 days"

Semi-open head with excellent eye appeal

* Red seed with excellent yield potential
* Resistant to biotypes C and E greenbugs
* Great uniformity

TR 465 "96-106 days" New

Resistant to biotypes C, E and I Greenbugs

* Solid yielding bronze
* Semi-open head type
* Moderately resistant to head smut

TR 459 "100-110 days"

Performs great under stress with super standability

TR 462 "102-112 days"

Proven performer on tighter soils and excellent plant health

* Red hybrid with excellent uniformity and health
* Good yields for maturity
* Resistant to biotypes C and E greenbugs

TR 464 "105-115 days"

Big yielding bronze hybrid with great eye appeal

* Open head
* Stands well under stress
* Good drought tolerance and plant health

TR 65-G "105-115 days"

Exceptional yields in dryland or irrigated conditions

* Versatile, medium-maturity red grain
* Hard seed coat with good weatherability
* Resistant to biotypes C and E greenbugs

TR 481 "110-120 days"

Superior standability and head smut resistance

* Medium late, red grain with very good yield potential
* Performs well under dryland or

* Excellent standability on dryland and under irrigation
* Widely adaptable
* Ideal for narrow-row plantings

irrigated conditions
* Adapts to almost all soil types

TR 82-G "115-125 days"

Full season, red with tremendous yield potential
* Performs best under high fertilization
* Resistant to biotypes C and E greenbugs
* Provides excellent yields

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Product Descriptions

Warner grain sorghum seed is grown in the best locations of the irrigated High Plains, a very desirable production area. The seed is processed in a modern plant with strict and constant attention to quality control. Warner Seeds has an extensive and ongoing research program and enters many State field trials to test the performance of Warner sorghum hybrids. The following is a list of Warner grain sorghums available with comparative descriptions, physiological-environmental responses, varieties suggested for growing in various areas and a planting rate guide. We would be glad to consult with you regarding your particular sorghum needs. And, we invite you to visit our seed operation at Hereford.

W-494

A new early maturity grain sorghum hybrid with deep red-colored grain. W-494 has a short, stiff stalk for excellent standability under the worst conditions. W-494 has outstanding yield potential for its maturity class. We recommend this hybrid for double cropping situations or late planting.

W-528-W

Short Uniform Plant Height | Medium Early Maturity | Cream-Colored Grain

A hot new hot release. W-528-W is a medium early, cream-colored hybrid with excellent performance results. With all of the same outstanding characteristics as W-632-W and being 7-10 days earlier, W-528-W is an excellent choice for dryland and late planting situations. W-528-W is extremely uniform and has very strong plant health and standability.

W-560-T

A medium-early maturing hetero-yellow endosperm hybrid with tolerance to biotype "C" greenbug. It is an extremely uniform hybrid with good standability and threshability. Because of its uniformity and showy semi-open head, it is a real eye opener. W-560-T has an excellent yield record for its maturity class. It is especially adapted for late season planting where a bin-busting yield is wanted.

NEW! W-588-Y

Medium Early | Yield Performance with Standability | Excellent Dryland Choice

W-588-Y is a high-yielding, medium-early grain sorghum with outstanding staygreen. It is a hybrid that will give you top end yields across a wide range of soil types and excellent standability. A very uniform, open-headed hybrid. A"Super Showy" hybrid.

NEW! W-614-W

A Cream-Colored Hybrid | Excellent Standability | Open-Headed, Showy

A new medium maturing grain hybrid sorghum with an outstanding yield performance under most environmental conditions. This hybrid has the same high level of digestibility and conversion as our older W-632-W. This will be our replacement for the longtime high-yielding W-632-W. This hybrid should be your choice if you need a high yielding showy versatile hybrid.

NEW! W-622-E

A new hybrid released by us that we feel is going to make a big impression on the medium season hybrid market. Add to this biotype E and earliness and you have an early replacement for W-844-E or W-644-E.

NEW! W-614-W

A Cream-Colored Hybrid | Excellent Standability | Open-Headed, Showy

A new medium maturing grain hybrid sorghum with an outstanding yield performance under most environmental conditions. This hybrid has the same high level of digestibility and conversion as our older W-632-W. This will be our replacement for the longtime high-yielding W-632-W. This hybrid should be your choice if you need a high yielding showy versatile hybrid.

W-624-Y

High Yield Under Stress | Untouchable Standability | Medium Maturity

W-624-Y is a pure yellow hybrid with excellent drought tolerance. W-624-Y has strong staygreen qualities which give you a flexible stalk and outstanding standability. With strong germ and early vigor, we recommend this hybrid for dryland or marginal irrigation. W-624-Y has been the top performer in Eastern New Mexico dryland and higher altitude areas.

W-625-Y

Excellent Yield Under Stress | Stands When Others Fall | Strong Staygreen Qualities

W-625-Y is a medium maturity hybrid, which was new for the 1991 season. W-625-Y has a deep yellow colored grain with high test weights. With good disease resistance, excellent standability, and outstanding performance under stress. W-625-Y is proving its potential under conditions where others fall apart.

W-632-W

A Cream-Colored Beauty | Higher Level of Digestibility | Excellent Standability

A medium-plus maturing cream-colored hybrid grain sorghum with excellent performance under all environmental conditions. With a higher level of digestibility and conversion, W-632-W makes an excellent choice for livestock feeding operations. With years of proven superiority among the cream hybrids available, W-632-W is the only choice for farmers needing a versatile hybrid of medium plus maturity.

W-644-E

Biotype C & E Greenbug | Resistance Excellent | Medium-Early Hybrid | Dark, Red-Colored Grain

W-644-E is a medium-early maturing dark red-color hybrid that has a great deal of eye appeal and good yield potential. W-644-E is a very uniform hybrid with biotype C & E tolerance. This will be a good backup as an early alternate hybrid to W-844-E. This hybrid has a semi compact head type, but threshes easily.

W-644-T

A medium maturing hetero-yellow grain hybrid that is related to W-655-T, but is slightly shorter. W-664-T retains that high yielding potential. It has excellent eye appeal and stands where others lodge. It does very well on dryland or late planted irrigated. Use this hybrid for genetic variability.

W-816-E

Biotype C & E Greenbug Resistance | Intense Red-Colored Grain | Excellent Yield Performance

W-816-E was released in limited quantities in 1992 and the response from those growers who planted the hybrid was unanimous: Excellent! W-816-E is a medium-plus maturity hybrid grain sorghum with outstanding eye appeal and yield potential. W-816-E has superb cold soil emergence, high test weights and will have a plant height about 6-8" shorter than W-917-E.

W-818-E

HStrong Biotype C & E Greenbug Resistance | Strong Healthy Plants | Good Exertion Under Stress

W-818-E is a new hybrid grain sorghum. W-818-E is medium-plus in maturity and has an intense orange-colored grain. With excellent stress tolerance and a high level of tolerance to charcoal rot, W-818-E is a top performer under dry conditions. With strong staygreen characteristics, outstanding standability and high top end yield capability, W-818-E fits into a wide variety of farming operations.

W-839-DR

A medium-plus, hetero-yellow endosperm hybrid with red seed coat, this is highly tolerant to downy mildew pathotype 1 & 2, maize dwarf mosaic virus, sorghum head smut (not race 4) and anthracnose. W-839-DR is adapted to natural rainfall or irrigated areas where these diseases are often prevalent. It has excellent combine height and good exertion with semi-compact head that is easily threshed.

W-844-E

A medium-plus, red-seeded endosperm hybrid that has biotype "E" greenbug tolerance added to its strong disease resistance as well as tolerance to biotype "C" greenbug. Standability is excellent even though it is slightly taller than W-839-DR orW-839-A.This hybrid is easily threshed. Head exertion is excellent and is better than either W-839-DR or W-839A. This hybrid is very "showy" with a deep red color and has an increased potential to outyield most others in its class. W-844-E also has very good drought tolerance for a hybrid in this maturity class.

W-858-E

Biotype C & E Greenburg Resistance | Outstanding Yield Performance | Good Test Weights

A medium plus maturity red seeded hybrid with biotype C&E Greenbug tolerance as well as excellent tolerance to anthracnose downy mildew and head smut. This hybrid has an outstanding yield performance where conditions are good with adequate moisture. This hybrid should not be planted under stress conditions for best results.

W-876-DR

A medium-plus to full-season, hetero-yellow endosperm hybrid with high foliar disease resistance as well as tolerance of chemical burn, W-876-DR is a uniform hybrid with a strong stalk, semi-open head and very good exertion. A superior yielder compared with any hybrid in its maturity class. W-876-DR has tolerance to pathotype 1, 2, and 3 of Downy Mildew.

W-902-W

Food Grade Quality Grain | Potential to Neat Any Hybrid on the Market | Full Season Maturity

W-902-W is a full season white colored hybrid with outstanding grain quality. Combining a strong healthy plant with excellent standability. W-902-W has the potential to outyield any other hybrid on the market, and give you a highly desirable food quality grain. Recommended for irrigated and medium to higher rainfall areas when you are shooting for maximum production.

W-917-E

Tremendous Yield Performance | Excellent Grain Quality | High Test Weights

W-917-E is a medium-plus season hybrid grain sorghum with intense red colored grain, and strong tolerance to both biotype C & E Greenbugs. With quick, cold soil emergence, excellent grain quality and strong healthy plants, W-917-E will give you the maximum yield possible.

W-965-E

Biotype C & E Greenbug Resistance | Outstanding Yield Performance | Very Showy Uniform Hybrid

A medium-plus red seeded endosperm hybrid that is biotype "C" & "E" greenbug tolerance as well as outstanding disease resistance. It has improved standability over W-844-E. It has good head exertion and threshes easily. This hybrid has good drought tolerance and has shown to have an increased yield over most of its competitors.

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Maintained by the Web Site Design Team

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Thank you very much Linda Anderson lifestyle writer/Extension communications specialist Texas Cooperative Extension Texas A&M University (979) 862-1460

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A Glimpse Back, A Look Forward, Celebrating 10 years -- College Station, Texas

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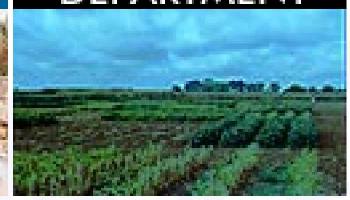

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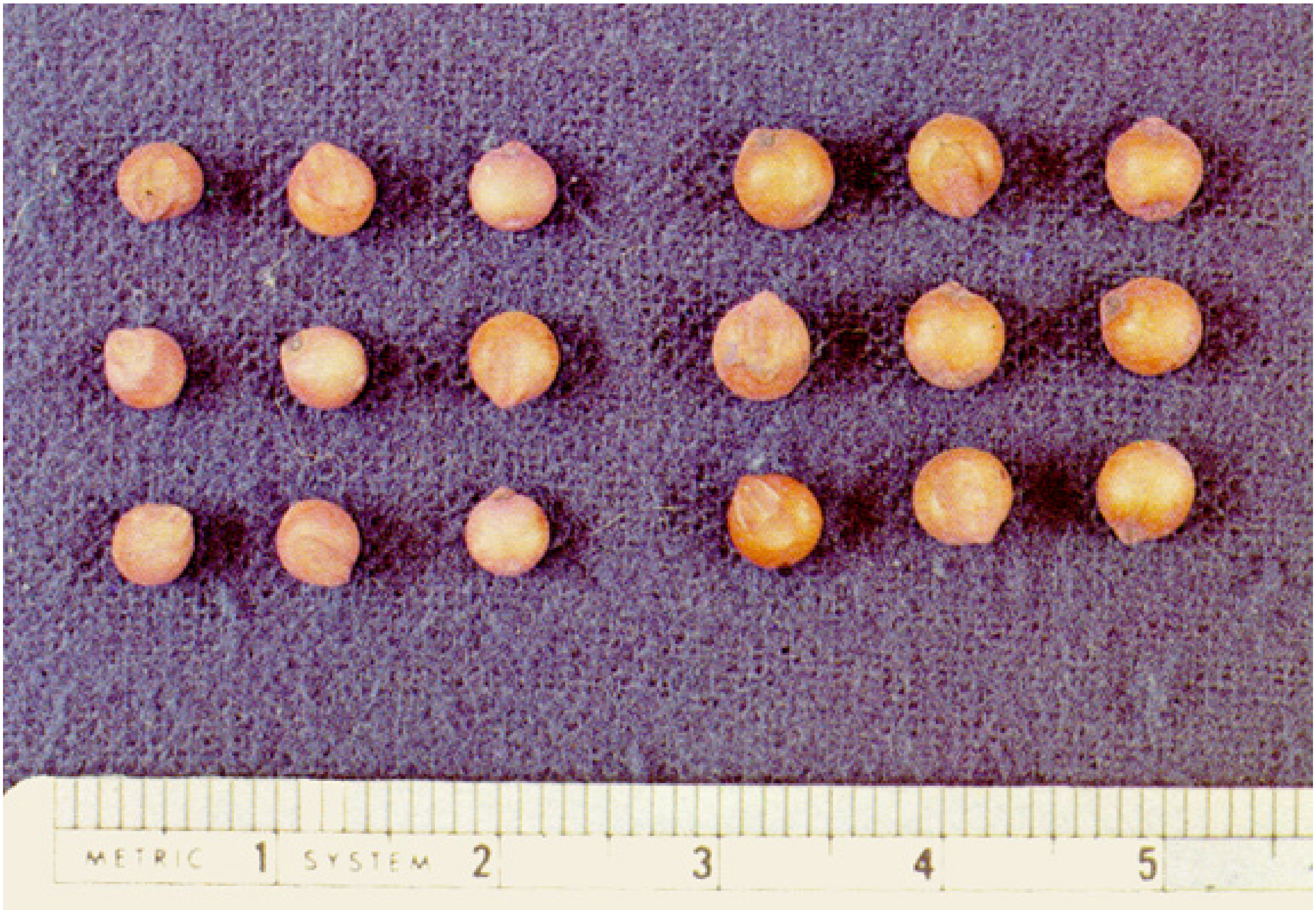
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L-5155

Correcting Iron Deficiencies in Grain Sorghum

S. D. Livingston, C. G. Coffman, and L. G. Unruh*

Understanding the Problem

Until grain sorghum develops an extensive root system, young plants may not be able to obtain enough ferrous iron to maintain normal growth on some Texas soils. Although iron is not a part of the chlorophyll molecule, it is required to supply enough chlorophyll to support the growth of new leaf tissue.

High-pH, calcareous soils not only reduce the availability of soluble iron in the soil; they also change the soil's cation-exchange capacity so that less iron is present and available for exchange overall. The result is a more slowly growing plant and subsequent uneven flowering dates. This not only delays ripening of grain and harvest, but the uneven pollination undermines an effective insecticide spray program for controlling sorghum midge. The distribution of soils having a potential for iron chlorosis is shown in Figure 1.

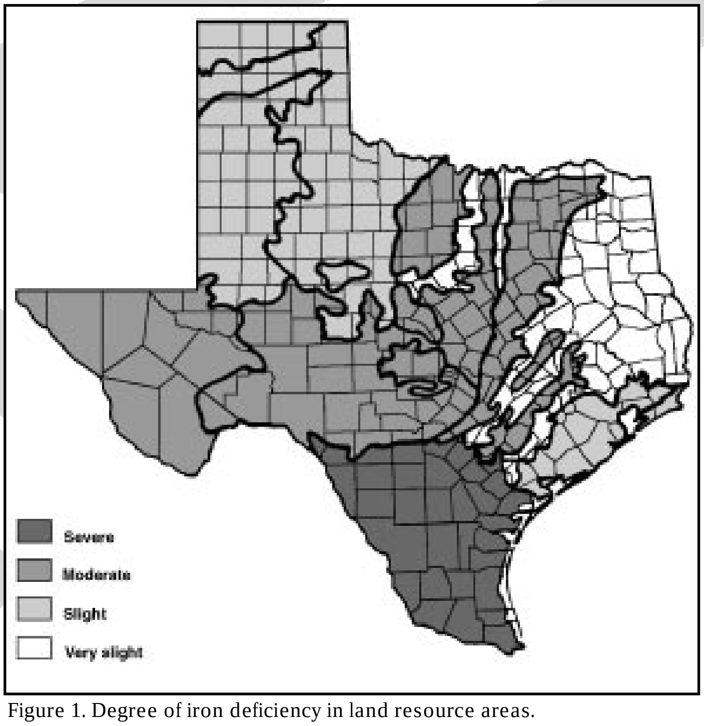

Figure 1. Degree of iron deficiency in land resource areas.

Visual Symptoms

Mild chlorosis ranges from a lighter green leaf color that progresses to increasing interveinal striping, to almost no visual symptoms. New leaves may appear normal as the sorghum outgrows the deficiency. In some cases, the rate of growth may be so close to normal that no difference in flowering date is observed; while in other deficient plants treated sorghum may flower 2 to 3 days earlier than untreated plants.

Moderate chlorosis is seen where sorghum plants are yellow or yellow-green in strips, or irregularly shaped areas of the field. Fields may have intermittent blotches of chlorotic plants scattered in a salt-and-pepper (random) arrangement. Iron chlorosis is often sporadic throughout the field, or it may be associated with some land-moving event. Often the higher ground in a field will exhibit greater chlorosis, while terracing and land leveling may also result in new chlorotic zones. Since available ferrous iron is responsible for this anomaly, both pH change and available soil moisture influence the iron concentration in soil solution. If not treated with ferrous sulfate, some hybrids may yield less grain. Losses result from both uneven midge control and lost yield potential.

Severe chlorosis occurs when tissue develops a very pale yellow to almost white coloration. Some hybrids are more sensitive than others. Leaves of affected plants are thinner and narrower and tend to injure more easily. Shallow, calcareous outcrops; sandy lenses of high-pH soil (8.0+); and shells of land snails are usually associated with these sites. By the time severe chlorosis is observed, it may already be too late to restore even-flowering dates, or to escape

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some yield reductions. The earlier the treatments are made, the greater the effect of the applications. Treatments with ferrous sulfate could result in yield differences of 800 to 2,000 pounds per acre with some chlorosis-sensitive hybrids. Severe chlorosis may kill young sorghum plants or cause stunting so severe that flowering is prevented.

Diagnosis of Problem

Visual symptoms are often the best indicator of whether or not to treat chlorotic fields or parts of fields for iron chlorosis. A simple test area treated with an application of soluble iron in a hand sprayer is sufficient.

One of the simplest methods for confirming iron deficiency is to apply a 1- to 2$^1/_2$-percent solution of iron sulfate (copperas) on some chlorotic leaves. This solution may be prepared by dissolving 1 tablespoonful of iron sulfate and $^1/_2$ teaspoonful of detergent in 1 gallon of water. Apply the solution by spraying, dipping individual leaves in the solution, or painting a portion of the chlorotic leaf.

If the chlorosis is caused by iron deficiency, a darker green color should be noticeable on treated plants in 4 to 7 days under favorable growing conditions. Young or recently matured leaves should be used for this test since old, severely chlorotic leaves tend to lack the ability to form chlorophyll, even when supplied with iron.

Correcting Iron Deficiency

Several products are available for field use to correct iron chlorosis. While a number of attempts have been made with iron-containing slags and acidic byproducts to supply iron to the soil, these have never proven effective because of an almost immediate oxidation of the soluble ferrous iron, converting it to the less-soluble ferric state.

Attempts to correct iron deficiency by applying acidifying materials to calcareous soils generally have not been successful or practical on a field basis because of the large amount of acidifying material required. For example, it would take 5 tons of sulfuric acid per acre to neutralize 1 percent calcium carbonate in a 6-inch layer of soil. Many iron-deficient soils contain as much as 10 percent free calcium carbonate, which represents 50 tons of sulfuric acid. If elemental sulfur were used, it would require one-third that amount to give the equivalent acidifying effect. Products of acidifying reactions may greatly increase soil salinity. Localized acidification through banding or using pelleted sulfur has been successful in some situations.

For the past several decades, producers have had to rely on foliar amendments to place available iron into the plant. If early deficiency symptoms are observed or occur every year on certain fields, banded foliar treatments should begin as early as sufficient leaf area is present to intercept the material used. This is usually 10 to 14 days after the sorghum has emerged. A common mistake is not starting ferrous applications soon enough and then failing to follow-up with subsequent needed applications.

A spray solution can be prepared using 20 pounds of iron sulfate (copperas) in 100 gallons of water, plus a spreader sticker, and spraying the solution over the crop row at 5 gallons per acre (10 to 14 days after emergence). After the first treatment, products should be applied as required at 7 to 10 day intervals using the same solution concentration, but increasing application rates to 10 to 15 gallons per acre.

Potential for Damage

If sorghum is under stress, foliar applications of ferrous sulfate can result in a net yield reduction. Applications made early in the morning or late in the afternoon may reduce risks, but ferrous applications in hot, dry weather may only aggravate an already failing yield potential. This is more likely to occur on plants that really had no need for additional iron. Some iron-chlorosis-tolerant hybrids have been observed to produce less grain when normal plants were sprayed with chlorotic ones. Because entire sorghum fields seldom require iron applications, some producers have installed solenoid valves with a pressure switch to selectively apply ferrous iron while cultivating.

Iron sprays require a spreader-sticker or detergent in order to be effective. If a commercial spreader-sticker is not available, ordinary household detergent may be used at rates of $^1/_4$ to $^1/_2$ pint per 50 gallons of solution. Thorough coverage and wetting of the entire leaf surface is necessary for good results. Avoid too much detergent to minimize the chances of leaf burn.

Yield reductions can also occur if foliar iron is sprayed directly onto large sorghum as the heads are exposed. Application should be discontinued when the sorghum plants reach boot stage. Flowering parts of any exposed heads will be damaged if the iron product is applied at this time.

Other Conditions Causing Chlorosis

Large phosphorus corrections banded next to the seed row may also intensify iron deficiencies. Since iron phosphate is one of the less-soluble phosphates, already low levels of iron in soil solution may become worse during dry, wet, or cold weather when root uptake is less or root systems are damaged. If phosphorus applications greater than 30 pounds per acre are planned on potentially chlorotic fields, growers should be prepared to apply foliar iron as required.

Formulations Available

Dry ferrous products have a long shelf life so long as they are stored properly. Copperas is the least expensive form of ferrous sulfate, but contains sand and impurities that must be filtered. Otherwise, copperas is very abrasive to nozzles. Vitatone is a dry product containing 3 percent ammoniacal N and 1 percent chelated iron from ferrous sulfate and citric acid. It is slightly more expensive than the copperas. PenGreen iron is a highly soluble, 5 percent iron sulfate that is easy to handle and requires no agitation. PenGreen II contain an addition of 3 percent N.

Several manufacturers of foliar products have constructed iron materials that also contain nitrogen, phosphorous, zinc, magnesium, and manganese, as well as other micronutrients. These additions are usually not recommended by soil or tissue test, and while they do not injure the sorghum and may be needed occasionally, they may increase product cost.

Since nitrogen can also effect plant color, urea-based nitrogen may also be added. This small nitrogen addition is useful in that it corrects chlorosis that might have been due to low N levels. Iron reactions will be observed as dark green blotches on leaves where spray droplets fell.

Except on low-fertility or sandy soils, the addition of micronutrients may neither help nor hurt sorghum, but provide insurance against possible deficiencies. The manganese is particularly prone to precipitate from solution with time. Unless the overall pH of the product is kept low enough to maintain solubility, settling occurs to where shelf life seldom spans more than two growing seasons. The pH and salt content of the amendment has much to do with its potential for foliar burn and subsequent leaf damage.

In selecting foliar iron products, consider product efficacy, safety from leaf burn, cost, ease of application, and shelf life.

Product	Rate Per Acre	Form	Agitation Required
Copperas	4-5 lb.	dry, coarse	yes
Vitatone	1.5-3 lb.	dry, fine	yes
Chelate	1-2 lb.	dry, fine	yes
PenGreen	3-6 qt.	liquid	no

Using Chlorosis-Tolerant Hybrids

Over the last several years, grain producers, universities, and seed companies have been observing advantages in selecting certain sorghum hybrids for planting on high pH soils along the Texas Gulf Coast. On the worst of soils, chlorosis continued to be expressed; but on soils with light or moderate chlorosis, some of these hybrids retain a green color throughout the growing season or required fewer applications to sustain normal growth. This small group of hybrids was identified as “iron chlorosis tolerant hybrids” in that the plants still require additional iron, but do not require the intensive number of applications required by sensitive hybrids. One or two iron applications may be sufficient to correct chlorosis problems.

The hybrid response is thought to be due to a greater solubility and uptake of ferrous iron at the root surface rather than a greater proliferation of root surface area. There is insufficient research to fully explain these observed differences in performance beyond the fact that they do exist. Several of the hybrids studied have already been replaced by other commercial hybrids having greater iron utilization efficiency. The following Gonzales County data (see Table 1) are typical of results obtained on high-pH soils.

Product-Sensitive Hybrids

Hybrids respond favorably to iron applications only if iron is deficient in the plant. Some sorghum hybrids may be sensitive to specific foliar iron products. Two years out of three, Pioneer 8313 produced less grain when treated with PenGreen, with no merited increase in the third year. A 1,280 pound yield increase was achieved with copperas in a fourth year of evaluation. It is suspected that this hybrid is sensitive to foliar burn from the pH of the PenGreen solution.

Chlorosis-Sensitive Hybrids

A number of sorghum hybrids have shown a greater potential for chlorosis when grown on high-pH soils. These hybrids lack the ability to fully assimilate iron from the soil. Several of the food-grade white and cream-colored sorghums have been observed to lack this tolerance and should be further evaluated before large acreages are grown. Except for the weakest hybrids of this group, most commercial hybrids will respond to multiple applications of product if properly applied according to time of need.

Soil Testing Concerns

If a soil test is being requested for iron considerations, air drying of the sample should be specified and the iron should be determined by atomic absorption or a method that best indicates available iron in production fields.

The ICAP (Inductive Coupled Argon Plasma) method of analysis is prone to evaluate some of the iron on the clay structure as well as suspended iron. Therefore, adequate (but false) values are sometimes reported. One way to avoid this problem is to air-dry the samples instead of oven-drying them. Oven-drying shrinks the clays, drives off the water, and sometimes doubles the iron and potassium values. For iron testing, the soil samples should be evaluated by atomic absorption spectrometry.

