1 - Growth and Development

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Grain sorghum is an important feed grain crop grown in Arkansas. The plant's ability to produce respectable yields under adverse growing conditions has made it a popular crop for many producers. However, many producers have the perception that grain sorghum will produce good yields with minimal management inputs. In reality, grain yields are often reduced by environmental stresses and poor management. Like any other crop, grain sorghum will respond to optimum growing conditions and proper timing of management inputs for maximum yields. Understanding how the grain sorghum plant develops is critical for understanding the crop's needs and planning management inputs for maximum yields.

Understanding how the grain sorghum plant develops begins with learning the structures and anatomy of the plant. Figure 1-1 shows a young plant with three fully developed leaves. A leaf is counted when the collar (the point where the leaf blade and sheath attach) is visible. Identification of individual leaves early in the growing season may also be aided by considering the shape of the leaf. The first leaf visible at emergence is the coleoptile leaf and has a round tip. If the lowest leaf is pointed, then at least one leaf has been lost. Figure 1-2 shows a plant in the boot stage. All leaves are fully expanded and the flag leaf is the last leaf to emerge and is considerably smaller than the other leaves. The head (panicle) emerges from the flag leaf sheath and is supported by the peduncle. Figure 1-3 represents a plant that has headed and is at physiological maturity. The head emerges from the flag leaf sheath and is supported by the portion of the stalk called the peduncle.

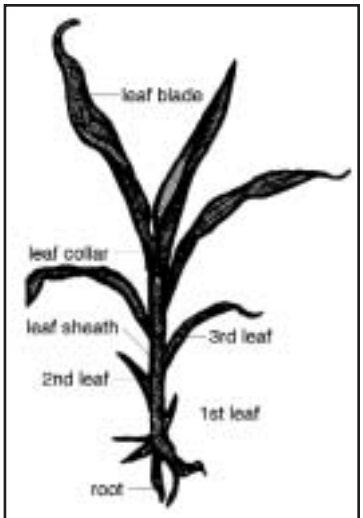

Figure 1-1. Grain sorghum plant in the 3-leaf stage.

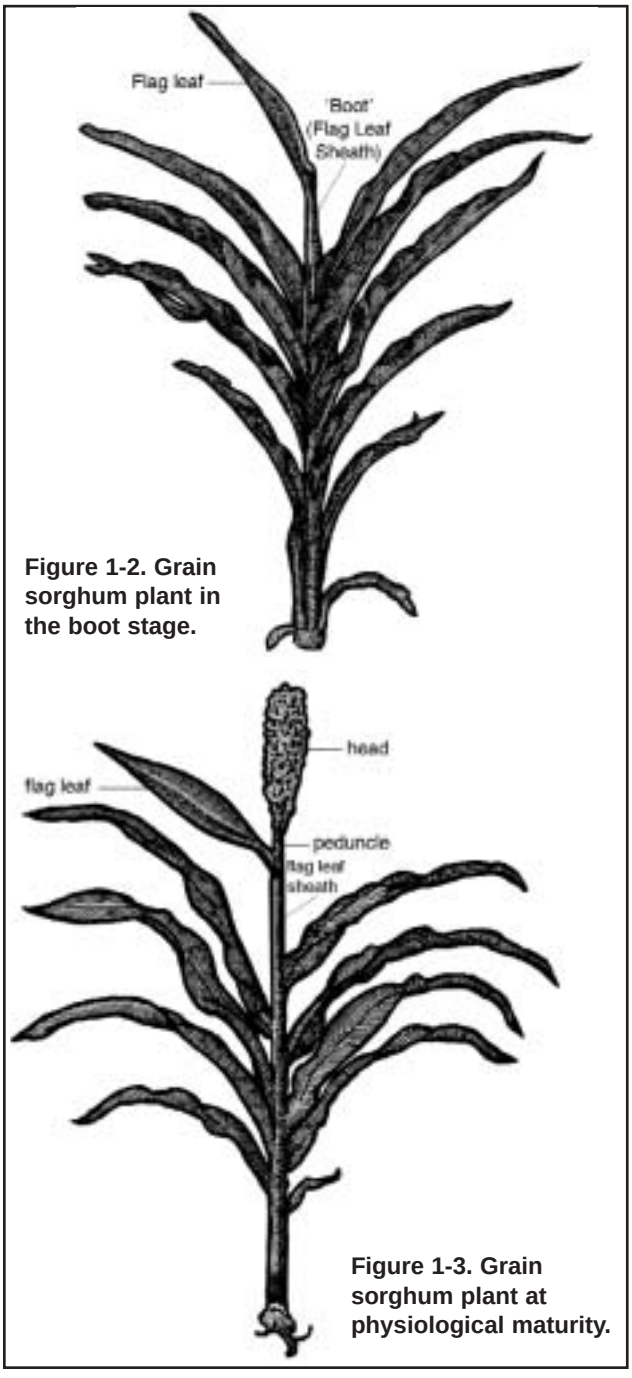

Figure 1-2. Grain sorghum plant in the boot stage.

Figure 1-3. Grain sorghum plant at physiological maturity.

Growth Stages

Grain sorghum goes through three distinct stages of development after emergence – seedling development, panicle initiation and reproduction. The time required for the plant to go through each stage is dependent upon hybrid maturity and temperatures encountered during the growing season. In Arkansas, the plant will spend approximately 35 days in each stage. Grain sorghum planted early in the season when temperatures are still cool will progress through the stages more slowly than grain sorghum planted later in the season when temperatures are warmer. Each growth stage is discussed in detail below.

