General Production Information

- Mississippi produces only long grain rice.
- Mississippi rice acreage has fluctuated between 210,000 and 315,000 acres 1988 – 2002 [13,14].
- Mississippi rice yields have more than doubled since the early 1950’s and currently average greater than 6,030 lbs/A [13,14].
- Average Mississippi rice yields reached 6,400 lbs/A in 2002 [14].
- Mississippi is primarily a one-variety state.
- Cocodrie is grown on about 60 percent of the acreage; Priscilla on 15 percent; Wells on five percent; with the remaining acreage planted to CL 161, Lemont, Wells, and Jefferson [9].
- A limited acreage of Francis and hybrid rice has been planted recently. [9]

General Information

Successful rice production can depend on seven essential steps. These steps are: (1) choose the most profitable variety with the least risks, (2) establish a uniform stand, (3) control weeds early, (4) apply the correct nitrogen rate for each variety, (5) manage water efficiently, (6) control diseases and insects if necessary, and (7) harvest on time. Choosing the right variety involves consideration of several factors such as length of growing season, grain type, availability of red rice free seed, disease susceptibility,
processing characteristics, yield potential, and market demand. Rice can be grown on any soil type provided it has a slow permeability to reduce infiltration. A continuous flood culture is preferred. Ample water is basic to a good water management program in rice production. Fields should be reasonably flat so that levees constructed at 0.2-foot intervals in elevation can be accomplished, with sufficient distance between levees for efficient harvesting. Properly constructed, water tight levees are necessary for flushing and to simplify water management, weed control and drainage. [1]

**Insect Pests**

Mississippi rice growers identified the insects that caused the greatest monetary loss in rice as follows: stink bug (46%), water weevil (38%), armyworms (8%), grasshoppers (6%), and other (2%) [4,9].

Mississippi rice growers were estimated to have used zetamethrin on 40 percent, lambdacyhalothrin on 30 percent, and methyl parathion on 20 percent, and other insecticides on 10 percent of their acreage [4,9].

**Rice Water Weevil**

*Lissorhoptrus oryzophilus Kuschel*

Rice water weevils occur throughout Mississippi’s rice growing area. Fields in rice production for several years usually experience larger populations than fields recently brought into production. The adults are grayish brown, broad-nosed insects about 1/8 inch long. Adults overwinter in grasses and ground trash near rice fields. They are strong fliers and migrate into rice fields in the spring. Adult weevils usually are not found in rice before flooding but may invade fields in large numbers soon after flooding. However, if the field is flushed earlier, they may be attracted into the field before a permanent flood is established. More weevil activity will occur in areas with open water, such as around levees and areas of thin stands. Higher populations are usually found in fields flooded during late May through Mid-June. Adult weevils feed on the rice plant’s leaves. They remove portions of the upper leaf surface, resulting in a feeding scar. These feeding scars are about the width of a pencil line, cigar shaped and range in size from ½ inch to 2 inches long; they are usually parallel with the midvein of the leaf. These scars usually are white but may be tan or brown. Under windy conditions, the thin layer of tissue in the scar may break loose and leave a hole in the leaf. This adult leaf feeding does not seriously damage rice plants and is not economically important but does indicate whether or not adult weevils are present. The adults lay eggs on young plants after they move into a field of young rice. The eggs hatch and the larvae move down the plants to the root system. The larvae feed on the root system until they pupate. The larvae stage of rice water weevils can seriously injure rice plants by reducing plant vigor, stand and yield. Larvae or white root larvae, as they are commonly called, feed on the roots and cause injury by pruning the root system. They are white, legless, and ¼ inch long or smaller. Larvae feed on roots for about 3 weeks after hatching. They spend about 2 weeks in the pupa stage before emerging as adults.
Depending on the severity of infestation, losses on untreated fields typically range from 10 to 33% but can be as high as 50 to 70% under heavy pressure [2].

**Monitoring:** Rice fields with a history of water weevil infestations are more likely to require treatment than those that have not experienced damaging populations in previous seasons. The most likely place for adults to first appear is in areas where water is deep and stands are sparse, exposing open water. Populations will occur at a higher level around open areas and levee ditches than in thicker stands in bay areas. Six to ten locations that are representative of rice plant populations should be checked. Correct timing of the insecticide application is necessary for acceptable control. The most accurate method of timing the insecticide application is to determine if feeding scars are found or adult weevils are found.

**Controls:**

**Cultural:**
Current RWW management involves the use of either chemical or cultural control practices based on established monitoring procedures and economic thresholds. Host-plant resistance and biological control are the subject of much previous and current research efforts (see below), but are not currently available for RWW management. Early planting and delayed flooding are cultural controls but often are not always attainable (delay maturity) or interfere with weed control.

