

1 – Rice Growth and Development

Karen Moldenhauer and Nathan Slaton

Rice is an annual grass (Figure 1-1) with round, hollow, jointed culms; narrow, flat, sessile leaf blades joined to the leaf sheaths with collars; well-defined, sickle-shaped, hairy auricles; small acute to acuminate or two cleft ligules (Figure 1-2); and terminal panicles. The life cycle of rice cultivars in Arkansas ranges from 110 to 150 days from germination to maturity, depending on the variety and the environment.

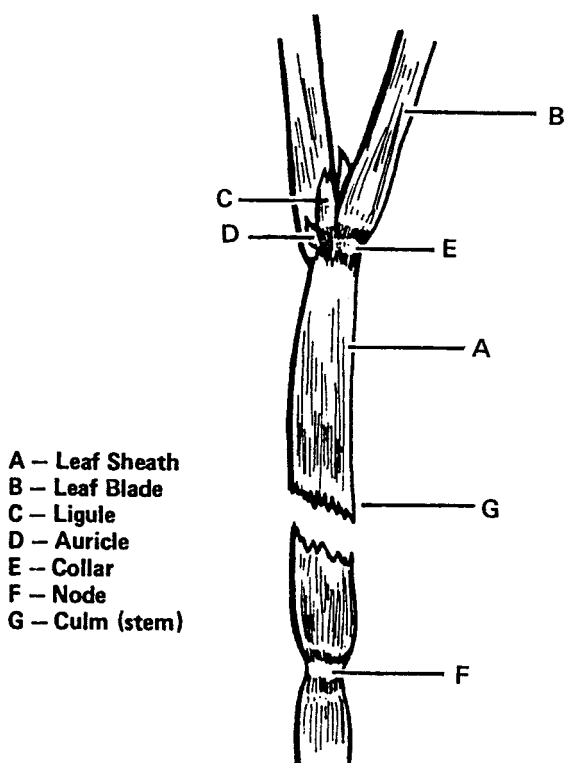


Figure 1-1. Leaf and Culm Morphology

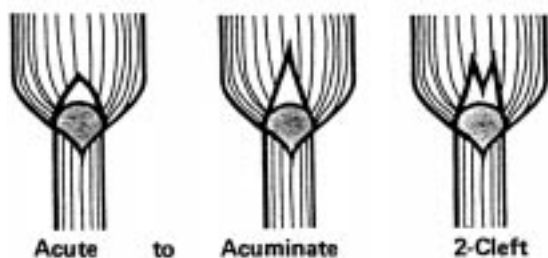


Figure 1-2. Ligule Shapes of U.S. Rice Cultivars

Principle: Identification of plant parts is essential in differentiating rice plants from weeds.

Rice plant growth can be divided into three agronomic stages of development:

1. vegetative (germination to panicle initiation);
2. reproductive (panicle initiation (PI) to heading); and
3. grain filling and ripening or maturation (heading to maturity – Figure 1-3).

These stages influence the three yield components: 1) number of panicles per unit land area, 2) the average number of grain produced per panicle and 3) the average weight of the individual grains. These three components determine grain yield.