Laboratories using the DTPH method of analysis, developed at Colorado State University, will encounter problems in obtaining accurate iron levels on soils with recent phosphorous amendments. The phosphorus will precipitate the low amounts of available iron. While some laboratories suggest adequacy with iron levels of 4.5 ppm or higher, the level should be moved to 10 or 15 where high levels of phosphorous were added recently.

Table 1. Grain yields and economic relationships observed with the application of PenGreen 25% ferrous sulfate to iron-chlorosis-tolerant and conventional sorghum hybrids on a high-pH soil, Walter and Michael Kuck Farm, Gonzales County, Texas, 1992.

				Dollars			
	(Grain lb./A)			Untreated Grain	Treated Grain	Value Added	Fe Benefit/Cost
Hybrid	w/o Fe	w/Fe	Grain	Value	Value	Fe	Ratio[2]
Chapparal	3078	3570	492	113.89	132.09	18.20	4.85
Cargill 837	2770	3241	471	102.49	119.92	17.43	4.65
NK KS 737	2851	3282	431	105.49	121.43	15.94	4.25
Cargill 857	2397	2790	393	88.69	103.23	14.54	3.88
DPL 1552	2047	2330	283	75.74	86.21	10.47	2.79
Rustler	2371	2593	222	87.73	95.94	8.21	2.19
DK 50	2726	2917	191	100.86	107.93	7.07	1.89
Pioneer 8313	2667	2133	<534>	98.68	78.92	<19.76>	<5.27>

[1]Sorghum grain value used was $3.70/cwt (Jul 92).

[2]Product cost fixed at a value of $1/gallon.
Application cost estimated @ $2.75/acre.

Note: Fe = iron.

Elizabeth Gregory, Editor
Rhonda R. Kappler, Graphic Designer

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2M–1-96, New AGR 14-2

How to Estimate Soil Moisture by Feel

Knowing the available soil water for use by the developing plant is information that can be used to make important management decisions throughout the growing season. If favorable moisture is available, then plant populations can be adjusted and needed nutrients applied to increase production; that statement based on environmental conditions remaining favorable for plant growth through the remainder of the growing season.

However, if the soil moisture level declines to the point that the plant is still wilted early in the morning then no additional investment is justified and plant development will be unfavorably impacted. Apply irrigation water, if available, to keep the plants from reaching this point of permanent wilt.

Where large acreages are irrigated, several days may be required to cover the entire acreage; consequently, irrigation must be started soon enough to arrive at the last portion of the field before its available water has been exhausted.

Most producers that apply water obtain information as to the rate at which moisture is being used by crops from different soil depths by using soil moisture probes. This provides a basis for determining when and how much water to apply. For most crops, irrigation should be started when about 50 percent of the available moisture in the soil root zone is depleted.

An alternative to the soil moisture probes is a method of estimating the available soil moisture by feel. To do this take a small amount of soil; squeeze it in the hand so as to form a ball, then refer to the chart below for a description of the feel.

Degree of Soil Moisture	Percent Useful Soil Moisture Remaining	Feel or Appearance of Soils			
		Coarse (Sand)	Light (Sandy Loams)	Medium (Silt and Clay Loams)	Heavy (Clay)
Dry	0	Dry, loose, single-grained, flows through fingers.	Dry, loose, flows through fingers.	Powdery, dry, sometimes slightly crusted but easily breaks down into powdery condition.	Hard, baked, cracked; sometimes has loose crumbs on surface.
Low	50% or less	Still appears to be dry; will not form a ball with pressure.*	Still appears to be dry; will not form a ball.*	Somewhat crumbly, but will hold together from pressure.*	Somewhat pliable; will ball under pressure.*
Fair	50 to 75%	Still appears to be dry; will not form a ball with pressure.*	Tends to ball under pressure but seldom will hold together.	Forms a ball, somewhat plastic; will sometimes slick slightly with pressure.	Forms a ball; will ribbon out between thumb and forefinger.

Excellent	**75% to field capacity**	**Tends to stick together slightly; sometimes forms a very weak ball under pressure.**	**Forms weak ball, breaks easily, will not slick.**	**Forms a ball and is very pliable; slicks readily if relatively high in clay.**	**Easily ribbons out between fingers, has a slick feeling.**
Ideal	**At field capacity**	**Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.**	**Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.**	**Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.**	**Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.**
Too Wet	**Above field capacity**	**Free water appears when soil is bounced in hand.**	**Free water will be released with kneading.**	**Can squeeze out free water.**	**Puddles and free water forms on surface.**
***Ball is formed by squeezing a handful of soil very firmly with fingers.**					

By knowing the texture of the soil and the depth of topsoil, a producer can estimate the amount of water available to produce a crop. If the soil texture is sand, then it can hold between 0.5 and 1.0 inch of water per foot of soil depth. If a producer had four foot of topsoil, there is 2 to 4 inches of water available for the crops use. If the soil texture is sandy loam, there is 1.0 to 1.5 inches of available water per foot of topsoil. If the soil texture is silt or a clay loam, there is 1.5 to 2.0 inches of available water per foot of topsoil. If the soil texture is clay, there is 2.0 to 2.5 inches of available water per foot of topsoil.

Plant, water and soil interrelationship is a complex study. This is only a small reflection of the information available. Additional information is available from a number of reliable sources. My preference is unbiased research based information that is available from most university systems.

Soil Moisture Measuring Devices

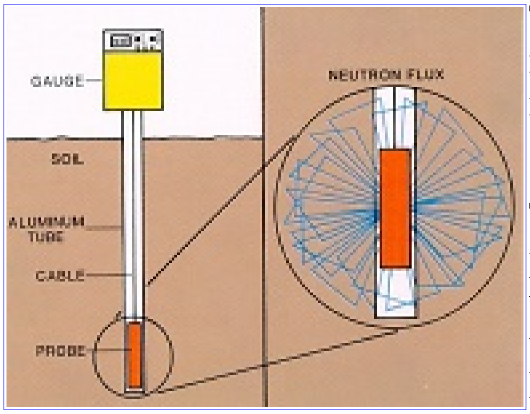
Neutron Probe **Tensiometers** **Soil Moisture Blocks**

NEUTRON MOISTURE METERS

One of the more accurate devices available for measuring the amount of moisture in the soil is the neutron moisture meter (neutron probe).

To assist the reader in understanding the special terms used in describing the neutron moisture meter's functions and operation, the following definitions are provided.

- Alpha Particle: A heavy high-energy particle, containing two protons and two neutrons.
- Fast Neutron: A high-energy neutron, which travels at a speed of about 6,000 miles per second.
- Flux: The number of particles crossing a unit of area per unit of time.
- Half-Life: The amount of time required for a radioactive element to decay to one-half of its original strength.
- Neutron: Elementary nuclear particle with a mass of one and a charge of zero.
- Slow Neutron: A low-energy neutron, which travels at a speed of about 1.7 miles per second.
- Source: A small sealed capsule which contains a mixture of radioactive material and beryllium.



The probe is lowered into the soil down an access tube where neutrons are emitted and interact with soil water. The density of the neutron flux is dependent upon the amount of water in the surrounding soil.

The neutron moisture meter consists of two main components, a probe and a gauge. The probe contains a source of fast neutrons, and the gauge monitors the flux of slow neutrons scattered by the soil. In using the neutron meter, a cased hole in the ground is necessary for lowering the probe to obtain readings.

The Source

The source of fast neutrons is generally obtained by mixing alpha particles from a radioactive emitter with beryllium. Beryllium atoms contain a loosely held neutron in their nucleus. When bombarded with alpha particles, beryllium is converted to carbon, and a high-energy neutron is released.

The source materials are chosen for their longevity. They can be used for a number of years without an appreciable change in radiation flux. Neutrons emitted by the source have an average speed of about 6,000 miles per second and are called "fast neutrons."

How It Works

The fast neutrons are emitted in all directions, where they collide with atoms in the soil. Through repeated collisions, they are scattered and some lose part of their energy. As the energy is lost, the neutrons are slowed to a speed of about 1.7 miles per second. Neutrons that have been slowed are said to be "thermalized" and are called "slow neutrons." The neutron detector in the neutron moisture meter is designed to ignore fast neutrons and count only thermalized or slow neutrons.

The average energy in a collision with another atom is much greater with atoms of low atomic weight than in collisions involving heavier atoms. Hydrogen is the only element with a low atomic weight that is found in significant amounts in typical soils. Hydrogen found in soils is almost entirely in the form of water. The occurence of hydrogen in water allows for the use of the neutron probe to measure soil water content.

The principle involved in the neutron method of measuring soil moisture is as follows. When a source is lowered into the soil and fast neutrons are emitted, the soil causes the neutron to slow and scatter. The result is that the probe becomes surrounded by a cloud of slow neutrons. The density of the neutron cloud around the probe does not increase indefinitely, but reaches an equilibrium determined by the rate neutrons are absorbed into the soil. If the soil is dry, the cloud of neutrons will be less dense and extend further from the probe. If the soil is wet, the neutron cloud will be more dense and extend a shorter distance.

The density of the neutron cloud is measured by the detector and the resultant signals are processed electronically and displayed as a number on the front panel of the gauge. The gauge reading is an index of soil moisture.

The upper gauge reading of 1.82 inches is representative of a dry Acuff Loam soil. The lower gauge reading of 4.54 inches of water per foot is typical of the same soil after full irrigation where the soil is near field capacity.

With the commonly used americium-beryllium source, the so-called sphere of influence, or effective radius of measurement, varies with a radius of less than four inches in wet soil to ten inches or more in dry soil. Measurements close to the surface (for instance, within six to eight inches of the surface) are not accurate when the soil is dry because of the escape of fast neutrons through the soil surface. A special surface probe is used to measure the moisture in the top layer of the soil.

Access Holes

An access hole and tube must be provided at each measurement site to allow the probe to be lowered into the soil. Tubes should be installed in snug-fitting holes pre-drilled with a hand or machine operated soil core barrel or auger. Placing the access tube in an oversized hole and back filling is not recommended.

Access holes should be lined with a durable tubing which will hold the dimensions of the hole at a constant size and exclude free water from moving into the hole. The access tube should be as small as possible, yet allow easy movement of the probe, have minimum wall thickness, and be made of a material that does not hender the movement of neutrons.

Aluminum is practically transparent to neutrons and, therefore, is a desirable material for accesstubes. Other types of tubes have been used successfully with appropriate calibration curves.

There are at least five conditions that should be met in the placement of access tubes.

- The site should be representative of the field to be monitored.
- No void spaces should exist between the access tube and soil.
- Mixing of soils adjacent to access tubes should be avoided during placement.
- No vertical flow of water should occur along the access tube from the surface.
- The top of the tube must be plugged to exclude water.

Permanent tubes are buried below plow depth and covered with soil. The soil cover is removed when measurements are to be made. This is satisfactory for annual measurements, such as those used in the High Plains Underground Water Conservation District No. 1 and Natural Resources and Conservation Service's annual pre-plant soil moisture monitoring program.

When tubes are to be monitored more often, they should be installed in the crop row after seedling emergence with the top extending above ground.

Calibration

Other factors besides soil water may affect neutron moisture meter measurements. Certain elements in the soil (e.g., boron, cadmium, iron and chlorine) have a high absorption capacity for slow neutrons. Other forms of soil hydrogen, such as humus, plant organic matter, and water bound in the crystalline structure of calcium carbonate and gypsum cause inaccurate readings.

Therefore, measurements taken with a neutron moisture meter must be corrected to account for these factors. In conjunction with the annual pre-plant soil moisture monitoring program, the High Plains Water District and the Natural Resources and Conservation Service have developed calibration curves for the major soil types on the Texas High Plains. These are available upon request from the Water District's Lubbock office and when properly used should prove adequate for any irrigation scheduling program.

Interpreting the Data

Neutron moisture meter measurements are correlated to soil types. The neutron moisture meter measures the TOTAL water content of a soil. Only a part of the water in a soil is available for plant use. The amount of water depleted from a soil (soil water deficit) is determined by subtracting the corrected neutron meter measurement from the total water-holding capacity of the soil.

Safely Handling The Equipment

Common sense procedures for handling the neutron moisture meter are necessary. Two objectives which must always be kept in mind are: (1) keep radiation exposure to a minimum, and (2) avoid physical damage to the instrument.

Any radioactive substance can be a potential health hazard no matter how small the quantity. Understanding the hazards, and the use of adequate and sensible handling procedures will safeguard against possible injury.

Shielding used with commercially available neutron moisture probes is a compromise between complete shielding and ease of handling. Careful handling and use of moisture probes result in radiation exposures within permissible limits.

A film badge similar to those worn by X-ray technicians must be worn by operators of neutron moisture meters to monitor exposure levels. Depending on the type of badge chosen, it must be replaced by a new badge and the old badge returned to a film badge service company at 30 or 90 day intervals. The operator must also maintain a daily use log for the neutron moisture meter.

Possession and use of a neutron moisture meter requires a special license from the Texas Department of Health. Strict storage and transportation procedures must be followed. A leak test must be performed semi-annually. Following recommended procedures and using caution, the neutron method for measuring soil moisture may be used with confidence and safety.

Summary

While the neutron moisture meter is not yet commonly used by individual irrigators, understanding its operations and function should be of interest to the farmer. Neutron moisture meters are not hampered by environmental factors such as temperature and barometric pressure. It is only slightly affected by salinity, chemical composition of normal soils, or the degree of binding of water to the soil particles. This implies that the neutron method could have wide general applicability and that necessary corrections for use are generally easily made.

Acknowledgements

This information was written by Mike Risinger, USDA-NRCS and Ken Carver, High Plains Underground Water Conservation District No. 1

TENSIOMETER

A Gauge For Measuring Soil Moisture

A tensiometer is a water-filled tube with a special porous tip and a vacuum gauge. This instrument measures soil water suction, which is similar to the process a plant root uses to obtain water from the soil.

Tensiometers are available in various lengths as pictured at left. When installed, only the top of the water-filled tube and the vacuum gauge are visible for readings and field maintenance as shown at right.

Tensiometers are relatively inexpensive and reusable. They are simple to operate, although they require some maintenance in the field. Maintenance requires the addition of water and the use of a hand vacuum pump to remove air from the tube.

Tensiometers are available in lengths ranging from 6 to 72 inches, allowing installation in the soil at various depths. A single tensiometer measures existing soil moisture conditions only at the depth of the porous tip, and cannot monitor conditions above or below this point. Two or more tensiometers of varying lengths may be installed at one site in order to monitor soil moisture conditions at more than one depth within the root zone.

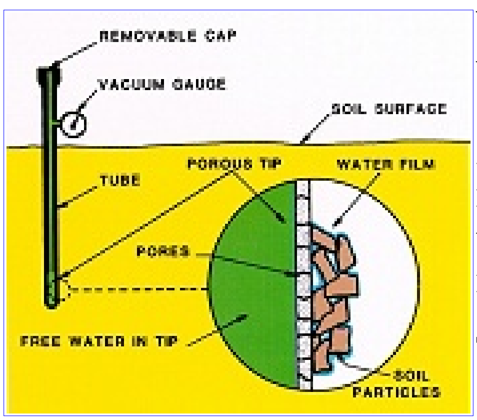
Soil Water Suction

Water is stored in the soil as a film around each soil particle and in the pore spaces between the soil particles. The water stored in the pore spaces is held by surface tension and is the easiest for the plant to extract. The water film around each soil particle is held by stronger molecular forces and is much more difficult for the plant to withdraw from the soil.

Water from the soil is pulled or sucked into the plant root due to a higher concentration of salts in the plant root. This water extraction process is called "soil water suction." When the soil is at field capacity, the plant must exert suctions equaling two to five pounds per square inch (psi) to obtain the water it needs. As the soil becomes drier, the amount of suction by the plant must increase to obtain adequate water for its needs.

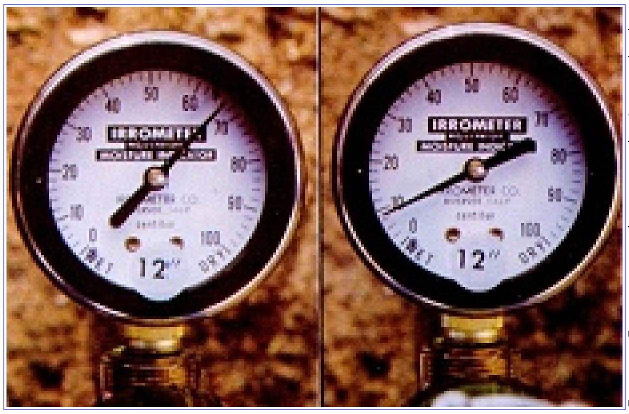
The permanent wilting point, or death of the plant, occurs when the soil dries to a level that the plant must exert 220 psi or more of suction in an attempt to fulfill its water needs.

In essence, the tensiometer gauges the amount of soil moisture suction required by the plant to extract water from the soil. The dryer the soil, the greater the suction and the higher the reading on the tensiometer vacuum gauge.



When plant roots remove water from the soil and the soil becomes drier, water is drawn from the porous tip of the tensiometer into the soil until a state of equilibrium is reached between the soil moisture and the suction in the tensiometer. Water added to the soil by rainfall or irrigation will reverse this action. The greater suction previously created in the tensiometer will pull water back into the tensiometer and lower the gauge reading.

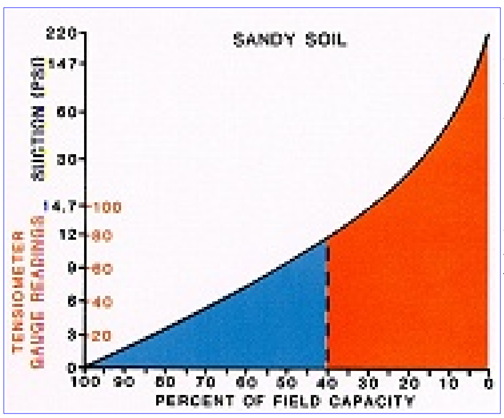
Tensiometers gauge negative soil suctions up to 14.7 psi (100 on the gauge) which is only a part of the available soil moisture. When the soil suction exceeds about 12 psi (80 on the gauge), the film of water covering the porous tip is broken, which allows air to enter the tube. The gauge reading drops sharply, then rebuilds until air enters the system again. When this occurs, the soil must be rewet and the tensiometer refilled before it will again function properly.



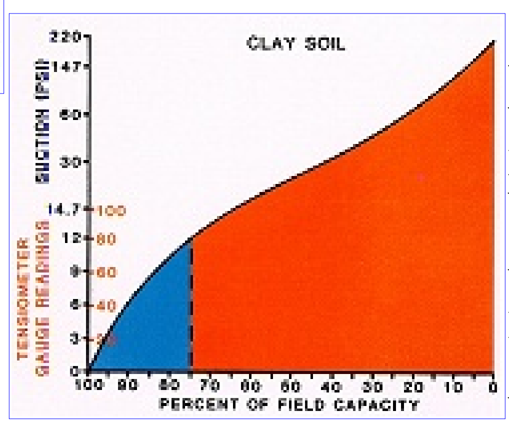
As indicated on the gauges to the left, the higher the reading the drier the soil. The gauge that has a reading of 66 would indicate that the plant must exert close to ten psi to extract water from the surrounding soil. The gauge that has a reading of 9.5 would indicate that one psi would be needed to extract water for the soil.

Tensiometers in Different Soil Textures

Tensiometers are reliable within certain limitations. For example, the range of usefulness is dependent on soil texture. The finer the soil particles (as in soils high in clay content), the more water the soil can hold, but the harder a plant has to work to draw moisture out of the soil. The coarser the particles (as in sandy soils), the less moisture the soil will hold, but more of the moisture is available for plant use. Tensiometers can, therefore, measure a wider range of available moisture in a sandy soil than in a soil high in clay content.



In sandy soils, a gauge reading of 80 indicates soil moisture of about 40 percent of field capacity. In sandy soils, most crops need additional irrigation water for maximum plant growth at about 50 percent of field capacity, which is a gauge reading of about 60 on the tensiometer. In sandy soils tensiometers can measure soil moisture from 100 to 40 percent of field capacity because the relatively large pore spaces in these soils release water at lower tensions.



In soils high in clay content, the tensiometer gauge will read about 80 when the soil moisture is at about 75 percent of field capacity. Clays hold water at greater tensions than sandy soils; therefore, the tensiometer breaks suction at a higher moisture level in soils high in clay. When the gauge reads 80, the tensiometer breaks suction and ceases to function. This occurs before the soil is dry to the level that irrigation is required for most crops. Tensiometers can only measure soil moisture from 100 to 75 percent of field capacity in clay soils because the finer pore spaces hold water at higher tensions.

In MEDIUM TEXTURED SOILS, the range of measurement would be intermediate to the values illustrated for sandy and clayey soils.

The texture of the soil also determines the rate of penetration of moisture from the ground surface to the root zone. Tensiometers can be helpful in determining how much moisture has actually penetrated and how quickly.

Tensiometers With Various Crops

Tensiometers are best used when soil moisture will be maintained at 50 to 75 percent of field capacity such as in high moisture demand crops like corn or vegetables.

They do not gauge the low soil moisture ranges from which crops such as cotton, grain sorghum or other small grains can extract adequate soil moisture. However, when installed early in the season, they can indicate the depth to which roots have developed and are extracting water from the soil.

Installation

Tensiometers are normally installed after the crop is established, and they do not interfere with normal tillage operations during the growing season.

Installation of a tensiometer can be made by driving a standard one-half inch pipe or other coring tool into the ground to the desired depth, then removing it to create a hole of exactly the right size and depth for the tensiometer. According to the manufacturers, this method assures good contact between the soil and the instrument with minimum damage to existing roots and soil structure.

Tensiometers are installed in a tight-fitting hole, then a vacuum pump is used to remove air from the tube. The gauge on the vacuum pump is also used to check to make sure the gauge on the tensiometer is functioning properly.

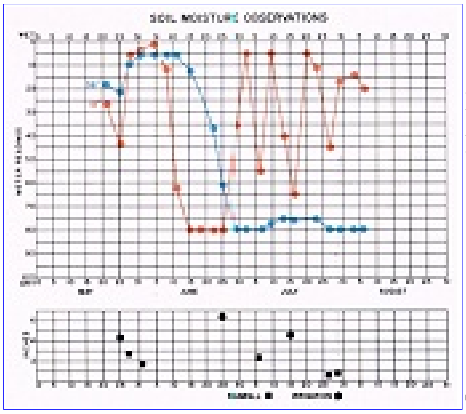
Detailed instructions for proper installation are provided by tensiometer manufacturers. However the tensiometer is installed, it should be done with minimum disturbance of the soil structure typical of the site. Installation into a large diameter hole and then backfilling is not recommended.

For furrow or flood irrigation, the stations may be placed about two-thirds of the way down the run. If the run is especially long, however, a station at each end of the field may be needed.

The important points in choosing placement of tensiometers for sprinkler irrigation are that obstructions do not exist between the sprinkler and the tensiometer and that excessive water is not concentrated at the point of installation.

Record Keeping

The success of any soil moisture monitoring system lies with careful record keeping. Over a period of time, the irrigator will better understand the readings and variations. The following is an example of a graph which shows the effect of rainfall, cool weather and moisture penetration.



Records throughout the growing season reveal the effects of irrigation and rainfall on soil moisture conditions. Notice that the 12-inch depth reading responded rapidly to rainfall and irrigation in June and July, however, the 36-inch depth reading was unaffected by these events.

Disadvantages

The main disadvantage of the tensiometer is that it can only operate when the soils are relatively wet. Additionally, the instrument should be read daily when crop water use is high to detect false readings due to air bubbles entering the tube. Temperatures below freezing can also seriously damage the tensiometer. It must be removed from the ground and stored before temperatures drop to freezing.

Portable Tensiometers

Portable tensiometers are also available. They incorporate a small porous ceramic sensing tip that minimizes reading time. It allows the user to take quick spot-check readings in varying locations. They are very sensitive. Therefore, it is easy to introduce error into the measurements. They also require more maintenance and care in handling than permanently installed tensiometers.

Acknowledgements

This information was written by Mike Risinger, USDA-NRCS and Ken Carver, High Plains Underground Water Conservation District No. 1

Soil Moisture Blocks and Resistance Meters

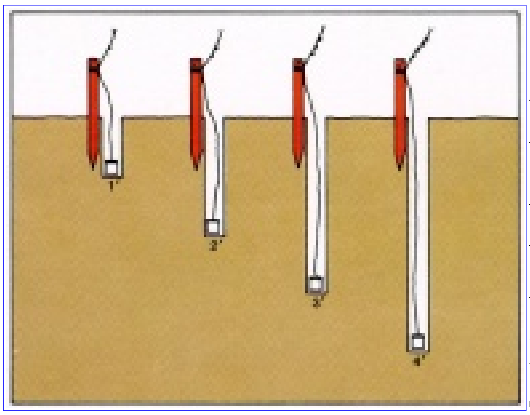
Installation

Soil moisture blocks are installed after crop emergence and are buried in the root zone soil profile. If an auger is used to dig the hole, four blocks can be installed in the same hole at one foot depth intervals. However, care should be taken to backfill and pack the soil around each of the blocks in the same order it was removed from the hole. Each block should be soaked in water just before it is installed in the hole. It should be dripping wet as it is placed in the hole.

Cut away the gypsum and the stainless steel electrodes which make up the core of the soil moisture block is revealed. An indication of soil moisture is obtained through the electrical resistance which occurs between these electrodes.

One of the most commonly used soil moisture monitoring tools is the moisture block used with a conductance meter. Most moisture blocks are made by casting an inch-long cylinder of gypsum around two stainless steel electrodes with lead wires trailing.

Installing four soil moisture blocks in one hole requires care and attention to detail. One block should be lowered into the hole then a mud mixture is placed around the block. Next, the native material that was removed from the hole above the depth the block was installed is packed into the hole until it is filled to the level for the next block. This is repeated for each block.