Treatment of RWW infested fields consists of either application of an insecticide, or water management by draining fields to reduce numbers of RWW larvae. For RWW control by water management, apply 50%-60% of the required amount of nitrogen per acre pre-plant or prior to permanent flood. When RWW populations reach threshold, fields should be drained and left without water for two to three weeks, allowing the soil to dry to the point of cracking. It is almost impossible to drain Cocodrie because of the short time from flooding to mid-season. Fields should be top dressed with the remaining 40%-50% of the recommended amount of nitrogen per acre and reflooded. If RWW populations do not warrant draining, it should be topdressed with the remaining nitrogen allowance when rice reaches the green ring stage of growth. Draining fields is the only method of RWW management available for rice grown in rotation with crawfish [14].

Cultural control of RWW by draining rice fields was first suggested in 1881. Subsequent research found that appropriately timed draining of rice fields reduced damage caused by feeding of RWW larvae. Since RWW adult, eggs, and first and later instars may be present in fields, and may be affected by draining flooded fields; water management is a potentially effective means of managing RWW. Adult RWW oviposit preferentially in flooded fields, and the lack of standing water may lower infestations levels. In addition, soil drying resulting from prolonged periods of drainage may prevent or adversely affect the establishment of RWW larvae in the root zone of rice plants. Several studies have attributed lower RWW infestation levels in drained fields with increased mortality of root-feeding larvae [14].

Although potentially effective, the cost of water management can be high. Drainage increases water, labor, and associated costs. Water management may also conflict with current agronomic practices and
adversely affect rice growth. Drainage of fields can result in loss of fertilizer and pesticides in water, promote weed growth, and can increase the severity of rice blast. The lack of standing water in mineral soils reduces the availability of nutrients and stresses rice plants. Early drainage of fields may not be effective because frequent rains prevent fields from drying sufficiently to reduce numbers of RWW larvae. Since crawfish production in Mississippi rice producing areas is almost non-existent, the cost of labor and water as well as delay of rice development would make water management as know today unacceptable [4].

Researchers continue to participate in host-plant resistant research. More than 7200 rice accessions from the USDA World Rice Collection have been screened and nine lines with moderate levels of resistance have been identified. Other plant lines with low levels of resistance have been identified from varieties of Philippine origin. Recent examination of rice breeding and tissue culture also revealed low levels of resistance to RWW. To date, no variety capable of providing significant levels of protection from RWW in the absence of insecticide use has been identified [14].

Research into refinement of existing, and implementation of new water management methods that include various draining and delayed flood scenarios, and planting date manipulations, continue. However, because of conflicts with weed and disease management programs, with agronomic practices (i.e. fertilizer and water management), and considering weather related difficulties, there is little hope of significantly improving RWW control using cultural practices for the foreseeable future [14].

The rice water weevil in rice represents interesting challenges for control with natural enemies. Because of it’s use of aquatic and terrestrial habitats by adults, and soil habitat by larvae, no arthropod parasites of RWW are known, and progress in biological control has been difficult. Arthropod and vertebrate predators of RWW adults and larvae are known but offer little potential for effective biological control. However there has been some progress in the search for fungal and nematode pathogens of RWW. The fungus *Beauvaria spp.* has been isolated from overwintering beetles, but infection rates are low. A mermithid nematode found parasitizing adult RWW has also been collected but parasitism rates are not sufficient to affect RWW population dynamics [14].

Several rice lines producing toxins of *Bacillus thuringiensis* have been developed and are currently being evaluated by University and USDA researchers in Louisiana [14].

**Chemical:**
Control of RWW using chemical pesticides, including arsenicals and various organochlorine compounds, has been practiced since the early part of this century. By the 1960’s effective RWW control was achieved by application of the organochlorine pesticide aldrin to rice seed. However, this success was short-lived as aldrin resistant RWW began appearing in the mid-1960’s. Research into improved chemical control compounds eventually resulted in adoption and registration of the carbamate insecticide carbofuran for RWW control. The formulation used is a three percent sand core granule specifically developed for use on rice. The pyrethroids offer further improvement in cost and total environmental load but require new scouting methods. Pyrethroids must be applied in a short interval
Icon (Fipronil) is now approved for rice water weevil control. Icon, which is available as a seed treatment, will be sold only to seed dealers, who will be licensed to treat the seed. Rice water weevil control with Icon has been good to excellent. In research plots and field demonstration plots, Icon seed treatment has provided effective water weevil control. Icon also controls rice stalk borer and chinch bug. The desired rate of Icon to be applied is 0.025 to 0.05 pounds per acre and will be based on planting 100 pounds of seed per acre. The cost of Icon seed treatment is around $14 to $15 dollars per acre for the 100-pound seeding rate.

Although Icon provides good control of rice water weevil, the decision to use it must be made by the first part of January to give the seed dealers time to treat and bag the seed. The cut-off date for ordering Icon treated seed will vary depending upon the seed dealer but the decision will have to be made early. Although there is no good method of predicting the infestation levels of rice water weevils in any year, if rice is being produced on old rice land, which has had water weevil infestations in the past, it is reasonable to expect to have water weevils again. Water weevils at high infestation levels can reduce rice yields by 20 percent in dry seeded rice and higher in water seeded rice.

