2018
Ruben Stringer Memorial
Texas Rice Education Contest
Study Guide
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General Information

1. For the Rice Education Contest, identification and written questions will be asked. You are responsible for studying all information provided.

2. Location of the contest:

   Texas A&M AgriLife Research and Extension Center (Beaumont Center)
   Auditorium
   1509 Aggie Drive Beaumont, TX 77713
   (409) 752-2741 ext. 2231
   (409) 658-2186 (cell)
   moway@aesrg.tamu.edu

   The actual contest will be held at least 1 week before the Texas Rice Festival. The contest will take about 1 – 1½ hours. The contest judges will hand out the exam, pencils, and any reference materials. Specific information on the location and time of the announcements and awards ceremony will be given at the time of the contest.

   Cheating will not be tolerated during the contest! Cheaters will be disqualified. Students who help other students will also be disqualified. No talking during the contest. Students: make sure you hide your test from your fellow competitors. Students can use simple calculators during the contest---cell phones will not be allowed during the contest.

3. Individual and team awards will be presented at the Texas Rice Festival. The top 4 teams will be presented awards. To compete for team awards, at least 4 students from a given FFA chapter are required to participate in the contest. For instance, if only 3 students from a particular FFA chapter participate in the contest, this FFA chapter is not eligible to compete for team awards. We encourage the Vo-Ag teachers to enroll as many students as possible in the contest. For FFA chapters with 4 or more participating students, the scores of the top 4 students will be summed and divided by 4 to arrive at an average score for the team. This average score will determine team placement. Individual and team awards will be determined by Texas A&M AgriLife Research staff and the Texas Rice Festival. Usually, team awards consist of plaques and ribbons. Individual awards usually consist of a belt buckle (high point individual), 4 belt badges (2nd-5th place individuals), ribbons and cash/checks for the top 10-16 individuals. Tests will be graded by Texas A&M AgriLife Research staff. Partial credit will be given for certain questions. Graded tests will not be returned to students. Results are final and will be disseminated to the Vo-Ag teachers. A key to the test will be given to the Vo-Ag teachers following the contest.

4. Competitors are required to be active members of a FFA chapter or 4-H club.

5. The contest is open to anyone in the southeastern Texas Rice Belt (east of Houston) that meets the above criteria.
6. The contest will consist of multiple choice, true or false, fill in the blank questions and word problems. There will also be a section on identification of diseases, pests, and weeds in rice. Also, management problems such as calculating amounts of fertilizer, cost and application of a pesticide product, and other problems dealing with management will be considered. Don’t forget to study the plant parts of rice!!

7. Announcement of results by the contest Co-chairs are final.
2018 Ruben Stringer Memorial Texas Rice Education Contest Review

The exam will consist of identification, fill in the blank, multiple choice, true/false, short answer and word problems. The list below details the sections from the Study Guide and types of questions from each section.

- Morphology and Development of the Rice Plant – identification (label diagram of rice plant), fill in the blank, multiple choice, true/false, and short answer from vocabulary only
- Rice Plant Morphology and Development Vocabulary – fill in the blank, multiple choice, true/false, and short answer
- Variety Information Table – identification (samples of long, medium and short grain rice) in conjunction with characteristics from Variety Information table
- Insect Pests of Rice – identification (samples in vials)
- Diseases of Rice – identification (samples of plants with disease)
- Weeds of Rice – identification (samples of plants)
- Red Rice – identification (sample of rough and hulled red rice)
- Stages of Processed Rice – identification (samples of rice from various milling stages)
- Rice Grain Quality – identification of grain quality issues (samples of affected rice grains), fill in the blank, multiple choice, true/false, and short answer
- Solved Word Problems – word problems
- Generalized Texas Rice Production Practices/Useful Facts – fill in the blank, multiple choice, true/false, short answer, and word problems
- Useful Facts – fill in the blank, multiple choice, true/false, short answer, and word problems

Tips:
About 1/3 of the test will be identification (rice plant diagram, insects, weeds, diseases, milling stage, red rice, variety)
Be sure to indicate life stage (larva, pupa, nymph, adult) of insects when appropriate
Some figures from the “Useful Facts” section will be needed to solve word problems
Morphology and Development of the Rice Plant

Morphology
Cultivated rice is generally considered a semiaquatic annual grass, although in the tropics it can survive as a perennial, producing new tillers from nodes after harvest (ratooning). At maturity the rice plant has a main stem and a number of tillers. Each productive tiller bears a terminal flowering head or panicle. Plant height varies by variety and environmental conditions, ranging from approximately 0.4 m to over 5 m in some floating rices. The morphology of rice is divided into the vegetative phases (including germination, seedling, and tillering stages) and the reproductive phases (including panicle initiation and heading stages).

Seeds
The rice grain, commonly called a seed, consists of the true fruit or brown rice (caryopsis) and the hull, which encloses the brown rice. Brown rice consists mainly of the embryo and endosperm. The surface contains several thin layers of differentiated tissues that enclose the embryo and endosperm.

The palea, lemmas, and rachilla constitute the hull of indica rices. In japonica rices, however, the hull usually includes rudimentary glumes and perhaps a portion of the pedicel. A single grain weighs about 10-45 mg at 0% moisture content. Grain length, width, and thickness vary widely among varieties. Hull weight averages about 20% of total grain weight.

Seedlings
Germination and seedling development start when seed dormancy has been broken and the seed absorbs adequate water and is exposed to a temperature ranging from about 10 to 40 °C. The physiological definition of germination is usually the time when the radicle or coleoptile (embryonic shoot) emerge from the ruptured seed coat.

Under aerated conditions the seminal root is the first to emerge through the coleorhiza from the embryo, and this is followed by the coleoptile. Under anaerobic conditions, however, the coleoptile is the first to emerge, with the roots developing when the coleoptile has reached the aerated regions of the environment. If the seed develops in the dark as when seeds are sown beneath the soil surface, a short stem (mesocotyl) develops, which lifts the crown of the plant to just below the soil surface. After the coleoptile emerges it splits and the primary leaf develops.

Tillering plants
Each stem of rice is made up of a series of nodes and internodes. The internodes vary in length depending on variety and environmental conditions, but generally increase from the lower to upper part of the stem. Each upper node bears a leaf and a bud, which can grow into a tiller. The number of nodes varies from 13 to 16 with only the upper 4 or 5 separated by long internodes. Under rapid increases in water level some deepwater rice varieties can also increase the lower internode lengths by over 30 cm each. The leaf blade is attached at
the node by the leaf sheath, which encircles the stem. Where the leaf blade and the leaf sheath meet is a pair of clawlike appendages, called the auricle, which encircle the stem. Coarse hairs cover the surface of the auricle. Immediately above the auricle is a thin, upright membrane called the ligule. The tillering stage starts as soon as the seedling is self supporting and generally finishes at panicle initiation. Tillering usually begins with the emergence of the first tiller when seedlings have five leaves. This first tiller develops between the main stem and the second leaf from the base of the plant. Subsequently when the 6th leaf emerges the second tiller develops between the main stem and the 3d leaf from the base.

Tillers growing from the main stem are called primary tillers. These may generate secondary tillers, which may in turn generate tertiary tillers. These are produced in a synchronous manner. Although the tillers remain attached to the plant, at later stages they are independent because they produce their own roots. Varieties and races of rice differ in tillering ability. Numerous environmental factors also affect tillering including spacing, light, nutrient supply, and cultural practices.