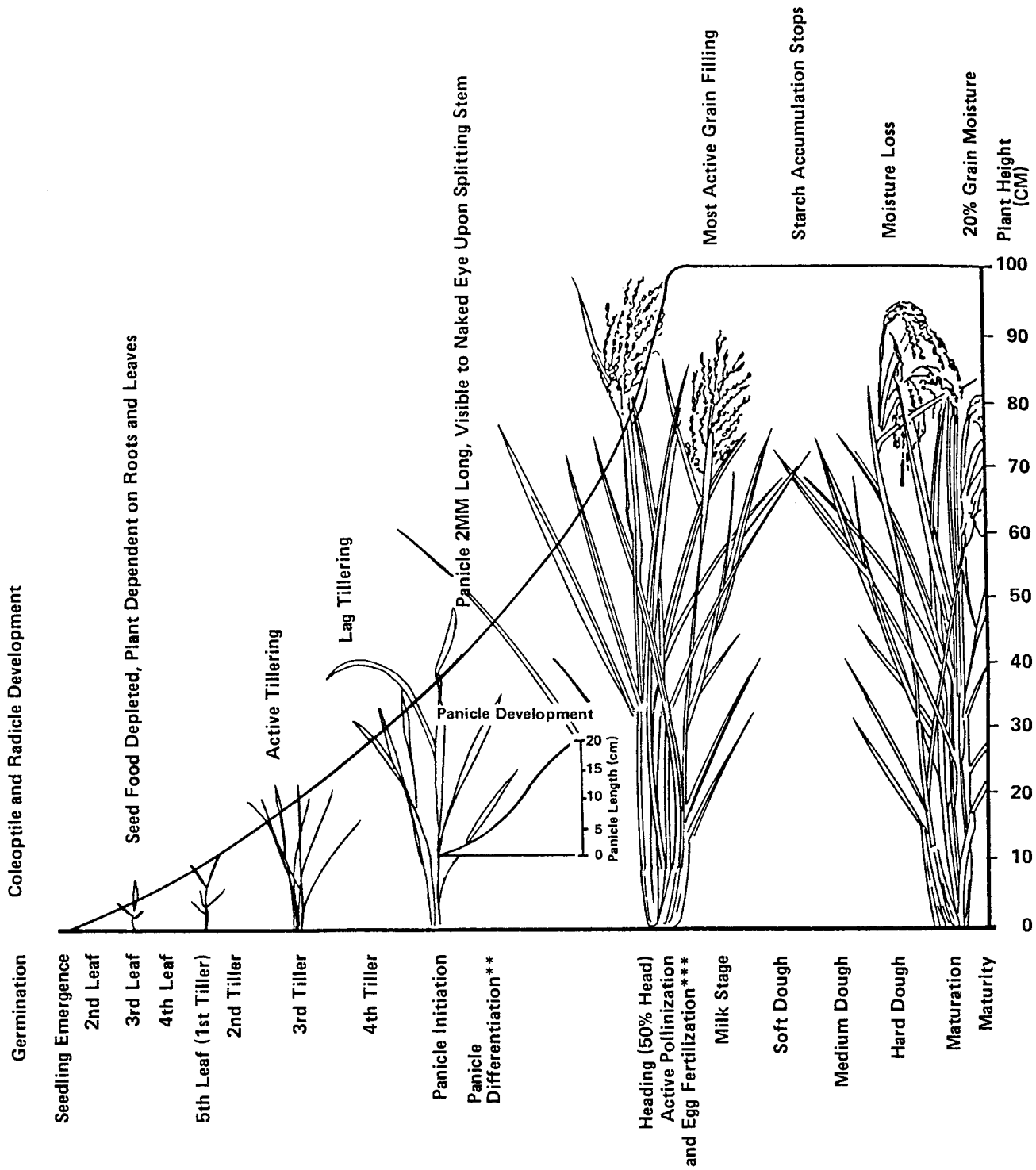
The following descriptions and diagrams characterize the growth stages for rice plants.

Vegetative Stage

The vegetative growth stage is characterized by active tillering, a gradual increase in plant height and leaf emergence at regular intervals. The length of this stage primarily determines the growth duration of varieties. Some very-early maturing varieties have a shortened vegetative growth stage, while others have both shortened vegetative and reproductive growth stages. Panicle initiation (PI) may occur before the maximum tiller number is reached in very-short-season and some short-season varieties. Heading in these varieties may be staggered due to later tillers which produce panicles. In midseason varieties, the maximum tiller number is reached and followed by a vegetative lag phase before panicle initiation (PI) occurs.

The following distinct steps occur during the vegetative stage:

Figure 1-3. Development Stages of the Rice Plant



5-20 Days*	15 to 25 Days*	24 to 42 Days*	Variable ****	†	19 to 25 Days*	30 to 45 Days*
STAGE I VEGETATIVE					STAGE II REPRODUCTIVE	STAGE III GRAIN FILLING & MATURATION

†3 to 5 days.

*Under warm conditions use the lower number of days and for cool conditions use the larger number of days.