Blocks can also be installed with each block in a separate hole. Here four blocks have been placed in individual holes and the lead wires trailing to surface have been tied in knots to indicate the depth at which the block is buried.

When a push tube or drive rod is used to make the hole, only one block should be used in each hole. Each block should be pressed into the bottom of the hole. These types of holes may be backfilled and packed with surface soil.

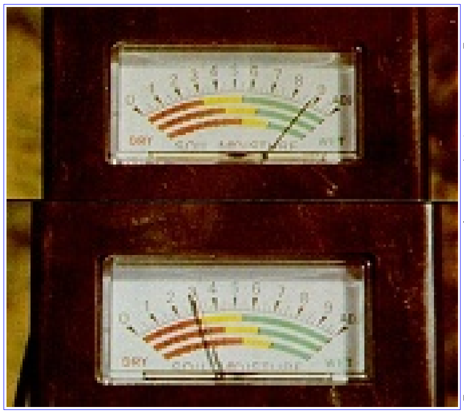
Taking Readings

Wires from the buried blocks are connected to a stake at ground surface and coded to indicate the depth at which the block is buried. Tie one knot in the wire for the block buried at the one foot level, two knots in the wire for the block buried at the two foot level, etc. These wires are connected to a small, hand-held resistance meter for readings.

The meter measures electrical resistance and displays it as a percent of field capacity value. Electrical resistance varies with the amount of moisture in the soil. A reading of "0" is dry and a "10" is wet.

Moisture blocks help the irrigator determine what is occurring in the root zone soil moisture profile and see from what depth his crop is extracting moisture, as well as, how much moisture is being extracted.

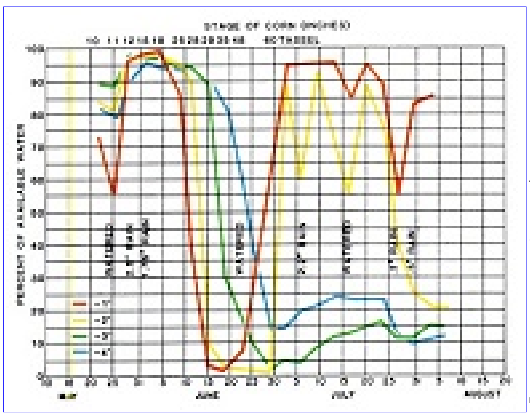
Irrigators should take special care to monitor the effects of rainfall on soil moisture conditions. Summer rainfall events can be very deceptive. The top six inches of the soil generally is weather dried and requires an extra measure of water to rewet to field capacity.



The dial on an electrical resistance meter reads from "0" which indicates dry soil moisture conditions to "10" which indicates a full soil moisture profile. The top reading of 9 would show a moisture condition near field capacity, while the bottom meter reading of 3 would indicate soil moisture that is relatively dry.

Keys to Success

The key to successful use of soil moisture blocks is making frequent readings to indicate crop root development and soil moisture conditions at each foot of depth. Good records should be kept of block readings, with notations as to crop development stages and weather conditions.



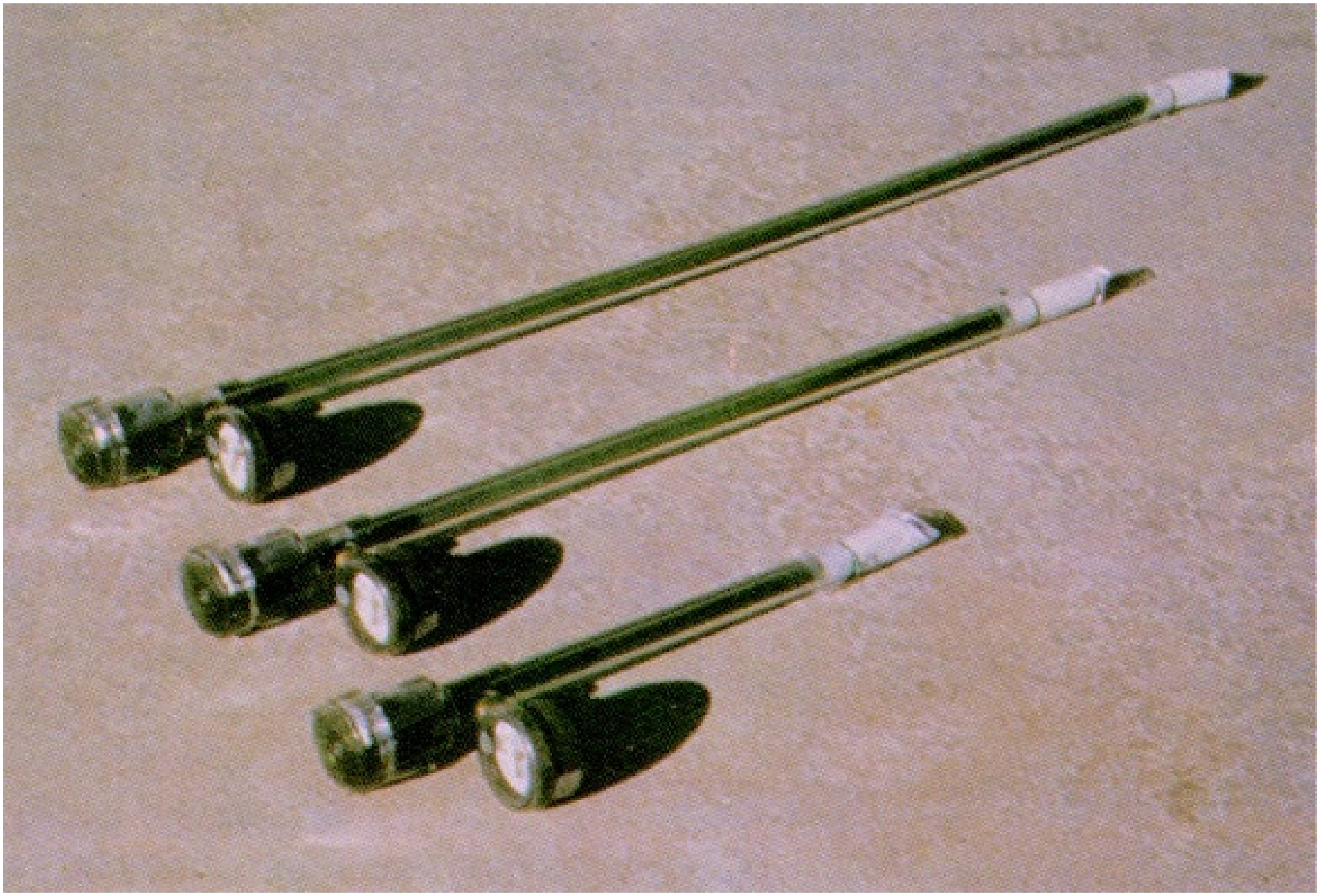
Monitoring soil moisture throughout a growing season could result in a graph of readings like that pictured to the left. Attention is given to aspects of crop growth, rainfall and irrigation applications. Crop water use is seen in the line dips. Note that neither rainfall nor irrigation amounts were adequate to wet the three and four foot levels during the last part of the growing season.

Summary

This system has a relatively low cost and allows measuring the same field location throughout the season. New blocks must be installed each growing season because gypsum dissolves and the wires are usually destroyed during land preparation and planting activities. The level of accuracy obtainable with resistance blocks, while not perfect, is sufficient for making most irrigation water management decisions.

Acknowledgements

This information was written by Ken Carver and A. Wayne Wyatt, High Plains Underground Water Conservation District No. 1 and Mike Risinger, USDA-NRCS

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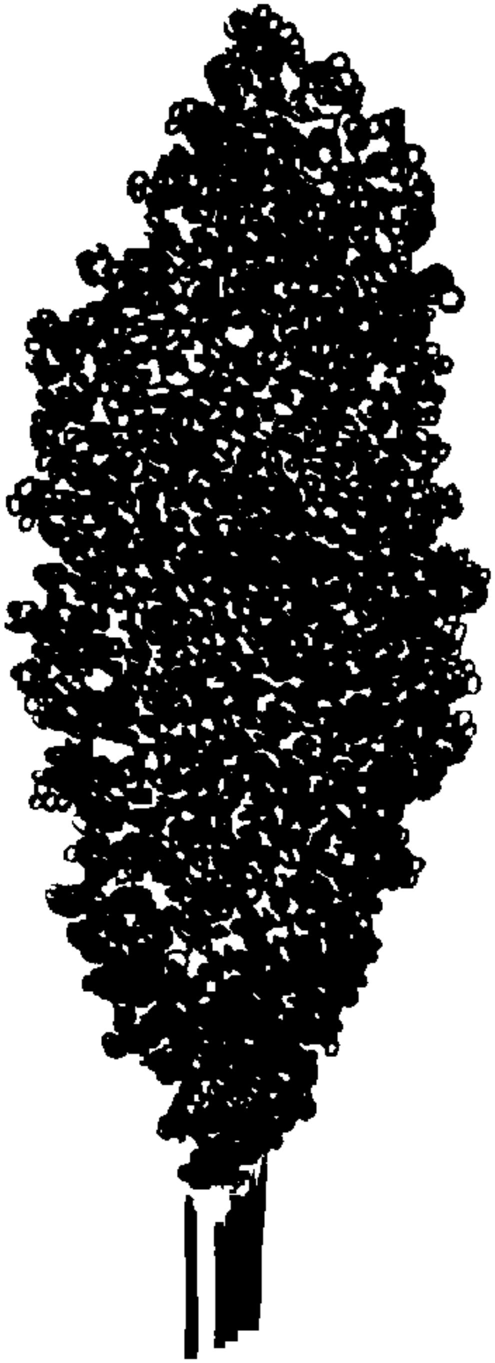

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Texas Agricultural Extension Service
The Texas A&M University System

SUGGESTIONS FOR WEED CONTROL IN SORGHUM

Texas Agricultural Extension Service
Chester P. Fehlis, Deputy Director
The Texas A&M University System
College Station, Texas

Suggestions for Weed Control in Grain Sorghum

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Dr. Cloyce G. Coffman, *Extension Agronomist*
Texas Agricultural Extension Service
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The suggestions contained herein are based primarily on herbicide labels, research by the Texas Agricultural Experiment Station and demonstrations by the Texas Agricultural Extension Service. The use of product names is not intended as an endorsement of the product or of a specific manufacturer, nor is there any implication that other formulations containing the same active chemical are not equally as effective. Product names are included solely to aid readers in locating and identifying the herbicides suggested.

The information given herein is for educational purposes only. Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement by the Cooperative Extension Service is implied.

This publication is no substitute for the herbicide product labels! It is intended to serve only as a guide for controlling weeds in sorghum. Labeled rates and restrictions change constantly, therefore, consult the product label prior to use.

Weed can be controlled in cropland through cultural, mechanical and chemical means. Wise use of these individual methods or a combination of them can manage weeds effectively without causing economic loss or harming the environment. Deciding which practice to use will depend largely on the weed(s) being controlled and the infestation level. Also, the crop being planted will play a major role in determining the timeliness of mechanical measures.

Considerations for cultural and mechanical weed control include:

1. Remove light or spotty weed infestations by hand hoeing or spot cultivation to prevent spreading weed seed, rhizomes or roots. Exercise caution when plowing perennial weeds, being careful to prevent plant parts from spreading to other areas of the field.
2. Use weed-free planting seed to protect against weed infestations in the row and the introduction of new weed species.
3. Thoroughly clean harvesting equipment before moving from one field to the next, or require it of custom harvesters before they enter your fields.
4. Use mechanical tillage to remove initial weed flushes before planting, thereby eliminating or at least reducing the potential for continued infestation.
5. Consider the economics of using mechanical cultivation alone for weed control in the crop, especially where annual weed infestations are light.
6. Practice rotation to crops that physically out-compete certain weeds, resulting in their gradual decline.

Table 1. Winter weed control

Weeds controlled	Product (Herbicide common name) Company	Application rate per acre	Time to apply	Remarks
Annual broadleaf weeds such as thistles, henbit and seedling dock (refer to label for specific weeds controlled)	**AAtrex ® 4L or** **atrazine 4L** **AAtrex ® Nine-O** 0.9 to 1.1 lbs. (atrazine) Novartis and several others	0.8 to 1.0 qt. 0.9 to 1.1 lbs.	Postemergence to small weeds.	A surfactant or crop oil concentrate will enhance postemergence control. Additional herbicides will be needed for spring and summer weed control.
Numerous annual broadleaf weeds (refer to label for specific weeds controlled)	**Harmony ® Extra 75DF** (thifensulfuron-methyl (50%) plus tribenuron-methyl (25%)) DuPont	0.5 to 0.6 oz.	Apply postemergence at least 45 days before planting, to weeds less than 4 inches tall or wide.	Add nonionic surfactant or crop oil concentrate to spray mixture. A total rate of Harmony Extra ® cannot exceed 1 oz. product per acre applied during one fallow cropland season.

Table 2. Preplant herbicides for postemergence weed control

Weeds controlled	Product (Herbicide common name) Company	Application rate per acre	Time to apply	Remarks
Emerged annual broadleaf weeds and grasses, and suppression of perennials	**Gramoxone ® Extra** (paraquat dichloride) Zeneca	1.0 to 3.0 pts.	Apply postemergence to weeds.	Add nonionic surfactant or crop oil concentrate to spray mixture. Avoid drift to emerged crops. Beds should be preformed to permit maximum weed and grass emergence. This herbicide is useful in minimum tillage systems. ***Note: Gramoxone ® (1.5 to 2.5 pts./A) may be combined with atrazine or Bladex ® if applied to sorghum planted directly into cover crop or previous crop residues. See label. Tank mixtures with Lasso ® and atrazine, Dual ® and atrazine and Bladex ® are on the label.***
Numerous annual grasses and broadleaf weeds (refer to label for specific weeds controlled)	**Roundup Ultra ®** (glyphosate) Monsanto	0.5 to 1.0 qt.	Apply postemergence before planting or after harvest.	Apply when weeds are growing vigorously and are 6 inches or less in height. Consult label for specific rate for weeds.

Table 2 (continued). Preplant herbicides for postemergence weed control

Weeds controlled	Product (Herbicide common name) Company	Application rate per acre	Time to apply	Remarks
Bermudagrass	**Roundup Ultra ®** (glyphosate) Monsanto	5.0 qts. (control) 3.0 qts. (partial control)	Before planting or after harvest.	Apply when bermudagrass is actively growing and seedheads are present. Allow at least 7 days before tillage.
Field bindweed	**Roundup Ultra ®** (glyphosate) Monsanto **Roundup Ultra ® + Banvel ®** (dicamba) BASF **Roundup Ultra ® + 2,4-D ®** (2,4-D) Several Manufacturers	4.0 to 5.0 qts. 2 qts. + 1 pt. (0.5 lb. a.i.) 2 qts. + 1 qt. (1 lb. a.i.)	Before planting or after harvest.	Apply when bindweed is actively growing and at or beyond full bloom. For best results, apply in late summer or fall. Wait at least 7 days to till. Apply with ground equipment only. Refer to Banvel ® label for crop rotation restriction and cautionary statements. (See Roundup Ultra ® label for this use).
Johnsongrass	**Roundup Ultra ®** (glyphosate) Monsanto	1.0 to 3.0 qts.	Before planting or after harvest.	Apply when actively growing and in boot stage for best results. Do not apply after johnsongrass turns brown in fall. Allow 7 days before tillage. Do not tank-mix with residual herbicides when using the 1 qt./A rate.

Table 3. Preplant incorporated and preemergence herbicides for residual weed control

Weeds controlled	Product (Herbicide common name) Company	Application rate per acre	Time to apply	Remarks
Annual broadleaf weeds and some annual grasses (refer to label for specific weeds controlled)	**AAtrex ® 4L** **AAtrex ® Nine-O** **Atrazine ® 4L** **Atrazine ® 90DF** (atrazine) Novartis and others	3.2 - 4 pts. 1.8 to 2.2 lbs. 3.2 - 4 pts. 1.8 to 2.2 lbs.	Preemergence.	May be used in Texas Gulf Coast and Blacklands; however, injury may occur on some soils. Application rate will depend on the NRCS soil erodability classification. On highly erodable soils, apply 3.2 - 4 pts. depending on residue cover. On non-highly erodible soils, apply 4 pts./A. Refer to label for additional precautions, recommendations and restrictions.

Table 4. Preemergence sorghum herbicides requiring seed protectants (safeners)

Weeds controlled	Product (Herbicide common name) Company	Application rate per acre	Time to apply	Remarks
Annual grasses and broadleaf weeds (refer to label for specific weeds controlled)	**Dual ® 8E or** **Dual II ® 7.8E** **Dual II ® Magnum** (metolachlor) (s-metolachlor) Novartis	1.5 to 2.5 pts. 1 to 1.67 pts.	Early preplant (30 to 45 days before planting), preplant incorporated or preemergence.	Concep ® treated seed are required. Under high soil moisture conditions before to sorghum emergence, injury may occur. Small grains may be planted 4½ months following treatment. Dual ® may be tank-mixed with atrazine in Gulf Coast areas only. See label for instructions.
Annual grasses and broadleaf weeds (refer to label for specific weeds controlled)	**Bicep ® or Bicep II ®** **Bicep II ® Magnum** (metolachlor + atrazine) Novartis	1.8 to 2.4 qts. 1.6 to 2.1 qts.	Same as above.	Do not use in Texas except in Texas Panhandle, Gulf Coast and Blacklands areas. Do not use on sand, loamy sand, or sandy loam soils or on soils with less than 1.0% organic matter. If sorghum seed is not properly pretreated with Concep ® (a seed safener) severe crop injury can result. Under high soil moisture conditions before crop emergence, injury may occur. Dry weather following preemergence application may reduce effectiveness. This tank mixture can be mixed with Gramoxone ® Extra or Roundup Ultra ® for use in minimum tillage systems. Early preplant applications may require additional Dual ® at planting, refer to label. This product provides expanded broadleaf weed control over Dual ® alone.
Annual grasses and broadleaf weeds **Weeds partially controlled:** lambsquarters, prickly sida (teaweed), ragweed, sandbur, seedling johnsongrass, shattercane	**Lasso ®** (alachlor) Monsanto	2.0 to 3.0 qts. (preplant incorporated) 1.5 to 2.5 qts. (preemergence)	Preplant incorporated (shallowly) within 7 days before planting or preemergence.	Incorporation is not suggested on coarse soils. May be applied after planting, before crop and weed emergence and within 5 days after last preplant tillage operation. Most effective when a to ¾ inch rainfall or irrigation occurs within 7 days. If weeds emerge due to insufficient moisture, use a rotary hoe or cultivate shallowly to improve performance. Use only "protected" sorghum seed.
Annual grasses and broadleaf weeds (refer to label for specific weeds controlled)	**Lariat ®** (alachlor + atrazine) Monsanto	2.5 to 3.25 qts.	Same as above.	As above and apply rates according to soil type. Plant only corn, peanuts, soybean or sorghum the year after application. Use only "protected" sorghum seed. Use only on fine-textured soils of the Texas Gulf Coast and Blacklands. Use only preemergence in the Texas Panhandle. Applications to calcareous or alkaline soils may injure crop.

Table 4 (continued). Preemergence sorghum herbicides requiring seed protectants (safeners)

Weeds controlled	Product (Herbicide common name) Company	Application rate per acre	Time to apply	Remarks
Annual grasses and broadleaf weeds (refer to label for specific weeds controlled)	**Partner ® 65 WDG** (alachlor) Monsanto	3.0 to 4.5 lbs. (preplant incorporated) 2.3 to 3.8 lbs. (preemergence)	Preplant incorporated (shallowly) up to 7 days before planting or preemergence.	Partner ® is a dry micro-encapsulated formulation of alachlor. "Protected" sorghum seed must be used. Additional weed control may be obtained by tank-mixing with atrazine. However, only preemergence applications are labeled for this combination. Refer to label for restrictions or use areas and rotational crops.
Annual grasses and broadleaf weeds (refer to label for specific weeds controlled)	**Micro-Tech® 4EC** (alachlor) Monsanto	2 to 3 qts. (preplant incorporated) 1.5 to 2.5 qts. (preemergence)	Preplant incorporated (shallowly) 7 days or less before planting, or preemergence.	MicroTech ® is an encapsualted formulation of alachlor. Use only in Texas Panhandle and fine-textured soils of the Gulf Coast and Blacklands. In Texas Panhandle, apply only preemergence. Refer to label for additional restrictions and use precautions. Use only "protected" sorghum seed.
Annual grasses and broadleaf weeds (refer to label for specific weeds controlled)	**Bullet ®** (alachlor + atrazine) Monsanto	2.5 to 3 qts.	Same as above.	Bullet ® contains the micro-encapsulated formulation of alachlor and with the atrazine provides expanded broadleaf weed control over Micro-Tech ®. Use only in Texas Panhandle and fine-textured soils of the Gulf Coast and Blacklands. In Texas Panhandle, apply only preemergence. Refer to label for additional restrictions and use precautions. Use only "protected" sorghum seed.
Annual grasses and broadleaf weeds	**Frontier ® 6.0** (dimethenamid) BASF	16 to 28 oz. Rate dependent on soil texture, C.E.C. and organic matter content	Preplant surface applied, preplant incorporated or preemergence.	For use only on "safened" seed that has been treated. For use with chloracetamide herbicides. Not for use on sweet or forage sorghums.
Annual grasses and broadleaf weeds	**Guardsman ®** (dimethenamid + atrazine) BASF	3 to 4.5 pts. (medium and fine 8021 types). Rate dependent on soil texture, organic matter content and C.E.C.	Preplant surface applied, preplant incorporated or preemergence.	Not recommended for use on coarse textured soils. Use only on "safened" sorghum seed. Guardsman ® will provide expanded broadleaf weed control over that provided by Frontier ®.

Table 5. Postemergence herbicides

Weeds controlled	Product (Herbicide common name) Company	Application rate per acre	Time to apply	Remarks
Several annual broadleaf weeds, yellow and purple nutsedge (refer to label for specific weeds controlled)	**Permit ® 75 WSG** (halosulfuron) Monsanto	0.67 oz.	Postemergence from 2-leaf stage through layby but before grain head emergence.	Only one application of Permit ® is allowed per season. Weeds vary in susceptibility, so refer to label for application timings. Slight injury may occur if Permit ® is applied to sorghum under stress. Permit ® may be combined with Banvel ®, 2,4-D ®, Buctril ®, or atrazine for expanded broadleaf weed control. Refer to label for additional precautions and rotational crop restrictions. Add surfactant to improve control.
Several annual broadleaf weeds	**Peak ®** (prosulfuron) Novartis	0.75 to 1.0 oz.	Postemergence when weeds are 1 to 12 inches tall, and sorghum is 5 to 30 inches tall and before head emergence.	Application timing is very weed-specific so CONSULT THE LABEL for weed size limitations per application rate. Use drop nozzles for applications in sorghum over 20 inches tall. Always add a crop oil concentrate to spray mixture for optimum performance. Do not apply Peak ® when sorghum is under growth stress because of drought, cold weather, water-logged soils, etc. Consult the Peak ® label for further precautions and restrictions.
Annual broadleaf weed control and some grasses (refer to label for specific weeds controlled)	**atrazine 4L** **AAtrex ® Nine-O** (atrazine) Novartis and others	2.4 pts. 1.3 lbs.	Postemergence before weeds are 1½ inches high, and sorghum is 6 to 12 inches tall.	Do not graze or feed forage for 21 days after application. Plant only corn or sorghum the year after application. Do not apply on sand or loamy sand soils. Add surfactant to improve control.
Numerous annual broadleaf weeds (refer to label for specific weeds controlled)	**Banvel ® 4** (dicamba) BASF	0.5 pt.	Postemergence to sorghum from spike to 15 inches tall.	To minimize potential for injury, treat when sorghum is 3 to 5 inches tall. Use drop nozzles on sorghum over 8 inches tall to keep spray out of whorl. Use with care near cotton and soybeans. May be tank-mixed with atrazine for expanded broadleaf control. Refer to label for additional recommendations and precautions. Add surfactant to improve control.
Numerous annual broadleaf weeds (refer to label for specific weeds controlled)	**Basagran ® 4EC** (bentazon) BASF	1.5 to 2.0 pts.	Postemergence. Growth stage of weed determines rate (see label).	Sorghum is tolerant at all growth stages. Slight speckling may occur but sorghum generally outgrows this condition. Can be applied as a band or broadcast. Do not apply more than 4 pts./A per season. Basagran ® may be mixed with atrazine to expand broadleaf weed control. Refer to label for additional recommendations and precautions.