Roots that develop from nodes above the soil surface usually are referred to as nodal roots. Nodal roots are often found in rice cultivars growing at water depths above 80 cm. Most rice varieties reach a maximum depth of 1 m or deeper in soft upland soils. In flooded soils, however, rice roots seldom exceed a depth of 40 cm. That is largely a consequence of limited O₂ diffusion through the gas spaces of roots (aerenchyma) to supply the growing root tips.

Panicle and spikelets

The major structures of the panicle are the base, axis, primary and secondary branches, pedicel, rudimentary glumes, and the spikelets. The panicle axis extends from the panicle base to the apex; it has 8-10 nodes at 2- to 4-cm intervals from which primary branches develop. Secondary branches develop from the primary branches. Pedicels develop from the nodes of the primary and secondary branches; the spikelets are positioned above them. Since rice has only one fully developed floret (flower) per spikelet, these terms are often used interchangeably. The flower is enclosed in the lemma and palea, which may be either awned or awnless. The flower consists of the pistil and stamens, and the components of the pistil are the stigmas, styles, and ovary.

Development

The growth duration of the rice plant is 3-6 months, depending on the variety and the environment under which it is grown. During this time, rice completes two distinct growth phases: vegetative and reproductive. The vegetative phase is subdivided into germination, early seedling growth, and tillering; the reproductive phase is subdivided into the time before and after heading, i.e., panicle exsertion. The time after heading is better known as the ripening period.

Potential grain yield is primarily determined before heading. Ultimate yield, which is based on the amount of starch that fills the spikelets, is largely determined after heading. Hence, agronomically it is convenient to regard the life history of rice in terms of three growth phases: vegetative, reproductive, and ripening. A 120-day variety, when planted in a tropical environment, spends about 60 d in the vegetative phase, 30 d in the reproductive phase, and 30 d in the ripening phase.

Vegetative phase

The vegetative phase is characterized by active tillering, gradual increase in plant height,
and leaf emergence at regular intervals. Tillers that do not bear panicles are called ineffective tillers. The number of ineffective tillers is a closely examined trait in plant breeding since it is undesirable in irrigated varieties, but sometimes an advantage in rainfed lowland varieties where productive tillers or panicles may be lost due to unfavorable conditions.

Reproductive phase

The reproductive growth phase is characterized by culm elongation (which increases plant height), decline in tiller number, emergence of the flag leaf (the last leaf), booting, heading, and flowering of the spikelets. Panicle initiation is the stage about 25 d before heading when the panicle has grown to about 1 mm long and can be recognized visually or under magnification following stem dissection.

Spikelet anthesis (or flowering) begins with panicle exsertion (heading), or on the following day. Consequently, heading is considered a synonym for anthesis in rice. It takes 10-14 d for a rice crop to complete heading because there is variation in panicle exsertion among tillers of the same plant and among plants in the same field. Agronomically, heading is usually defined as the time when 50% of the panicles have exserted.

Anthesis normally occurs between 1000 and 1300 h in tropical environments and fertilization is completed within 6 h. Only very few spikelets have anthesis in the afternoon, usually when the temperature is low. Within the same panicle it takes 7-10 d for all the spikelets to complete anthesis; the spikelets themselves complete anthesis within 5 d. Ripening follows fertilization, and may be subdivided into milky, dough, yellow-ripe, and maturity stages. These terms are primarily based on the texture and color of the growing grains. The length of ripening varies among varieties from about 15 to 40 d.
# Vocabulary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf blade</td>
<td>The thin, elongated, flat portion of the leaf.</td>
</tr>
<tr>
<td>Ligule</td>
<td>A thin, upright, membranous appendage at the top of the leaf sheath. It is attached to the base on the inside of the leaf collar of the rice plant.</td>
</tr>
<tr>
<td>Auricle</td>
<td>An ear-shaped appendage, usually occurring at the junction of the leaf sheath and the blade that may not be present in older leaves.</td>
</tr>
<tr>
<td>Leaf sheath</td>
<td>The lower part of the leaf enclosing the stem, originating from a node and wrapping around the culm above the node.</td>
</tr>
<tr>
<td>Node</td>
<td>The solid portion of the culm, panicle axis, and panicle branches. Leaves, tillers, and adventitious roots arise from nodes on the culm.</td>
</tr>
<tr>
<td>Internode</td>
<td>The portion of a stem between two nodes.</td>
</tr>
<tr>
<td>Tiller</td>
<td>A vegetative branch of the rice plant composed of roots, culm, and leaves which may or may not develop a panicle. Shoot arising from the main culm (stem).</td>
</tr>
<tr>
<td>Nodal roots</td>
<td>Roots developing from the upper nodes of the stem when deepwater rice varieties are flooded. These roots can also develop if there are hormonal imbalances, or the soil is deficient of oxygen. Roots are also known as adventitious roots.</td>
</tr>
<tr>
<td>Mat roots</td>
<td>The mat of tangled roots developed below the soil surface or in floodwater.</td>
</tr>
<tr>
<td>Ordinary roots</td>
<td>Roots developed at the base of the plant. They absorb nutrients and anchor the plant.</td>
</tr>
<tr>
<td>Variety</td>
<td>Grain type</td>
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<tr>
<td>----------</td>
<td>------------</td>
</tr>
<tr>
<td>Antonio</td>
<td>long</td>
</tr>
<tr>
<td>CL151</td>
<td>long</td>
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<tr>
<td>CLXL745</td>
<td>long</td>
</tr>
<tr>
<td>Cheniere</td>
<td>long</td>
</tr>
<tr>
<td>Jupiter</td>
<td>medium</td>
</tr>
<tr>
<td>Pirogue</td>
<td>short</td>
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<tr>
<td>Presidio</td>
<td>long</td>
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<tr>
<td>Sierra</td>
<td>long</td>
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<tr>
<td>Tesenai</td>
<td>medium</td>
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<tr>
<td>XL723</td>
<td>long</td>
</tr>
</tbody>
</table>
Insect Pests of Rice

Rice Water Weevil – *Lissorhoptrus oryzophilus*

The rice water weevil is the most serious pest of rice in the US. It is native to Texas, but was accidentally introduced into California, as well as China, North and South Korea, Taiwan, Japan and Europe. Thus, it is now a global pest of rice. Adults feed on rice leaves and lay their eggs underwater in rice stems. Eggs hatch and larvae move to the roots upon which they feed. As the larvae grow, they shed their skins periodically and increase in size. The larvae complete four instars (stages between molts) before pupating in a mud cocoon attached to rice roots. Research shows that an average of 1 larva per plant reduces yield about 80 lb/acre. This is a linear relationship; thus, 3 larvae per plant reduce yield about 240 lb/acre. Thus, 3 larvae per plant is the economic injury level (EIL) for the rice water weevil. The EIL is the population density that causes damage equal to the cost of control.

This insect is controlled by 3 seed treatments (Dermacor X-100, NipSit INSIDE and CruiserMaxx Rice) and various foliar-applied insecticides. Currently, the United States Environmental Protection Agency (USEPA) is concerned about the use of pesticides because of possible toxicity to honey bees. USEPA and the Texas Department of Agriculture (TDA) regulate and label pesticides for use in our country and state.