Karate (cyhalothrin) has continued to provide good to excellent control of adult rice water weevils. There have not been any failures when Karate was applied within seven days after permanent flood establishment. Timing is important to control the adult water weevil before eggs are deposited. One application of Karate has been sufficient to effectively control water weevils in most situations although two applications may be required in locations with high water weevil populations or in water seeded rice. Karate also controls armyworm, stink bug, aphid, green bugs, and suppresses grasshoppers. The current cost of the low rate of Karate is about $5.60 per acre plus the airplane cost.

Dimilin (diflubenzuron) when applied interferes with chitin production and prevents eggs from hatching and larvae from molting. This insecticide must be applied within 2-5 days after a permanent flood has been established to be present as the adults oviposit. Dimilin has been shown to prevent RWW larvae from damaging roots and protecting rice yields. Dimilin has not been used as extensively as the pyrethroids. Dimilin must be applied 80 days prior to harvest. It is labeled only for RWW control. It has been priced higher than pyrethoids.

Fury, Mustang Max (zetamethrin) has continued to provide good to excellent control of adult rice water weevils. There have been no known failures when Fury has been applied following label directions. Mustang Max, a new formulation of zetamethrin, was labeled for rice in 2003. Application is aimed at adults and must be timed within 5 days of a permanent flood. Second applications are needed during prolonged RWW emergence. Zetamethrin controls armyworms, stink bugs, aphids, green bugs, and grasshoppers.
**Rice Stink Bug**  
*Oebalus pugnax (Fabricius)*

The adult rice stink bug is light brown in color, shield-shaped and about ½ inch long. It spends the winter in clumps of grass and other ground litter before emerging in the spring to feed on grasses. The adult migrates to rice soon after rice begins to head. There it feeds and deposits eggs. Females lay light – green cylinder-shaped eggs in two row clusters on leaves and stems. Eggs are red-black just before hatch. Both the adults and the developing young nymphs feed by sucking juice from the developing kernels. Feeding on the flowering and milk stage of rice produces blank, empty grains and reduced yields. Feeding on the soft dough stage can cause peckiness of the grains, but peckiness can be caused by factors other than stink bug feeding [2].

**Monitoring:** Start checking the rice fields when the rice plants begin heading. Four to six locations should be sampled. Sampling should be performed with a 15 inch diameter sweep net. Sampling should be conducted in the morning to obtain the best estimate of the population with 10 sweeps being made in 180° arcs in front and to the sides of the person doing the sampling. The sweep net should be handled in such a manner that the open mouth of the net makes contact with the heads of the rice plants in order to capture any insects on the rice head in the net. Scout fields at least once a week until rice heads are mature [2].

**Controls:**

Several natural enemies are important in reducing the density of RSB populations in rice. Adults and nymphs are parasitized by *Beskia aelops* (Walker), and *Euthera tentatrix* Lav. (both Diptera: Tachinidae). Eggs of RSB are parasitized by *Oencyrtus anasae* (Ashm.) (Hymenoptera: Encyrtidae), and *Telonomus podisi* (Ashm.) (Hymenoptera: Scelionidae). Management of RSB relies significantly on the activity of these naturally occurring biological control agents. Intervention using chemical control based on established monitoring procedures and thresholds is recommended when RSB escapes from the control provided by natural enemies [14].

**Chemical:**

Insecticides for control of rice stink bug [4]

- **Carbaryl (Sevin 80S)** is applied at 1 ¼ -1 7/8 lbs/A up to 14 days prior to harvest
- **Carbaryl (Sevin XL R 4L)** is applied at 1-1.5 quarts/A (2.7-4 A/gal) up to 14 days prior to harvest
- **Malathion 57% EC** is applied at 1-1 ½ pts/A (8-6 A/gal) up to 7 days prior to harvest
- **Methyl Parathion 4EC** is applied at ½ -1 pt/A (16-8 A/gal) up to 15 days prior to harvest.

Although recommended, carbaryl is not generally used for rice stink bug control since it is two to three times more expensive than methyl parathion and is slower acting.
• **Lambdacyhalothrin (Karate with Zeon Technology)** is applied at 1.6-2.56 oz/A (80-50 A/gallon) 21 days prior to harvest.

• **Zetamethrin (Fury)** is applied at 2.8-4.3 oz/A (30-45 A/gallon) 14 days prior to harvest.

• **Zetamethrin (Mustang Max)** is applied at 2.64-4.0 oz/A (32-48 A/gallon) 14 days prior to harvest.

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**Fall Armyworm**  
*Spodoptera frugiperda (J.E. Smith)*

**Damage.** Fall armyworm larvae feed on the leaves of young rice plants, destroying large amounts of leaf tissue. Seedlings are eventually pruned to the ground as the larvae feed. Fall armyworm infestations generally occur along field borders, levees, and in high areas of fields, where larvae escape drowning. The most severe damage occurs in fields of seedling rice that is too young to flood.