**The reproductive stage begins with panicle initiation.

***Stage III begins when 50% of the florets are pollinated.

****Variable time – 0 to 25 days (dependent upon variety).

1. **Seed Germination** – occurs when the seed coat has imbibed adequate water becoming soft and elastic. The coleorhiza (the sheath covering the radicle or embryonic primary root) elongates slightly, emerging through the seed coat and the radicle breaks through the coleorhiza and becomes anchored in the soil. The coleoptile or primary leaf elongates. Thus, under dry-seeded or aerobic conditions, the radicle emerges before the coleoptile. Under water-seeded or reduced oxygen (anaerobic) conditions, the coleoptile may emerge before the root. This occurs within two days when temperatures are between 70° to 97°F. Below or above this temperature, germination requires more time. Germination occurs within the temperature range of 50° to 107°F with an optimum temperature of about 87°F. The coleoptile continues to elongate and several lateral roots called seminal roots form. (Figure 1-4)

Principles: (1) Imbibition of water by the seed is essential before application of the preemergence herbicide Bolero to prevent injury. (2) There will be minimal seedling emergence from rice seed covered with both soil and water because of lack of O₂. (3) Higher seeding rates will not compensate for low temperatures or other adverse conditions.

2. **Seedling Emergence** – occurs when the first internode called the mesocotyl has elongated and pushed the tip of the rice coleoptile (epiblast or first sheathing leaf) through the soil surface. The length of the mesocotyl varies with cultivars. Some semi-dwarf varieties may have a very short mesocotyl and generally will not emerge if covered by more than 1/2 to 3/4 inch of soil. The mesocotyl only develops in the dark and doesn't show up in water-seeded rice. (Figure 1-4)

Principles: (1) Semi-dwarf varieties with short mesocotyls may not emerge if covered with more than 1/2 to 3/4 inch soil. When growing these varieties, a gibberellic acid seed treatment (Release or GibGro) may be used to increase the mesocotyl length and, thus, emergence. (2) Emergence for starting the DD50 program is defined as the date when 10 of the rice coleoptiles per square foot have emerged above the soil surface. (3) Seedling germination and emergence typically vary from 5 to 28 days depending on the environment.

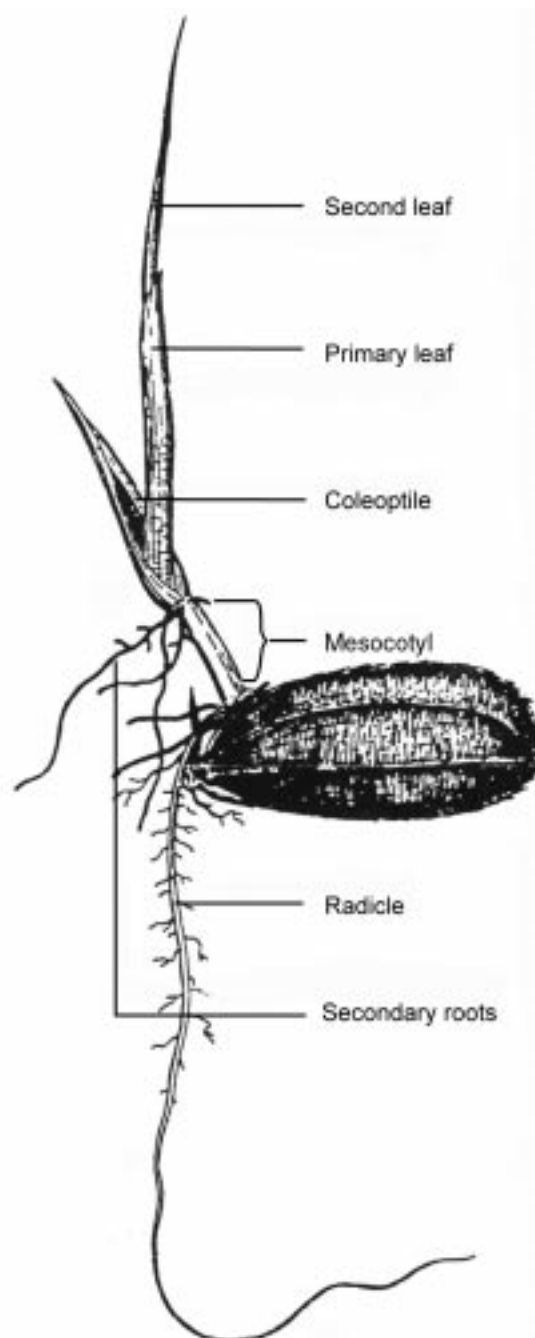


Figure 1-4. Parts of a Germinating Seedling (Chang and Bardenas, 1965)

3. **Pre-Tillering** – the period from the development of the first to fourth leaf stage requires 15 to 25 days. During this time, the seminal roots further develop, the secondary or lateral roots develop and the first four leaves appear (Figure 1-4). After seedling emergence a new leaf emerges for every 100 to 175 accumulated DD50 units.
4. **Tillering** – usually begins at the fifth leaf stage when the first tiller is visible and emerges from the axillary bud of the second

leaf on the culm. Tillering continues when the sixth leaf emerges, the second tiller comes from the axillary bud of the third leaf.