Rice Stink Bug – *Oebalus pugnax*

The rice stink bug is another serious pest of rice. It is native to Texas and the other southeastern rice-producing states---Arkansas, Louisiana, Mississippi and Missouri. It does not occur in California---the other rice-producing state. This insect has piercing-sucking mouthparts which the insect inserts in rice grains and extracts the contents. Generally, no yield losses are associated with this feeding but rice quality can be affected. Damage results in ‘pecky’ rice which is discolored rice caused by rice stink bug feeding. In addition, upon milling, ‘pecky’ rice tends to break so head rice (% whole grain rice after milling) is reduced. Farmers receive less money for lower quality rice. The rice stink bug lays its eggs in masses (two rows per mass) on rice foliage.
After egg hatch, nymphs (immature rice stink bugs without wings) complete five instars before becoming adults. Each instar is a little bigger than the previous instar. The later instars (4th and 5th) and adults cause the most severe damage. The rice stink bug is controlled by various insecticides including Tenchu 20SG which is systemic (absorbed by the plant), pyrethroids and carbaryl. The most susceptible stages of rice to rice stink bug are heading (flowering) and milk. Thus, the EILs for rice stink bug are lower for these stages than later stages—soft dough and hard dough.

Fields with abundant weeds (particularly barnyardgrass) generally harbor high rice stink bug populations. Also, populations of rice stink bug are generally higher near the margins of fields.

**Fall Armyworm – Spodoptera frugiperda**

The fall armyworm is a sporadic pest of rice. The larvae have chewing mouthparts and defoliate (consume foliage) of rice. The adult is a moth which lays its eggs in masses on rice leaves. Eggs hatch and the larvae complete four to six instars (stages of growth) before pupating in a cocoon in the soil. Generally, fall armyworm are more severe on rice before the permanent flood. Usually, fall armyworm can be controlled by applying a flush (temporary flood) or permanent flood which drowns the larvae. A wasp parasite (*Cotesia* sp.) and egrets also can help control populations. Dermacor X-100 seed treatment controls fall armyworms. Some farmers apply pyrethroid insecticides (not systemic) when defoliation reaches 20% which is the EIL for this insect.

**Chinch Bug – Blissus leucopterus leucopterus**

The chinch bug is another sporadic pest of rice. This insect has piercing-sucking mouthparts like the rice stink bug. Adults are winged and are black and white. Adult female chinch bugs lay their orange eggs singly in soil cracks or on rice stems. Eggs hatch and nymphs begin feeding on rice stems usually near the soil surface. The insect completes five nymphal instars before becoming an adult. Seedling rice is very susceptible to attack. At this stage, an average of only one adult per two seedlings can kill rice. Frequently, an effective method of
control is to flush rice or apply a permanent flood which drowns insects or forces them to move up the plants where feeding results in less damage compared to feeding on stems near the soil surface. However, rice growing on levees can still be damaged. NipsIt INSIDE and CruiserMaxx Rice seed treatments control this pest. Foliar applied insecticides, such as pyrethroids, also provide control.

**Stalk Borers** – Mexican rice borer (*Eoreuma loftini*), rice stalk borer (*Chilo plejadellus*) and sugarcane borer (*Diatraea saccharalis*)

The most abundant and damaging stem borer is the Mexican rice borer which was introduced from Mexico into the Texas Rice Belt in 1988. The Mexican rice borer lays eggs on dead or dying rice foliage. Eggs hatch and larvae move to the inside of leaf sheaths where they are partially protected from natural enemies and pesticide residues. These small larvae feed in the sheaths and eventually bore into the culm. Inside the culm, they feed between nodes to cause “deadhearts” (dead leaves) and “whiteheads” (panicles with unfilled grains). After completing five larval instars, the insect pupates within the culm and emerges as an adult moth. Stem borers are controlled with the seed treatment insecticide Dermacor X-100. They can also be controlled with pyrethroids applied late in the season shortly before and after panicle emergence. Late planted rice is more susceptible to stem borers than earlier planted rice. Hybrid rice varieties tend to be more resistant to stem borers than other varieties.
Grasshoppers – Orthoptera

Grasshoppers are seldom pests of rice. Usually populations are highest near the margins of fields. Grasshoppers feed on foliage and sometimes panicles. The most common grasshoppers in rice are long-horned grasshoppers which can also be beneficial since they feed on pest insects as well as rice. Long-horned grasshoppers are easily identified by their very long antennae.

Blister Beetles – Epicauta texana

Blister beetles are sporadic pests of rice. The adults usually move in mass from weedy field margins. They typically defoliate rice and broadleaf weeds late in the season. Occasionally, blister beetles will also feed on the reproductive organs of rice flowers. Insecticides registered for rice stink bug also control blister beetles. Usually ‘spot’ treatments of insecticides effectively control blister beetle populations.

Leafhoppers – Cicadellidae (Graminella nigrifrons)

Leafhoppers are sporadic pests of rice. The most common leafhopper in Texas rice fields is the blackfaced leafhopper. Leafhoppers have piercing-sucking mouthparts and remove fluids from the plant causing yield and quality losses. Sooty mold fungus is black and grows on leafhopper exudates called honeydew. A good indication of high populations of leafhoppers is abundant sooty mold fungus on rice foliage. In addition, foliage takes on a bronze appearance.
Rice Delphacid – *Tagosodes orizicolus*

A new pest of rice is the rice delphacid which is related to a leafhopper. These insects are native to Latin America and have piercing-sucking mouthparts like leafhoppers. They were found for the first time attacking maturing ratoon rice in 2015 in several counties in the western part of the Texas Rice Belt. High densities can kill rice plants. Honeydew and black sooty mold fungus are associated with high numbers of this exotic insect which also has the ability to transmit a virus to the rice plant which causes “hoja blanca” disease. Hoja blanca means white leaf in Spanish; thus, symptoms of the disease are bleaching of foliage and stunting of the affected rice plant. In addition, in severe cases, panicles do not develop resulting in 100% yield loss.
Diseases of Rice

Sheath Blight (fungus – *Rhizoctonia solani*)

Sheath blight is the most important disease of rice in Texas. Initial symptoms usually develop as lesions on sheaths of lower leaves near the water line when plants are in the late tillering or early internode elongation stage of growth (approximately 10 -15 days after flooding). These lesions usually develop just below the leaf collar as oval-to-elliptical, green-gray, water-soaked spots about 1/4 inch wide and 1/2 to 1 1/4 inch long.

With age, the lesions expand and the center of the lesions may become bleached with an irregular tan-to brown border. When humidity exceeds 95 percent and temperatures are in the range of 85-90 degrees F, infection spreads rapidly by means of runner hyphae to upper plant parts, including leaf blades, causing extensive, tan, irregularly shaped lesions with brown borders. Disease development progresses very rapidly in the early heading and grain filling growth stages during periods of frequent rainfall and overcast skies. Plants heavily infected at these stages produce poorly filled grain, particularly in the lower portion of the panicle. Additional losses result from increased lodging or reduced ratoon production due to infection of the culm and reduced carbohydrate reserves. As plants senesce from maturity, lesions will dry and become grayish-white to tan with brownish borders. Sclerotia, initially white but turning dark brown at maturity, are produced superficially on or near the lesions. Sclerotia are loosely attached and easily dislodge from the plant. Sclerotia are the primary means for fungus survival between crop years. They survive long periods in the soil and will float to the surface of flooded rice fields in the subsequent rice crop, infect rice plants at the waterline and continue the disease cycle. Sclerotia can survive from one to several years in the soil. They can also attack several weed hosts and cause infection.