**Management.** Fields should be monitored for the presence of fall armyworm at one week intervals after the emergence of seedling rice. Fields should be monitored by checking plants every 10 feet along a line across the field. The process should be repeated in a total of three areas per field. Research data indicate that a 25% leaf loss during the seedling stage decreases rice yields by about 130 pounds per acre. The field should be treated when there is an average of one armyworm per two plants. [2]

The preferred treatment option is to flood infested fields. Fields must remain flooded for several hours in order to drown armyworm larvae. If plants are too young to flood, treat with insecticides. There are 2 subspecies of fall armyworm; one is exceptionally hard to control. The one on grass is easily controlled. The grass species seem to be the one we encounter in rice. [2]

**Problems.** Flooding rice fields to control fall armyworm may be more expensive than chemical control, and may not be possible in drill-seeded rice fields where levee construction has been delayed. Chemical control using methyl parathion may interact with weed management practices. Applying methyl parathion within 14 days of the herbicide propanil may cause severe damage to rice. If infestations occur before scouting is initiated and if infestations are not detected early, economic damage may occur. [2]

**Controls:**

**Chemical: [4]**
Control when finding 1 worm per 2 plants

- **Carbaryl (Sevin)** 1 lb/A
- **Malathion** 1 lb/A
- **Methyl Parathion** 1 lb/A
- **Cyhalothrin (Karate)** 0.025-0.04 lb ai/A
- **Zetamethrin (Fury)** 0.04-0.05 lbs ai/A
Grasshopper

Several species of grasshoppers may be found in rice fields. Green grasshoppers from the longhorn species usually feed on the flower parts of the plants. The brown species feed on leaves and the sides of stems of rice plants. Injured plants will sometimes produce white heads [2].

Grasshoppers are very seldom an economic problem in rice fields. However, during drought conditions, large numbers may move into fields as food plants surrounding the fields desiccate. In most situations only border treatment is necessary to control a damaging population [2].

Controls:

Chemical [4]:
Early in the season applications should be made when there are 3 grasshoppers/10 sweeps. Later in the season applications should be made when there are 5 grasshoppers/10 sweeps.

- **Carbaryl (Sevin)** should be applied at 1 lb/A
- **Malathion** should be applied at ½ lb/A.
- **Methyl parathion** should be applied at ¼ lb/A
- **Cyhalothrin (Karate)** should be applied at 0.025 – 0.04 lb ai/A
- **Zetmethrin (Fury)** 0.04-0.05 lbs ai/A
- **Zetmethrin (Mustang Max)** 0.02-0.025 lbs ai/A

For large grasshoppers:

- **Methyl parathion** should be applied at ½ lb/A

Chinch Bug

Blissus leucopterus leucopterus (Say)

**Biology:** Chinch bugs overwinter as adults in grass clumps, leaf litter, and other protected areas, emerging in early to mid spring to feed and mate on grass hosts that include small grains such as wheat, rye, oats and barley. Adults are small, black insects about 3-4 mm long, with white forewings. Each wing has a triangular black spot near the middle of the costal margin. White, elongate eggs about 1 mm long are deposited behind lower leaf sheaths or in the soil near the roots and turn red before hatching in 7-10 days. There are generally five nymphal instars. Early instar nymphs are red with a yellow band on the anterior margin of the abdomen. Late instar nymphs are black and gray with a conspicuous white spot dorsally. Adults and nymphs feed by piercing the leaves and stems of rice plants and sucking plant
juices. The life cycle from egg to adult takes 30-40 days, and adults may live 2-3 weeks [14].

**Damage.** Economic damage to rice generally occurs when favorable weather conditions and production practices allow large chinch bug populations to build up in corn, sorghum, and wheat fields. As these crops mature and/or are harvested, large numbers of chinch bugs may migrate to young plants in nearby rice fields. Chinch bug feeding on young seedlings causes leaves and stems to turn light brown. Heavy infestations can kill young plants resulting in severe stand reductions. Both adult and immature chinch bugs contribute to damage in rice [14].

The chinch bug is a sporadic pest of rice in Mississippi. Serious economic losses due to chinch bug feeding have occurred. The chinch bug is generally only a problem in dry planted fields in heavy clay soils. [9]

**Management.** Chinch bug management using either cultural or chemical control tactics is based on the results of field scouting for the presence of chinch bugs. No thresholds or damage functions for chinch bug in rice are currently available. Unflooded fields near small grain fields should be checked every 3-5 days from seedling emergence until application of permanent flood. Foliage in rice fields is checked for the presence of chinch bug damage. If damage is present, check plants for the presence of chinch bugs. Remove soil from around the crown and examine the plant below the soil line for chinch bug adults and immatures (nymphs). Alternately, insert a metal can with both ends cut out (or other similar object) into the soil around rice plants. Fill the can with water and wait 3-5 minutes for chinch bugs to float to the surface. Repeat the procedure in several areas of the field. If large numbers of chinch bugs are present, the field should be treated. Cultural control consists of flooding fields to reduce chinch bug populations [14].

**Problems.** In drill seeded rice, where chinch bug damage is most likely to occur, levee construction is frequently delayed for some time after seeding fields. Although flooding is the preferred method of control, it is not possible before levees have been constructed. Chemical control can also be problematic. Since chinch bugs typically feed on plant tissue at or below the soil line, non-systemic pesticides such as Methyl Parathion may not provide consistently effective control. Also, weed and insect management practices may conflict with each other. Applying methyl parathion within 14 days of the herbicide propanil may cause severe damage to rice [14].

