Productive Rotations on Farms in Texas
PROFIT

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Grain Sorghum Irrigation

Leon New*

LIKE MOST OTHER GRAIN CROPS, grain sorghum responds to irrigation more at certain growth stages (boot, flower and grain fill) when water use is greater than at other stages (early vegetative and dough) when the demand is less. Adequate soil moisture is most important during the booting, heading, flowering and grain filling stages of plant growth. Although sorghum can tolerate short periods of water deficit, extended moisture stress slows plant growth and grain development that can reduce yields, especially if it occurs during critical reproductive stages when water needs are highest. More healthy, functioning leaves typically lead to greater yield.

*Agricultural Engineer, Texas Cooperative Extension — Amarillo, The Texas A&M University System.

Growth Stages

Sorghum water use is highest just before and during the booting stage. Plants are likely to require 3 to 4 inches of water every 10 days during this period, which usually begins 35 to 40 days after emergence. Irrigation at this stage usually yields an additional 3,000 to 4,000 pounds per acre. Even short periods of water stress just before and during the booting growth stage can reduce yields quickly. Moisture stress reduces both the number and size of seeds per head. **Figure 1 illustrates flag leaf and early boot growth stages, when adequate water is most important.**

Adequate soil moisture levels must also be maintained during heading and flowering to maintain yield. Although water needs decline slightly after booting, a sorghum crop still requires 2 to 3 inches of water every 10 days. Irrigating during heading and flowering generally produces an increase of 1,200 to 1,500 pounds per acre. Insufficient water during heading primarily limits seed size and weight, but it can also reduce the number of seeds per head. With little to no rainfall and no reserve soil moisture during this important growth stage, production from irrigation will need to be greater, often yielding increases of more than 3,000 pounds per acre. **Figure 2 shows heading and flowering growth stages.**

Figure 1. Flag leaf and early boot stages when adequate soil water contributes to seed number and size.

Figure 2. Adequate soil water contributes to seed size and weight at heading and flowering growth stages.

The need for water decreases during the grain filling stage that follows. Plants normally have reached mature size by the early dough stage of grain maturity, so water is used primarily to produce grain and maintain plant carbohydrate transfer to the seeds set earlier. Water requirements for the crop will normally drop to about 2 inches every 10 days during grain filling and continue to decrease as the plants mature. Irrigation during the milk to soft dough stage of grain filling normally increases yield 700 to 1,000 pounds per acre. **The grain fill stage is shown in Figure 3.**

After the soft dough stage, irrigation usually increases production by 400 pounds per acre or less, depending upon rainfall. Limited to no increase in yield is likely after a general red color appears over the field. The only benefit from late season irrigation may be to maintain stalk quality for harvest, when needed. **(See Figure 4.)**

Soil

Grain sorghum grown on deep, permeable soil usually develops extensive fibrous root systems. In ideal soil, mature plants will likely penetrate to depths of at least 4 feet. However, soil conditions, such as excessively wet soil, especially early in the growing season, compaction and hard pan can restrict root development. Shallow top soil, where caliche lies near the surface, will restrict root exten-

Figure 3. Water maintains seed development and weight during the grain fill growth stage.

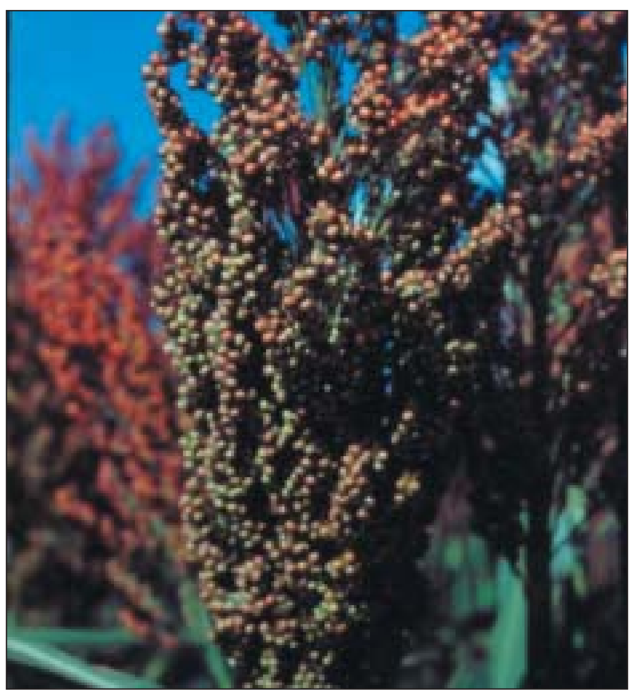


Figure 4. Limited yield increases are likely following the dough growth stages.

sion. Restricted root systems may significantly limit plant development and yield during hot, dry weather. The top 3 feet of soil normally supplies more than 75 percent of water for production.