New varieties and changing cultural practices often combine many of the factors that favor disease development. In recent years, the wide acceptance of susceptible varieties, because of their high yielding potential, has contributed greatly to the rapid increase in sheath blight. In addition, high levels of nitrogen fertilizer are applied in order to achieve high yield potential. Excessive vegetative growth predisposes susceptible plants to attack by the sheath blight organism. Rotation with susceptible alternative crops, such as soybeans can also increase the severity of sheath blight in succeeding rice crops.
**Blast (fungus – *Pyricularia grisea*)**

This disease can cause serious losses to susceptible varieties during periods of weather conditions favorable to growth of blast. Depending on the part of the plant affected, the disease is often called leaf blast, rotten neck, or panicle blast. The fungus produces spots or lesions on leaves, nodes, panicles, and collar of the flag leaves. Leaf lesions range from somewhat diamond-shaped to elongated with tapered, pointed ends. The center of the spot is usually gray and the margin brown or reddish-brown. Both the shape and color of the spots may vary and resemble those of the brown leaf spot disease. Blast differs from brown leaf spot in that it causes longer lesions and develops more rapidly. The blast fungus frequently attacks the node at the base of the panicle and the branches of the panicle. If the panicle is attacked early in its development, the grain on the lower portion of the panicle may abort giving the head a bleached whitish color, giving the term "blasted" head or rice "blast". If the node at the base of the panicle is infected, the panicle breaks causing the "rotten neck" condition. If neck rot occurs early, the entire panicle may die prematurely, leaving it white and completely blank. Later infections may cause incomplete grain filling and poor milling quality. Other parts of the panicle including panicle branches and glumes may also be infected. Panicle lesions are usually brown, but may also be black. In addition, the fungus may also attack the nodes or joints of the stem. When a node is infected, the sheath tissue rots and the part of the stem above the point of infection often is killed. In some cases, the node is weakened to the extent that the stem will break causing extensive lodging.

Blast generally occurs scattered throughout a field rather than in a localized area of the field. Late planting, frequent showers, overcast skies, and warm weather favor development of blast. Spores of the fungus are produced in great abundance on blast lesions and can become airborne, disseminating the fungus a considerable distance. High nitrogen fertilization should be avoided in areas that have a history of blast. Control measures include early planting, avoiding excessive or high levels of nitrogen, proper flood management, resistant varieties, and fungicides. Varietal resistance is the most effective method of controlling rice blast. Some foliar fungicides can reduce the incidence of blast, but severe losses can occur on susceptible varieties even when fungicides are applied.

Photo by IRRI
Brown Leaf Spot (fungus – *Bipolaris oryzae*)

This disease, previously called *Helminthosporium* leaf spot, is common in Texas. Most conspicuous symptoms of the disease occur on leaves and glumes of maturing plants. Symptoms also appear on young seedlings and the panicle branches in older plants. Brown leaf spot is a seed-borne disease. Leaf spots may be evident shortly after seedling emergence and continue to develop until maturity. Leaf spots vary in size, are typically 1/8 inch in diameter, and are circular to oval in shape. The smaller spots are dark brown to reddish brown, and the larger spots have a dark-brown margin and reddish brown to gray centers. Damage from brown spot is particularly noticeable when the crop is produced in nutritionally deficient or otherwise unfavorable soil conditions. Significant development of brown spot is often indicative of a soil fertility problem. Brown spot may be reduced by balanced fertilization, crop rotation, and the use of high quality planting seed. Foliar fungicides are not economical for controlling brown leaf spot on most commercial long grain varieties. Rice seed with infected glumes can result in diseased seedlings. Seed treatment fungicides reduce the incidence and severity of seedling blight caused by this fungus.

Narrow Brown Leaf Spot (fungus – *Cercospora janseana*)

The disease varies in severity from year to year and usually becomes most severe as rice approaches maturity, causing premature ripening and yield reduction. Leaf spots are long (1/10 to 1/2 inch), narrow (1/32 inch), and cinnamon-brown. Premature leaf death will occur in severe cases. Late in the growing season, the fungus often attacks the sheath of the flag leaf causing the "brown blotch" or "net blotch" phase of the disease in which a large (1 1/2 to 3 inch long) cinnamon brown lesion is formed and typically encircles the uppermost internode about an inch below the base of the panicle. Early maturing varieties tend to escape the major impact of the disease. There are differences in susceptibility among some rice varieties, however, due to buildup of certain races of the fungus, resistance does not remain reliable. Some foliar fungicides effectively suppress this disease and may be economical if other diseases are also controlled along with the narrow brown leaf spot.
Kernel Smut (fungus – *Tilletia barclayana*)

Kernel smut is a serious disease caused by the fungus *Tilletia barclayana* (Neovossia horrida). The fungus infects and replaces the endosperm of the rice grain completely or partially with a mass of black smut spores. Usually only a few grains per panicle are infected. Although yield losses are insignificant, monetary losses can be very high if the rice cannot be sold or the price is reduced at the mill. Infested lots of grain often have a dull, grayish cast caused by the smut spores. Rice lots exceeding 3% kernel smut infection presently will not qualify for government loan.

The disease is not systemic. The smut spores fall to the soil surface, where they remain dormant until the following rice crop, or they can be introduced into a field on the surface of infested rice seed. The smut spores float to the surface of the irrigation water where they germinate and produce air-borne spores that infect individual rice florets. Disease development is favored by frequent light showers and high relative humidity.

Kernel smut is difficult to control. Field tests indicate that a late boot application of Tilt® or Propimax® at 4 to 6 fluid ounces per acre reduces the number of smutted kernels. Some varieties are less susceptible to the disease than Cocodrie or Cypress. Heavy nitrogen fertilization favors the disease. A 3-year crop rotation should help reduce the number of smut spores present. Do not plant seed contaminated with smut spores.
Weeds of Rice

**Barnyardgrass** – *Echinochloa crus-galli*

A warm-season vigorous grass reaching up to 5 feet, barnyardgrass has panicles that may vary from reddish to dark purple. The seed heads contain crowded large seeds in spikelets, each with a short, stiff awn. Leaf blades are flat, 3/8 to 5/8 inch wide, smooth, and without a ligule, a papery-like membrane at the collar of the plant where the leaf blade contacts the stem. The stem is flat not round.

**Broadleaf signalgrass** – *Brachiaria platyphylla*

A spreading summer annual, broadleaf signalgrass has short, wide leaf blades, ranging from 1.5 to 6 inches long and 1/4 to 2/3 inch wide. Leaf blades are typically hairless, except for hairs that occur in the margins and the lower portion of young plants. It doesn't have a ligule, a papery-like membrane at the junction of the sheath and leaf blade.

**Sedge** – *Cyperus* spp.

There are many species of sedges that are weeds in rice fields. Some are annuals and some are perennials. The perennial species produce underground rhizomes or bulbs. They are not grasses or broadleaf weeds. But, they are distinctive because their stems are triangular in cross-section.