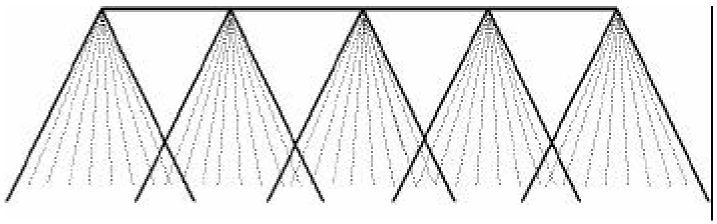
Table 5 (continued). Postemergence herbicides

Weeds controlled	Product (Herbicide common name) Company	Application rate per acre	Time to apply	Remarks
Numerous annual broadleaf weeds (refer to label for specific weeds controlled)	**Buctril ®** (bromoxynil) Rhone-Poulenc	1.0 to 2.0 pts. (rate depends on weed size)	Postemergence when sorghum is at least 5-leaf stage of growth.	Application when weeds are small is important. Do not add surfactant or mix with liquid fertilizer. Temporary leaf scorch to sorghum may occur under cool, cloudy conditions but will soon disappear. Do not plant rotational crops until the following season. Useful for broadleaf weed control near crops where volatile herbicides might cause injury. Buctril ® may be applied with other herbicides to broaden spectrum of weed control. Refer to label for recommendations and rotational crop restrictions.
Numerous annual broadleaf weeds (refer to label for specific weeds controlled)	**2,4-D ® amine** (2,4-D) Several manufacturers	0.5 to 2 pts. (4 lbs./gal. product)	Postemergence after crop is 6 inches tall but before boot stage, preferably before 12 to 15 inches tall.	Do not use near susceptible crops. Use low rate after high rainfall or root damage may result. When crop is more than 8 to 10 inches tall, use drop nozzles to avoid contact with sorghum leaves. Sorghum hybrids vary in tolerance to this herbicide. Addition of a surfactant will increase the likelihood of sorghum injury. See label for details.
Annual broadleaf weeds (refer to label for specific weeds controlled)	**Direx ® 4L** (diuron) Griffin **Karmex ® 80DF** (diuron) DuPont	0.2 to 0.4 qt. 0.25 to 0.50 lb.	Postemergence as directed spray only. Use when weeds are 2 to 4 inches tall and after crop is 15 inches tall.	Always use surfactant for improved postemergence control. Do not replant to any crop within 4 months of last application.
Selected broadleaf weeds (refer to label for specific weeds controlled)	**MCPA ®** Several manufacturers	3.0 pts.	Postemergence when crop is 6 to 12 inches tall but before boot stage. Apply before weeds are 5 inches tall.	Avoid cultivation after treatment while sorghum is brittle. Hybrids vary in tolerance to MCPA ®. Do not graze dairy or meat animals until 7 days after treatment. Addition of a surfactant will increase the likelihood of sorghum injury.
Numerous annual grass and broadleaf weeds	**Roundup Ultra ®** (glyphosate) Monsanto	1 qt. maximum (refer to label for specific rates)	Postemergence applications only through a hooded sprayer when sorghum is at least 12 inches tall.	This application is approved only when using hooded sprayers approved for use by Monsanto. A hooded sprayer is a type of shielded applicator, where the spray pattern is enclosed on the top and all four sides by a "hood," thereby shielding the crop from the spray solution. Consult the supplemental label for additional precautions.

Table 6. Postemergence incorporated

Weeds controlled	Product (Herbicide common name) Company	Application rate per acre	Time to apply	Remarks
Annual grasses and broadleaf weeds (refer to label for specific weeds controlled)	**Prowl ® 3.3 EC** (pendimethalin) American Cyanamid	1.2 to 3.6 pts.	Postemergence when sorghum is from 4 inches tall to layby.	Germinated or emerged weeds must be destroyed by cultivation before application. Cultivate with sweep or rolling cultivators at a speed sufficient to throw at least 1 inch of soil over the bases of the sorghum plants. This covers small weed seedlings in the row and prevents direct contact of the herbicide with the zone of brace root formation during application. Use drop nozzles if foliage prevents uniform coverage of the soil surface. Thorough and uniform incorporation into the soil to a depth of 1 to 2 inches with sweep or rolling cultivators should be accomplished soon after application. Incorporation should move some treated soil over the bases of the sorghum plants to improve control of weeds germinating in the rows. Do not use on sands, loamy sands or sandy loam soils. ***Note:*** *Prowl ® can be tank-mixed with atrazine for a broader spectrum of broadleaf weed control. Apply before sorghum reaches 12 inches.*
Annual grasses and broadleaf weeds (refer to label for specific weeds controlled)	**Treflan ® 5** **Treflan ® 4EC** (trifluralin) Dow Agrosciences	0.6 to 1.6 pts. 0.75 to 2.0 pts	Postemergence when sorghum is 8 inches tall or more.	Incorporation as described above. Use drop nozzles if foliage prevents uniform coverage of the soil surface. Do not apply as a preplant or preemergence treatment.

Boom Sprayer Calibration



1. Determine nozzle spacing.
2. Refer to the table below for length of calibration course.
3. Mark off the calibration course on the actual area to be sprayed.
4. Record the time required to drive calibration course at desired field gear and rpm to be used while spraying.
5. Park tractor, maintain rpm used to drive course, turn on the sprayer and set it at proper pressure for desired nozzle tips.
6. Catch water from one nozzle for the time equal to that required to drive calibration course.
7. Ounces of water caught = gallons per acre.
8. Divide gallons per acre into the number of gallons in spray tank to determine how many acres will be sprayed. Add appropriate amount of herbicide for number of acres to be sprayed.

Chart for Nozzle Spacing and Length of Calibration Course

Nozzle Spacing (inches)	18	20	30	40
Length of Calibration Course* (linear feet)	227	204	136	102

**To determine the calibration course for a nozzle spacing not listed, divide the spacing expressed in feet into 340 (340 sq. ft. = 1/128 of an acre).*

***Example**: Calibration distance for 19-inch nozzle spacing = 340 ÷ **19**/12 = 215 feet).*

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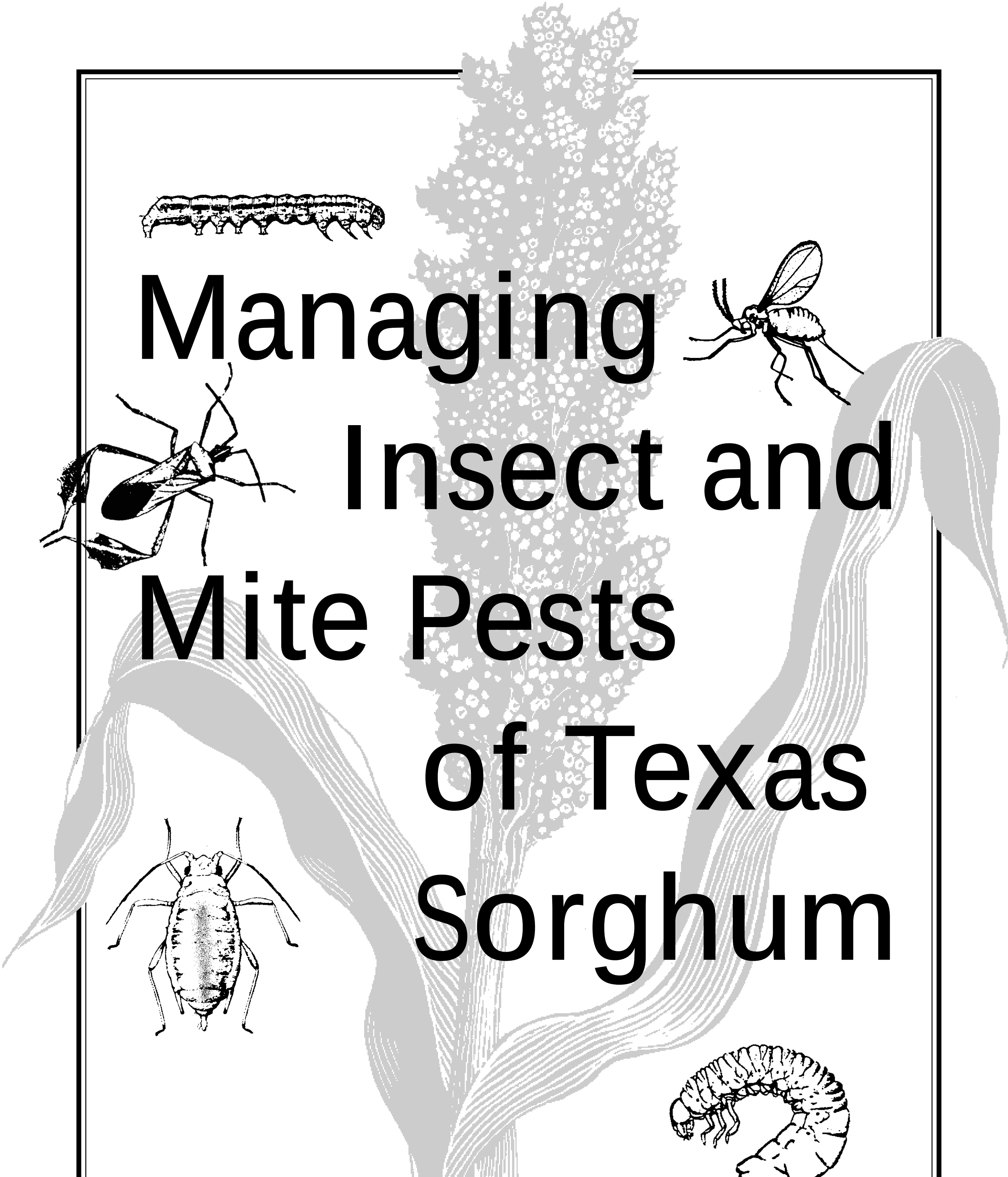

Managing Insect and Mite Pests of Texas Sorghum

Contents

Managing Insect and Mite Pests of Texas Sorghum

Greg Cronholm, Allen Knutson, Roy Parker, George Teetes and Bonnie Pendleton*

AN INTEGRATED APPROACH TO managing insect and mite pests can help Texas sorghum growers and crop protection specialists:

- Prevent damaging insect pest infestations;
- Diagnose the presence and severity of an insect pest infestation; and
- Control an infestation with insecticides when preventive methods are not fully effective and sampling justifies the need for insecticide.

Sorghum has an advantage over other grain crops because it can withstand relatively harsh, hot, dry climates, but responds well to favorable production conditions and irrigation. The crop adds important agricultural diversity in a production region. Beneficial insects associated with sorghum often help reduce the severity of insect and mites in sorghum and in other crops such as cotton. Sorghum is an important rotation crop with cotton and soybeans, and rotation helps manage some weeds, diseases and insect pests.

Some insect and mite pests can reach damaging levels throughout the growing season. Others can cause damage only at a specific plant growth stage. Figure 1 illustrates the probability of various insect and mite pests occurring at each plant development stage.

Most insect pests of sorghum are occasional pests, meaning they cause economic damage in localized areas or only during certain years. Only one or two key insect pests are usually in any sorghum-growing area in Texas. These insects occur most years and dominate control practices. Examples of key insect pests of sorghum are greenbug and sorghum midge.

Some pests, such as Banks grass mite, are induced. These are present in sorghum fields or surrounding areas, but usually in nondamaging numbers. They increase to economically important levels after changes in cultural practices or crop varieties, or insecticide use for other insect pests.

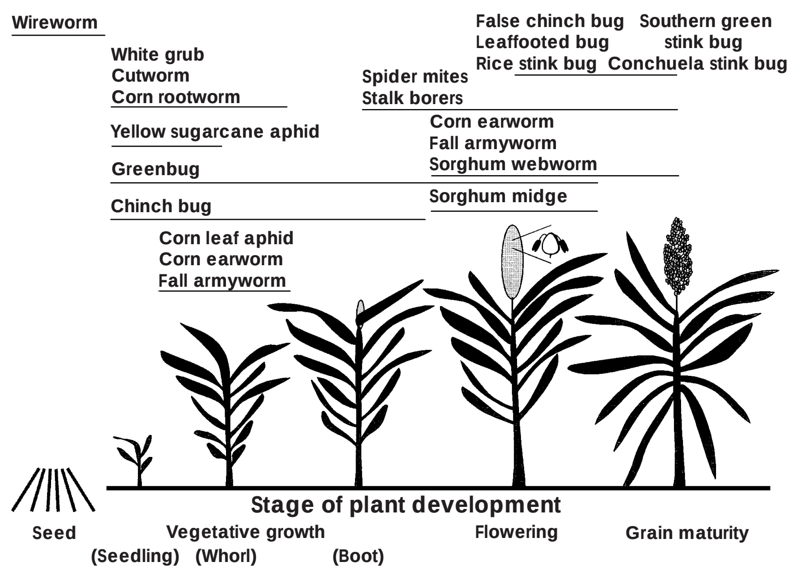

Figure 1. Sorghum insect pest occurrence.

Methods to prevent insect pest infestations

Managing insect and mite pests of sorghum involves actions that prevent pests from increasing to high enough numbers to cause economic damage. These practices help avoid pests, reduce their abundance or slow their rate of increase, delay the time they reach damaging levels and/or increase the plant's tolerance to the insect pest.

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Cultural management methods

Cultural management methods involve using crop production practices to reduce pest abundance or damage.

Crop rotation involves successive use of host and non-host crops. Sorghum benefits most when rotated with a broad-leaf or tap-rooted crop such as cotton or soybeans. Growing sorghum in a field planted to a different crop the previous year significantly reduces the potential for problems from some insect pests, diseases and weeds.

Crop rotation is especially effective against insect pests with a limited host range, long life cycle (one or fewer generations a year) and limited ability to move from one field to another. For example, wireworms, white grubs and some cutworms have only one generation a year, must have a grass-type crop to develop and reproduce, and cannot move during the damaging larval stage from one field to another. Thus, growing a crop such as cotton or soybeans in the field before growing sorghum helps reduce abundance of these soil-inhabiting pests. Sorghum growers should rotate crops regularly.

Destroying the previous crop, volunteer and alternate host plants eliminates breeding and/or overwintering habitats to reduce insect pest abundance and damage. This involves mechanically or chemically destroying sorghum plants soon after harvest to kill or expose insect pests and remove their food supply. This method also includes destroying volunteer crop and alternate host plants within and outside a field.

Where conservation tillage practices are used, herbicides can be applied post-harvest to kill crop, volunteer and alternate host plants. Herbicides stop crop growth effectively and are compatible with cultural management practices to reduce insect pest abundance. Where crop residue must be destroyed mechanically to expose overwintering insect pest life stages, conservation tillage may enable certain species of insect pests to become more abundant.

Destroying previous crop, volunteer and alternate host plants reduces insect pest abundance the following year. This practice is particularly important to reduce the abundance of southern corn rootworm, cutworms, sorghum webworm, sorghum midge and stalk-boring insects. Johnsongrass is a non-cultivated host of many sorghum insect pests, including greenbug, yellow sugarcane aphid and sorghum midge. Destroying this weed is difficult but very helpful in managing insect pests.

Seed selection, seedbed preparation and seed treatment are important in reducing the effects of sorghum insect pests. When deciding on a sorghum hybrid to plant, consider how well the hybrid is adapted to the locale and its susceptibility to insect pests and diseases.

Use sorghum hybrids that tolerate greenbugs. Hybrids resistant to sorghum midge are less available, but are highly advantageous in southern parts of the state. Sorghum hybrids with loose (open) rather than tight (compact) grain heads are less infested with larvae of corn earworm, fall armyworm and sorghum webworm, all of which feed on developing kernels. Also, sorghum with open grain heads is less likely to show the effects of grain deterioration from weather, grain head-infesting bugs and pathogens. Early, uniform hybrids avoid infestation by several insect pests, including sorghum midge, corn earworm and fall armyworm, in addition to avoiding late-season weather problems.

Sorghum hybrids resistant to pathogens and with good standability also reduce the detrimental effects of insect pests. Insect pests add to the stress on sorghum plants during the growing season, and, combined with pathogen infection, increase plant lodging. Some insect pests, such as greenbug and corn leaf aphid, transmit maize dwarf mosaic virus and other sorghum diseases. This problem is best dealt with by using disease-resistant sorghum.

Good seedbed preparation promotes rapid seed germination and seedling growth, which are essential to avoiding damage by wireworms, red imported fire ant and yellow sugarcane aphid. Rapidly growing seedlings are more tolerant of damage.

Fungicide- and insecticide-treated seed protects against some diseases and seed-feeding insects. Seed bought pre-treated with the systemic insecticide imidacloprid (Gaucho®) is protected against seed-feeding insects and those such as aphids and chinch bug that attack sorghum during the seedling stage. However, this systemic insecticide also suppresses corn leaf aphids that attract beneficial arthropods needed for natural control of greenbug and other insect pests.

Planting time should be as early as practical, but not when temperatures are too cool for rapid seed germination and seedling growth. In dryland areas of the state, early planting usually takes advantage of seasonal rainfall patterns.

Early planting avoids infestation and damage by some sorghum insect pests because plants grow beyond a vulnerable stage before these insect pests are present. Also, young plants can reach a more tolerant stage before insect pests are present, be susceptible for a shorter period of time or mature before an insect pest becomes abundant enough to cause serious damage. Early-planted sorghum generally avoids damaging numbers of sorghum midge, corn earworm, fall armyworm, sorghum webworm, stalk borers and grain head-infesting bugs.

Fertilizer and irrigation applied to sorghum can both help and harm efforts against insect pests. Using too much fertilizer and irrigation can cause sorghum plants to be succulent and attractive to sorghum insect pests and extend the time to maturity. On the other hand, healthy, vigorously growing plants better tolerate insect pest infestation and other plant stresses. In areas with alkaline soils where iron-deficiency is a problem, applying iron is important for production of healthy sorghum.

Chinch bugs and spider mites favor hot, dry conditions and stressed plants. Dense stands of vigorously growing sorghum are less susceptible to chinch bugs. Rainfall tends to reduce greenbug and spider mite numbers. Yield potential reductions by most leaf-feeding insect pests partially depend on plant condition.

Biological management methods

Biological management methods reduce insect pest abundance by using natural enemies — predators, parasites and pathogens that kill insect pests. Natural enemies can be used in three ways:

- Conservation, or enhancing numbers of already existing natural enemies. Conserving natural enemies is the most applicable biological management method to suppress the abundance of sorghum insect pests.
- Augmentation, the mass culturing and periodic release of a natural enemy.
- Importation, the introduction of non-native natural enemies.

Conservation of natural enemies involves protecting existing natural enemies so they are abundant enough to suppress the insect pests they attack. Sorghum hosts an abundance of natural enemies, primarily because of aphid infestations. The corn leaf aphid, usually non-injurious to sorghum, often becomes very abundant. Corn leaf aphids attract many different natural enemies that attack aphid and caterpillar pests.

Natural enemies allowed to increase can hold some insect and mite pests below damaging levels. Insecticides often destroy natural enemies, because most insecticides used in sorghum are broad spectrum, killing insect pests as well as natural enemies. The fact that insecticides kill natural enemies is a primary reason for making sure insecticides are needed before applying them. Once natural enemies have been destroyed, there is no natural (biological) protection against insect pests. This results in resurgence of the treated insect pest or allows a secondary pest such as corn earworm or spider mites to increase.

Sorghum pests most affected by natural enemies are greenbug, corn earworm, fall armyworm, sorghum webworm and spider mites. Important natural enemies include ladybird beetles, lacewing fly larvae, syrphid fly larvae, minute pirate bug, insidious flower bug, damsel bug, big-eyed bug and parasitic wasps. Predators affect abundance and rate of increase of greenbugs, often preventing them from causing damage.

This is particularly true when greenbug-resistant hybrids are used. Parasites often terminate a greenbug infestation. Predators are important in suppressing abundance of corn earworms and fall armyworms that infest sorghum grain heads. Although several parasites attack sorghum midge, their effect is minimal. Several pathogens, mostly fungi, infect some aphids, chinch bug and caterpillars.

Augmentation is the purchase and periodic release of natural enemies not normally occurring in sufficient numbers to control pests. Commercially available natural enemies sold for pest control in sorghum include convergent lady beetles, lacewing flies and the greenbug parasite *Lysiphlebus testaceipes.*

Naturally occurring convergent lady beetles help control greenbug infestations in sorghum. However, the convergent lady beetles available to buy are collected from natural hibernating sites and stored in refrigerators. When released in the field, they quickly fly away or feed at low and ineffective rates without reproducing.

The effectiveness of augmenting other natural enemies for control of sorghum pests is unknown. Because definitive information on augmentation (when to apply, how many to apply, etc.) is lacking, entomologists with the Texas Agricultural Extension Service cannot provide guidelines for augmentation as a management tool in sorghum.

Importation is the identification, collection and release of natural enemies in areas where they do not occur naturally. This method has been effective where an exotic pest has entered Texas without the natural enemies that help control the pest in its native country. Certain species of parasitic wasps and lady beetles that feed on the greenbug have been imported and released in Texas.

Methods to diagnose insect pest infestations

Sampling

Sampling insects and mites in sorghum is critical to determining the severity of an infestation and need for insecticide application. Insect pest numbers in sorghum fields can change rapidly. Inspect sorghum at least once a week, especially during critical times when insect pests are likely to be present, to determine the pests present, their abundance and damage. Growers may need to inspect flowering sorghum daily when assessing abundance of sorghum midge. Record the information collected during each field inspection for future reference to determine changes in insect abundance and plant damage.

The number of samples needed depends on the size of the sorghum field, uniformity, plant growth stage and severity of the insect infestation. Seldom are insect pests distributed evenly in a sorghum field. Examine plants from all parts of a field. Avoid examining only field borders. Take at least two samples per acre in the sorghum field.

Growers can estimate the abundance of most insects in sorghum by visually inspecting the plants and plant parts. Some insects, especially those infesting sorghum grain heads, are effectively sampled by using the "beat-bucket" method. Insect pests that live in the soil are hard to detect and most need to be sampled before the crop is planted.

Soil-dwelling insects, such as white grubs and cutworms, can be found by searching through the soil. Wireworms are difficult to detect in soil. A grain-baited trap can be used to attract them (See wireworm section on page 7 for details.)

For visual examination, randomly select and carefully inspect plants to detect insects and associated damage. During inspection, consider other factors such as predators, parasitized aphids, plant growth stage and condition. Visual examination is used most often to sample aphids, chinch bug, spider mites and sorghum midge.

The beat-bucket technique is the best way to estimate the number of corn earworm, fall armyworm, sorghum webworm and bugs in sorghum grain heads. Shake sorghum grain heads vigorously into a 5-gallon plastic bucket. Then count the caterpillars and bugs in the bucket. Because adult bugs can fly, take care to count those flying from the bucket or sampled plant.

Economic threshold level

The economic threshold level is the abundance of an insect pest or amount of plant damage that justifies applying insecticide. Although economic treatment levels provided in this publication are based on research, consider them only guidelines, because environmental and crop conditions vary from year to year and region to region.

Economic treatment levels for most insect pests are provided in tables that consider differences in insecticide and application costs and per-acre value of the sorghum crop. To determine if the abundance of insect pests justifies applying insecticide, first estimate the per-acre value of the crop. Then determine the per-acre cost of control including the insecticide and application. Read across the columns for cost of control and down the table columns for the market value of the crop. The abundance of the insect pest at that point in the table warrants the cost of control.

Chemical management methods

Insecticides are chemicals that kill insects. They are powerful tools and have several advantages. The major advantage is they are often the only practical control for insect pests at or near damaging levels. The key disadvantages of insecticides are cost and broad toxicity. They can harm nontarget organisms in the crop and nearby areas. From a sorghum insect management standpoint, cost of insecticide and killing natural enemies are of most concern.

Use an insecticide in the proper amount and only when necessary to prevent economic loss. The cost of achieving full crop potential can exceed potential benefits. Apply insecticides only when insect pests are becoming more abundant and economic crop loss is expected. When deciding whether to apply an insecticide, consider the cost of insecticide applications, prevailing market conditions, expected yield, insect pest abundance, insect age and duration of attack, and stage and condition of the plants attacked.

Indiscriminate insecticide use can lead to pest resistance, resurgence of the treated pest and outbreaks of secondary pests. Selective insecticide use by application method, choice of product or dosage can greatly reduce occurrence of these problems. Treating insect pests in sorghum can affect the abundance of beneficial and pest insects in adjacent crops.

Seed insecticide treatments

Gaucho®-treated seed can be purchased to control wireworms, fire ant, greenbug, yellow sugarcane aphid and chinch bug. Use of Gaucho®-treated seed is discussed within the sections on these pests. Contact your seed dealer to buy Gaucho®-treated seed.

Lindane can be used in the planter box or as a direct seed treatment. To directly treat seed, add 1 pint of water to each 100 pounds of seed in a cement mixer or commercial or homemade seed treater and mix to fully coat the seed. Add insecticide slowly and in the correct amount, thoroughly mixing until insecticide is distributed evenly on all seeds. Treated seeds should be planted within 20 days of treatment because longer exposure to insecticide may lower seed germination of some sorghum hybrids.

Take care to avoid inhaling the dust when placing and mixing insecticide in a planter box to treat planting seed. Use an old broom handle, stick or similar device to mix insecticide and seed in the planter box.

Lindane used on planting seed can delay and reduce seed germination when soil is cold and wet, or very hot. Lindane should at all times be used according to label instructions. If the 7-day forecast is for a cold, wet period or the soil temperature is marginal for seed germination, it may be best not to use lindane. Despite these precautions, lindane has been an effective, low-cost method of protecting sorghum planting seed from insect attack. **Do not use treated sorghum seed for human consumption or livestock feed.**

Seed sometimes is treated with insecticides such as malathion, methoxychlor or pirimiphos-methyl to control stored-grain pests and do not control seed-feeding insect pests once seed is planted.

Soil insecticide treatments

Insecticides for controlling some soil-inhabiting insect pests must be applied before the crop is planted or at planting time. Granular or liquid formulations may be used. The formulation used usually depends on available equipment and the target insect. Several application techniques are used to treat soil: preplant row treatment, row band at planting and in-furrow at planting.

Preplant row treatment requires special equipment to incorporate insecticide to a depth of 2 to 4 inches. Row treatments must be made after or during bed formation because further cultivation or bed shaping changes the position of insecticide in the row. For best control, treat a band of soil 7 to 10 inches wide and 2 to 4 inches deep, and place seed in the center of the band.

Row band and in-furrow applications may be used to apply insecticide to soil at planting. The technique chosen depends on the pest insect and how a particular insecticide is labeled. Mount the granular applicator spout or spray nozzle just behind the opening plow or disc opener and in front of the covering shovels or press wheel. Adjust spouts or nozzles to make the treatment band 6 to 8 inches wide, treating the seed furrow as well as covering soil. Incorporating insecticide by covering shovels is adequate. Insecticide also can be incorporated with short parallel chains, loop chains, press wheels, finger tines or other suitable devices. Do not apply insecticides directly on seed unless the label clearly describes that use, because doing so usually results in poor seed germination. In-furrow insecticide application for other insect pests does not adequately control white grubs when they are abundant.

Some insecticides (e.g., aldicarb, carbofuran, disulfoton, phorate, terbufos) are systemic and can be applied at planting. Applied to soil, these chemicals are absorbed into the young growing sorghum plant and control or suppress such early-season insect pests as greenbug, corn leaf aphid, yellow sugarcane aphid and chinch bug.

Certain insecticides, besides being systemic, are effective against some soil-inhabiting insect pests, such as wireworms and corn rootworms. Duration of systemic activity varies with insecticide and rate, but generally suppress insect pests for 2 to 6 weeks after application.