Most area soils normally store 4 to 6 inches of available water in 3 feet of soil. That is typically sufficient water for the remaining growing season when it is fully available at the late dough growth stage. **Available water storable in three feet of some area soils are listed in Table 1.** An additional irrigation prior to the hard dough stage is more likely to be profitable for sandy soils where less water can be stored and is typically applied more frequently using center pivot systems. Actual soil water depletion before a plant experiences stress depends on the soil type and texture. Significant plant stress generally occurs when available soil water drops to approximately 50 percent.

Table 1. Available water holding capacity in feet of area soils.

Soil description	Available water in 3 feet - inches
Sherm Silty Clay Loam	6.57
Olton Clay Loam	6.12
Pullman Clay Loam	5.94
Acuff Loam	5.71
Dalhart Fine Sandy Loam	5.67
Amarillo Fine Sandy Loam	5.20
Grandfield Fine Sandy Loam	4.80
Brownfield Fine Sand	3.36

Irrigation Systems

The time (hours) required to irrigate a crop is especially important in minimizing moisture stress. One way to cover acreage faster is to irrigate alternate rows or furrows. But if Pullman and similar tight clay soils crack, it is difficult to push water through. More success has been achieved with alternate furrow irrigation on lighter loam soils and on Pullman and Sherm silty clay loam soils with furrows spaced 30 inches apart. An additional seasonal irrigation may be needed to keep soil moisture levels up, since less water is often applied for individual applications. **Field tests with growers show two-thirds to three-fourths the amount of irrigation water is normally applied irrigating alternate furrows compared to every furrow**.

When water is applied in alternate furrows, the acreage can usually be irrigated more quickly. Seasonal irrigation typically requires 65 to 75 percent of the amount used by watering every furrow to produce similar yields. Surge-flow surface irrigation that uses a directional valve to intermittently apply water to two areas of the field has reduced runoff and improved furrow irrigation water distribution uniformity 15 to 20 percent. While surge valves are inexpensive compared to the potential reduction in irrigation water applied, they require grower experience, management and good soil water knowledge. Surge time and the level of irrigation efficiency achieved are influenced by the site's soil type, field terrain and tillage preparation.

With LEPA (Low Energy Precision Application) or LESA (Low Elevation Spray Application) center pivots, 4.0 gallons [of water] per minute (GPM) per acre achieves a seasonal irrigation capacity of 1.50 inches per week or 0.21 inches per day. Almost 13.0 inches of water can be applied in 60 days of irrigation. An irrigation capacity of 4.5 GPM per acre can apply 1.67 inches of water per week 0.24 inches per day and 14.30 inches in 60 days. With good early season soil water and soils that can store 4 to 6 inches of water, these irrigation capacities are typically adequate for grain sorghum production. **Four, 4.5 and additional GPM per acre irrigation capacities are described more in Table 2.** These higher efficiency center pivot irrigation systems apply water in a concentrated area that prevents wind and crop foliage water losses.

Table 2. Daily and seasonal irrigation capacity.

GPM/ acre	Inch/day	Inch/day	Inches in irrigation days 30	45	60	80	100
1.5	.08	.55	2.4	3.8	4.8	6.4	8.0
2.0	.11	.75	3.2	4.8	6.4	8.5	10.6
3.0	.16	1.10	4.8	7.2	9.5	12.7	15.9
4.0	.21	1.50	6.4	9.5	12.7	17.0	21.2
5.0	.27	1.85	87.0	11.9	15.9	21.2	26.5
6.0	.32	2.25	9.5	14.3	19.1	25.4	31.8

Planting crop rows in a circular pattern, maintaining crop residue, furrow diking and deep chiseling irrigated furrows can control water runoff. Changing the optional speed control setting to match water application to soil infiltration is a common practice to control runoff. Avoid running tractor and other field equipment wheels in furrows where LEPA center pivots apply irrigation water. Additional information is available in Texas Cooperative Extension publications B-6096, "Center Pivot Irrigation," and B-6113, "Economics Of Irrigation Systems."