**Fringerush** – *Fimbristylis* spp.

Fringerush, also called fan sedge, is an annual often found in the coastal plains. Leaves are flattened, very narrow and up to 12-18 inches long. The seed head is onion-like in appearance with fruiting bodies rounded and scaley.
Sprangletop – *Leptochloa* spp.

Sprangletop (*Leptochloa uninervia*), bearded sprangletop (*Leptochloa fasciculais*) and red sprangletop (*Leptochloa filifomis*). All three are tall with thin, flat leaf blades, running 1/4 to 1/3 inch wide and up to 12 inches long. Sprangletop has a ligule, a papery-like membrane at the collar of the plant where the leaf blade contacts the stem. All three have a large, open panicle when mature.

Dayflower – *Commelina communis*

[Image]

A crawling, spreading summer annual, dayflower grow up to 2 feet. The plant may grow either upright or creeping with numerous branches sprouting at the nodes and stems. Leaves have conspicuous sheaths at the base, and flowers feature two upright blue petals and one smaller white petal. The egg-shaped leaves are 0.3-0.6 inches long and 0.3-1.5 inches wide.

Ducksalad – *Heteranthera limosa*

[Image]

An aquatic annual or perennial, ducksalad grows in open water either near water inlets or in openings in sparse stands. The mature plant grows up to 6 inches tall. Leaf blades may either narrow to a point or be duckbilled at the tip.

Gooseweed – *Sphenoclea zeylandica*

[Image]

Sometimes known as chicken spike, gooseweed may grow up to 4' feet tall. Leaves grow opposite each other and are shaped and smooth. Stems are hollow and branch above the base. The elliptical leaves vary in size, ranging to about 2" wide and 5" long. The flowers are borne on a distinctive cylindrical terminal spike.

Eclipta – *Eclipta prostrata*

[Image]

A spindly growing annual weed, Eclipta has simple opposite leaves. Leaves measure 3-5 inches long and are elliptical, lacking stalks. Lower surfaces of leaves are hairy. Stems feel sand papery.
Ammannia – *Ammannia* spp.

Several different species fall under the genera *Ammannia* and are commonly called purple ammannia, redstem and toothcup. These annual weeds grow upright up to 3-4 feet tall. The stems are square and slightly winged with opposite, ear-like, clasping leaves up to 4 inches long. The flowers are reddish to purple and small, running 0.05 to 0.1 inches long.

Northern jointvetch – *Aeschynomene* spp.

Two different species may infest rice fields: Indian jointvetch (*Aeschynomene indica*) and northern jointvetch (*Aeschynomene virginica*). Both are upright and usually bushy, growing up to 3-4 feet tall. Indian jointvetch differs from northern jointvetch in that its fruit stalk and leaflets are shorter and its flower smaller. Northern jointvetch plants have large stipules or bracts at the base of the leaf stalk or petiole. Both have pea-like flowers and can be distinguished from hemp sesbania because of a smaller size and more delicate appearance. The alternating leaves have as many as 56 oblong leaflets with smooth edges. Leaflets fold when touched.

Hemp sesbania – *Sesbania exaltata*

Commonly called coffeebean or coffeeweed, hemp sesbania is a tall, blue-green, spindly weed growing up to 12-14 feet. The plants have a yellow, pea-like flower. Seed pods are 4-8 inches long, curved and often tipped with a 0.4-inch-long beak. The leaves are opposite and may feature as many as 70 leaflets with a smooth surface and somewhat hairy surface below.

Annual arrowhead – *Sagittaria montevidensis*

More of a problem in water-seeded rice, annual arrowhead is also known as giant arrowhead. The plants, growing up to 20 inches tall, feature arrowhead-shaped leaves and flower petals with green spots. The plants only stems are erect, leafless and have only flowers. The leaves arise from the stem base with a stout, spongy stalk and may be up to 8 inches long.
**Alligatorweed** – *Alternanthera philoxeroides*

Alligatorweed is an aquatic perennial that forms dense floating mats. It has hollow stems, opposite leaves with distinctive midribs and a single white flower head. The leaves are elliptically shaped and 0.2 to 0.8 inches wide.

**Texasweed** – *Caperonia palustrus*

Although also referred to as Mexicanweed (*Caperonia castanifolia*), Texasweed is a different species. The annual upright plant grows to about 2-3 feet tall with coarse male and female flowers with unique three-capsuled fruit. Leaves are alternating and broad, with serrated edges.

**Paspalum/Vasey grass** – *Paspalum* spp.

Perennial grass that forms a clump; thus, sometimes called a clump grass. Seeds arranged in 4 rows along seedhead.

**Water primrose** – *Ludwigia* spp.

Perennial broadleaf weed that can be erect near shoreline, but can produce runners on wet soil or on water surface. Roots are produced at nodes along runners. Single flowers are yellow with 4-5 petals. Waterfowl consume seeds. Plant provides food and shelter for many aquatic invertebrates.
**Morning glory –*Convolvulus* spp.**

Perennial broadleaf weed with ability to produce vines. Produces underground rhizomes which cannot be detected above ground. At each node, a new plant can be generated. Can also reproduce from seeds which can lay dormant in soil for many years.

**Red rice –*Oryza sativa***

Genetically the same species as rice, but is a serious weed pest of rice. Sometimes called wild rice. Used to be more problematic before the advent of CLEARFIELD technology, more effective herbicides and drill seeding. The bran layer of the seed is reddish; thus, the name. Weedy rice is red rice that is resistant to imazethapyr as a result of interbreeding with Clearfield rice.

**Johnson grass –*Sorghum halepense***

Perennial grass native to the Mediterranean. The plant has been introduced all over the world; one of the 10 worst weeds in the world. Can be toxic to livestock when the plant is under stress---like drought. Stress can trigger the plant to produce excessive amounts of hydrogen cyanide; can also cause bloat due to accumulation of excessive amounts of nitrates.
Red Rice

Red rice is a weed that infests much of the southern rice growing area in the United States. It is a wild rice type that competes with cultivated rice for nutrients, water, and space. Currently, any herbicide that would kill red rice would harm the cultivated rice. While California appears virtually red rice free, all southern rice producing States—Arkansas, Louisiana, Mississippi, Missouri, and Texas—have infestations that have endured since rice was first introduced.

Although red rice is an annual plant, it persists in rice fields because of the long dormancy of its seeds. Once in the soil, red rice seeds may readily germinate or stay latent for years before germinating. Red rice exhibits an uneven development period and produces seeds that shatter upon reaching maturity. Because selective weed control between red rice and cultivated rice is difficult, herbicides have not been able to successfully control red rice.

Farmers currently control red rice by depleting the seed bank through an integrated weed management program that combines preplant-incorporated herbicide applications, continuous or pinpoint flooding, and crop rotations. In Arkansas, farmers typically grow soybeans for 2 years and plant rice the third year. During the soybean cropping, herbicides which control grasses can be used, which kill any red rice seed that grows. This program has severe drawbacks because it seldom completely eradicates red rice. In fact, if just 5 percent of the red rice survive, a seed bank can be restored. In addition, in the last few years returns to soybeans have been, on average, lower than for rice production and thus it is not an economically beneficial rotation crop.