Foliar and grain-head insecticide treatments

Aircraft or ground machines may be used to apply insecticides to sorghum foliage and grain heads. Aerial applications work best when insecticide swaths meet or overlap. Insecticide sprays are more effective and hazards minimized when wind velocity is less than 10 miles per hour.

Nozzle size and number, ground speed and pressure influence the rate of insecticide spray output per acre by a ground machine. Calibrate the sprayer carefully to ensure the recommended amount of insecticide is applied. One nozzle per row usually is adequate for young sorghum planted in rows. Two to three nozzles may be needed to adequately cover larger plants and broadcast-planted sorghum. Optimal pump pressure depends on the kind of nozzle used.

Some insecticides discolor foliage of certain sorghum hybrids. Yield losses may occur from extensive leaf damage after these chemicals are used on susceptible hybrids. Review the label carefully before using an insecticide. If you do not know whether the sorghum is susceptible to insecticide, consult the insecticide manufacturer and/or seed company. Carefully follow instructions on the label of an insecticide container to avoid hazards to the applicator, wildlife and the environment.

Endangered Species Act

The Endangered Species Act is designed to protect and recover animals and plants in danger of becoming extinct. Under provisions of this act, the U.S. Fish and Wildlife Service helps the Environmental Protection Agency and Food and Drug Administration to implement pesticide programs by analyzing the biological effects of pesticides on threatened and endangered species.

Many pesticide labels now list restrictions limiting use of products or application methods in areas designated as biologically sensitive. These restrictions often change. Refer to Environmental Hazards of Endangered Species discussion sections of product labels and/or call your local county Extension agent or fish and wildlife service personnel to determine what restrictions apply in your area. Regardless of the law, pesticide users can be good neighbors by knowing how their actions may affect people and the environment.

Bees and other pollinators

Protect bees and other pollinators from insecticides. Pollination by bees is important in producing such crops as alfalfa, clover, vetch and cucurbits. Sorghum is an important source of pollen for honey bees in many parts of Texas. However, sorghum is wind- or self-pollinated and does not require insect pollinators.

Take care to minimize bee losses by:

- Applying insecticides, if practical, before bees move into fields or adjacent crops. When bees are present in the field or vicinity, make applications during the evening after bees have left the field.
- Where insecticides are needed, using materials least toxic to bees and notifying beekeepers so they can protect bees.
- Preventing insecticide spray from drifting directly onto bee colonies.

Inbred lines for hybrid seed production

Inbred lines used for sorghum hybrid seed production often are more susceptible than hybrids to insect pest damage and insecticide phytotoxicity. The increased susceptibility to insecticides and higher crop value of sorghum for hybrid seed production generally require lower economic threshold levels for insect pests. Also, insect pests that influence seed quality and germination are more important in hybrid seed production.

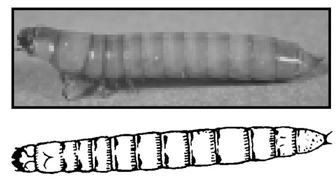
Monitor hybrid seed production fields regularly and consider the increased susceptibility to insect pests and insecticide phytotoxicity. Before applying an insecticide, check the insecticide label carefully and consult the manufacturer and seed company about possible phytotoxic effects.

Seed and root insect pests

Wireworms

Elateridae and Tenebrionidae

True and false wireworms are immature stages of click and darkling beetles. Wireworms generally are shiny, slender, cylindrical and hard-bodied. Their color ranges from yellow to brown.



Wireworm

Wireworms feed on planted sorghum seed, preventing germination. To a lesser degree, they feed on seedling plant roots, reducing plant stands and vigor.

Cultural practices that reduce abundance of and damage by wireworms include:

- Preparing good seedbeds and planting when soil moisture and temperature are adequate to promote rapid seed germination;
- Cultivating to reduce non-crop plant material; and
- Planting sorghum in a field where a taprooted crop such as cotton was grown the previous year.

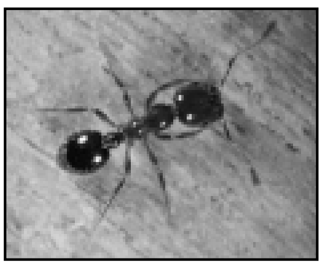
Sample fields before planting to determine the need to use insecticide-treated seed or to apply insecticide at planting. Soil examination and bait traps can be used to sample for the presence of wireworms.

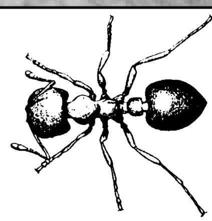
To build a bait trap, place 6 to 12 ounces of nontreated sorghum seed in a 4-inch wide by 6- to 8-inch deep hole in the soil. Cover the hole with soil, and mark the trap with a stake. Covering the trap location with a 4- by 4-foot sheet of black plastic warms the soil and makes trapping more effective. At least 2 weeks before planting, install one trap for each 10 to 20 acres. Two weeks later, examine the grain in the trap and count the wireworms. Also, growers may thoroughly examine soil samples 1 foot square by 4 inches deep. *If you find one wireworm larva per square foot or two or more larvae per bait trap, treat either seed or soil with insecticide.*

Lindane applied as a seed or planter box treatment effectively controls wireworms. Information on seed treatment procedures is contained in the section on seed treatment. Gaucho®-treated seed also is labeled for wireworms. Applying some insecticides in furrow at planting also may control wireworms.

Red imported fire ant

Solenopsis invicta





Red imported fire ant

Under certain conditions in the eastern and southern parts of the state, red imported fire ants feed on planted seed. Worker ants chew through the thin seed coat and remove the embryo (germ). They rarely consume the endosperm (starch) of the seed. They prefer water-soaked or germinating seeds, but also damage dry seeds.

Cultural management practices that reduce damage by wireworms to planted sorghum seed also reduce red imported fire ant. Use seed with good vigor and plant into a well-prepared seedbed when soil temperature and moisture are adequate for rapid seed germination. Firmly pack covering soil to prevent easy access of fire ants to planted seed and thus reduce damage by fire ants. Insecticide-treated seed as described for wireworms is effective against red imported fire ants. Gaucho®-treated seed or in-furrow, at-planting application of insecticide may provide effective control.

Table 1. Suggested insecticides for seed treatment for wireworms and red imported fire ants.

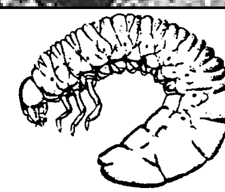
Lindane formulation	% Lindane	Concentrate
Gammasan®	16.6	3 oz./bu.
Seed Mate Lindane 25®	25	4 oz./cwt.
Sorghum Guard®	16.6	3 oz./bu.

Remark

Seed Mate Lindane 25®. If soil temperature is extremely high (hot weather, mid-summer planting) reduce recommended dosage by one-half.

White grubs

Phyllophaga crinita and others



White grub

White grubs are the larvae of May or June beetles. White grubs are characteristically "C-shaped" with white bodies and tan to brown heads and legs. Because the last abdominal segment is transparent, dark-colored digested material can be seen in the larva. Larvae vary in size according to age and species.

Rarely are white grubs serious pests of sorghum. However, because they can be present in a field at planting and cannot be controlled once sorghum is planted, their presence must be determined before planting. Grubs damage sorghum by feeding on the roots. They may kill small seedlings, resulting in stand loss. Severely pruned roots of larger plants result in plant stunting and lodging and increased susceptibility to drought and stalk rot organisms.

Planting sorghum in a field where a non-grass crop was grown the previous year is the most important cultural management tactic against white grubs.

To determine the abundance of white grubs before planting, examine 1 square foot of soil in each 5 to 10 acres. *If more than two white grubs are found per square foot, severe damage to sorghum could result.* No insecticides for white grubs are currently labeled for broadcast, incorporated application. *If white grubs average one per square foot, growers can adequately suppress them with an in-furrow or row band application of terbufos.*

Table 2. Suggested insecticide for controlling white grubs.

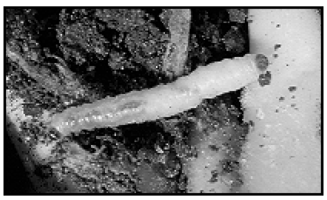
Insecticide — Toxicant per pound	Concentrate/ 1,000 ft. of row	Days from last application to: Harvest	Grazing
Terbufos		See remark	
(Counter® 15G)	8 oz.		
(Counter® 20CR®)	6 oz.	100	50

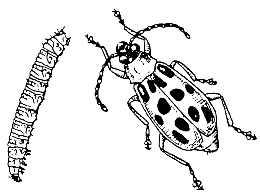
Remark

Terbufos. Apply once per season in a 5- to 7-inch band directly behind the planter shoe in front of the press wheel, and not in direct contact with seed.

Southern corn rootworm

Diabrotica undecimpunctata howardi





Southern corn rootworm

Southern corn rootworms are the larvae of the spotted cucumber beetle. Rootworms are small, brown-headed and creamy white, with wrinkled skin. They burrow into germinating seeds, roots and crowns of sorghum plants.

Symptoms of rootworm damage include reduced stands and plant vigor, and occurrence of "dead heart" in young plants. Later in the season, maturity may be delayed, weeds may increase in abundance because of a nonuniform plant stand, and plants may lodge. Damage by southern corn rootworms is most likely to occur in the area of Texas shaded on the map (Figure 2).

Granular or liquid formulations of several insecticides are labeled for in-furrow or row band application for controlling rootworm. Base the need for insecticide treatment on a field history of previous damage by rootworms. Rotating insecticides decreases the possibility of rootworms developing resistance. Seed treatment with lindane controls light infestations of rootworms present at planting.

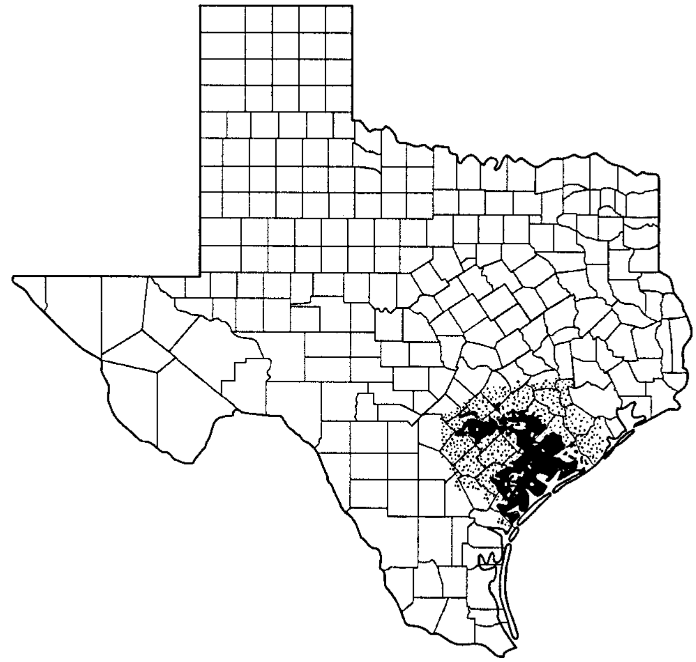


Figure 2. Areas of potentially economically damaging southern corn rootworm infestations in Texas.

Table 3. Suggested insecticides for controlling southern corn rootworm.

Insecticide (listed alphabetically) — Toxicant per gallon or pound	Concentrate per unit area	Days from last application to: Harvest	Grazing
Carbofuran		See remarks	
(Furadan® 4F)	24-32 oz./acre	75	75
Chlorpyrifos		See remarks	
(Lorsban® 15G)	4-8 oz./1,000 ft. of row		
Terbufos		See remarks	
(Counter® 15G)	4-8 oz./1,000 ft. of row		
(Counter® 20CR®)	3-6 oz./1,000 ft. of row	100	50

Remarks

Carbofuran. Apply in seed furrow or 7-inch band and incorporate.

Chlorpyrifos. Apply once per season in a 6- to 7-inch band, behind the planter shoe and in front of the press wheel.

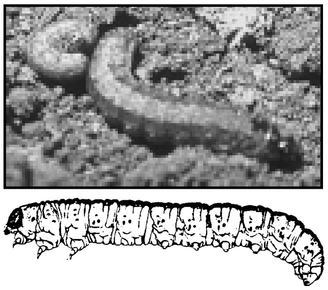
Terbufos. Apply once per season in a 5- to 7-inch band directly behind the planter shoe in front of the press wheel, and not in direct contact with seed.

NOTE: Lower rates of insecticides listed have been shown to provide most favorable economic returns; however, where high infestations consistently occur, use the higher insecticide rate.

Stem and leaf insect pests

Cutworms

Agrotis and *Euxoa spp.*



Cutworm

Cutworms of several species can damage sorghum. Cutworms are immature stages of moths that are active at night. Cutworm moths prefer to lay eggs in grassy and weedy fields. Eggs are laid on stems or leaves of sorghum, grassy weeds or in the soil, and hatch in 2 to 14 days.

The typical cutworm larva attacking sorghum is plump and curls into a “C” shape when disturbed. Larvae vary in color from grayish white to grayish black or brown depending on species. Fully grown larvae are 1 to 2 inches long. Some species pass the winter in the soil as pupae and others as adults; most overwinter as small larvae in cells in the soil, under trash, or in clumps of grass. They start feeding in spring and continue growing until early summer, when they pupate in the soil. Larvae of most species remain underground during the day and feed at night.

The most common cutworms in sorghum (surface-feeding cutworms) cut plants off at, slightly below or above the surface of the soil. Some (climbing or army cutworms) feed on above-ground plant parts; others are subterranean and feed on underground plant parts including roots of seedlings.

Cultural controls for cutworms include plowing under or using herbicides to control vegetation in late summer or early fall, destroying weeds and thoroughly preparing the seedbed at least 3 to 6 weeks before planting. Cutworms are more severe in weedy fields.

Determining the presence of cutworms in sorghum is based on visible damage to plants. For surface-feeding and subterranean cutworms, determine the number of severed or dead and dying plants per foot of row. Base your decision to apply insecticide on the degree to which an adequate stand is threatened. For cutworms that feed on above-ground plant parts, significant losses occur when more than 30 percent of the leaf tissue has been eaten.

Insecticide sprayed as a broadcast treatment on the ground and plants usually protects against cutworms. However, cutworms spend the day hidden in the soil. Late-afternoon applications sometimes are more effective. Insecticidal baits are available and effective against some cutworms, but are expensive. Insecticide applied at planting controls subterranean cutworms. Apply the insecticide in a 6- to 7-inch band and incorporate it into the top 1 to 2 inches of soil.

Aerial or ground application of approved insecticide is effective in controlling cutworms in an established sorghum stand. However, insecticide is more effective on climbing than subterranean cutworms. Refer to Table 4 for insecticides suggested for cutworm control. Also refer to labels of insecticides listed for southern corn rootworm control for labeled use against cutworms.

Table 4. Suggested insecticides for controlling cutworms.

Insecticide (listed alphabetically) Toxicant per gallon or pound	Concentrate per unit area	Days from last application to: Harvest	Grazing
Chlorpyrifos		See remarks	
(Lorsban®)			
(4E)	16-32 oz./acre	30-60	30-60
(15G)	8 oz./1,000 ft. of row		
Cyfluthrin		See remarks	
(Baythroid® 2E)	1.0-1.3 oz./acre		14
Cyhalothrin		See remarks	
(Karate® 1E)	1.92-2.56 oz./acre		

Remarks

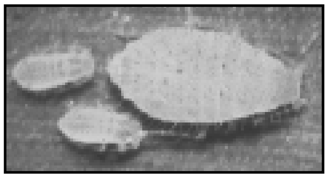
Chlorpyrifos. *4E* - To minimize insecticidal injury, do not apply to drought-stressed plants or within 3 days after irrigation or rain except where insecticide is applied in irrigation water. The waiting period from last application to harvest or grazing is 30 days for the 16-oz. rate and 60 days for the 32-oz. rate.

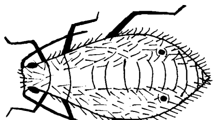
Cyfluthrin. If applied once or twice, green forage may be fed or grazed on the day of treatment. For three applications, allow at least 14 days between last application and grazing.

Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.

Yellow sugarcane aphid

Sipha flava





Yellow sugarcane aphid

Yellow sugarcane aphids usually are lemon-yellow, but under some conditions are pale green, are covered with small spines and have two double rows of dark spots on the back. Both winged and wingless forms live in the colony. This aphid feeds on many different grasses, including johnsongrass and dallisgrass. Females give birth for 28 days to living young, averaging two nymphs a day by each female. Nymphs mature in 13 to 19 days; adults live for 25 to 30 days.

Yellow sugarcane aphids feed on sorghum and inject toxin into leaves of seedlings and older plants. Aphids feeding on seedling plants turn the leaves purple and stunt growth. On more mature plants, leaves turn yellow. By the time discoloration symptoms are visible, plants have been injured significantly. Damage often leads to delayed maturity and plant lodging that may be worsened by associated stalk rots.

The presence of yellow sugarcane aphids must be determined soon after sorghum plants emerge. The presence of purple-colored seedling plants is an indication of a yellow sugarcane aphid infestation. Scout sorghum by inspecting plants beginning the first week of plant emergence and twice weekly until plants have at least five true leaves. As plants grow larger, they become more tolerant of aphid feeding. Very small seedling sorghum plants (one to three true leaves) often are significantly damaged after being infested for a week or less.

Discoloration symptoms may be useful in assessing yield losses, and may be used in a decision to replant. Information in Table 5 describes plant damage and corresponding percentage yield loss associated with levels of damage. Do not consider the first two "seed leaves" when estimating damage.

Economic injury levels presented in Tables 6 to 8 are based on percentage of yellow sugarcane aphid-infested plants at the

Table 5. Estimated yield loss based on damage by yellow sugarcane aphids to three true-leaf stage sorghum plants.

Description	% Loss/plant
No discoloration	0
Localized discoloration	8
Less than one entire leaf discolored	11
One entire leaf discolored	31
More than one leaf discolored	54
More than two leaves discolored	77
Dying/dead plant	100

Table 6. Economic injury levels for yellow sugarcane aphid based on percentage of seedling plants infested at the one true-leaf stage.

Control cost ($) per acre	Crop market value ($) per acre								
	100	125	150	175	200	225	250	275	300
	Percent infested plants								
6	15	12	10	9	8	7	6	6	5
8	20	16	13	11	10	9	8	8	7
10	25	20	17	14	12	11	10	10	9
12	30	25	21	17	14	13	12	11	10

Table 7. Economic injury levels for yellow sugarcane aphid based on percentage of seedling plants infested at the two true-leaf stage.

Control cost ($) per acre	Crop market value ($) per acre								
	100	125	150	175	200	225	250	275	300
	Percent infested plants								
6	26	21	18	15	13	12	11	10	10
8	35	28	24	20	17	16	14	13	13
10	43	35	29	25	22	20	17	16	16
12	51	42	35	30	26	23	20	19	18

Table 8. Economic injury levels for yellow sugarcane aphid based on percentage of seedling plants infested at the three true-leaf stage.

Control cost ($) per acre	Crop market value ($) per acre								
	100	125	150	175	200	225	250	275	300
	Percent infested plants								
6	67	53	44	38	33	30	27	25	24
8	89	71	60	51	44	38	36	33	32
10	*	90	76	64	55	48	44	41	39
12	*	*	92	77	66	57	53	49	44

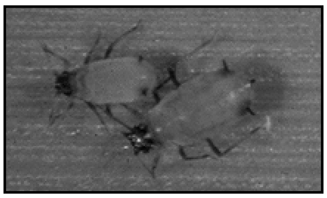
*Do not treat.

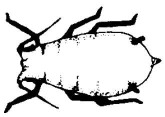
1, 2 or 3 true-leaf stage. Do not count the two seed leaves that appear first.

Many predators feed on yellow sugarcane aphid, but the aphid is rarely parasitized. Insecticides are currently the only way to manage yellow sugarcane aphids in sorghum. Gaucho®-treated seed or insecticide applied at planting (carbofuran, disulfoton or phorate) reduces severity of yellow sugarcane aphid infestations (Table 9).

Corn leaf aphid

Rhopalosiphum maidis





Corn leaf aphid

Corn leaf aphids often infest the whorl and underside of leaves of sorghum in great numbers. This dark bluish-green aphid is oval-shaped, with black legs, cornicles and antennae. There are winged and wingless forms.

Corn leaf aphids are found most frequently deep in the whorl of the middle leaf of pre-boot sorghum but also occur on the underside of leaves, on stems or in grain heads. When feeding, corn leaf aphids suck plant juices but do not inject toxin as do greenbug and yellow sugarcane aphid. The most apparent feeding damage is yellow mottling of leaves that unfold from the whorl.

This insect rarely causes economic loss to sorghum. In fact, they can be considered helpful. Beneficial insects such as lady beetles are often attracted to feed on corn leaf aphids. When corn leaf aphid numbers rapidly decline at sorghum heading, the beneficial insects are present to suppress greenbug and other insect pests. These beneficial insects also are believed to move to adjacent crops, such as cotton, and help manage insect pests in those crops.

When abundant, corn leaf aphids are easily seen within the whorl of sorghum plants. The whorl leaf can be pulled from the plant and unrolled to detect aphids when numbers of aphids are low. Occasionally, corn leaf aphids will become so abundant on a few plants in a field that grain head exertion and development are hindered. Moisture-stressed sorghum plants are more likely than non-stressed plants to be damaged by corn leaf aphids. Although very

Table 9. Insecticides for yellow sugarcane aphid.

Insecticide (listed alphabetically) Toxicant per gallon or pound	Concentrate per acre	Days from last application to: Harvest	Grazing
Commercially treated seed			
Imidacloprid (Gaucho®)	Commercially applied		45
Applied at planting			
Carbofuran		See remarks	
(Furadan® 4F)	24-32 oz.	75	75
Disulfoton			
(Di-Syston®)			
(8E)	16 oz.		
(15G)	5.0-6.7 lb.		
Phorate		See remarks	
(20G)	4.9 lb.		
Applied post-emergence			
Carbofuran		See remarks	
(Furadan® 4F)	8-16 oz.	75	75
Dimethoate		See remarks	
(4E)	8-16 oz.	28	28
(5E)	6.4-12.8 oz.	28	28
Disulfoton		See remarks	
(Di-Syston®)			
(8E)	4-8 oz.	7	45
(15G)	5.0-6.7 lb.	30	45
Parathion (ethyl)		See remarks	
(4E)	16 oz.	12	12
(8E)	8 oz.	12	12
Phorate		See remarks	
(20G)	4.9 lb.	28	

Remarks

Carbofuran. Applicator must use proper protective equipment when applying this highly toxic insecticide. Do not apply to foliage more than twice per season. Do not apply after heads emerge from the boot.

Dimethoate. Do not apply more than three times per season. Do not apply after heads emerge from the boot.

Disulfoton. 8E - A maximum of three foliar applications may be made, with the last application no later than flowering. Post-harvest interval is 34 days for three foliar applications. ***15G*** - Granular formulation applied post emergence is recommended as whorl application only.

Parathion. Aerial application only. Do not substitute methyl parathion.

Phorate. Do not place in contact with seed at planting. Apply only once after plant emergence.

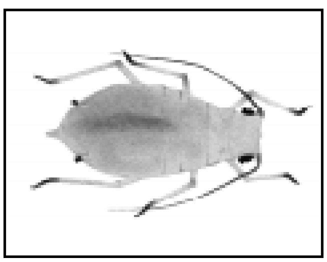
rare, infestations on seedling sorghum might cause stand loss, and grain head infestations might cause harvesting problems.

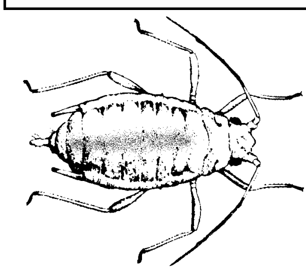
Because corn leaf aphids prefer to live and feed in the whorl of sorghum, aphid numbers normally decline rapidly after the grain head exerts (emerges) from the boot. Sometimes molds grow on the honeydew that corn leaf aphids produce. Honeydew on sorghum grain heads has been associated with harvesting problems. The aphid also transmits maize dwarf mosaic virus.

Although insecticide is rarely justified, corn leaf aphid can be controlled with the insecticides used for greenbug. Gaucho®-treated seed or carbofuran, disulfoton, phorate or terbufos at planting are effective in controlling corn leaf aphids. However, corn leaf aphids do not inject toxin as they feed and very rarely damage sorghum. Because it is rarely a pest, sampling procedures and damage assessment information are unavailable.

Greenbug

Schizaphis graminum





Greenbug

The greenbug is an aphid that sucks plant juices and injects toxin into sorghum plants. The adult greenbug is light green, approximately 1/16 inch long, with a characteristic darker green stripe down the back. Usually, the tips of the cornicles and leg segments farthest from the body are black. Winged and wingless forms may be present in the same colony.

Females produce living young (nymphs) without mating. Under optimum conditions, the life cycle is completed in 7 days. Each female produces about 80 offspring during a 25-day period.

Greenbugs feed in colonies on the underside of leaves and produce much honeydew. The greenbug may be a pest during the seedling stage and in the boot or heading stage. Infestations may be detected by the appearance of reddish leaf spots caused by the toxin greenbugs inject into the plant. The reddened areas enlarge as the number of greenbugs and injury increase. Damaged leaves begin to die, turning yellow then brown. Damage at the seedling stage may result in stand loss.

Larger sorghum plants tolerate more greenbugs. Yield reductions during boot, flowering and grain-development stages depend on greenbug numbers, length of time greenbugs have infested the plants, and general plant health. Many greenbugs on booting and older plants can reduce yields and weaken plants that may later lodge.

Scouting sorghum for greenbugs is easy. Examine a minimum of 40 randomly selected plants per field each week. Greenbugs are seldom distributed evenly in a field, so examine plants from all parts of the field; avoid examining only field borders. In fields larger than 80 acres, or if making a control decision is difficult, examine more than 40 plants.