Tillering continues in a synchronous manner with the n th leaf of the main culm and tiller emerging from the axillary bud of the $(n-3)$ th leaf. During this period, the secondary roots grow down until flooding. Once flooded, these roots grow both vertically and laterally. The lateral growth is probably due to the O_2 availability at the soil-water interface. During active tillering new leaves on the main culm emerge at a faster rate requiring about 75 to 150 DD50 units.

Principle: Tillering is necessary with low plant population (6 to 10 plants per square foot) and can be stimulated by extra pre-flood nitrogen during the rapid tillering stage as defined by the DD50 program.

- Maximum Tillering** – tillering increases in a sigmoidal-shaped curve until the maximum tiller number is reached. At this point, the main culm may be difficult to distinguish from the tiller. In direct-seeded rice fields with a normal plant population (10 to 20 plants per square foot), rice plants generally produce 2 to 5 panicle bearing tillers per plant compared to 10 to 30 tillers per plant in transplanted rice where more space is available between plants. After maximum tillering has occurred, no more effective tillers are produced. A portion of the late tillers will generally die due to competition effects. The first yield component, potential panicles per unit area, is determined at this time.

Principle: Because of rapid growth during the active tillering stage, avoid using phenoxy herbicides (2,4-D or MCPA) to prevent excessive injury.

- Vegetative Lag Phase** – is the period from the end of active tillering to the beginning of the reproductive stage. Tiller number decreases; height and stem diameter continue to increase but at a slower rate. This is the time when phenoxy herbicides should be applied. The length of this period is a function of the maturation period of the cultivar. For very-short season cultivars with 110-day maturity, this period may not be evident. In this situation, maximum tillering stage and the beginning of reproductive growth may overlap. In a 150-day rice cultivar, the lag

phase period may last more than two weeks. During this slow growth period, the number of DD50 units required for a new leaf to emerge increases to about 200 per leaf and continues to increase with each new leaf produced.

Principle: The vegetative lag phase in midseason varieties is characterized by yellowing plants. There is not much activity occurring in the rice; therefore, there is a low nitrogen demand and extra fertilization is not needed.

Reproductive Stage

The reproductive stage is characterized by culm elongation, a decline in tiller number, booting, emergence of the flag leaf, heading and flowering. The reproductive stage usually lasts approximately 30 days in most varieties. This stage is sometimes referred to as the internode elongation or jointing stage and varies slightly by variety and weather conditions.

The following processes occur during the reproductive stage:

- Panicle Initiation (PI)** – is the time when the panicle primordia initiate the production of a panicle in the uppermost node of the culm. At this point, the panicle is not visible to the naked eye. It is sometimes referred to as the green ring stage in rice (Figure 1-5). A thin green band is visible just above the top node, and represents the very beginning of internode elongation and is evident for only a couple of days.

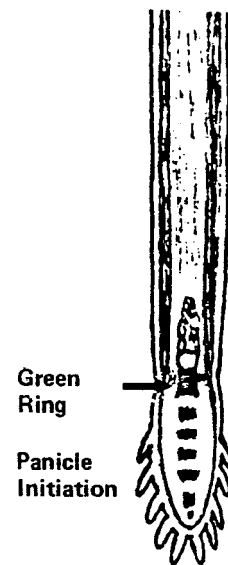


Figure 1-5.

Principle: Beginning internode elongation or panicle initiation (PI) is the time to begin scouting for sheath blight as outlined by the DD50 program.