The costs associated with controlling red rice depend on the weed management practices employed. Current systems are expensive and time consuming because several herbicides are required to manage various grasses and none can selectively kill red rice without injuring commercial rice. Controlling red rice also involves flooding and crop rotations. In addition, red rice plants can grow tall and may lodge when mature. This can cause the cultivated rice to lodge as well as increase harvesting and drying costs. Without better weed control, red rice will continue to reduce farm yields and lower grain value. However, during the last few years herbicide resistant rice varieties have been developed through mutation breeding. The varieties possess a gene which conveys tolerance to specific herbicides. Thus, when the herbicide is applied, the cultivar suffers no damage but the red rice plant is killed.

Red rice also raises milling costs. Red rice produces seeds with either black or straw-colored hulls and red bran. When harvested, they mingle with commercial white rice. Removing the red seeds from the commercial rice is necessary but raises costs to the miller, who in turn discount the price to the farmer. Red rice removal requires additional milling and separation through a sorting machine. The additional milling decreases the milling yield because of greater breakage and damage to the rice kernel. The higher content of broken grains reduces the value of the milled rice.
Stages of Processed Rice

**Rough rice** - threshed rice as it comes out of the field; still has the hull

**Head rice** - whole grain milled rice

**Brown rice** - hulled rough rice with bran layer

**Brokens** - broken grain milled rice

**Milled rice** - bran layer removed (head rice and brokens)

**Parboiled rice** - rough rice subjected to a steam or hot water treatment before milling
Kernel Form

Rough (Paddy) Rice
Rice that has been harvested from the plant with its hull (husk) intact is known as rough or paddy rice. The hull is not eaten by humans but is sometimes burned for use as an energy source.

Brown (unmilled) Rice
When the hull is removed from rough rice it is called brown rice. However, not all dehulled rice is brown in color. The outer bran layer of the grain and embryo (germ) is what gives rice its color and can vary from light yellow to red to dark purplish black. Rice bran and germ contains greater amounts of dietary fiber, vitamins, minerals and other health-related components than the white center portion of the kernel (endosperm). But those outer portions of the kernel also contain more lipid (fats) material, making brown rice more susceptible to becoming rancid (spoiling). Brown rice, therefore, has a shorter shelf life compared to milled white rice. Storage under cool conditions will lengthen its shelf life. Cooked brown rice has higher fiber content and is chewier in texture than its white rice counterpart and is described as having a slightly nutty flavor.

White (milled) Rice
Rice that has had its bran and hull layers removed by milling is called white, table, polished, or milled rice. White rice cooks faster than brown rice and has a longer shelf life. In the U.S., most white rice is coated with iron, niacin, thiamin and folic acid to enhance its nutritional quality.

Milling Yield

One of the most important aspects of rice grain quality is its milling yield. During the process of milling, the hull is removed from rough rice using a huller to yield brown rice. After the hull is removed, the embryo and the bran layer is removed from the brown rice through an abrasive mill to produce total rice (broken and whole kernels). The final step is separation of the whole (intact) kernels from the broken kernels using screens sized for use on long, medium or short grain varieties to produce whole grain rice. Head rice milling yield is the percentage of whole kernels recovered after milling and removal of the broken kernels. Producers are paid less for broken kernels than for whole.

Milling of rice increases its shelf life and provides consumers with a physical property they have come to desire, whiteness. Therefore the goal of milling is to remove as much of the colored bran and germ as possible. The quantity of bran remaining on the surface of the grain after milling is defined as milling degree. A high milling degree means that the milled rice is very white with relatively light milling. Degree of milling is influenced by grain hardness, size and shape, depth of surface ridges, bran thickness and mill efficiency. Consumers also have a preference for rice that is transparent and not chalky. Chalky areas of the grain are a result of air spaces in between the starch granules that make up the endosperm. Variation in kernel whiteness and transparency can be due to differences in rice varieties, cultural management methods, weather conditions during the crop year, and storage conditions of the harvested rice. Milling rice results in a loss of
vitamins, minerals and dietary fiber. In less developed countries, where rice is a major component of the people’s diet, such nutritional losses may significantly impact human health. As a result, in some areas, the government has encouraged the production of undermilled rice to improve nutritional well being in its population.

**Rice Grain Quality Factors**

*Peck* is a discoloration of the rice grain. It often takes the shape of a “bullseye” and is caused by the interaction of rice stink bug feeding and activity of microorganisms, like fungi, that enter the stink bug feeding wound. In general, farmers are docked during the grading of their rice crop when peck is above 2% by weight in milled rice.

*Chalk* is an imperfection of the rice grain. Ideally, after milling, white rice should be translucent. But rice grains with chalk are not translucent. All or part of the endosperm has a milky or chalky appearance consumers deem undesirable. Some rice varieties have more chalk than others. For instance, Cheniere is a long grain variety that usually has little chalk, while Milagro usually has a lot of chalk. Chalk can also cause grains to break lowering the % whole grains. Chalk is also associated with environmental conditions, such as high temperatures during grain fill. This causes the grains to fill too fast leaving tiny air pockets in the grain which results in chalk. In general, farmers are docked during the grading of their rice crop when chalk is above 2% by weight in milled rice.

*Kernel Smut* is a disease of rice caused by a fungus whose scientific name is *Neovossia horrida*. This fungus can get inside the grain and discolor milled rice. Milled white rice takes on a grey color. Kernel smut is often associated with overfertilized (nitrogen) rice. Kernel smut recently has become more of an issue in Texas. Certain fungicides can help reduce kernel smut. In general, farmers are docked during the grading of their rice crop when “smutty” kernels represent more than 2% by weight of milled rice.
Grain Shape

Rice is primarily classified according to its grain shape. However, within grain shape categories there are differences in cooking qualities that are determined by the chemical make up of the grain and affect cooked grain texture. The various grain shape and specialty rice categories are described below.

Long Grain

The category known as long grain contains milled rice that is approximately three times longer than it is wide. A conventional U.S. long grain rice has 19 to 23% grain amylose content. After cooking, it is firm and fluffy (not sticky). Consumers in areas of the world such as North and South America, Southern China, Europe, and the Middle East often prefer this type of rice.

Medium Grain

The medium grain rice category describes milled rice that is from 2.1 to 2.9 times longer than it is wide. Medium grain rice is generally has an amylose content of 16-18% and after cooking is soft, moist and sticky in texture. This type of rice is in general preferred by people from Japan, Northern China and North and South Korea.

Short Grain

Rice that is less than two times longer than it is wide is classified as short grain. In general short grain rice has cooking quality and amylose content similar to that of rice in the medium grain category. Because this type of rice is used for making sushi some call it sushi rice.

Specialty Rice

Rice that has cooking or processing quality different from the standard market classes described above is known as specialty rice. These are used for special styles of cooking and in specific products. Acreage of these types of rice in the U.S. is much lower than rice that fits into the standard long, medium and short grain market classes.

Arborio

This rice type originated in Italy where it has traditionally been used for making risotto. Arborio rice is classified as a medium grain, but it has fairly firm internal texture and a unique creamy exterior. It often has a very large white chalky center that is thought to be responsible for its ability to take up the flavor of the stock or sauce it is cooked in.