**Controls [4]:**

**Chemical:**

- **Carbaryl (Sevin)** should be applied at 1 lb/A.
- **Malathion** should be applied at ½ lb/A
- **Methyl Parathion** should be applied at ¼ lb/A
- **Cyhalothrin (Karate)** should be applied at 0.025-0.04 lbs ai/A
- **Zetamethrin (Fury)** should be applied at 0.033-0.05 lbs ai/A
**Diseases**

The incidence of rice diseases in Mississippi is on the increase. Rice diseases are influenced by varietal susceptibility, seeding rate, environmental conditions, and intensity and frequency of rice culture within a given area. Certain diseases can be controlled by using resistant varieties, seed treatment, and better cultural and management practices. Diseases can cause substantial losses in yield as well as quality. All commercial varieties possess some level of resistance to certain diseases. When a troublesome disease persists, a variety with higher resistance should be used if available [2].

Diseases have become more important in rice production for several reasons: expanded rice acreage in Mississippi, prolonged recropping of rice in certain areas and fields and the limited availability of new land for long rotations. Soilborne diseases, such as sheath blight, build up when fields are frequently cropped to rice. Furthermore, rice is grown in an aquatic system, resulting in a humid microclimate that favors disease development [5].

The release and adoption of short-statured, high-yielding varieties (semidwarfs) that respond to high rates of nitrogen fertilizer have also contributed to disease increases. Unfortunately, high nitrogen fertility not only increases yield but also increases susceptibility of rice to certain serious diseases [5].

Losses caused by rice diseases can be effectively reduced by following these general control practices:
1. Avoid undue stressing of rice plants during the growing season (drought, fertilizer, chemical stress, etc.). 2. Apply recommended rates of nitrogen and other crop nutrient fertilizers at the proper time for the variety grown. 3. Use foliar fungicides if they are available to aid in control of specific diseases. 4. Crop rotation will retard a build-up of disease organisms. 5. Plant the recommended seeding rate per acre. 6. Plant during recommended planting dates on a well prepared seedbed. 7. Use high quality seed treated with an effective fungicide. 8. Use varieties with the greatest resistance to diseases most prevalent in an area. 9. Control weeds and grasses early. 10. Destroy previous crop stubble as soon as possible. 11. If possible do not plant a blast susceptible variety on fields with light soils [2].

In 2002, Mississippi rice acreage was treated with three fungicides: propiconazole (30% of the acreage), azoxystrobin (20% of the acreage), and Stratego (15% of the acreage). [9,10].

**Sheath Blight**

*Rhizoctonia solani*

Sheath blight caused by the fungus *Rhizoctonia solani* has become the most important rice disease in Mississippi. The disease is widespread, occurs yearly, and reduces yields and milling quality. The
disease has become more prevalent and more severe since the seventies. A reason for the increased prevalence is the widespread planting of susceptible semidwarf varieties along with the high rates of nitrogen fertilizers used to produce high yields with these varieties. Increased rates of nitrogen have been shown to be correlated with increased plant susceptibility as well as making the environment within the rice canopy more favorable for disease development. *R. solani* causes numerous diseases of many crops. The strain that attacks rice also causes aerial web blight of soybeans, primarily in south Mississippi [5,8].

Sheath blight causes a blight of leaf sheaths, leaves, and panicles. Early infections also attack the culm (stem). Culms weakened by sheath blight are prone to lodging. The primary cause of yield loss results from a reduction of effective leaf area. This effect is most severe when the disease attacks the flag leaf before grain fill. Incomplete grain fill reduces total yield and results in lower head rice yields because the poorly filled grain breaks during the milling process [5,8].

Premature ripening associated with severe sheath blight also causes low moisture content in affected grain and makes it more susceptible to breakage during milling. Direct blighting of panicles by the fungus is thought to be a minor portion of potential yield loss [5,8].

**Controls: [9]**

Control of sheath blight is difficult and must rely on an integrated management approach:

- Although no truly resistant varieties of the long-grain type are commercially available, choose the least susceptible variety on current Extension recommendations for problem fields. The cultivars Wells and Priscilla have moderate resistance to sheath blight.
- Do not exceed recommended nitrogen or seeding rates for a given variety.
- Avoid alternate-year rice rotations if possible, and do not plant consecutive rice crops. Surveys shows these rotations result in higher levels of sclerotinia and sheath blight compared to rotations where rice is cropped every third year.
- Thoroughly scout fields to determine the incidence of sheath blight if considering the use of a fungicide.

Quadris has become the standard for sheath blight control. The label calls for the application of 12.3 to 18.5 ounces per acre at the first sign of the disease. Under heavy disease pressure, a second application may be made. Stratego, a mixture of trifloxystrobin and propiconizole received USEPA approval in 2002 for use on rice for sheath blight. Moncut (flutolanil) is used on a limited basis [9].