Growth Stage I (Seedling Development)

The seedling development stage is characterized by vegetative growth. The plant develops leaves and tillers, which ultimately support grain formation and growth. The duration of the Growth Stage I is largely dependent on air temperature and the hybrid maturity. The more leaves formed by the plant, the longer maturity. Early maturity hybrids typically produce 15 leaves per plant, while medium and late maturity hybrids produce 17 and 19 leaves each. The plant can tolerate stress from drought, hail and freezing temperatures in Growth Stage I with little negative effect on grain yields. Sunny days with temperatures below 65°F promote tillering when the plants are in the 4- to 6-leaf stage. Plant densities less than three plants per foot of row promote tillering. Panicles of tillers are often smaller and flower later than those of the main stem. Tillers formed can compensate somewhat for low plant populations.

Growth Stage II (Panicle Initiation)

The stage begins with panicle initiation and continues to flowering. This growth stage is the period when reproductive structures of the panicle form and the maximum number of seeds per panicle is set. During this period, plants are especially sensitive to any type of stress such as temperature extremes, nutrient deficiencies or water deficits or excess, any of which may reduce the potential seed numbers. It is considered the most critical period for grain production since seed number per plant accounts for 70 percent of the grain yield. The rate of water uptake increases rapidly during this period. If the crop is irrigated, it is important that the crop not be allowed to stress at the beginning of this stage when the potential number of seeds per plant is being set.

At the boot stage (Figure 1-2) all leaves are now fully expanded, providing maximum light interception. The head has now developed to nearly full size and is enclosed in the flag leaf sheath. Peduncle elongation is beginning and will result in exertion of the head from the flag leaf sheath. Potential head size has been determined. Moisture stress at the boot stage may prevent the head from exerting completely from the flag leaf sheath, which may cause harvest difficulty. The crop will respond favorably to irrigation at this stage. Following the boot stage, the peduncle grows rapidly extending the head through the flag leaf sheath.

Growth Stage III (Reproduction)

The final growth stage begins with flowering and continues until physiological maturity. Flowering begins when yellow anthers appear at the tip of the head five to seven days after head exertion. Over the next four to nine days, anther development progresses down the head. The plant is considered at half bloom when flowering has progressed half way down the head. Many grain sorghum hybrids grown in Arkansas require approximately 75 days from emergence for the plant to reach half bloom. The most critical time for water begins about one week before head emergence or the boot stage and continues through two weeks past flowering.

Scouting for sorghum midge is critical at flowering. One midge per head can lower grain yield 10 to 20 percent. After flowering, seed development begins and progresses through development stages of milk, soft dough, hard dough and physiological maturity over a 25 to 45 day period after flowering, depending on hybrid and growing conditions. Kernels reach their maximum volume approximately 10 days after flowering during the milk stage. The seed is soft and a white milky fluid appears when the seed is squeezed. The soft dough stage occurs approximately 15 to 25 days after flowering when 50 percent of the seed weight has been accumulated and little to no fluid appears when the seed is squeezed. The grain is very susceptible to bird and head webworm feeding during the soft dough stage. When the seed is in the hard dough stage, the grain cannot be squeezed with the

fingers and approximately 75 percent of the seed weight has been accumulated.

Drought stress during the soft or hard dough stage can result in shriveled grain with a low test weight. Physiological maturity occurs when a black-layer appears immediately above the point of kernel attachment in the floret near the base of the kernel. The seed moisture is approximately 30 to 35 percent and has reached its full potential weight. Grain harvest can begin at approximately 20 percent moisture with no mechanical damage to the seed.

Growing Degree Units

Grain sorghum follows a predictable pattern of growth from planting through physiological maturity. The duration between growth stages is closely dependent upon the air temperatures and relative maturity of the hybrid. The number of days required for a hybrid to reach maturity depends primarily on location, date of planting and temperature. A hybrid labeled as being in half bloom at 75 days may take fewer or more days to reach half bloom, depending on growing conditions. Because daily minimum and maximum temperatures vary from year to year and between locations, the number of days from planting to physiological maturity varies and is not a good predictor of crop development. A better system to estimate crop development is the growing degree unit (GDU) system.

Growing Degree Unit Calculation

GDU = (Daily max. air temp + daily min. air temp)/2 - 50

Example: 86°F for a high temp and 60°F for a low temp

86 (high) + 60 (low) = 146

146/2 = 73

73-50 = 23 GDU

The base temperature or lower temperature limit of grain sorghum development is 50°F, while the upper limit is 100°F. Air temperatures greater than 100°F are entered as 100°F and temperatures less than 50°F are entered as 50°F. The key growth stages of sorghum and the cumulative GDUs (from planting) required to reach each growth stage are illustrated in Table 1-1. Because grain sorghum hybrids differ in maturity, the table illustrates cumulative GDUs expected for early and late maturing hybrids.

Table 1-1. Cumulative Growing Degree Units (F) from Planting to Successive Growth Stages for Short and Long Season Grain Sorghum Hybrids.

Growth Stage	Cumulative GDUs (F)	
	Short Season Hybrid	Full Season Hybrid
Planting	---	---
Emergence	200	200
3-leaf	500	500
4-leaf	575	575
5-leaf	660	660
Panicle Initiation	924	1365
Flag Leaf Visible	1287	1470
Boot	1683	1750
Heading	1749	1890
Flowering	1848	1995
Soft Dough	2211	2310
Hard Dough	2508	2765
Black Layer	2673	3360

References

Vanderlip, R. L., *How a Grain Sorghum Plant Develops*, Kansas State University, January 1993.

Gerik, T., B. Bean, and R. Vanderlip, *Sorghum Growth and Development*, Texas Cooperative Extension Service. 2003.