Basmati-Type

Rice of this type has the kernel dimensions of a long grain rice. It has a moderately firm cooked texture, is dry and not sticky after cooking and has an aroma often described as being popcorn like.
This category is unique in that its grains become very long and thin (extreme elongation) after cooking. Basmati rice originated in India and Pakistan. Today, however, rice that has these same unique quality traits are also grown in the U.S.

**Aromatics**
This type of rice is a long grain aromatic rice whose aroma is said to be popcorn like. Although the aroma is similar to Jasmine- and Basmati-style rice its texture mimics that of conventional U.S. long grain firm cooking rice.

**Japanese Premium Quality**
Japanese Premium Quality rice is similar to conventional U.S. medium grain rice in terms of grain length and amylose content. However, these rice differ from standard medium grain rice because of their glossiness, lack of flavor, sticky but smooth texture, and softness after cooling. These properties have been traditionally desired by some people of Japanese and Korean descent.

**Jasmine-Type**
This style of rice is originally from Thailand. Much of the jasmine-style rice sold in the U.S. is imported from Thailand. However, U.S. produced jasmine-style rice is also available. Jasmine-style rice has long grains that when cooked are soft and cling to each other. It is considered aromatic rice because it possesses a distinctive aroma often reported to be popcorn-like.

**Superior Processing Quality**
Some long-grain rice has been developed to remain intact, firm and fluffy after parboiling or canning and thus produces a better appearing rice for use in canned soups and frozen dinners. This type of rice also has less solids loss and kernel splitting after processing compared to conventional U.S. long grain rice and has about 26% grain amylose content. Parboiled rice is produced by steeping and cooking the rice while the hull is still on the kernel. As a result, the color from the hull and the nutrients from the bran layer penetrate the grain during cooking. After parboiling the rice is dried and then milled, producing a slightly amber colored grain.

**Toro-Type**
This is long grain rice that after cooking is soft in texture and the kernels cling to each other. The apparent amylose content is similar to that of conventional U.S. medium grain rice. Toro-Type rice is primarily used in certain ethnic (i.e. Cajun) style cooking.

**Waxy (glutinous, sweet or sticky)**
This style of rice can be in the long, medium or short grain form, and is eaten both milled and unmilled. Milled waxy rice appears opaque (solid white), as opposed to nonwaxy rice, which is translucent. Waxy rice has very little amylose and cooked milled waxy rice is extremely soft and sticky. When the bran is left on, waxy rice is slightly chewy and flavorful. Flour made from waxy rice is also used in products such as candy, salad dressings, baked crackers, and snack foods. It is a ceremonial rice used in areas of Asia.

**Wild Rice**
Wild rice is not rice nor is it wild. It is a grass, which is native to North America. It used to be just a natural grass found in shallow lakes and waterways, but it is now grown commercially in the
U.S. Its nutty, chewy texture and dark brown to black color provide its appeal.

**Processing**

**Parboiled**
Rough rice that has been exposed to some combination of soaking in water and exposure to steam, dried, and then milled, is said to have been parboiled or converted. This process results in the natural vitamins and minerals being transferred from the rice bran layer into the starchy endosperm. Parboiling is thought to have originated in India and Pakistan more than 2,000 years ago. It came into use in the U.S. during World War II because it fit the military’s need for nutritious food that had a long shelf life. Long grain is the type of rice that is generally parboiled for consumption as table rice. Medium grain rice is also parboiled and ground into flour for use as an ingredient in food products.

**Quick cooking and Pre-cooked Rice**
Quick cooking brown or white rice has been pre-cooked to reduce its cooking time; its starch may either be partially gelatinized (cooked) or not at all. The process sometimes entails cooking in water or steam and then drying.

**Rice Flour**
White rice that has been ground into a flour or meal is used in many different types of food products around the world. A few examples follow. The relatively bland flavor of rice makes it well suited for use in products with mild flavors. It has advantages over other grains in that it will not obscure what natural flavors are present and less added flavor is needed. Waxy rice is often used to make baked crackers, which are light and crispy. When a firmer less delicate baked cracker is desired medium grain rice is often used. Fried snack foods made using a blend of waxy rice flour and other grains will tend to be crisper and take up less fat than if made without the rice flour. Rice flour made into a cereal is ideal as an initial food for babies because it is hypoallergenic. Being hypoallergenic, plus having the ability to prevent and correct dehydration has resulted in beverage mixes being developed which are rice-based and used in the treatment of diarrheal diseases such as cholera and AIDS.
Generalized Texas Rice Production Practices

- Prepare land in fall and spring
- Form the levees (approximately every 1/10 – 2/10 foot of fall in elevation)
- Drill plant at 20-80 lb seed/acre (about 7 inches between rows)
  - Organic rice > 100 lb seed/acre
- Fertilize (a of total N)
  - Total N = 150-170 lb/acre (at planting, preflood and panicle differentiation)
- Flush as needed until permanent flood (3-6 weeks after emergence)
- An array of insects attack the rice crop from planting to harvest
  - Insecticides are applied to seed and various times after planting
- Apply herbicides at planting, early post-emergence, before and after flood (worst weeds = red rice, barnyardgrass, sedges, sprangletop, dayflower, alligatorweed, broadleaf signalgrass)
- Inspect for sheath blight, blast, narrow brown leaf spot, brown spot; apply fungicide if justified
- Drain fields 2 weeks before harvest
- Harvest main crop
- Fertilize (100 lb N/acre)
- Apply permanent flood
- Harvest ratoon crop (“lagniappe”)

Rice Production Facts

- Rice is grown in AR, CA, LA, MS, MO and TX
- AR is the state with most rice acreage (about 1.5 million)
- Avg. yields in Texas = 7500 lb/acre (range = 4000 – >12,000 lb/acre)
- 190,000 acres rice in Texas in 2018; 40% is ratoon cropped
- It costs about $1100/acre to produce 1 acre of rice
- Hybrid rice seed costs about $140/acre (very expensive)
- Water is the biggest issue facing the future of Texas rice production; water costs are increasing
- Rice is water-intensive
  - Rice requires about 2-4 acre feet of water to produce a main crop
  - Research has decreased rice water requirement by about ½
- Optimum planting window = mid-Mar to mid-Apr
- Plant in March/April, harvest main crop in July/August, harvest ratoon crop in October/November
- Stages of rice development
  - Seedling
  - Tillering
  - Panicle differentiation (when plant goes from vegetative to reproductive phase)
  - Heading
  - Flowering
  - Milk
  - Soft dough
Hard dough

- Rule of thumb: if main crop is harvested by Aug 15, then ratoon crop is possible and profitable
- Ratoon crop = 1/3 to 1/2 of main crop yield
Useful Facts

Useful Conversions/Definitions
- 1 acre = 43,560 ft\(^2\)
- 1 acre about the size of a football field
- urea = 46% nitrogen by weight
- barrel = 162 lb
- cwt = 100 lb
- 1 ton = 2000 lb
- AI = active ingredient