**Blast**

*Pyricularia grisea*

Blast is caused by the fungus *Pyricularia grisea* (formerly *Pyricularia oryzae*) and is one of the most damaging and, therefore, important rice diseases in Mississippi. Occurrence of blast is unpredictable
because of yearly changes in weather, acreage planted to susceptible varieties, and the development of new races of the fungus that are capable of attacking varieties previously resistant [5].

Blast damages plants and reduces yield in a number of ways. Leaf spot or lesions reduce the effective leaf area. Lesions form on nodes of the stem and panicle, panicle branches that support individual grains, causing girdling that results in incomplete grain fill or total grain failure. Losses in severely affected fields may exceed 50 percent [5].

**Controls: [9]**

**Cultural:**
Failure to maintain an adequate flood greatly increases the occurrence and severity of blast. Often a blast epidemic in a field begins in a high area or an area where the flood has been lost. Growing rice on sandy soils or steep contours often makes it difficult to maintain a flood. The best way to control blast is to use resistant varieties. Integrate the use of resistant varieties with good cultural practices (proper field selection, seeding rate, fertilization, and flooding) [10].

**Chemical:**
If symptoms of this disease occur, Quadris or Gem will partially control blast if applied correctly. Susceptible varieties should be treated with a fungicide in 10 gallons of water per acre when plants are 80% headed. However, if blast is present in the area or leaf blast was found earlier, a fungicide should be applied at early boot (1-1 ½ in panicle) and a second application at 80% heading.

**Kernel Smut**

*Neovassia barclayana*

Kernel Smut is caused by the fungus *Neovassia barclayana*. The disease is first noticed as the rice crop nears maturity. First symptoms include small black spots or streaks on the grain. Diseased grains can be entirely replaced by a black mass of smut spores. Usually 1 to 5 grains per panicle are affected by the disease but infestation levels as high as 85% have been reported. Yield losses due to the disease are generally insignificant. However, processed rice from infested fields can have a dull grayish appearance and infested grains turn black during parboiling. Therefore, rice mills, especially mills that parboil, commonly dock or refuse to buy this rice. The disease is not systemic or internally seed transmitted. Therefore, seed treatment will not control kernel smut. The spore can overwinter in smutted kernels on the soil or be carried to the field on the surface of infected rice seed [2].

**Controls: [9]**

**Cultural:**
Some varieties recommended for Mississippi have been reported to have some resistance to this disease. In addition to the general control practices mentioned earlier, the following practices may aid in
reducing the incidence of this disease: Plant smut free seed, do not use an excessive amount of nitrogen, plant early maturing varieties during the early planting dates suggested for the variety, because smut is more severe when they are planted late, maintain a shallow flood on fields if possible during flowering of the rice plant, unless the variety is susceptible to blast [3].

**Chemical:**
Seed treatments have not been correlated with a decrease of smut incidence in rice fields.

Tilt, Propimax or Stratego have proven effective in controlling kernel smut with proper timing of application.

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**Brown Spot**  
*Cochliobolus nizabranus*

This disease is caused by the fungus *Cochliobolus nizabranus*. The first symptoms of the disease are small oval to circular brown spots (1/6 to 1/8 inch in diameter) on leaves. When plants are severely affected, large parts of the leaf area may be damaged before the grain is mature. Therefore, carbohydrate production in the leaves is adversely affected which results in a reduced yield and quality. Reduced grain quality may also occur when the hulls become infected. Brown spot in combination with stink bug damage is most common on weak plants resulting from such factors as low temperatures, herbicide injury, other diseases and nitrogen deficiency or excess [2].

**Control:**

**Cultural:**
To reduce the probability of the occurrence of this disease, avoid factors, which may lead to stress, plant resistant varieties, and control stink bugs [2].

**Chemical:**
Dithane or Thiram seed treatment is effective against brown spot. [9]

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**Seedling Blight**  
*Pythium spp.; Rhizoctonia spp.*

This disease is caused by several species of *Pythium* and *Rhizoctonia* and is most likely to occur on young rice seedlings as a result of environmental stress. This stress can occur as a result of planting too early or too late when the environmental conditions are unfavorable for rice growth [2].

**Controls:**
Cultural:
In many cases, if the field is flushed or flooded when young seedlings begin dying, most will recover and a satisfactory stand will be obtained [2].

Chemical:
Seed treatment with Apron XL or Aliegiance is effective against *Pythium*. Maxium and Vitavax are effective against *Rhizoctonia*. [10]

**Stem Rot**
*Sclerotium oryzae*

This disease is caused by the fungus *Sclerotium oryzae*. The disease is usually first noticed in the later stages of plant growth. If an infected stem is examined carefully, a small blackish irregular lesion will be found on the outer leaf sheath at or slightly above the water line. Black or dark brown streaks are usually present along the stalk in the more advanced stages of this disease. If the stalk is split, a white cottony, grayish material will be found inside. Later, many small, round, black, seedlike, fruiting bodies (sclerotia) form within the infected stems and rotting sheath tissue. These sclerotia can remain alive for several years in the soil. Lodging (falling over) may occur when several adjacent plants are affected. Reduction in grain yield and quality result when infection occurs early [2].