When deciding whether to control greenbugs, consider the amount of leaf damage, number of greenbugs per plant, percentage of parasitized greenbugs (mummies), numbers of greenbug predators (lady beetles) per plant, moisture conditions, plant size, stage of plant growth and overall condition of the crop. It is important to know from week to week whether greenbug numbers are increasing or decreasing. For example, insecticide treatment would not be justified if the recommended treatment level (based on leaf damage) had been reached but greenbug numbers had declined substantially from previous observations.

In seedling sorghum (less than 6 inches tall), greenbugs may be found on any part of the plant including the whorl or in the soil at the base of the plant. When scouting seedling sorghum, examine the entire plant and the soil around the base of the plant. Note the presence or absence of greenbugs and any damage to plants (yellowing, death of tissue). Refer to Table 10 for economic thresholds for greenbugs on different plant growth stages.

Table 10. Economic threshold levels for greenbug on sorghum at different plant growth stages.

Plant size	When to treat
Emergence to about 6 inches	20% of plants visibly damaged (beginning to yellow), with greenbugs on plants
Larger plant to boot	Greenbug colonies causing red spotting or 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% of plants
Heading to hard dough	When greenbug numbers are sufficient to cause death of two normal-sized leaves on 20% of plants

Plants can tolerate about 30 percent leaf loss before yield is reduced. Greenbug infestations after sorghum flowering and before the hard-dough stage should be controlled before they kill more than two normal-sized leaves on 20 percent of the plants. In the Texas Blacklands, insecticide application is suggested when greenbugs are colonizing the upper leaves of booting sorghum and causing red spotting or yellowing of leaves.

These guidelines are based on the assumption that greenbugs are increasing so rapidly that control by beneficial insects is ineffective. However, when more than 20 percent of the greenbugs appear brown and swollen from being parasitized, an insecticide treatment is usually unnecessary. Also, plants showing drought or other stress cannot tolerate as much greenbug damage without suffering reduction in yield.

Greenbug colonies usually begin on the underside of lower leaves and move up the plant. On most sorghum hybrids, only the underside of lower leaves need to be examined, although in some cases greenbug colonies may be found first on the underside of upper leaves. Do not confuse greenbugs with the bluish green corn leaf aphid, often found with greenbugs in the plant whorl.

Greenbugs in a field can increase 20-fold per week, but the seasonal average is 5- to 6-fold increase each week. Rain and predators suppress aphid abundance early in the season, although the increase of natural enemies has a lag time of 1 to 2 weeks. A common parasitoid usually is responsible for a rapid decline in aphid abundance late in the season.

Sorghum hybrids resistant to greenbug are available commercially. However, greenbug biotypes have consistently occurred and new resistant hybrids have had to be developed. Hybrids resistant to greenbug biotypes C, E, I and K have been or are being developed. Using greenbug-resistant hybrids is suggested. Resistance mainly is tolerance, and therefore resistant hybrids will not be free of greenbugs. Damage thresholds for resistant sorghums are the same as for susceptible sorghums because thresholds are based on plant damage.

When deciding on insecticide treatment, consider the previously listed factors and consult the recommended treatment levels in Table 10. When estimating leaf damage, consider any leaf to be dead if more than 75 percent of its surface is red, yellow, or brown. Do not mistake for greenbug damage the natural senescence of the small bottom leaves. Estimate an average leaf damage level for the entire field unless it is feasible to spot treat areas of the field.

The greenbug usually is susceptible to labeled insecticides (Table 11), but resistance to organophosphorous insecticides exists in several counties in the Texas Panhandle. Continued extensive use of certain insecticides could expand the resistance problem. Where resistance exists in an area, apply the initial insecticide at the higher labeled dosage rate and increased application volume to ensure complete coverage.

Chinch bug

Blissus leucopterus leucopterus

Chinch bugs are sporadic pests of sorghum in Texas. Adult chinch bugs are black, with reddish yellow legs and with conspicuous, fully developed white forewings, each of which has a black triangular spot at the middle

Chinch bug

Table 11. Suggested insecticides for controlling greenbug.

Insecticide (listed alphabetically) Toxicant per gallon or pound	Concentrate per unit area	Days from last application to: Harvest	Grazing
Commercially treated seed			
Imidacloprid (Gaucho®)	Commercially applied		45
Applied at planting			
Aldicarb		See remarks	
(Temik® 15G)	7 lb./acre	90	
Carbofuran		See remarks	
(Furadan® 4F)	24-32 oz./acre	75	75
Disulfoton (Di-Syston®)			
(8E)	1.2 oz./1,000 ft. of row		
(15G)	6-8 oz./1,000 ft. of row		
Phorate		See remarks	
(Thimet®)			
(15G)	8 oz./1,000 ft. of row	30	30
(20G)	6 oz./1,000 ft. of row	30	30
Terbufos		See remarks	
(Counter® 15G)	8-16 oz./1,000 ft. of row		
(Counter® 20CR®)	6-12 oz./1,000 ft. of row	100	50
Applied post-emergence			
Carbofuran		See remarks	
(Furadan® 4F)	24-32 oz./acre	75	75
Chlorpyrifos		See remarks	
(Lorsban® 4E)	8-32 oz./acre	30-60	30-60
Dimethoate		See remarks	
(4E)	8-16 oz./acre	28	28
(5E)	6.4-12.8 oz./acre	28	28
Disulfoton		See remarks	
(Di-Syston®)			
(8E)	4-8 oz./acre	7	45
(15G)	5.0-6.7 lb./acre	30	45
Malathion			
(57EC)	24 oz./acre		
Parathion (ethyl)		See remarks	
(4E)	8-16 oz./acre	12	12
(8E)	4-8 oz./acre	12	12
Phorate		See remarks	
(Thimet®)			
(15G)	6.7 lb./acre	30	30
(20G)	4.9 lb./acre	30	30

Remarks

Aldicarb. Do not feed green forage to livestock.

Carbofuran. Applicator must use proper protective equipment when applying this highly toxic insecticide. Do not apply after heads emerge from the boot.

Chlorpyrifos. Do not exceed three applications. The waiting period from last application to harvest or grazing is 30 days for the 16-oz. rate and 60 days for more than 16 oz.

Dimethoate. Do not apply more than three times per season. Do not apply after heads emerge from the boot.

Disulfoton. 8E - Do not apply foliar spray or granules more than three times per crop season. Post-harvest interval is 34 days for three foliar applications. ***15G*** - Granular formulation applied post emergence is recommended as whorl application only.

Parathion. Aerial application only. Do not substitute methyl parathion.

Phorate. Do not place in contact with seed. Do not feed foliage before grain harvest.

Terbufos. May be knifed in at bedding, or banded (except in West Texas) or knifed in at planting (see label for dosage differences). Do not place granules in direct contact with seed. For early season control of light to moderate infestations.

of the outer margin. Immature chinch bugs resemble adults in shape but lack wings. Young nymphs are yellowish, later turning reddish with a white or pale yellow band across the front part of the abdomen. Older nymphs are black and gray with a conspicuous white spot on the back between the wing pads.

Eggs are laid behind the lower leaf sheaths of sorghum plants, on roots or in the ground near the host plant. The life cycle is completed in 30 to 40 days, and there are at least two generations a year. Chinch bugs overwinter as adults in bunch grass. They begin moving to sorghum when temperatures reach 70° F.

Adult and immature chinch bugs suck juices from stems, leaves or underground

Table 12. Suggested insecticides for controlling chinch bug.

Insecticide (listed alphabetically) Toxicant per gallon or pound	Concentrate per unit area	Days from last application to: Harvest	Grazing
Commercially treated seed			
Imidacloprid (Gaucho®)	Commercially applied		45
Applied at planting			
Aldicarb	7.5 oz./1,000	See remarks	
(Temik® 15G)	ft. of row	90	
Chlorpyrifos (Lorsban®15G)	8 oz./1,000 ft. of row		
Terbufos		See remarks	
(Counter® 15G)	8 oz./1,000 ft. of row		
(Counter® 20CR®)	6 oz./1,000 ft. of row	100	50

Insecticide (listed alphabetically) Toxicant per gallon or pound	Concentrate per unit area	Days from last application to: Harvest	Grazing
Applied post-emergence			
Carbaryl		See remarks	
(Sevin®)			
(4F)	32-64 oz./acre	21	14
(80S or 80WSP)	1.25-2.5 lb./acre	21	14
(50W)	2-4 lb./acre	21	14
(4XLR+®)	32-64 oz./acre	21	14
Carbofuran		See remarks	
(Furadan® 4F)	8-16 oz./acre	75	75
Chlorpyrifos		See remarks	
(Lorsban® 4E)	16-32 oz./acre	30-60	30-60
Cyfluthrin		See remarks	
(Baythroid® 2E)	1.3-2.8 oz./acre		14
Cyhalothrin		See remarks	
(Karate® 1E)	3.84 oz./acre		

Remarks

Aldicarb. Apply granules in furrow and cover with soil. Do not feed green forage to livestock.

Carbaryl. Use high-gallonage ground application directed at bases of plants.

Carbofuran. Ground application only. Use 20-30 gallons of water per acre. Do not apply more than twice per season. Do not apply after heads emerge from the boot.

Chlorpyrifos. Apply with enough water to ensure a minimum spray volume of 20-40 gallons per acre. Use ground equipment to direct spray toward bases of plants. The waiting period from last application to harvest or grazing is 30 days for the 16-oz. rate and 60 days for more than 16 oz. Do not apply more than 48 oz. per acre per season. Do not treat sweet sorghum.

Cyfluthrin. 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. Direct applications at the basal portion of the plant.

Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.

Terbufos. Apply in 5- to 7-inch band over the row in front of or behind press wheel and lightly incorporate into soil. Do not place granules in direct contact with seed. For early-season control of light to moderate infestations.

plant parts. Young plants are highly susceptible. Older plants withstand attack better, but they, too, become reddened, weakened and stunted. Chinch bugs are favored by hot, dry weather, and large numbers of immature bugs often migrate from wild bunch grasses or small grains to congregate and feed behind lower leaf sheaths of sorghum plants.

To find chinch bugs, carefully examine plants and surrounding soil. Make at least five random checks per field.

Cultural practices that stimulate dense, vigorous plant stands are recommended because these conditions are less favored by chinch bugs, and injury usually is reduced. Plant sorghum as early as practical.

Apply insecticide when two or more chinch bugs are found on 20 percent of seedling plants less than 6 inches tall. On taller plants, insecticide often is justified when chinch bugs infest 75 percent of the plants. Generally, one chinch bug per seedling sorghum plant reduces grain yield by 2 percent.

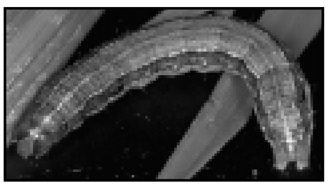
Chinch bugs sometimes are difficult to control with insecticides. In fields with a history of economically damaging infestations of chinch bug, at-planting, soil-incorporated insecticides or Gaucho®-treated seed may be justified. Granular insecticides must receive about one-half inch of rainfall after application to effectively suppress early-season chinch bug infestations.

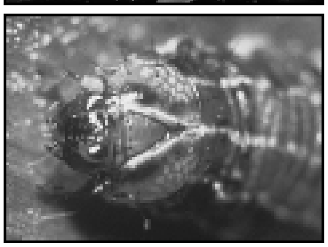
If infestations reach the economic threshold after plant emergence, apply post-emergence insecticide using at least 20 gallons of water per acre through nozzles directed at the bases of plants. Control is seldom satisfactory on plants in the boot stage or later. Aerial insecticide application is seldom effective and not suggested.

Corn earworm and fall armyworm (whorlworms)

Helicoverpa zea and *Spodoptera frugiperda*

Corn earworm





Fall armyworm

Corn earworm and fall armyworm infest the whorls and grain heads of sorghum plants. Larvae hatching from eggs laid on sorghum leaves before grain heads are available migrate to and feed on tender, folded leaves in the whorl.

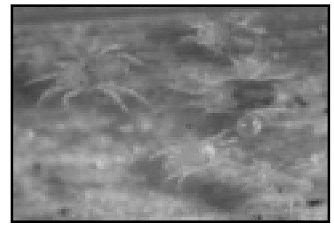
To find larvae in sorghum whorls, pull the whorl leaf from the plant and unfold it. Frass, or larval excrement, is present where larvae feed within the whorl. Damaged leaves unfolding from the whorl are ragged with "shot holes." Although this may look dramatic, leaf damage usually does not reduce yields greatly, and control of larvae during the whorl stage is seldom economically justified. Also, larvae within the whorl are somewhat protected from insecticide.

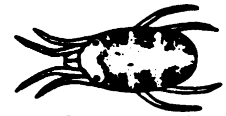
Insecticide application may be justified if larval feeding reduces leaf area by more than 30 percent or is damaging the developing grain head or growing point within the whorl. See the section on Corn earworm and fall armyworm (headworms) for information on these insects as pests of sorghum grain heads.

Banks grass mite

Oligonychus pratensis

Large numbers of Banks grass mites sometimes occur on sorghum, especially in more arid areas of Texas. These mites are very small; females are larger than males. After feeding, mites turn deep green, except for the mouthparts and first two pairs of legs that remain light salmon colored. Eggs (about 50 per female) are laid in webbing on the underside of sorghum leaves. Eggs are pearly white, spherical, one-fourth the size of the adults and hatch in 3 to 4 days. The life cycle requires about 11 days under favorable conditions.





Banks grass mite

Spider mites suck juices from the underside of sorghum leaves. Mite infestations begin along the midrib of the lower leaves. Infested areas become pale yellow initially and later become reddish on the top surface. The entire leaf may turn brown. As spider mites become more abundant on the lower leaves, the infestation spreads upward through the plant. The underside of heavily infested leaves has a dense deposit of fine webbing spun by the spider mites.

Increases in spider mite abundance generally occur after sorghum grain heads emerge. Large numbers of spider mites occurring early in kernel development can reduce the ability of sorghum plants to make and fill grain. After kernels reach hard dough, grain is not affected. However, high spider mite abundance may cause sorghum plants to lodge, resulting in harvest losses.

Inspect the underside of lower leaves carefully. Mites occur in colonies, first along midribs of leaves, but later spread away from the midrib and up the plant to higher leaves. Webbing indicates the presence of mites. Mite infestations commonly begin along field borders, and may spread quickly throughout a field.

Hot, dry weather may favor a rapid increase in mite abundance. Also, mites in sorghum may respond as induced (secondary) pests after an insecticide application for a key insect pest such as greenbug. Rapid increases in spider mite abundance after insecticide application is thought to be caused by tolerance of mites to some insecticides, destruction of beneficial insects and dispersal of mites from colonies.

Natural enemies do not always control spider mites adequately. Because spider mites increase more rapidly on moisture-stressed plants, irrigation, where available, should be timed to prevent plant stress. Also, spider mites may move from small grains, especially wheat, to sorghum. To avoid direct infestation by mites moving from small grains, plant sorghum away from small grains.

Insecticides produce varying degrees of success. Historically, insecticidal control of mites in sorghum has been erratic. *Insecticide application may be justified when 30 percent of the leaf area of most sorghum plants in a field show some damage symptoms from mite feeding.* Thorough coverage is required; apply at least 3 to 5 gallons of spray mixture per acre. Banks grass mites are often resistant to insecticides.

Table 13. Suggested miticides for controlling Banks grass mite.

Miticide (listed alphabetically)		Days from last application to:	
Toxicant per gallon or pound	Concentrate per acre	Harvest	Grazing
Dimethoate		See remarks	
(4E)	16 oz.	28	28
(5E)	12.8 oz.	28	28
Disulfoton			
(Di-Syston® 8E)	8 oz.	7	45
Phorate		See remarks	
(20G)	4.9 lb.	28	
Propargite		See remarks	
(Comite® 6.55E)	24-32 oz.	30	

Remarks

Dimethoate. Ground application: Apply in 25-40 gallons of water. Do not apply more than three times per season. Do not apply after heads emerge from the boot. Do not use in the Trans-Pecos area.

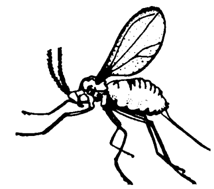
Phorate. Broadcast into whorl of plant. Do not use in the Trans-Pecos area.

Propargite. Do not apply more than once per season. Slight phytotoxicity may occur on some sorghum hybrids.

Grain head insect pests

Sorghum midge

Stenodiplosis sorghicola



Sorghum midge

The sorghum midge is one of the most damaging insects to sorghum in Texas, especially in the southern half of the state. The adult sorghum midge is a small, fragile-looking, orange-red fly with a yellow head, brown antennae and legs and gray, membranous wings.

During the single day of adult life, each female lays about 50 yellowish white eggs in flowering spikelets of sorghum. Eggs hatch in 2 to 3 days. Larvae are colorless at first, but when fully grown, are dark orange. Larvae complete development in 9 to 11 days and pupate between the spikelet glumes. Shortly before adult emergence, the pupa works its way toward the upper tip of the spikelet. After the adult emerges, the clear or white pupal skin remains at the tip of the spikelet.

A generation is completed in 14 to 16 days under favorable conditions. Sorghum midge numbers increase rapidly because of multiple generations during a season and when sorghum flowering times are extended by a range of planting dates or sorghum maturities.

Sorghum midges overwinter as larvae in cocoons in spikelets of sorghum or johnsongrass. Johnsongrass spikelets containing diapausing larvae fall to the ground and become covered with litter. When sorghum is shredded, spikelets containing larvae fall to the ground and are disked into the soil. Sorghum midges emerging in spring do so before flowering sorghum is available, and these adults infest johnsongrass. Sorghum midges developing in johnsongrass disperse to fields of sorghum when it flowers.

Early-season infestations in sorghum are usually below damaging levels. As the season progresses, sorghum midge abundance increases, especially when flowering sorghum is available in the area. Numbers often drop late in the season.

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 midges has various proportions of normal kernels scattered among non-kernel-bearing spikelets, depending on the degree of damage.

Effective control of sorghum midge requires integration of several practices that reduce sorghum midge abundance and 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 midge 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 midges increase to damaging levels.

Cultural practices that promote uniform heading and flowering in a field also are important in deciding on treatment and in achieving acceptable levels of insecticidal control. To reduce sorghum midge abundance, use cultivation and/or herbicides to eliminate johnsongrass inside and outside the field. Where practical, disk and deep plow the previous year's sorghum crop to destroy overwintering sorghum midges. Use sorghum midge-resistant hybrids if they are available.

Multiple insecticide applications are used to kill adults before they lay eggs. Sorghum planted and flowering late is especially vulnerable to sorghum midge. To determine whether insecticides are needed, evaluate crop development, yield potential and sorghum midge abundance daily during sorghum flowering. Because sorghum midges lay eggs in flowering sorghum grain heads (yellow anthers exposed on individual spikelets), they can cause damage until the entire

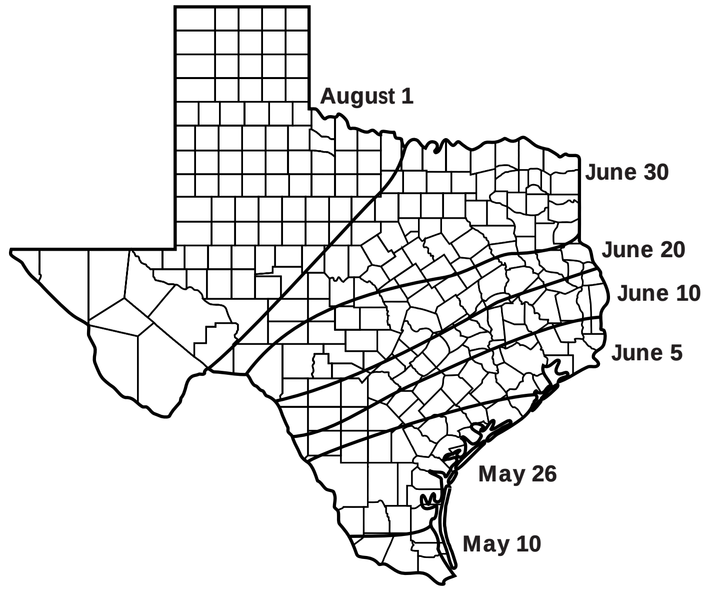


Figure 3. Estimated latest sorghum flowering dates most likely to escape significant damage by sorghum midge.

grain head or field of sorghum has flowered. The period of susceptibility to sorghum midge may last from 7 to 9 days (individual grain head) to 2 to 3 weeks (individual field), depending on uniformity of flowering.

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 are most abundant then on flowering sorghum grain heads. Because adult sorghum midges live less than 1 day, each day a new brood of adults emerges. This fact requires sampling almost daily during the time sorghum grain heads are flowering. Sorghum midge adults can be seen crawling on or flying about flowering sorghum grain heads.

The simplest and most 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 as a trapping device for adults.

Because they are relatively weak fliers and rely on wind currents to aid their dispersal, adult sorghum midges usually are 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.

However, if you find more than one sorghum midge per flowering grain head in border areas of a sorghum field, inspect at least 40 more grain heads from the entire field (avoiding plants within 150 feet of field borders). Calculate the average number of sorghum midge per flowering grain head. Sample at least 20 flowering grain heads for each 20 acres in a field.

Base the need for insecticide treatment on the number of adult sorghum midges per flowering grain head after at least 20 percent of the grain heads in a field are flowering. Tables 14 and 15 present economic injury levels for susceptible or resistant sorghum hybrids. (See page 5 for an explanation of economic threshold tables.)

Insecticide residues should effectively suppress sorghum midges 1 to 2 days after treatment. However, if adults still are present 3 to 5 days after the first application of insecticide, immediately apply a second insecticide treatment. Several insecticide applications at 3-day intervals may be justified if yield potential is high and sorghum midges exceed the economic injury level.

Table 14. Economic injury levels based on number of adult sorghum midges per flowering grain head of a susceptible sorghum hybrid.

Control cost ($) per acre	Crop market value ($) per acre								
	100	125	150	175	200	225	250	275	300
	Number of sorghum midges								
6	2.4	2.0	1.6	1.3	1.2	1.1	0.9	0.8	0.8
8	3.0	2.5	2.2	1.8	1.6	1.4	1.2	1.1	1.1
10	3.5	3.0	2.6	2.2	1.9	1.7	1.5	1.4	1.3
12	3.9	3.5	3.1	2.7	2.3	2.0	1.8	1.6	1.4

Table 15. Economic injury levels based on number of adult sorghum midges per flowering grain head of a resistant sorghum hybrid.

Control cost ($) per acre	Crop market value ($) per acre								
	100	125	150	175	200	225	250	275	300
	Number of sorghum midges								
6	12	10	8	7	6	6	5	4	4
8	15	13	11	9	8	7	6	5	5
10	17	15	13	11	10	9	8	7	6
12	19	17	15	13	11	10	9	8	7

Table 16. Suggested insecticides for controlling sorghum midge.

Insecticide (listed alphabetically) Toxicant per gallon or pound	Concentrate per acre	Days from last application to: Harvest	Grazing
Chlorpyrifos (Lorsban® 4E)	8 oz.	30	30
Cyfluthrin (Baythroid® 2E)	1.0-1.3 oz.	See remarks	14
Cyhalothrin (Karate® 1E)	1.92-2.56 oz.	See remarks	
Malathion (Fyfanon® ULV)	8-12 oz.	7	7
Methomyl (Lannate®) (2.4LV)	12-24 oz.	14	14
Methomyl (Lannate®) (90WSP)	4-8 oz.	14	14
Parathion (ethyl) (4E)	16 oz.	12	12
Parathion (ethyl) (8E)	8 oz.	12	12

Note: for Parathion (ethyl), "See remarks" is printed across the days columns.

Remarks

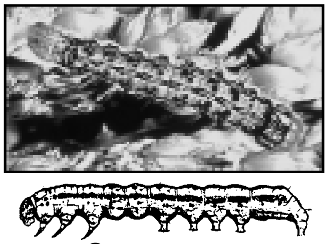
Cyfluthrin. If one or two applications are made, green forage may be fed or grazed on the day of treatment. If three applications are made, allow at least 14 days between last application and grazing.

Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.

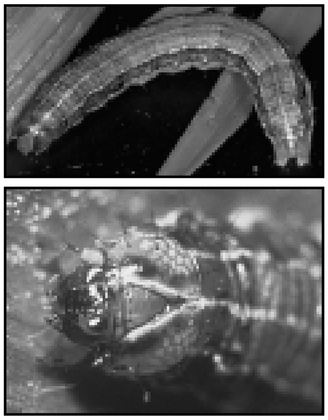
Parathion. Aerial application only. Do not substitute methyl parathion.

Corn earworm and fall armyworm (headworms)

Helicoverpa zea and *Spodoptera frugiperda*



Corn earworm



Fall armyworm

Corn earworm and fall armyworm moths lay eggs on leaves or grain heads of sorghum. Newly hatched corn earworm larvae are pale in color and only 1/8 inch long. They grow rapidly and become variously colored, ranging from pink, green or yellow to almost black. Many are conspicuously striped. Down the side is a pale stripe edged above with a dark stripe. Down the middle of the back is a dark stripe divided by a narrow white line that makes the dark stripe appear doubled. Fully grown larvae are robust and 1 1/2 to 2 inches long.

Young fall armyworm larvae are greenish and have black heads. Mature larvae vary from greenish to grayish brown and have a light-colored, inverted, Y-shaped suture on the front of the head and dorsal lines lengthwise on the body.

Corn earworm and fall armyworm larvae feed on developing grain. Small larvae feed on flowering parts of the grain head at first, then hollow out kernels. Larger larvae consume more kernels and cause most damage. The last two larval stages cause about 80 percent of the damage. Frass is common in infested grain heads, on tops of upper leaves and on the ground under plants. Under certain conditions, infested grain heads may have molds.

Natural mortality of small corn earworm and fall armyworm larvae is normally very high. Both corn earworm and fall armyworm moths can lay several hundred eggs on sorghum grain heads before or during flowering, but only a few larvae survive. Natural factors suppressing these insects include predators, parasites, pathogens and cannibalism among larvae.

Infestations usually are less in early- than late-planted sorghum. An important management tactic is to use sorghum hybrids with loose (open) grain heads. Early-planted sorghum and hybrids with open grain heads usually are less infested.