Pre-Plant Irrigation

Irrigation before planting generally is inefficient use of an already inadequate water supply. Watering-up (irrigating after seed are planted to provide moisture for germination and early root development), rather than pre-plant irrigation, can be effective in grain sorghum production. This procedure usually provides highest soil moisture levels for seed germination and, at the same time, adds water to the soil root zone. It is especially important to irrigate in precise amounts to prevent leaching of nitrogen fertilizer and deep percolation water loss.

Pre-plant irrigation is normally the largest and most costly application of the year. With soils dry and evaporation traditionally greater from high winds, low relative humidity and no ground cover, applying water efficiently is a challenge to the best irrigator and irrigation system. Research has found that only 35 to 55 percent of pre-plant irrigation water applied to Pullman silty clay loam is stored 6 to 8 weeks later and that the combined total storage of irrigation water and rainfall are very similar, regardless of when pre-plant irrigation is applied. The soil can store only a certain quantity of water in the effective root zone; any excess is lost. **(See Table 1.)** Adequate seed bed soil water for seed germination and uniform crop establishment can be aided by water-conserving procedures, such as:

- Planting flat
- Making furrows, if needed, after the crop is established
- Maintaining crop residue
- Reduced tillage.

Grower Demonstrations

Field demonstrations with growers during the past 6 years have shown average irrigated grain sorghum production to be **6,175** pounds per acre from **22.93** inches of irrigation, rainfall and soil water. Irrigation, rainfall plus additional soil water averaged **85** percent of that reported by the North Plains ET Network for fully irrigated grain sorghum. Production averaged **269** pounds per acre from each inch of water measured. Irrigation averaged **13.02** inches, and grain sorghum production averaged **474** pounds per acre from each inch of irrigation.

Grain sorghum production per inch of water is an excellent management tool. **Thirty-five** growers (**70** percent) irrigated with center pivot, and **fifteen** growers (**30** percent) used furrow systems. Irrigation averaged **11.89** inches of water using center pivot and **15.68** inches with furrow systems. **Eleven** dryland grower tests averaged **2,361** pounds of grain sorghum per acre from **11.07** inches of rainfall and soil water. **Grain sorghum production data from grower demonstrations are summarized in Table 3.** A 5-year running average has helped many growers improve manage-

Table 3. Grain sorghum production per inch of water. '98, '99, '00, '01, '02, '03 AgriPartner result demonstrations

		Water-inches		PET	Production		
Irrigation method	Number of tests	Irrigation soil	rain/irrig/soil	Percent of	Lbs/Ac	Lbs/ac - in irrigation	Lbs/ac - in rain/irrig/soil
Average all	61	—	20.80	78	5,487	—	264
Average irrigation	50	13.02	22.93	85	6,175	474	269
Average center pivot	35	11.89	21.69	81	5,838	491	269
Average row water	15	15.68	25.83	95	6,978	445	270
Average dryland	11	—	11.07	46	2,361	—	213

ment of resources, irrigation system application efficiency and grain sorghum production per inch of water.