Control:

Chemical:
Currently registered fungicides will only suppress this disease. Also, the incidence of disease may be reduced by following the general control practices mentioned earlier [2].

**Straighthead**

Straighthead is a disease that is abiotic (not caused by a living organism) in nature. Straighthead is sterility caused by either complex unknown chemical conditions that occur on light textured soils or as a result of the use of arsenical pesticides on previously grown crops. Varieties differ in their susceptibility to straighthead. When it occurs, the panicles remain upright at maturity because the grain fails to develop. Rice hulls may be distorted into a parrot beak shape or the florets may be missing or blank. Straighthead seldom occurs on clay soils in Mississippi [2].

Control:

Cultural:
If there is a possibility of straighthead occurring, the field should be drained according to the DD50 predicted drain date or approximately 10 days after a permanent flood is established. Once the field is
drained, it should be allowed to dry thoroughly prior to reflooding. Reflooding needs to be accomplished before the internode elongation exceeds ½ inch [2].

**Black Sheath Rot**  
*Gaeumannomyces graminis var. graminis*

This disease is caused by the fungus *Gaeumannomyces graminis var. graminis*. Disease symptoms are observed late in the growing season as a brown discoloration of the leaf sheath. Dark reddish brown irregular spots may be found in the inner surface of the examined sheaths. Infected plants tend to have a reduced number of tillers. Since this disease appears to be of minor economic importance, no controls are recommended [2].

**Sheath Rot**  
*Sarocladium oryzae*

Sheath rot is caused by the organism *Sarocladium oryzae*. This disease occurs in the uppermost leaf sheaths, enclosing the young panicles. The lesions start as oblong irregular spots with brown margins and gray centers. These lesions can enlarge and coalesce (Grow together into one big affected area) [2].

**Sheath Spot**  
*Rhizoctonia oryzae*

This disease is caused by *Rhizoctonia oryzae* and produces spots similar to sheath blight but is confined to the basal part of the rice plant [2].

**Leaf Smut**  
*Entyloma oryzae*

Leaf smut, which appears as blackish smutty spots on both sides of rice leaves, is caused by *Entyloma oryzae*. Numerous spots may be found on rice leaves late in the season; however, this disease does not cause economic damage at this time [2].

**Narrow Brown Leaf Spot**  
*Cercospora oryzae*

The fungus *Cercospora oryzae* produces short, linear, brown lesions, most commonly on leaves and becoming more numerous as the plant matures. Fortunately most of the currently grown varieties have fairly good resistance to this disease [2].
Weeds

Weeds are the most serious pest affecting rice production in Mississippi. Weeds compete with rice for water, plant nutrients, space and sunlight. Weeds increase harvesting costs and drying problems and can reduce crop yields, quality, and market value. Ten most common weeds in rice in Mississippi are barnyardgrass, hemp sesbania, pitted morningglory, palmleaf morningglory, red rice, ducksalad, purple ammannia, Amazon sprangletop, broadleaf signalgrass and yellow nutsedge. Ten most troublesome weeds in Mississippi in rice are barnyardgrass, palmleaf morningglory, pitted morningglory, red rice, Amazon sprangletop, ducksalad, purple ammannia, yellow nutsedge, broadleaf signalgrass, hemp sesbania. [15] Several algae may also cause problems. Research has shown that one barnyardgrass plant per square foot reduced rice yields by 25 percent where a good stand of rice existed. The study also indicated considerably higher yield losses occurred as rice population decreased. Also, considerable yield losses occurred when barnyardgrass competed for as little as three weeks. Therefore, maximum yield potential can only be expected when early weed control is obtained [2].

Hemp sesbania also causes significant losses, depending on how long it competes. Rice yields are reduced most during the time hemp sesbania shades rice plants. Control of weeds can best be accomplished by using an integrated program of cultural, mechanical, and chemical control practices [2].

A number of rice weed pests produce hard, dark colored seed. The harvesting and processing of rice from fields infested with these dark seed producing weeds often fail to eliminate these seeds from the finished commercial rice. Rice contaminated with these seeds has a greatly reduced value because of consumer preference for a noncontaminated, essentially white, final product [6].

Estimated Losses Due to Weeds in Rice in Mississippi:

Cost of Herbicides:

a. Acres 245,000
b. Cost/A 42.00
c. Value $10,290,00

Loss in Yield:

a. Acres 70,000
b. Cost/A 40.00
c. Value $2,800,000
Loss in Quality:

a. Acres 65,000  
b. Cost/A 53.00  
c. Value $3,445,000

Loss in Extra Land Preparation and Cultivation:

a. Acres 130,000  
b. Cost/A 15.00  
c. Value $1,950,000

Loss in increased Cost of Harvesting:

a. Acres 28,000  
b. Cost/A 10.00  
c. Value $280,000

Cultural practices for weed control prevent or reduce weed infestations, suppress weed growth and kill weeds. Some cultural control methods are planting weed-free seed, seedbed preparation, land leveling, levee construction, water management and hand roguing. Cultural practices in combination are more effective in controlling weeds than one method used alone.