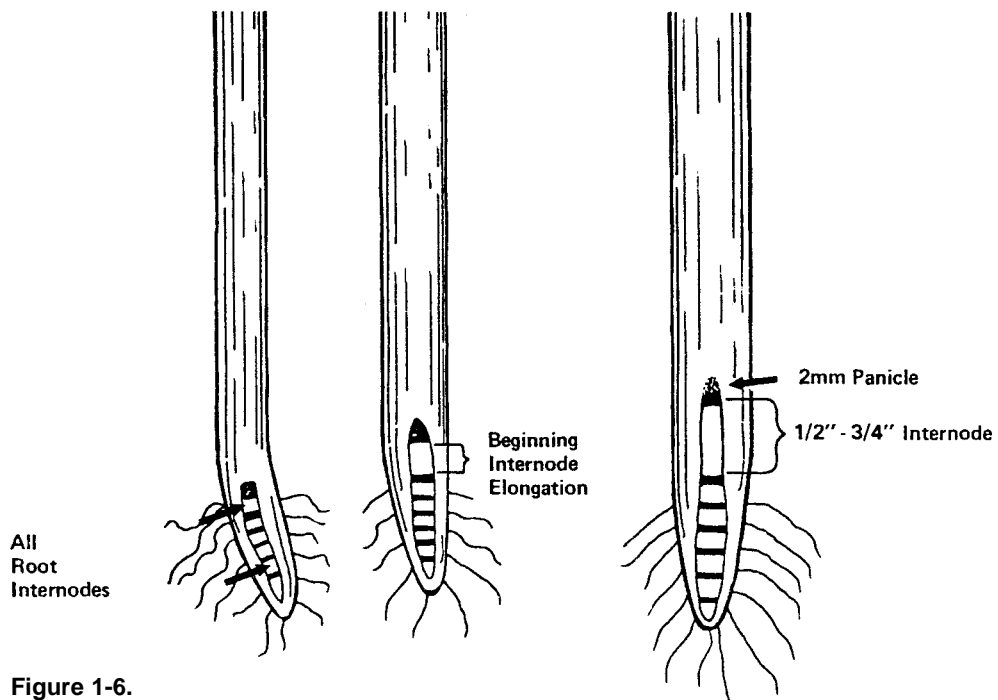


Figure 1-6.

2. **Internode Elongation** – begins about the time panicle initiation is occurring, continues until full plant height is reached and is followed by heading. The top five internodes may elongate. This stage is also referred to as the “jointing stage” (Figure 1-6). Stem internodes can be distinguished from root internodes by the green color in the stem wall.
3. **Panicle Differentiation (PD)** – is closely associated with “jointing” or the internode elongation stage. PD is roughly equivalent

to 1/2 to 3/4 inch internode elongation (Fig 1-6).

At this point, the panicle is 1 to 2 mm in length and the branching of the panicle is visible (Figure 1-7). This is a critical stage during rice plant development. At this stage, the environment can have a major effect on rice plant development. The second yield component, number of potential grains per panicle, is set by the time this development stage occurs.