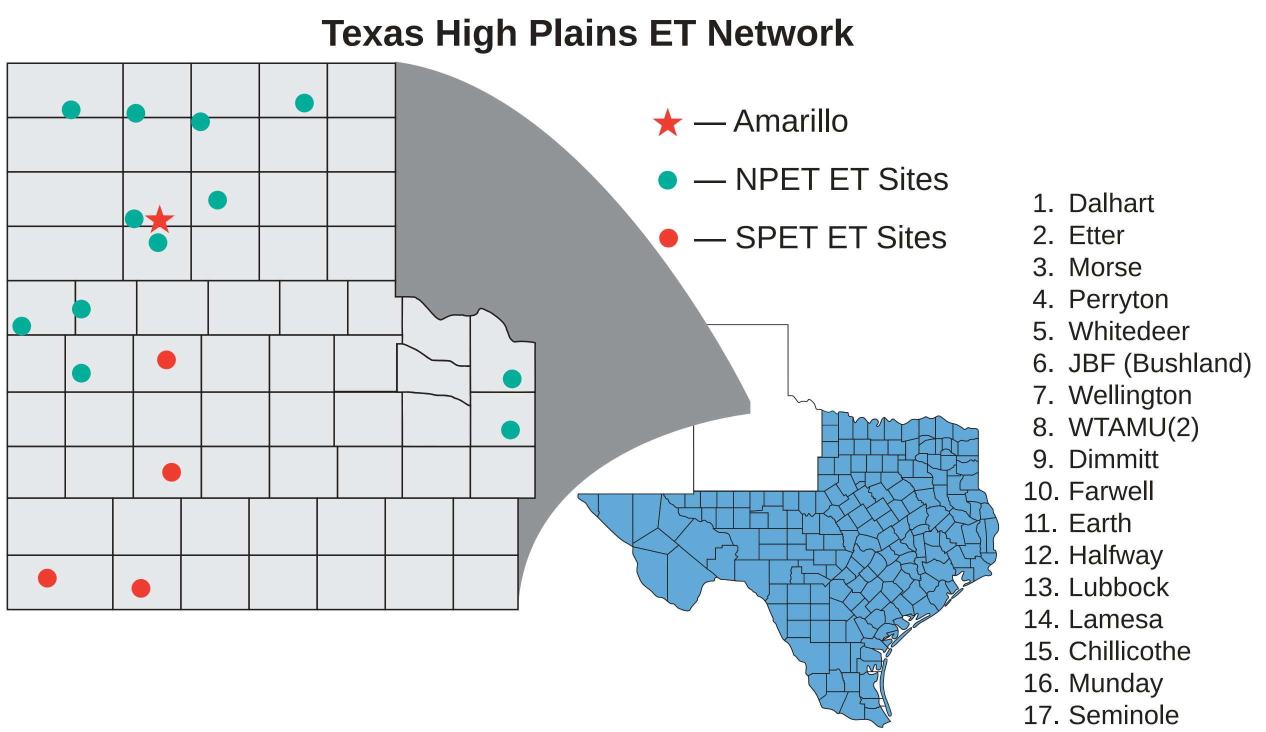
Management Tools

North Plains EvapoTranspiration Network

The North Plains ET (EvapoTranspiration) Network reports daily and seasonal grain sorghum water use for both long- and short-season hybrids. Water use reported represents fully irrigated grain sorghum. Some growers choose to provide only partial seasonal water, depending on availability, commodity prices and other factors. **The PET column in Table 3 describes the percent total irrigation, rainfall plus additional soil water measured in growers demonstrations as reported by the ET weather station network. Seventeen** strategically located weather stations record hourly climatic data that propels the computerized network serving growers, agribusiness, crop consultants, university and other personnel. **Location of the network weather stations are shown in Figure 5.** The web address is

http://amarillo2.tamu.edu/nppet/petnet1.htm.

Select the weather station (town) nearest your farm and the planting date nearest yours. **Figure 6 shows how 4 gallons per minute per acre irrigation capacity is insufficient to provide full irrigation for long season grain sorghum daily and seasonal water needs. Water requirement is for June 1st planting date reported by the network weather station near Dimmitt, Texas. Numbers by year in the upper left represent inches of insufficient water annually. Inches of insufficient water listed must be provided by rainfall and/or soil water to provide the crop full water. Growers use Figure 6 and other similar GPM per acre graphs to plan and commit available irrigation water to grain sorghum**



Climate data recorded for the past 24 hours at each site is retrieved at midnight every day. Daily and progressive seasonal crop water use, heat units, air and soil temperatures and other production management information are faxed to users by 7:00 A.M. The data is available on the internet at *http://amarillo2.tamu.edu/nppet/petnet1.htm*. Corn, cotton, grain sorghum, peanut, soybean and wheat production data are currently reported, following extensive research.

Figure 5. Texas High Plains ET Network.