Pest Control
- The main reason rice is flooded is to control weeds
- 3 types of weeds:
  - Grasses
  - Broadleaves
  - Sedges – have a triangular stem in cross-section
- In general, smaller the weed, the easier to kill (with an herbicide)
- Most rice pesticides and fertilizers are applied aerially; often, aerial cost to apply is greater than cost of the pesticide
- Integrated Pest Management (IPM) combines control tactics, such as biological, cultural, genetic and chemical, to minimize input costs and environmental damage, and maximize profits
- United States Environmental Protection Agency (USEPA):
  - Granted the authority to register pesticides
  - Farmers cannot use pesticides not registered by USEPA
- Texas counterpart to USEPA is Texas Department of Agriculture (TDA):
  - In emergency cases in which a pest cannot be controlled with pesticides approved by USEPA, TDA can request an emergency exemption for a particular non-registered pesticide, but USEPA must still approve the emergency request

Organic Rice Production
- Organic rice is grown without synthetic fertilizers (like urea) or pesticides.
- Organic rice acreage is increasing in Texas because organic rice receives about twice the price of conventional rice
- About 20% total rice acreage in Texas is organic

Breeding and GMO
- GMO = genetically modified organism
  - For example, Bt rice possesses a gene from a bacterium which produces a toxin deadly to certain insects like stem borers.
  - Currently, GMO rice is not allowed to be sold or consumed in the US (“Franken Food”).
- RoundUp Ready soybeans are GMOs, they possess a gene from another organism that produces a protein which protects the plant from injury from the non-selective herbicide glyphosate (trade name = RoundUp)

- **CLEARFIELD technology**
  - CLEARFIELD rice varieties resistant to the herbicide imazethapyr.
  - When this herbicide is applied, red rice and other grasses are killed, but CLEARFIELD rice varieties are not affected.
  - Technology developed by LSU through mutation breeding, **NOT** GMO technology
  - Weedy rice is becoming an issue for some rice farmers who grow CLEARFIELD rice varieties. CLEARFIELD rice can outcross with red rice in the same field. Eventually, the progeny of this red rice becomes resistant to the CLEARFIELD herbicides.

- **Provisia technology**
  - Similar to CLEARFIELD, but rice is resistant to a different herbicide---quizalofop (trade name Provisia).
  - The first Provisia rice variety (PVL01) was released in 2018.

- **It takes about 8 years to develop a new variety of rice**
  - To speed up the process, Texas rice breeders grow 1 crop and make selections at Beaumont then take those selections to Puerto Rico in the winter where they can grow another crop and make selections.

- **Hybrid rice**
  - Hybrid varieties are produced from parents genetically dissimilar.
  - The resulting offspring display hybrid vigor.
  - A mule is a hybrid with a horse as a mother and a donkey as a father. The mule offspring is smarter and more sure-footed than either parent. The same applies to hybrid rice.

- **Identity protection (IP)**
  - Big issue in the rice industry now
  - Rice varieties mill differently based on length and width of grains and other factors. When varieties that mill differently (like conventional vs hybrid varieties) are combined and milled, the milled rice contains more brokens and produces a less desirable product which consumers in Mexico and Central America do not want to buy. Thus, some farmers and millers are now separating and milling varieties based on their common milling properties (do not mill hybrid and conventional varieties together). Or are shipping rough rice identity protected to Mexico and Central America who like this rice better and are more apt to buy it.

**People**

- **Norman Borlaug**
  - Winner of the Noble Peace Prize in 1970 and Father of the Green Revolution
  - Saved a billion people from starvation
  - Quotes from Dr. Borlaug who died in 2009:
    - *Food is the moral right of all who are born into this world.*
    - *Without food, man can live at most but a few weeks; without it, all other components of social justice are meaningless.*
Almost certainly, however, the first essential component of social justice is adequate food for all mankind.

- Dr. Borlaug was a Professor at Texas A&M University
- Sid Miller
  - Texas Agriculture Commissioner (head of the Texas Department of Agriculture)
- Andrew Wheeler
  - Administrator of USEPA
- Sonny Perdue
  - US Secretary of Agriculture
- Greg Abbott
  - Governor of Texas
- Rachel Carson
  - Author of “Silent Spring” which described the harmful environmental effects of pesticides, particularly DDT
  - The book was instrumental in establishing the USEPA in 1972

Future issues:

- Reliable source of water biggest issue facing rice farmers in the future
- It takes about 3 acre feet of water to irrigate rice (about equal to flooding a football field to a depth of 3 feet)

As researchers and extension scientists, our goals are to:

- Increase yield and milling quality
- Decrease production costs
- Preserve/improve environment
1. Farmer Stevie Devillier wants to apply a total of 170 lb nitrogen per acre to his rice crop (30% at planting, 40% at flood and 30% at panicle differentiation). The cost of each aerial application is $10/acre. The cost of urea is $500/ton. What is Stevie’s total urea cost per acre? Don’t forget to add in the application costs.

\[
\begin{align*}
\text{Application cost:} & \quad 10 \times 3 = 30/acre \\
\text{Urea cost:} & \quad \frac{170}{0.46} = 370 \text{ lb urea/acre} \\
& \quad \frac{370}{2000} \times 500 = 92.50 \\
& \quad 92.50 + 30 = 122.50/acre
\end{align*}
\]

2. Farmer Linda Raun wants to spray Tenchu 20 SG at 8 oz/acre to control rice stink bugs on her heading rice crop. The aerial application cost is $10/acre if she chooses a final spray volume of 3 gallons/acre and $15/acre if she chooses a final spray volume of 10 gallons per acre. Linda chooses the higher rate of water. The cost of Tenchu 20SG is $15/lb (1 lb = 16 oz). What is the total cost per acre for Linda? Why did Linda choose the higher rate of water?

\[
\begin{align*}
\text{Cost of Tenchu:} & \quad \frac{15}{2} = 7.50/8 \text{ oz} \\
\text{Application cost:} & \quad 15 \text{ oz} = 7.50 + 15 = 22.50/acre
\end{align*}
\]

3. Farmer Chris Latta has spent the following growing his crop of rice:
1. $80/acre land rent
2. $60/acre for seed
3. $150/acre for water
4. $200/acre for fertilizer
5. $150/acre for pesticides
6. $100/acre for diesel
7. $100/acre for labor
8. $100/acre for harvesting and drying costs

Chris will receive $10/cwt for his rice. How much rice must Chris produce (on a per acre basis) to break even? Does this mean Chris must ratoon crop to break even?

\[
\begin{align*}
\text{Total costs:} & \quad 80 + 60 + \ldots = 940 \text{ acre} \\
\text{Break even yield:} & \quad 940 / 10 = 94 \text{ cwt} = 9400 \text{ lb/acre}
\end{align*}
\]

4. Organic rice farmer Cecil Slack has a problem with rice water weevil. He estimates he will lose 1000 lb/acre if he doesn’t use an insecticide to control this pest. He estimates his final yield will be 3000 lb/acre. He will receive $25/cwt when he sells his organic rice. How much loss in revenue (on a per acre basis) did the rice water weevil cost Cecil?

\[
\begin{align*}
\text{Loss in revenue:} & \quad 1000 \times 25 = 25,000
\end{align*}
\]

5. Farmer Clyde Barrow has a circular rice field. The field is 1 mile in diameter. How many acres does this field contain? (5280 ft = 1 mile, \(A = 3.14 \times \text{radius squared}\))

\[
\begin{align*}
\text{Area:} & \quad 3.14 \times 5280 \times 5280 = 21884544 \text{ sq ft} \\
& \quad 21884544 \div 43,560 = 502 \text{ acres}
\end{align*}
\]