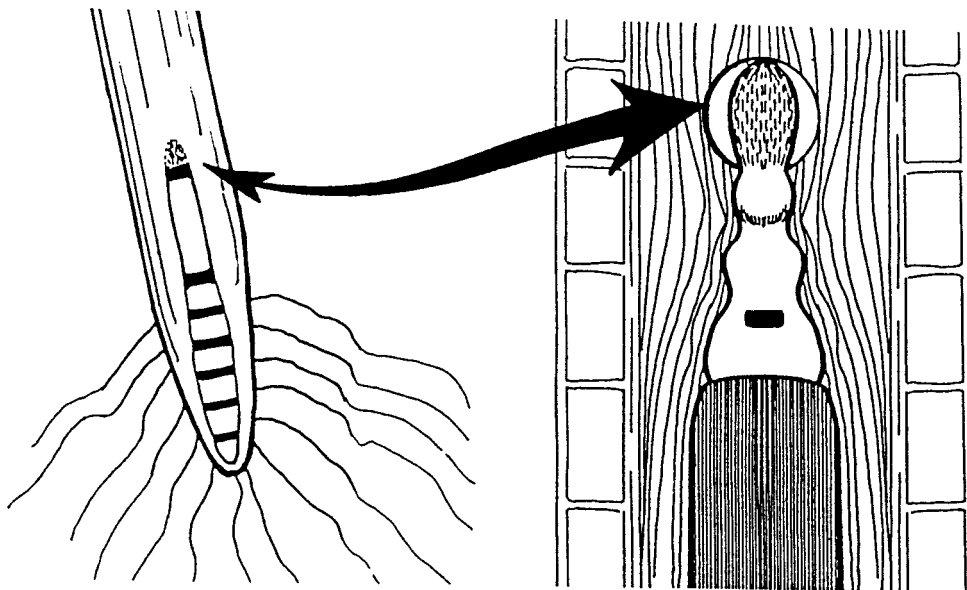


Figure 1-7. The panicle at the panicle differentiation stage of development (2 mm in length). Left – Panicle exposed by splitting culm lengthwise. Right – Location within main culm of rice plant.

4. **Booting** – this stage is loosely defined as that period characterized by a swelling of the flag leaf sheath which is caused by an increase in the size of the panicle as it grows up the leaf sheath. Full or late boot occurs when the flag leaf has completely extended. Booting is the stage in which meiosis occurs. Environmental stress during this stage may reduce rice grain yield. Late boot occurs about 6 days prior to heading. This date can be predicted by the DD50.

5. **Heading** – is the time when the panicle begins to exert from the boot. (Figure 1-8 shows common types of panicle exertion.) Heading may take over 10 to 14 days due to variations within tillers on the same plant and between plants in the field. Agronomically, “heading date” is defined as the time when 50 percent of the panicles have at least partially exerted from the boot.

Some panicles may never emerge completely from the boot. The Arkansas DD50 Management Program uses this same definition of “heading date.”

Principle: Long periods of low sunlight three weeks before and after heading may cause poor exertion of the panicles and lead to poor grain filling.

Types of panicle exertion – Panicles from some cultivars extend partially out of the boot while others extend 3 to 4 inches beyond the panicle base.

Principle: Heading date is the last visual check for DD50 accuracy and can be used to predict approximate draining and harvest dates.

6. **Anthesis** – or flowering (Figure 1-9) refers to the events between the opening and closing of the spikelet (floret) and lasts for 1 to 2 1/2 hours. Flowering generally begins upon panicle exertion or on the following day and is consequently considered synonymous with heading. Anthesis generally occurs between 9 a.m. and 3 p.m. in Arkansas. The steps involved are:

- The tips of the lemma and palea (hulls) open.
- The filaments elongate.
- The anthers exert from the lemma and palea.
- As the lemma and palea open further, the tips of the feathery stigma become visible.
- The filaments elongate past the tips of lemma and palea.
- The spikelet closes, leaving the anther outside. Anther dehiscence (pollen shed) usually occurs just prior to or at the time the lemma and palea open (step a).

Pollen grains are viable for about five minutes after emerging from the anther, whereas the stigma may be fertilized for three to seven days. Rice is a self-pollinating plant, because it is usually pollinated before the lemma and palea open to release pollen into the air. Fertilization of the ovary by the pollen grain is generally completed within five to six hours after pollination; at that point, the ovary becomes brown rice.