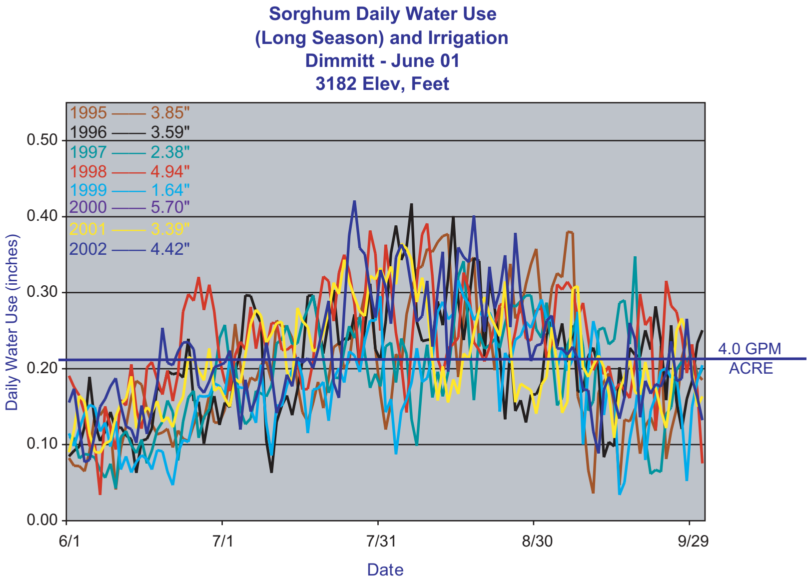


Figure 6. Grain sorghum daily and seasonal water use vs 4.0 GPM per acre irrigation capacity.

production. Use a rain gauge at or near your field to measure seasonal rainfall. **ET network crop water** use data is also delivered daily by fax. Your county Extension agent can add you to the fax delivery list.

Moisture Sensors

Soil moisture sensors installed at 1-, 2- and 3-foot depths provide timely management data. The sensors can identify existing soil moisture levels, monitor moisture changes, locate the depth of water penetration and describe crop rooting. Install a set of three sensors at a location in the field where soil is uniform. Avoid low areas where water may stand and slopes where it may run. Put the sensors in the crop row so they do not interfere with tractor equipment. Install gypsum block and porous tip sensors in a tight fit hole with an auger or driver the same size. It is essential to have the sensing tip in firm contact with undisturbed soil to obtain accurate readings. Read and record soil water at least twice a week during the irrigation season.

Figure 7 describes seasonal soil water levels at 1, 2 and 3 feet in the root zone measured in a cooperating grower's grain sorghum demonstration field. Companion irrigation, rainfall plus net soil water measured and grower management to produce the crop in relation to grain sorghum water use reported by the ET network are described in Figure 8. Grower irrigation and soil water management to supplement rainfall mimics daily and accumulative grain sorghum water use reported by the ET network weather station near White Deer, Texas.

Soil Probe

The portable soil moisture probe (rod) can improve your ability to manage irrigation, telling you significantly more than you can see. The probes are made of 5/16-inch spring steel in either 4- or 6-foot lengths. A 1/2-inch carbon steel ball is welded to one end , and a 1

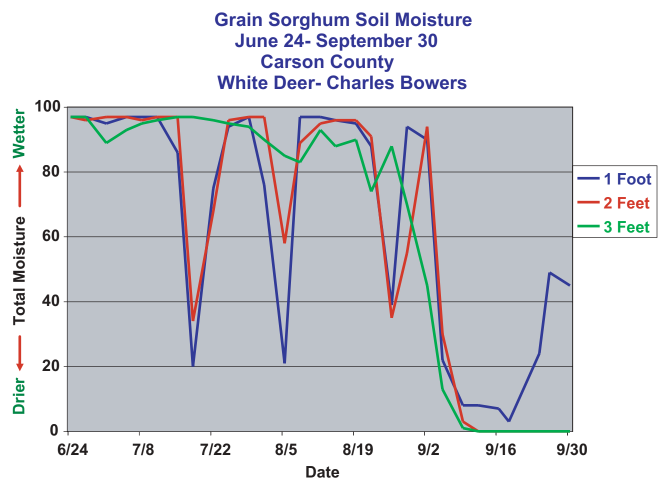


Figure 7. Seasonal soil water levels in a grower's grain sorghum demonstration field.

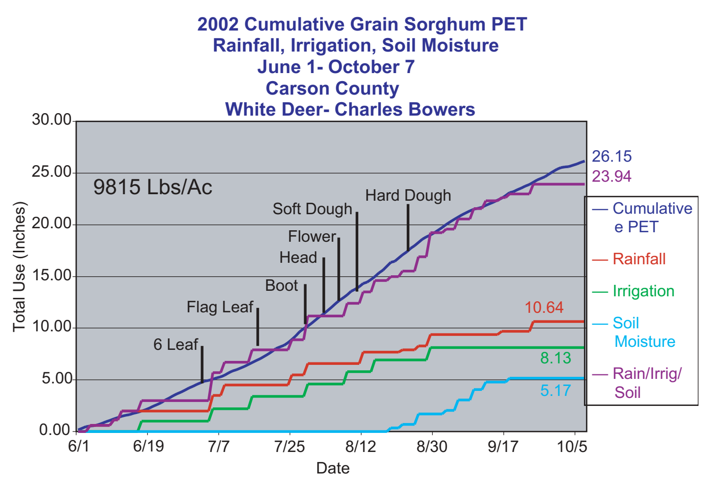


Figure 8. Irrigation, rainfall plus soil water vs ET network water use.