Begin inspecting sorghum grain heads soon after flowering and continue at 5-day intervals until hard dough. To examine grain heads for corn earworms and fall armyworms, shake randomly selected grain heads vigorously into a 5-gallon bucket, where larvae can be seen and counted easily. This "beat-bucket" technique permits detection of even small larvae (less than 1/4 inch) commonly overlooked during visual inspection of the grain head. Inspect at least 30 grain heads from a field to ensure reasonable reliability of sample size. Sample at least one grain head per acre in fields larger than 40 acres.

Because many young headworm larvae die naturally, do not apply insecticide until they are at least 1/2 inch long. The economic injury level is about 1 to 2 larvae per grain head of commercial sorghum (Table 17). (See economic threshold level discussion on page 5.) Fewer larvae per grain head may justify treatment on sorghum grown for seed because of the higher per-acre value. Table 18 lists insecticides suggested to control headworms.

Table 17. Economic injury levels based on number of corn earworm and fall armyworm larvae per sorghum grain head.

Control cost ($) per acre	Crop market value ($) per acre								
	100	125	150	175	200	225	250	275	300
	Number of headworms								
6	1.5	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.5
8	2.0	1.6	1.3	1.1	1.0	0.9	0.8	0.8	0.7
10	2.5	2.0	1.6	1.4	1.2	1.1	1.0	1.0	0.9
12	3.0	2.4	1.9	1.7	1.5	1.4	1.3	1.2	1.1

Table 18. Suggested insecticides for controlling corn earworm and fall armyworm in sorghum.

Insecticide (listed alphabetically) Toxicant per gallon or pound	Concentrate per acre	Days from last application to: Harvest	Grazing
Carbaryl			
(Sevin®)			
(4F)	32-64 oz.	21	14
(80S or 80WSP)	1.25-1.8 lb.	21	14
(50W)	2-4 lb.	21	14
(4XLR+®)	32-64 oz.	21	14
Cyfluthrin		See remarks	
(Baythroid® 2E)	1.3-2.8 oz.		14
Cyhalothrin		See remarks	
(Karate® 1E)	2.56-3.84 oz.		
Methomyl			
(Lannate®)			
(2.4LV)	12-24 oz.	14	14
(90WSP)	4-8 oz.	14	14
Parathion (ethyl)		See remarks	
(4E)	12-16 oz.	12	12
(8E)	6-8 oz.	12	12

Remarks

Cyfluthrin. 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.
Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.
Parathion. Aerial application only. Do not substitute methyl parathion.

Sorghum webworm

Nola sorghiella

Sorghum webworm

Sorghum webworms occasionally infest grain heads of sorghum planted 2 to 3 weeks later than normal. This insect occurs primarily in the more humid eastern half of Texas.

Adults are small, white moths active at night. They lay about 100 eggs singly but fastened rather securely to flowering parts or kernels of sorghum. Eggs are round to broadly oval and are flattened from top to bottom.

Webworm larvae are somewhat flattened, yellowish or greenish brown and marked with four lengthwise reddish to black dorsal stripes. When mature, larvae are about 1/2 inch long and covered with many spines and much hair. Pupae within a cocoon are reddish brown, slender and sub-cylindrical. A generation requires 1 month; as many as six generations may develop in a year. The larva overwinters in a cocoon on the host plant.

Many sorghum webworms may be found in grain heads of late-planted sorghum. Young larvae feed on developing flower parts. Older larvae gnaw circular holes in and feed on the starchy contents of maturing kernels, which usually are only partly consumed. Each larva may eat more than 12 kernels in 24 hours. Larvae do not spin webs (as the name might imply) over the sorghum grain head but, when disturbed, young larvae often suspend themselves by spinning a thin silken thread.

Inspect for sorghum webworms when grain heads begin to flower; continue at 5-day intervals until kernels are in the hard-dough stage. To examine grain heads for sorghum webworms, shake grain heads vigorously into a 5-gallon plastic bucket, where

Table 19. Suggested insecticides for controlling sorghum webworm.

Insecticide (listed alphabetically) Toxicant per gallon or pound	Concentrate per acre	Days from last application to: Harvest	Grazing
Carbaryl			
(Sevin®)			
(4F)	32-64 oz.	21	14
(80S or 80WSP)	1.25-2.5 lb.	21	14
(50W)	2-4 lb.	21	14
(4XLR+®)	32-64 oz.	21	14
Cyfluthrin		See remarks	
(Baythroid® 2E)	1.3-2.8 oz.		14
Cyhalothrin		See remarks	
(Karate® 1E)	2.56-3.84 oz.		
Methomyl			
(Lannate®)			
(2.4LV)	24 oz.	14	14
(90WSP)	8 oz.	14	14
Parathion (ethyl)		See remarks	
(4E)	12 oz.	12	12
(8E)	6 oz.	12	12

Remarks

Cyfluthrin. 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.

Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.

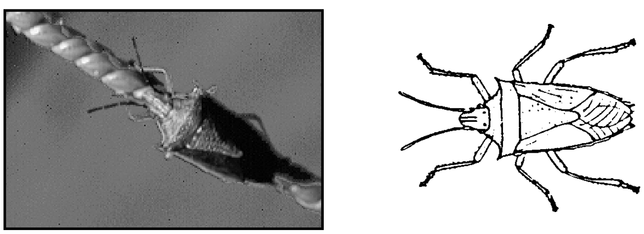
Parathion. Aerial application only. Do not substitute methyl parathion.

even small larvae can be seen and counted easily. Inspect at least 30 plants from a field to ensure that sample estimates are reasonably reliable. Sample at least one grain head per acre in fields larger than 40 acres.

Insecticide application is economically justified when grain heads are infested with an average of five or more small larvae. Cultural practices to reduce sorghum webworm abundance include plowing sorghum residues after harvest to destroy overwintering pupae, planting as early as practical and using sorghum hybrids with loose (open) grain heads.

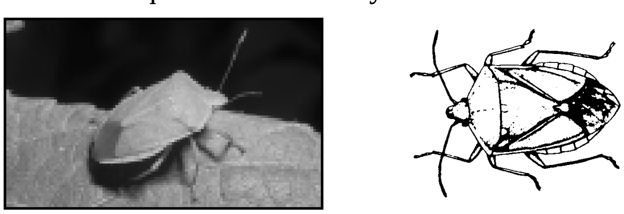
Grain head-feeding bugs

Several species of true bugs, primarily stink bugs, may move in relatively large numbers from alternate host plants into sorghum during kernel development. Bugs infesting sorghum in Texas include rice stink bug, southern green stink bug, conchuela stink bug, brown stink bug (*Euschistus servus*), red-shouldered stink bug (*Thyanta accerra*), leaffooted bug and false chinch bug.



Rice stink bug

The rice stink bug (*Oebalus pugnax*) is straw-colored, shield-shaped and 1/2 inch long. Females lay about 10 to 47 short, cylindrical, light-green eggs in a cluster of two rows. Eggs hatch after 5 days, and nymphs require 15 to 28 days to become adults.

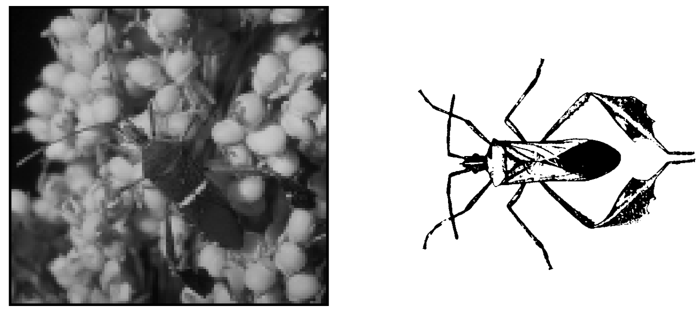


Southern green stink bug

The southern green stink bug (*Nezara viridula*) is about 3/4 inch long, green and somewhat shield-shaped. Females deposit 300 to 500 eggs in clusters of about 30. The eggs hatch in about 7 days, reaching the adult stage in about 6 weeks.

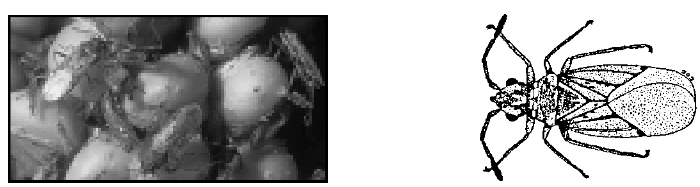
Conchuela stink bug

The conchuela stink bug (*Chlorochroa ligata*) varies in color from dull olive or ash gray to green, purplish pink, or reddish brown. The most characteristic markings are orange-red bands along the lateral margins of the thorax and wings and a spot of the same color on the back at the base of the wings.



Leaffooted bug

The leaffooted bug (*Leptoglossus phyllopus*) is brown, oblong and just longer than 3/4 inch. A white band extends across the front wings. The lower part of each hind leg is dilated or leaf-like. Eggs are laid in rows of 15 to 35. Nymphs are reddish.



False chinch bug

The false chinch bug (*Nysius raphanus*) resembles the chinch bug but with more uniform color, ranging from gray to brown. False chinch bugs are 1/10 inch long. Multitudes of the insect occasionally migrate from wild hosts, such as wild mustard, to sorghum, but these insects usually concentrate in small areas of a field.

Bugs suck juices from developing sorghum kernels and, to a lesser extent, from other grain head parts, and may cause economic damage. The extent of damage depends on number of bugs per grain head, duration of infestation, and stage of kernel development when infestation occurs. Bugs cause more damage early during kernel development and less as grain develops to the hard-dough stage. Both nymphs and adults can reduce grain weight, size and seed germination. Fungi often infect damaged kernels, causing them to turn black and further deteriorate in quality. Damaged kernels rarely develop fully and may be lost during harvest.

Grain head-feeding bugs tend to congregate on sorghum grain heads and sometimes within areas of a field. Use the beat-bucket technique to estimate abundance. Shake sorghum grain heads vigorously into a 5-gallon bucket, where bugs can be seen and counted more easily. However, adult bugs will fly from the sampled plant or the bucket. Count those that fly from sorghum grain heads or from the bucket and those on plant leaves. Sample at least 30 plants from a field. Take at least one sample per acre in fields larger than 40 acres.

To determine the profitability of controlling an infestation of rice, southern green, or conchuela stink bugs or of leaffooted bugs, consult economic injury Tables 20 through 23. (See economic threshold level discussion on page 5.) The number of bugs per sorghum grain head that will reduce grain yield varies depending on bug species and stage of grain development when infestation occurs. Determine the grain development stage at time of sampling and refer to the appropriate table. If the grain development stage is hard dough and the infestation per grain head is 16 or fewer bugs, an insecticide application likely is unjustified. *The economic threshold level for false chinch bug is 140 bugs per grain head when infestation begins at the milk stage of grain development.*

Not all stink bug species in sorghum are economic pests. Several species, such as the spined soldier bug, prey on harmful insects and thus are beneficial.

For more information on grain head-feeding insects, see B-1421, *Suggested Guide for Controlling Panicle-Feeding Bugs in Texas Sorghum*.

Table 20. Economic injury level based on number of rice stink bugs per sorghum grain head beginning at the milk stage of kernel development.

Control cost ($) per acre	Crop market value ($) per acre								
	100	125	150	175	200	225	250	275	300
	Number of rice stink bugs								
6	7	6	6	5	5	5	4	4	4
8	8	7	6	6	6	5	5	4	4
10	8	8	7	7	6	6	6	5	5
12	9	8	8	7	7	6	6	5	5

Table 21. Economic injury level based on number of rice stink bugs per sorghum grain head beginning at the soft-dough stage of kernel development.

Control cost ($) per acre	Crop market value ($) per acre								
	100	125	150	175	200	225	250	275	300
	Number of rice stink bugs								
6	9	8	8	7	7	6	6	6	5
8	10	9	9	8	8	7	7	7	6
10	12	10	10	9	9	8	8	7	7
12	13	12	11	10	10	9	9	8	8

Table 22. Economic injury level based on number of adult southern green stink bugs, conchuela stink bugs and leaffooted bugs beginning at the milk stage of kernel development.

Control cost ($) per acre	Crop market value ($) per acre								
	100	125	150	175	200	225	250	275	300
	Number of bugs								
6	5	4	4	4	4	3	3	3	2
8	5	5	5	4	4	4	4	3	3
10	6	6	5	5	5	4	4	4	3
12	6	6	6	5	5	5	4	4	4

Table 23. Economic injury level based on number of adult southern green stink bugs, conchuela stink bugs and leaffooted bugs per sorghum grain head beginning at the soft-dough stage of kernel development.

Control cost ($) per acre	Crop market value ($) per acre								
	100	125	150	175	200	225	250	275	300
	Number of bugs								
6	8	7	7	6	6	5	5	4	4
8	9	8	7	7	7	6	6	5	5
10	10	9	8	8	7	7	6	6	5
12	11	10	9	9	8	8	7	7	6

Table 24. Suggested insecticides for controlling grain head-feeding bugs.

Insecticide (listed alphabetically) Toxicant per gallon or pound	Concentrate per acre	Days from last application to: Harvest	Grazing
Carbaryl		See remarks	
(Sevin®)			
(4F)	32-64 oz.	21	14
(80S or 80WSP)	1.25-2.5 lb.	21	14
(50W)	2-4 lb.	21	14
(4XLR+®)	32-64 oz.	21	14
Cyfluthrin		See remarks	
(Baythroid® 2E)	1.3-2.8 oz.		14
Cyhalothrin		See remarks	
(Karate® 1E)	2.56-3.84 oz.		
Parathion (ethyl)		See remarks	
(4E)	12-16 oz.	12	12
(8E)	6-8 oz.	12	12

Remarks

Carbaryl. Direct spray into heads for optimum control.

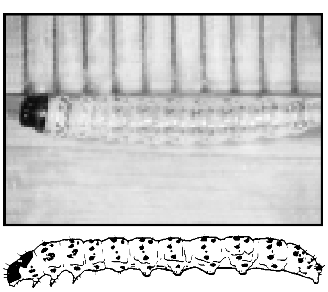
Cyfluthrin. If one or two applications are made, green forage may be fed or grazed on the day of treatment. If three applications are made, allow at least 14 days between last application and grazing.

Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.

Parathion. Aerial application only. Do not substitute methyl parathion.

Stem-boring insect pests

Sugarcane borer *Diatraea saccharalis*, Southwestern corn borer *Diatraea grandiosella*, Neotropical borer *Diatraea lineolata* and Mexican rice borer *Eoreuma loftini*



Sugarcane borer

These closely related insects tunnel in the stalks of sorghum, corn and other crops. The biology of these four species can be generalized: White to buff-colored adult moths lay clusters of elliptical to oval shaped, flattened eggs that overlap like fish scales in shingle-like arrangements on leaves of host plants. Eggs hatch in 3 to 7 days.

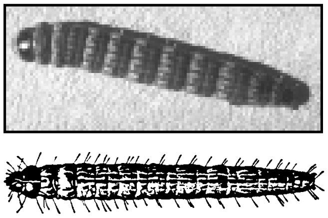
The larval stage lasts about 25 days and the pupal stage about 10. There are two to three generations a year. Larvae are creamy white, about 1 inch long when fully grown, and most body segments have conspicuous round brown or black spots. Spots are lighter colored or absent on mature overwintering larvae. Most stem-boring insects pass the winter as fully grown larvae in cells inside stalks that remain after the crop is harvested.

Young larvae feed for a few days on leaves or the leaf axis. Older larvae tunnel into the sorghum stalks. Larvae bore up and down the pith of the stalk. Borer-infested stalks may be reduced in diameter, and lodging of infested plants can result. Boring by larvae in the stem just below the grain head can cause it to break and the grain head to fall. Injury by borers makes the plant more susceptible to stalk rot diseases.

Planting sorghum early is important because borers typically are more abundant in late-planted sorghum. Shredding stalks very close to the ground or plowing and disking stubble destroys overwintering larvae by exposing them to cold temperatures in more northern regions of Texas. This practice reduces borer abundance the next year. Insecticidal control rarely is justified.

To determine the presence of stem borers, examine the sorghum plants carefully. Small holes near the leaf axis indicate that a larva has entered the stalk. Once larvae have entered the stalk, stalks must be split to see the larvae. Inspect leaves carefully, because eggs are hard to find. Clusters containing 10 to 20 individual eggs may be on the top or underside of leaves, depending on the borer species. Assess the abundance of eggs and small larvae before larvae bore into stalks. Insecticidal control is effective, only if applied before larvae bore into stalks. Karate and Sevin are labeled for controlling southwestern corn borer in sorghum.

Lesser cornstalk borer
Elasmopalpus lignosellus

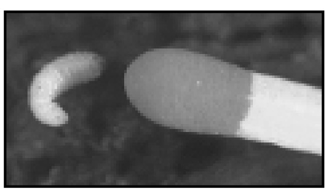


Lesser cornstalk borer

Larvae of the lesser cornstalk borer attack roots and bore into stalks of sorghum plants. Damaging infestations of this insect rarely occur in sorghum. Larvae are light bluish green with prominent transverse reddish-brown bands. They feed in silken tunnels covered with soil particles. Larvae pupate in silken cocoons under crop debris.

Lesser cornstalk borer usually is more severe during dry periods and in sandy soils. Cultural practices that preserve moisture and increase organic matter in the soil discourage the insect. Early planting and rotation with nonhost crops help avoid damage from lesser cornstalk borer. Insecticidal control rarely is justified.

Sugarcane rootstock weevil
Anacentrinus deplanatus



Sugarcane rootstalk weevil larva

The sugarcane rootstock weevil infests sorghum sporadically, especially during dry years and in fields where johnsongrass is abundant.

The adult weevil is dark brown or black, about 1/8 inch long and 1/16 inch wide. The insect overwinters as an adult on ground protected by plant residues. Weevils in early spring infest wild grasses, such as johnsongrass, and later move to sorghum. The female uses her mouthparts to make a small puncture at the base of the plant into which the egg is deposited and concealed. About 16 eggs are laid and hatch in 6 days. Larvae are white, legless grubs about 1/5 inch long when fully grown. A generation is completed in about 40 days.

Adult weevils feed on young sorghum plants and crowns. This damage is noticeable but not as serious as that caused by larvae. Larvae tunnel into the sorghum stalk just below or above the surface of the soil. Tunnels resemble those made by other borers, except they are much smaller and do not extend up the stalk. Larvae often are found at nodes and near the outer surfaces of the stalk. Their feeding often is responsible for a drought-stressed appearance and lodging of sorghum plants. Exit holes and feeding tunnels provide favorable areas where such pathogens as charcoal rot can enter the plant. Historically, control of this insect has not been required.

Policy statement

Information contained in this publication on managing insect and mite pests of sorghum is based on the research and experience of Texas Agricultural Extension Service and Texas Agricultural Experiment Station entomologists. Suggested management strategies are believed to be reliable. However, it is impossible to eliminate all risks associated with managing insect and mite pests in sorghum. Unexpected conditions or circumstances may result in less than satisfactory results when these suggestions are used. The Texas Agricultural Extension Service and The Texas Agricultural Experiment Station do not assume responsibility for ineffective results from using information contained in this publication. The user of the information in this publication assumes all risk.

Insecticides and miticides listed in this publication for use against insect and mite pests of sorghum must be registered and labeled for use by the Environmental Protection Agency and Texas Department of Agriculture. The status of insecticide labels change and may have changed since this publication was printed. Extension entomologists and other appropriate specialists are advised of changes in label status and may be contacted for this information. The USER always is responsible for effects of pesticide residues on livestock and crops, as well as problems that arise from drift or movement of pesticide from the application site to other areas. **Always carefully read and follow the instructions on the pesticide label.**

The information given herein is for educational purposes only. Reference to commercial products or trade names is made with the understanding no discrimination is intended and no endorsement by the Texas Agricultural Extension Service is implied.

Original color images courtesy of “Sorghum Insect Photo CD,” compiled by Phil Sloderbeck, Kansas State University Department of Entomology, 1995; and Greg Cronholm, Bart Drees, John Jackman and George Teetes, Texas A&M University System.

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GRAIN SORGHUM

Sorghum vulgare

Seed Rots and Seedling Diseases (fungi - *Rhizoctonia solani*, *Fusarium* sp., *Pythium* sp. and others): Seed rots and seedling diseases are more prevalent when seed is planted in cool, wet soils, and especially when packing rains seal the soil surface. Seedling emergence and growth is slowed under such conditions, and several soil-borne fungi are able to infect the tender seedlings. Other factors such as poor seed quality or improperly placed fertilizer or herbicide often contribute to the problem. Continuous growth of one crop over a period of years may favor buildup of organisms that cause seedling disease. Use of high quality seed treated with a recommended seed protectant is important. Precision planting to insure proper depth in a well-prepared seedbed is very helpful.

Sorghum Downy Mildew (fungus - *Peronosclerospora sorghi*): Young, systemically infected plants have light green to yellowish stripes lengthwise in the leaves often with a grayish-white downy fungal growth consisting of numerous tiny spores on the lower surface of the leaf opposite the pale striped areas. Figure 1. Soil-borne spores cause systemic infection of the young seedlings. These systemically infected plants will not produce heads. Later infections may parially or completely inhibit grain formation. Plants can also be infected by air-borne spores from the underside of infected leaves. These infections result in localized leaf lesions. Grain sorghum hybrids vary considerably in their susceptibility. Growers should select adapted, high producing hybrids that have resistance to this fungus. Growing highly susceptible grain or forage sorghum builds up populations of the organism in soil, making the problem more severe even in resistant hybrids. Use seed treated with a systemic fungicide containing metalaxyl and resistant hybrids to control this disease.

Crazy Top Downy Mildew (fungus - *Sclerophthora macrospora*): This fungal disease can be troublesome in low lying areas that become flooded. Infected plants have thick, stiff, twisted, pale green leaves with bumpy surfaces. The leaves often turn downward, and the plants produce many shoots or suckers giving a bunchy appearance. Infected plants do not produce heads or produce a proliferation of leafy tissue in place of the head. Wild and cultivated grasses can serve as sources of inoculum. There are differences in susceptibility among grain sorghum hybrids but these differences are not significant. Installing drainage structures and diverting water movement to avoid flooding is the most reasonable suggestion for control at this time.

Maize Dwarf Mosaic Virus (MDMV): maize dwarf mosaic is a virus disease that occurs over all the sorghum producing areas of Texas. Its ability to cause damage is dependent on the presence of an overwintering virus host (mainly Johnsongrass), aphid populations to facilitate virus transmission and the susceptibility of the hybrid being grown. Affected plants have mottled (light green blotchiness) terminal leaves. Figure 2.These alternate light- and darker-green areas in the leaf can be more easily seen when held between the viewer and a light source. Observers should always look at the newest leaves for the most severe symptoms. Highly susceptible hybrids are stunted with chlorotic symptoms in the upper leaves and suffer significant yield losses. Some hybrids produce a red leaf symptom when plants are infected and when night temperatures are below 55 degrees F. Use tolerant hybrids and control Johnsongrass in and around the field to manage this disease.

Head Smut (fungus - *Sporisorium reilianum*): This disease is characterized by the large, dark-brown smut galls that emerge in place of the panicle. Figure 3.The gall is first covered with a whitish membrane which soon breaks and allows spores to be scattered by the wind. Plants become infected while in the seedling stage but evidence of infection is not apparent until heading time. The smut gall produces thousands of spores which become soil-borne and initiate systemic infection of seedlings in subsequent years. Different races of the fungus exist which may result in a sorghum hybrid being resistant in one area but not another. New sources of resistance have been found and growers should utilize resistant hybrids to avoid losses from this disease.

Covered Kernel Smut (fungus - *Sporisorium sorghi*): This smut disease was once quite destructive but is seldom seen now because most seed is chemically treated. The disease destroys all kernels in a head and replaces them with a cone-shaped gall or may affect only portions of a panicle. At harvest time, these galls are broken and spores contaminate the outer surface of other kernels. This disease is controlled by use of chemical seed treatment, use of clean seed and planting resistant hybrids.

Loose Kernel Smut (fungus - *Sporisorium cruenta*): Galls formed by loose kernel smut are long and pointed and the thin membrane covering them usually breaks soon after galls reach full size. This disease presents no immediate problem because the control measures mentioned for covered kernel smut have virtually eliminated occurrence of this disease.

Foliage Diseases Caused by Fungi: A number of fungal organisms cause foliage infection and may become severe under certain conditions. Occurrence has seldom been consistent or damaging enough to warrant the development of specific control practices. No fungicides have been cleared for use on sorghum foliage. Hybrids vary in their susceptibility to these diseases and resistance is available if their occurrence becomes a problem.
The following information will aid in the identification of specific foliage diseases.

Name	Pathogen	Symptom
Leaf Blight	*Exserohilum turcicum*	Large elongated spots with gray centers and tan-to-reddish borders.
Target leaf spot	*Bipolaris sorghicola*	Round-to-elliptical spots with reddish purple centers and tan margins.
Anthracnose	*Colletotrichum graminicola*	Elliptical-shaped spots that are 1/8"-7/8" in diameter. Tan-to-red with distinct margins.
Gray leaf spot	*Cercospora sorghi*	Dark purple spots having a grayish cast when pathoggen is producing spores. Elongate to round, 1/4" and larger.
Zonate leaf spot	*Gleocercospora sorghi*	Large, irregular-shaped spots having a bullseye appearance.
Rough leaf spot	*Ascochyta sorghina*	Grayish spots that are rough to the touch because of raised black fruiting bodies.
Sooty stripe	*Ramulispora sorghi*	Elongate spots having a sooty appearance because of sclerotia.

Bacterial Stripe (bacterium - *Pseudomonas andropogoni*): This is the most common bacterial disease of sorghum. The disease is characterized by long narrow stripes that vary from red to black depending on the type of sorghum. These stripes are confined between the veins and may have a crusty surface when the bacterial slime dries on the surface. This disease has not been a serious enough problem to warrant specific control in Texas.

Bacterial Streak (bacterium - *Xanthomonas holcicola*): Streak first appears as dark-green watersoaked tissue between veins that later turns brown with red margins. Control measures have not been warranted.