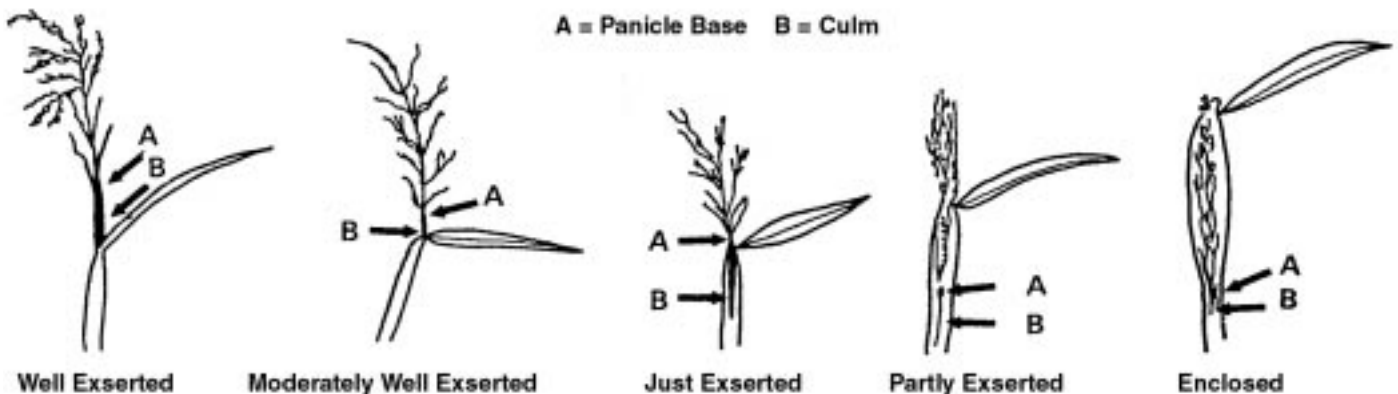
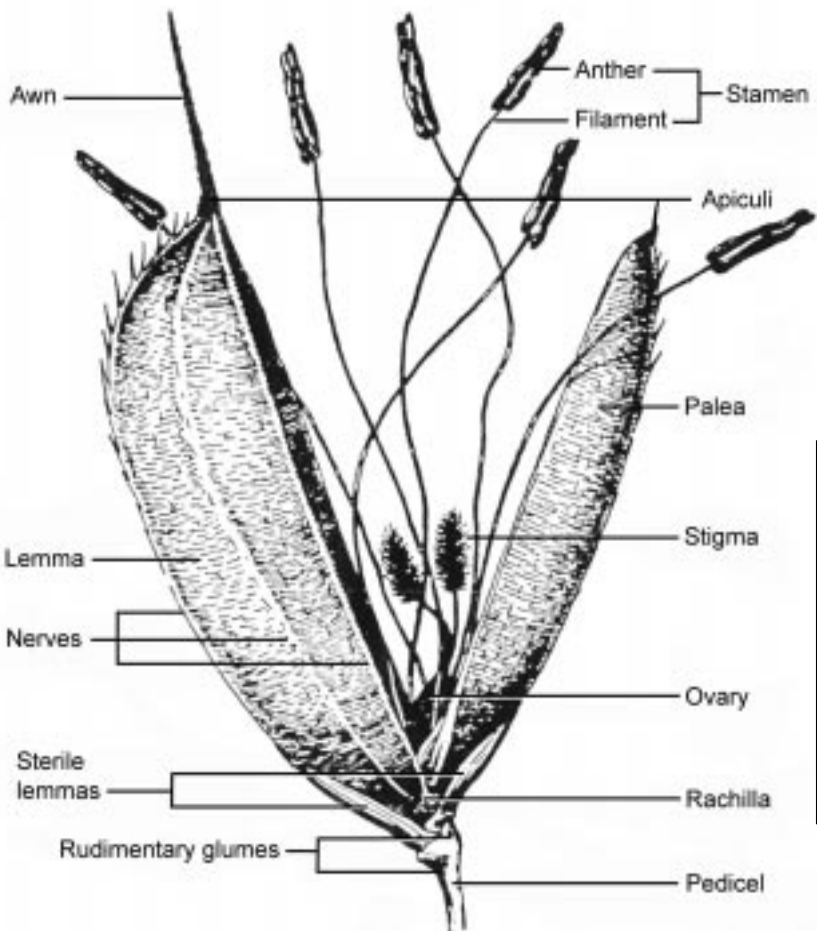


Figure 1-8.



Flowering begins at the tip of the panicle branches and moves down the branch to the panicle base (Figure 1-10). Flowering will begin on the upper branches as they emerge from the boot and continue on down the panicle to the lower branches. The time interval for flowering of an entire panicle is normally four to seven days. The number of filled grains per panicle has been established by this stage.

Principle: Extremes in temperatures, such as 50°F or less, for two consecutive nights two weeks prior to and/or at flowering can cause excessive sterility or blanks. Also, strong winds, rain showers, fertilizer or pesticide applications while blooming is occurring (9 a.m. to 3 p.m.) can increase sterility. During flowering, air temperatures > 95°F may increase blanking.