5/8-inch plastic ball is mounted on the handle end. The probe will not rust. The probe pushes into moist and wet soil but stops at the depth where the ball hits dry soil. Soil compaction can be difficult to penetrate and misleading. Try pushing the probe at five, six or more similar locations to more accurately evaluate soil water content and/or soil compaction.

Generally, if you cannot penetrate the soil surface with the probe, there is no subsurface moisture present. Prior to the grain sorghum booting stage, the soil moisture probe needs to be successfully pushed to 3 or 4 feet or to caliche subsoil. This indicates that 4 to 6 inches of available water is stored, depending on soil type. Pushing to 6 feet anytime usually indicates over-watering. When plant water use exceeds net effective rainfall and irrigation, even when irrigating, the crop will begin to deplete stored soil water. That is why 4 to 6 inches of water need to be stored before crop water use exceeds irrigation capacity. This will reduce the depth the soil probe can be pushed. Sufficient soil water should be maintained to push the probe to at least 8 to 10 inches during heading, flowering and grain fill growth stages, when adequate soil water is most essential. By physiological maturity (black layer) and after the crop is produced, 6 to 8 inches of subsoil probe penetration is desirable to maintain plants until harvest. **The portable soil probe is illustrated in Figure 9.**

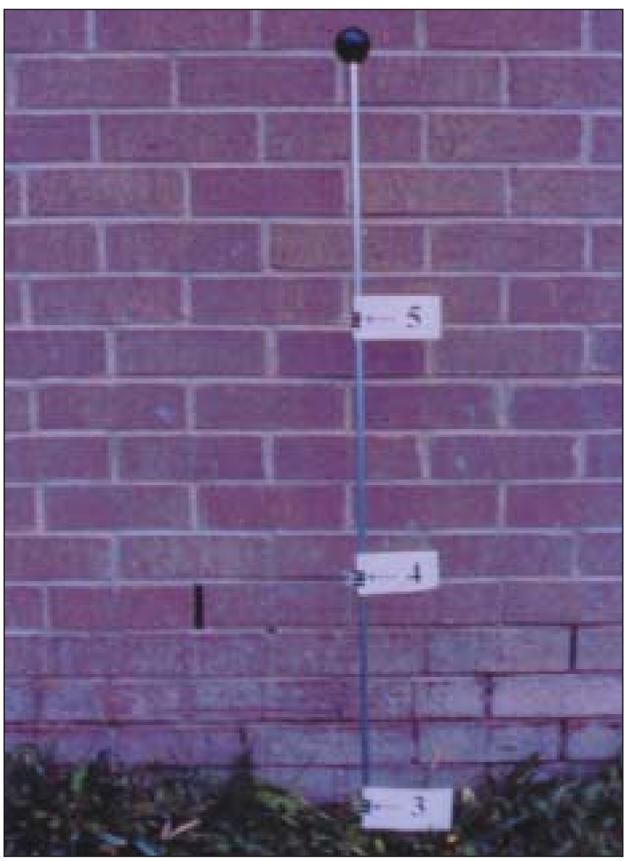


Figure 9. The portable probe can be pushed 6 feet into moist or wet soil.

Summary

Grain sorghum can endure limited, short term water stress. It responds rapidly to additional water. Adequate water is most essential during flag leaf and booting growth stages when the number of seed per head is set. Seed development and weight is enhanced from good soil water during heading and flowering. Plant water is less during grain fill, but remains important to maintain seed weight and production potential. Manage irrigation to compliment rainfall using high efficiency systems. Use soil available water storage and infiltration rate characteristics in conjunction with planned or available GPM per acre irrigation capacity to maintain desired soil water levels. Utilize soil water storage at full profile and capacity to keep GPM per acre acceptably low. Know approximate seasonal rainfall plus soil water required to adequately compliment GPM per acre irrigation capacity. Use daily seasonal grain sorghum water use reported by the ET weather station network, soil moisture sensors and/or the handy portable probe to help manage irrigation and soil water.

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