Bacterial Spot (bacterium - *Pseudomonas syringae*): Spots first appear as watersoaked, green areas on lower leaves before infection spreads to upper leaves. Spots later turn tan with reddish borders. Small lesions are often red throughout. Control measures are not usually necessary.

Anthracnose (fungus - *Colletotrichum graminicola*): The anthracnose fungus damages foliage and stems of grain sorghum. On susceptible hybrids, the stem holding the head (peduncle) becomes infected and a brown sunken area with distinct margins develops. Figure 4. When infected stems are cut lenghtwise with a knife, one can see that the fungus has penetrated the soft pith tissue and caused brick-red discolorations. This peduncle infection inhibits the flow of water and nutrients to the grain causing poor grain development. The fungus also invades individual grains and the small branches of the panicle. Rapid and severe yield loss can result from panicle and peduncle infections. Leaf lesions are small, elliptical to circular, usually less than 3/8-inch in diameter. These spots develop small, circular, straw-colored centers with wide margins that may vary in color from reddish to tan to blackish purple. The spots may coalesce to form larger areas of infected tissue. In Texas, anthracnose is restricted mostly to the gulf coast areas. The use of resistant hybrids and good management of crop residue are effective control measures.

Rust (fungus - *Puccinia purpurea*): Rust appears on leaves as small raised pustules or blisters that rupture and release many reddish-brown spores. These pustules occur on both the upper and lower leaf surfaces. This disease usually appears when plants near maturity and infection is confined primarily to mature leaves. Grain yield losses are usually not serious and occurrence of the disease is sporadic. Forage sorghum yields may be affected most. The rust fungus also attacks Johnsongrass and overwinters on this host in southern production areas.

Charcoal Rot (fungus - *Macrophomina phaseolina*): Grain sorghum plants affected by the charcoal rot fungus fail to fill grain properly and may lodge in the latter part of the season. Infected stalks show an internal shredding at and above the ground line. This can be observed by splitting the stalk and noting the deteriorated soft pith tissue leaving the tougher vascular strands. Figure 5. Fungal structures (sclerotia) can be observed in the affected tissue which appears as though it has been dusted with black pepper. Another type of stalk rot (*Pythium* sp. and *Fusarium* sp.) may show the shredded condition but the black specks (sclerotia) will be lacking. Conditions under which charcoal rot is favored include stressful hot soil tempertures and low soil moisture during the postflowering period. Host plants are usually in the early-milk to late-dough stage when infection occurs. The fungus is common and widely distributed in nature. Avoiding moisture stress, proper management of crop residue, crop rotation, avoiding excessive plant populations, balancing nitrogen and potassium fertility levels, and growing drought-tolerant, lodging-resistant hybrids represent the best means of control.

Fusarium Stalk Rot (fungus - *Fusarium moniliforme*): Like charcoal rot, *Fusarium* stalk rot usually develops on mature to nearly mature plants that have been subjected to some form of stress. Infection takes place at the base of the plant and produces discoloration in the stalk. When shredding of the vascular area occurs from this organism, black fungal bodies (sclerotia) are not present as they are with charcoal rot. Avoiding stress problems by proper use of cultural practices is the best approach to control.

Root Rot Complex (fungi - *Fusarium moniliforme*, *Pythium* sp. and others): Several fungi are involved in producing a root rot condition of grain sorghum. One or more of the causal fungi may be involved depending on conditions and organisms present in the soil. Each organism produces distinct symptoms, but identification becomes more complex when other factors are involved. Rotation with non-related crops will lower the population of pathogenic organisms present in the soil.

NOTE: Texas Cooperative Extension publication B-6004, "Disease Response of Grain Sorghum Hybrids" is available for helping to choose disease resistant commercial grain sorghum hybrids.

Sorghum

Sorghum vulgare




Disease Index

- Anthracnose
- Bacterial Diseases
- Charcoal Rot
- Covered Kernel Smut
- Crazy Top Downy Mildew
- Foliage Diseases/Fungal
- Fusarium Stalk Rot
- Head Smut
- Loose Kernel Smut
- Maize Dwarf Mosaic Virus
- Root Rot Complex
- Rust
- Seedling Diseases
- Sorghum Downy Mildew

Texas Agricultural Extension Service publication B-6004, "Disease Response of Grain Sorghum Hybrids: Downy Mildew, Head Smut, Maize Dwarf Mosaic, and Anthracnose" (3/95) is available for helping to choose disease resistant commercial grain sorghum hybrids.

The full sorghum text alone is also available.

April, 1996

Handbook Index

Downy mildew on sorghum. Note striping of upper surface of some leaves.
Courtesy Joseph Krausz, Texas Agricultural Extension Service - 1995.

Maize dwarf mosaic virus infection on sorghum showing characteristic mottling of leaf.
Courtesy Joseph Krausz, Texas Agricultural Extension Service - 1995.

Head smut infected sorghum plant. Courtesy Joseph Krausz, Texas Agricultural Extension Service - 1995.

Sorghum Downy Mildew on Sorghum

Downy mildew on sorghum. Note striping of upper surface of some leaves.
Courtesy Joseph Krausz, Texas Agricultural Extension Service - 1995.

Sorghum Downy Mildew (fungus - *Peronosclerospora sorghi*): Young, systemically infected plants have light green to yellowish stripes lengthwise in the leaves often with a grayish-white downy fungal growth consisting of numerous tiny spores on the lower surface of the leaf opposite the pale striped areas. Soil-borne spores cause systemic infection of the young seedlings. These systemically infected plants will not produce heads. Later infections may parially or completely inhibit grain formation. Plants can also be infected by air-borne spores from the underside of infected leaves. These infections result in localized leaf lesions. Grain sorghum hybrids vary considerably in their susceptibility. Growers should select adapted, high producing hybrids that have resistance to this fungus. Growing highly susceptible grain or forage sorghum builds up populations of the organism in soil, making the problem more severe even in resistant hybrids. Use seed treated with a systemic fungicide containing metalaxyl and resistant hybrids to control this disease.

April, 1996

Previous Disease

Back to Index

Maize Dwarf Mosaic Virus (MDMV) on Sorghum

Maize dwarf mosaic virus infection on sorghum showing characteristic mottling of leaf. Courtesy Joseph Krausz, Texas Agricultural Extension Service - 1995.

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April, 1996

Previous Disease

Next Disease

Back to Index

Head Smut on Sorghum

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Head smut infected sorghum plant. Courtesy Joseph Krausz, Texas Agricultural Extension Service - 1995.

April, 1996

Previous Disease

Next Disease

Back to Index

Anthracnose on Sorghum

Anthracnose infection results in a reddish discoloration of the sorghum peduncle. Courtesy Joseph Krausz, Texas Agricultural Extension Service - 1995.

Anthracnose (fungus - *Colletotrichum graminicola*): The anthracnose fungus damages foliage and stems of grain sorghum. On susceptible hybrids, the stem holding the head (peduncle) becomes infected and a brown sunken area with distinct margins develops. When infected stems are cut lenghtwise with a knife, one can see that the fungus has penetrated the soft pith tissue and caused brick-red discolorations. This peduncle infection inhibits the flow of water and nutrients to the grain causing poor grain development. The fungus also invades individual grains and the small branches of the panicle. Rapid and severe yield loss can result from panicle and peduncle infections. Leaf lesions are small, elliptical to circular, usually less than 3/8-inch in diameter. These spots develop small, circular, straw-colored centers with wide margins that may vary in color from reddish to tan to blackish purple. The spots may coalesce to form larger areas of infected tissue. In Texas, anthracnose is restricted mostly to the gulf coast areas. The use of resistant hybrids and good management of crop residue are effective control measures.

April, 1996

Previous Disease

Next Disease

Back to Index

Bacterial Diseases of Sorghum

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April, 1996

Previous Disease

Next Disease

Back to Index

Charcoal Rot on Sorghum

Charcoal rot of sorghum, showing the typical charcoal-grey within the split base of the stem. Courtesy Joseph Krausz, Texas Agricultural Extension Service - 1995.

Charcoal Rot (fungus - *Macrophomina phaseolina*): Grain sorghum plants affected by the charcoal rot fungus fail to fill grain properly and may lodge in the latter part of the season. Infected stalks show an internal shredding at and above the ground line. This can be observed by splitting the stalk and noting the deteriorated soft pith tissue leaving the tougher vascular strands. Fungal structures (sclerotia) can be observed in the affected tissue which appears as though it has been dusted with black pepper. Another type of stalk rot (*Pythium* sp. and *Fusarium* sp.) may show the shredded condition but the black specks (sclerotia) will be lacking. Conditions under which charcoal rot is favored include stressful hot soil tempertures and low soil moisture during the postflowering period. Host plants are usually in the early-milk to late-dough stage when infection occurs. The fungus is common and widely distributed in nature. Avoiding moisture stress, proper management of crop residue, crop rotation, avoiding excessive plant populations, balancing nitrogen and potassium fertility levels, and growing drought-tolerant, lodging-resistant hybrids represent the best means of control.

April, 1996

Previous Disease

Next Disease

Back to Index

Covered Kernel Smut on Sorghum

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April, 1996

Previous Disease

Next Disease

Back to Index

Crazy Top Downy Mildew on Sorghum

Crazy Top Downy Mildew (fungus - *Sclerophthora macrospora*): This fungal disease can be troublesome in low lying areas that become flooded. Infected plants have thick, stiff, twisted, pale green leaves with bumpy surfaces. The leaves often turn downward, and the plants produce many shoots or suckers giving a bunchy appearance. Infected plants do not produce heads or produce a proliferation of leafy tissue in place of the head. Wild and cultivated grasses can serve as sources of inoculum. There are differences in susceptibility among grain sorghum hybrids but these differences are not significant. Installing drainage structures and diverting water movement to avoid flooding is the most reasonable suggestion for control at this time.

April, 1996

Previous Disease

Next Disease

Back to Index

Foliage Diseases of Sorghum Caused by Fungi

Foliage Diseases Caused by Fungi: A number of fungal organisms cause foliage infection and may become severe under certain conditions. Occurrence has seldom been consistent or damaging enough to warrant the development of specific control practices. No fungicides have been cleared for use on sorghum foliage. Hybrids vary in their susceptibility to these diseases and resistance is available if their occurrence becomes a problem.

The following information will aid in the identification of specific foliage diseases.

Name	Pathogen	Symptom
Leaf Blight	*Exserohilum turcicum*	Large elongated spots with gray centers and tan-to-reddish borders.
Target leaf spot	*Bipolaris sorghicola*	Round-to-elliptical spots with reddish purple centers and tan margins.
Anthracnose	*Colletotrichum graminicola*	Elliptical-shaped spots that are 1/8"-7/8" in diameter. Tan-to-red with distinct margins.
Gray leaf spot	*Cercospora sorghi*	Dark purple spots having a grayish cast when pathoggen is producing spores. Elongate to round, 1/4" and larger.
Zonate leaf spot	*Gleocercospora sorghi*	Large, irregular-shaped spots having a bullseye appearance.
Rough leaf spot	*Ascochyta sorghina*	Grayish spots that are rough to the touch because of raised black fruiting bodies.
Sooty stripe	*Ramulispora sorghi*	Elongate spots having a sooty appearance because of sclerotia.

April, 1996

Previous Disease

Next Disease

Back to Index

Fusarium Stalk Rot on Sorghum

Fusarium Stalk Rot (fungus - *Fusarium moniliforme*): Like charcoal rot, *Fusarium* stalk rot usually develops on mature to nearly mature plants that have been subjected to some form of stress. Infection takes place at the base of the plant and produces discoloration in the stalk. When shredding of the vascular area occurs from this organism, black fungal bodies (sclerotia) are not present as they are with charcoal rot. Avoiding stress problems by proper use of cultural practices is the best approach to control.

April, 1996

Previous Disease

Next Disease

Back to Index

Loose Kernel Smut on Sorghum

Loose Kernel Smut (fungus - *Sporisorium cruenta*): Galls formed by loose kernel smut are long and pointed and the thin membrane covering them usually breaks soon after galls reach full size. This disease presents no immediate problem because the control measures mentioned for covered kernel smut have virtually eliminated occurrence of this disease.

April, 1996

Previous Disease

Next Disease

Back to Index

Root Rot Complex on Sorghum

Root Rot Complex (fungi - *Fusarium moniliforme*, *Pythium* sp. and others): Several fungi are involved in producing a root rot condition of grain sorghum. One or more of the causal fungi may be involved depending on conditions and organisms present in the soil. Each organism produces distinct symptoms, but identification becomes more complex when other factors are involved. Rotation with non-related crops will lower the population of pathogenic organisms present in the soil.

April, 1996

Previous Disease

Next Disease

Back to Index

Rust on Sorghum

Rust (fungus - *Puccinia purpurea*): Rust appears on leaves as small raised pustules or blisters that rupture and release many reddish-brown spores. These pustules occur on both the upper and lower leaf surfaces. This disease usually appears when plants near maturity and infection is confined primarily to mature leaves. Grain yield losses are usually not serious and occurrence of the disease is sporadic. Forage sorghum yields may be affected most. The rust fungus also attacks Johnsongrass and overwinters on this host in southern production areas.

April, 1996

Previous Disease

Next Disease

Back to Index

Seed Rots and Seedling Diseases of Sorghum

Seed Rots and Seedling Diseases (fungi - *Rhizoctonia solani, Fusarium* sp., *Pythium* sp. and others): Seed rots and seedling diseases are more prevalent when seed is planted in cool, wet soils, and especially when packing rains seal the soil surface. Seedling emergence and growth is slowed under such conditions, and several soil-borne fungi are able to infect the tender seedlings. Other factors such as poor seed quality or improperly placed fertilizer or herbicide often contribute to the problem. Continuous growth of one crop over a period of years may favor buildup of organisms that cause seedling disease. Use of high quality seed treated with a recommended seed protectant is important. Precision planting to insure proper depth in a well-prepared seedbed is very helpful.

April, 1996

Previous Disease

Next Disease

Back to Index

GRAIN SORGHUM

Sorghum vulgare

Seed Rots and Seedling Diseases (fungi - *Rhizoctonia solani*, *Fusarium* sp., *Pythium* sp. and others): Seed rots and seedling diseases are more prevalent when seed is planted in cool, wet soils, and especially when packing rains seal the soil surface. Seedling emergence and growth is slowed under such conditions, and several soil-borne fungi are able to infect the tender seedlings. Other factors such as poor seed quality or improperly placed fertilizer or herbicide often contribute to the problem. Continuous growth of one crop over a period of years may favor buildup of organisms that cause seedling disease. Use of high quality seed treated with a recommended seed protectant is important. Precision planting to insure proper depth in a well-prepared seedbed is very helpful.

Sorghum Downy Mildew (fungus - *Peronosclerospora sorghi*): Young, systemically infected plants have light green to yellowish stripes lengthwise in the leaves often with a grayish-white downy fungal growth consisting of numerous tiny spores on the lower surface of the leaf opposite the pale striped areas. Figure 1. Soil-borne spores cause systemic infection of the young seedlings. These systemically infected plants will not produce heads. Later infections may parially or completely inhibit grain formation. Plants can also be infected by air-borne spores from the underside of infected leaves. These infections result in localized leaf lesions. Grain sorghum hybrids vary considerably in their susceptibility. Growers should select adapted, high producing hybrids that have resistance to this fungus. Growing highly susceptible grain or forage sorghum builds up populations of the organism in soil, making the problem more severe even in resistant hybrids. Use seed treated with a systemic fungicide containing metalaxyl and resistant hybrids to control this disease.

Crazy Top Downy Mildew (fungus - *Sclerophthora macrospora*): This fungal disease can be troublesome in low lying areas that become flooded. Infected plants have thick, stiff, twisted, pale green leaves with bumpy surfaces. The leaves often turn downward, and the plants produce many shoots or suckers giving a bunchy appearance. Infected plants do not produce heads or produce a proliferation of leafy tissue in place of the head. Wild and cultivated grasses can serve as sources of inoculum. There are differences in susceptibility among grain sorghum hybrids but these differences are not significant. Installing drainage structures and diverting water movement to avoid flooding is the most reasonable suggestion for control at this time.

Maize Dwarf Mosaic Virus (MDMV): maize dwarf mosaic is a virus disease that occurs over all the sorghum producing areas of Texas. Its ability to cause damage is dependent on the presence of an overwintering virus host (mainly Johnsongrass), aphid populations to facilitate virus transmission and the susceptibility of the hybrid being grown. Affected plants have mottled (light green blotchiness) terminal leaves. Figure 2.These alternate light- and darker-green areas in the leaf can be more easily seen when held between the viewer and a light source. Observers should always look at the newest leaves for the most severe symptoms. Highly susceptible hybrids are stunted with chlorotic symptoms in the upper leaves and suffer significant yield losses. Some hybrids produce a red leaf symptom when plants are infected and when night temperatures are below 55 degrees F. Use tolerant hybrids and control Johnsongrass in and around the field to manage this disease.

Head Smut (fungus - *Sporisorium reilianum*): This disease is characterized by the large, dark-brown smut galls that emerge in place of the panicle. Figure 3.The gall is first covered with a whitish membrane which soon breaks and allows spores to be scattered by the wind. Plants become infected while in the seedling stage but evidence of infection is not apparent until heading time. The smut gall produces thousands of spores which become soil-borne and initiate systemic infection of seedlings in subsequent years. Different races of the fungus exist which may result in a sorghum hybrid being resistant in one area but not another. New sources of resistance have been found and growers should utilize resistant hybrids to avoid losses from this disease.

Covered Kernel Smut (fungus - *Sporisorium sorghi*): This smut disease was once quite destructive but is seldom seen now because most seed is chemically treated. The disease destroys all kernels in a head and replaces them with a cone-shaped gall or may affect only portions of a panicle. At harvest time, these galls are broken and spores contaminate the outer surface of other kernels. This disease is controlled by use of chemical seed treatment, use of clean seed and planting resistant hybrids.

Loose Kernel Smut (fungus - *Sporisorium cruenta*): Galls formed by loose kernel smut are long and pointed and the thin membrane covering them usually breaks soon after galls reach full size. This disease presents no immediate problem because the control measures mentioned for covered kernel smut have virtually eliminated occurrence of this disease.

Foliage Diseases Caused by Fungi: A number of fungal organisms cause foliage infection and may become severe under certain conditions. Occurrence has seldom been consistent or damaging enough to warrant the development of specific control practices. No fungicides have been cleared for use on sorghum foliage. Hybrids vary in their susceptibility to these diseases and resistance is available if their occurrence becomes a problem.
The following information will aid in the identification of specific foliage diseases.

Name	Pathogen	Symptom
Leaf Blight	*Exserohilum turcicum*	Large elongated spots with gray centers and tan-to-reddish borders.
Target leaf spot	*Bipolaris sorghicola*	Round-to-elliptical spots with reddish purple centers and tan margins.
Anthracnose	*Colletotrichum graminicola*	Elliptical-shaped spots that are 1/8"-7/8" in diameter. Tan-to-red with distinct margins.
Gray leaf spot	*Cercospora sorghi*	Dark purple spots having a grayish cast when pathoggen is producing spores. Elongate to round, 1/4" and larger.
Zonate leaf spot	*Gleocercospora sorghi*	Large, irregular-shaped spots having a bullseye appearance.
Rough leaf spot	*Ascochyta sorghina*	Grayish spots that are rough to the touch because of raised black fruiting bodies.
Sooty stripe	*Ramulispora sorghi*	Elongate spots having a sooty appearance because of sclerotia.

Bacterial Stripe (bacterium - *Pseudomonas andropogoni*): This is the most common bacterial disease of sorghum. The disease is characterized by long narrow stripes that vary from red to black depending on the type of sorghum. These stripes are confined between the veins and may have a crusty surface when the bacterial slime dries on the surface. This disease has not been a serious enough problem to warrant specific control in Texas.

Bacterial Streak (bacterium - *Xanthomonas holcicola*): Streak first appears as dark-green watersoaked tissue between veins that later turns brown with red margins. Control measures have not been warranted.

Bacterial Spot (bacterium - *Pseudomonas syringae*): Spots first appear as watersoaked, green areas on lower leaves before infection spreads to upper leaves. Spots later turn tan with reddish borders. Small lesions are often red throughout. Control measures are not usually necessary.

Anthracnose (fungus - *Colletotrichum graminicola*): The anthracnose fungus damages foliage and stems of grain sorghum. On susceptible hybrids, the stem holding the head (peduncle) becomes infected and a brown sunken area with distinct margins develops. Figure 4. When infected stems are cut lenghtwise with a knife, one can see that the fungus has penetrated the soft pith tissue and caused brick-red discolorations. This peduncle infection inhibits the flow of water and nutrients to the grain causing poor grain development. The fungus also invades individual grains and the small branches of the panicle. Rapid and severe yield loss can result from panicle and peduncle infections. Leaf lesions are small, elliptical to circular, usually less than 3/8-inch in diameter. These spots develop small, circular, straw-colored centers with wide margins that may vary in color from reddish to tan to blackish purple. The spots may coalesce to form larger areas of infected tissue. In Texas, anthracnose is restricted mostly to the gulf coast areas. The use of resistant hybrids and good management of crop residue are effective control measures.

Rust (fungus - *Puccinia purpurea*): Rust appears on leaves as small raised pustules or blisters that rupture and release many reddish-brown spores. These pustules occur on both the upper and lower leaf surfaces. This disease usually appears when plants near maturity and infection is confined primarily to mature leaves. Grain yield losses are usually not serious and occurrence of the disease is sporadic. Forage sorghum yields may be affected most. The rust fungus also attacks Johnsongrass and overwinters on this host in southern production areas.

Charcoal Rot (fungus - *Macrophomina phaseolina*): Grain sorghum plants affected by the charcoal rot fungus fail to fill grain properly and may lodge in the latter part of the season. Infected stalks show an internal shredding at and above the ground line. This can be observed by splitting the stalk and noting the deteriorated soft pith tissue leaving the tougher vascular strands. Figure 5. Fungal structures (sclerotia) can be observed in the affected tissue which appears as though it has been dusted with black pepper. Another type of stalk rot (*Pythium* sp. and *Fusarium* sp.) may show the shredded condition but the black specks (sclerotia) will be lacking. Conditions under which charcoal rot is favored include stressful hot soil tempertures and low soil moisture during the postflowering period. Host plants are usually in the early-milk to late-dough stage when infection occurs. The fungus is common and widely distributed in nature. Avoiding moisture stress, proper management of crop residue, crop rotation, avoiding excessive plant populations, balancing nitrogen and potassium fertility levels, and growing drought-tolerant, lodging-resistant hybrids represent the best means of control.

Fusarium Stalk Rot (fungus - *Fusarium moniliforme*): Like charcoal rot, *Fusarium* stalk rot usually develops on mature to nearly mature plants that have been subjected to some form of stress. Infection takes place at the base of the plant and produces discoloration in the stalk. When shredding of the vascular area occurs from this organism, black fungal bodies (sclerotia) are not present as they are with charcoal rot. Avoiding stress problems by proper use of cultural practices is the best approach to control.

Root Rot Complex (fungi - *Fusarium moniliforme*, *Pythium* sp. and others): Several fungi are involved in producing a root rot condition of grain sorghum. One or more of the causal fungi may be involved depending on conditions and organisms present in the soil. Each organism produces distinct symptoms, but identification becomes more complex when other factors are involved. Rotation with non-related crops will lower the population of pathogenic organisms present in the soil.

NOTE: Texas Agricultural Extension Service publication B-6004, "Disease Response of Grain Sorghum Hybrids: Downy Mildew, Head Smut, Maize Dwarf Mosaic, and Anthracnose" (3/95) is available for helping to choose disease resistant commercial grain sorghum hybrids.

Revised March 20, 1995 cb@tamu.edu

Home

Prepared by Texas Extension Plant Pathologists

Vegetable Crops	Fruit Crops	Nut Crops	Flowers
Ground Covers	Shrubs	Lawn & Turf	Trees
Cereal Crops	Fiber, Oil, Specialty	Forage Crops	Sugar Crops
Problems Affecting Multiple Crops	Methods & Materials		

I. VEGETABLE CROPS

- Bean (Snap, Lima, and Butter Beans)
- Beet (Table)
- Cabbage, Cauliflower, Brussel Sprouts, and Broccoli
- Cantaloupe, Cucumber, Squash, Pumpkin, and Crenshaw
- Carrot
- Celery
- Cilantro
- Corn (Sweet)
- Eggplant
- English Pea
- Garlic
- Lettuce
- Okra
- Onion (Revised 01/01)
- Parsley
- Parsnip
- Pepper (Revised 01/01)

- Potato (Irish)
- Radish
- Southern Pea (Blackeye, Cowpea)
- Spinach
- Sweet Potato
- Tomato
- Turnip and Mustard [Revised 3/20/95]
- Watermelon (Revised 01/01)
- Chemical Control Supplement for Vegetables (PDF format)

II. FRUIT CROPS

- Apple (Revised 02/01)
- Avocado (Revised 02/01)
- Assorted Berries (Blackberry, Dewberry and Boysenberry) (Revised 02/01)
- Blueberry (Revised 02/01)
- Common Sweet Cherry (Revised 02/01)
- Citrus (Revised 01/01)
- Fig (Revised 03/01)
- Grape (Revised 03/01)
- Loquat (Revised 03/01)
- Mango (Revised 03/01)
- Mayhaw (Revised 03/01)
- Papaya (Revised 03/01)
- Peach, Apricot and Nectarine
- Pear
- Plum
- Strawberry

Back to Top

III. NUT CROPS

- Black Walnut
- Hickory

Back to Top

IV. FLOWERS

Back to Top

V. GROUND COVERS

Back to Top

VI. SHRUBS

Back to Top

VII. LAWN AND TURF

Back to Top

VIII. TREES

Back to Top

IX. CEREAL CROPS

Back to Top

X. FIBER, OIL, AND SPECIALTY

Back to Top

XI. FORAGE CROPS

Back to Top

XII. SUGAR CROPS

Back to Top

XIII. DESCRIPTION OF PROBLEMS AFFECTING MULTIPLE CROPS

Back to Top

XIV. METHODS AND MATERIALS

Back to Top

Credits