Figure 1-9. Parts of a Spikelet

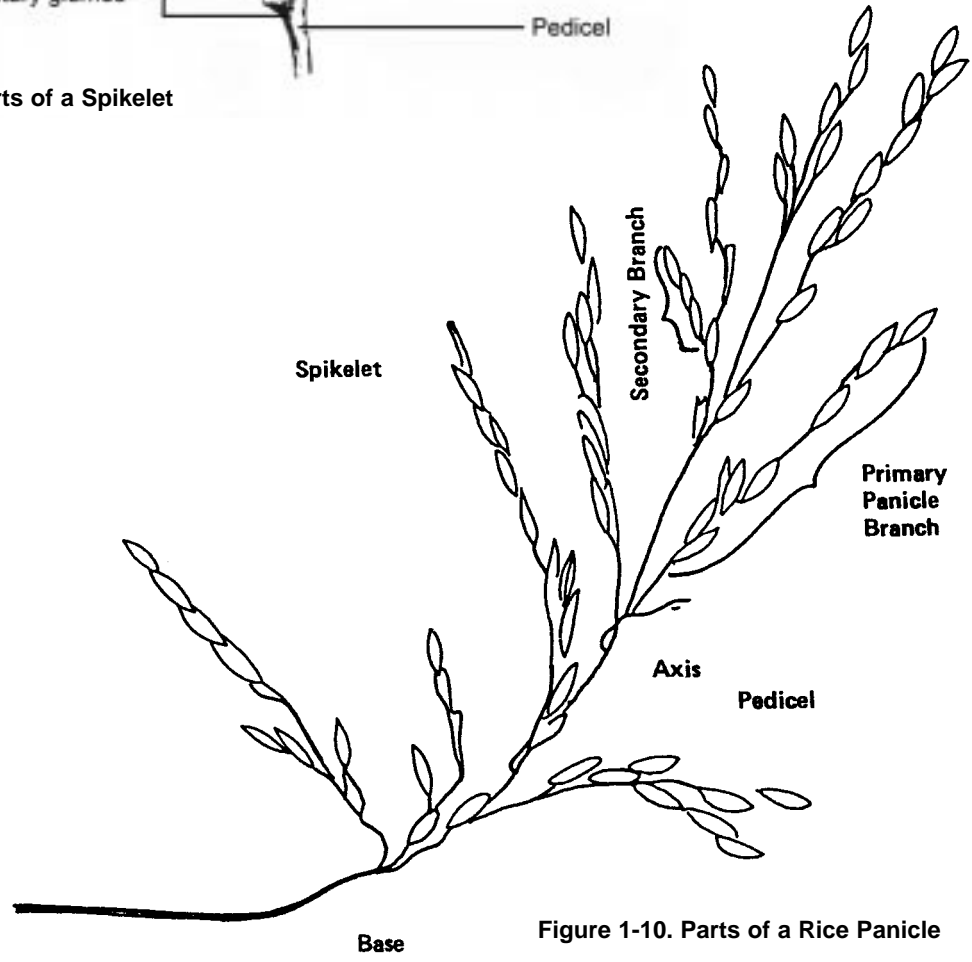


Figure 1-10. Parts of a Rice Panicle

Ripening Stage

The grain filling and ripening or maturation stage follows ovary fertilization and is characterized by grain growth. During this period, the grain increases in size and weight as the starch and sugars are translocated from the culms and leaf sheaths where they have accumulated, the grain changes color from green to gold or straw color at maturity and the leaves of the rice plant begin to senesce. Light intensity is very important during this interval since 60 percent or more of the carbohydrates used in grain filling are photosynthesized during this time interval. This period is also affected by temperature. In Arkansas, most long-grains ripen in 35 days, medium-grains in 45 days and short-grains in 50 days. The DD50 program supplies information for approximate maturity dates.

The final component, individual grain weight, is determined during the ripening stage. Although grain weight is relatively stable for a given variety, it can be influenced by the environment. High temperatures tend to reduce the grain filling period and may reduce grain weight. Low

temperatures tend to lengthen the time required for grain fill and ripening. The ripening process may cease after a significant frost occurs.

Steps in the ripening process are:

1. **Milk stage** – At this stage, the developing starch grains in the kernel are soft, and the interior of the kernel is filled with a white liquid resembling milk.
2. **Soft dough stage** – The starch in the grain is beginning to become firm but is still soft.
3. **Hard dough stage** – The whole grain is firm during this stage and almost ready for harvest. The moisture content is still above 22 percent.
4. **Maturity** – The whole grain is hard and ready for harvest. This stage is reached at approximately 20 to 22 percent moisture.

<p>Principle: Uniform maturity is the key to high milling yields so that harvest can be prompt.</p>
--