Planting quality seed is the first step to weed control by preventing fields from becoming infested. Using high quality seed allows quicker emergence, stand establishment, and flooding (2 to 4 inch depth). Purchasing seed which have been grown under a Mississippi certification program aids in weed control. Red rice is spread largely by planting rice seed contaminated with red rice. Other weeds such as sesbania and barnyardgrass can also be spread when planting rice seed [2].

Rotating rice with other crops, such as soybeans, wheat, milo, and cotton, helps broadleaf and aquatic weed control, if good weed control is achieved in the rotated crop. If red rice is a problem, generally a rotation of 2 years in soybeans and 1 year in rice permits the best weed control. However, red rice can be controlled in other rotational crops integrated in a program with soybeans and rice. Clearfield rice was approved for use in 2002 and offers an effective method of controlling red rice. Rotating rice with other crops also discourages dense infestations of aquatic weeds [2].

Non-chemical weed management is important in Mississippi rice production. Mechanical control after planting (exclusive of the destruction of weed vegetation prior to planting) is of no importance since rice is not grown in rows or is grown in rows of eight inches or less. This eliminates cultivation as an in-season weed control practice. Biological control to date has been of limited value. The commercialization of the mycoherbicide Collego was unsuccessful in Mississippi (and other states) because it only controlled one species of weed in a multiweed complex [14].
Water management continues to be vital in rice weed management. Precise timing, duration and depth of flooding of rice fields accounts for about 40% of obtainable weed control of most common weeds and over 60% of obtainable control of red rice. Many rice weeds cannot become established in a flooded field. Certain terrestrial weeds (pigweeds, most morningglories, etc.) will be controlled if covered by a flood even after they have become established. Rice production in Mississippi requires a drainage period to allow the rice to become established in a water-seeded situation or to allow the rice to emerge from the soil in a drill or dry-seeded system. The drainage period is crucial to the development of most weed problems. Prolonged flooding also can encourage the growth of true aquatic weeds (weeds able to germinate under flooded conditions). Aquatic weeds such as ducksalad, redstem and alligatorweed proliferate under prolonged periods of floodings [14].

Flooding of rice fields during the winter has enabled some farmers to avoid a burn-down spray, for broadleaf weed control. The use of precision flooding of rice fields has allowed some farmers to reduce the in-season applications of propanil from two to one. [2]

Preplant applications: [6]

- **Molinate (Ordram 8E)** Recommended rate of 3-4 lb ai/A for dry seeded rice and 4 lb/A for water seeded rice. Ordram 8E should be applied at 3-4 pt/A preplant incorporated (PPI). It controls early season grasses and sedges.

- **Glyphosate (Roundup Weathermax, Touchdown, Glyphomax)** Recommended rate of 0.37-2 lb ai/A. Glyphosate should be applied preplant/ preemergence at 12-64 oz/A. It controls annual and perennial grasses and broadleaf weeds.

- **Paraquat (Gramoxone Extra)** Recommended rate range of 0.7-0.94 lb ai/A. Gramoxone Extra should be applied preplant/ preemergence at 2-3 pt/A. It controls annual and perennial grasses and broadleaf weeds.

- **Glyphosate + thiobencarb (Roundup Ultra + Bolero)** Recommended rate of 0.37 –1.0 lb ai/A + 4 lb ai/A. Glyphosate should be applied at 12 to 32 oz/A + 4 pt/A Bolero. It should be applied preplant or preemergence to soils with greater than 45% clay. It controls most winter annual weeds and up to 4 weeks residual control of most annual grasses and aquatics.

- **Quinclorac + glyphosate (Facet 75 DF+ Glyphosate)** Recommended rate of 0.25 –0.5 lb ai/A + 0.37 –2.0 lb ai/A. Facet 75 DF + Glyphosate should be applied preplant within 7 days of planting at 0.33-0.67 lb/A + 12-64 oz/A. It controls winter annual and perennial grasses and broadleaf weeds.

- **Thifensulfuron + Tribenuron (Harmony Extra)** Recommended rate of 0.375 + 0.45 oz ai/A. Harmony Extra should be applied at least 45 days prior to planting at 0.5 to 0.6. oz/A. It controls winter annual and some perennial broadleaf weeds including curly dock.

- **2,4-D (Weedar 64)** Recommended rate of 1.2 lb ai/A. Weedar 64 should be applied at 2.5 pt/A during the winter and early spring at least 30 days prior to planting. It controls annual and perennial broadleaf weeds.

- **Thiobencarb (Bolero)** Recommended rate is 4 lb ai/A. Bolero should be applied at 4 pt /A
preplant/preflood (water seeded). It controls barnyardgrass, sprangletop and provides 3-4 weeks of aquatic weed control.

Preemergence/Delayed Pre: [6]

- **Clomazone (Command 3 ME)** Clomazone is currently sold as Command, Commit, and other trade names. Clomazone provides preemergence control of grass weeds but controls very few broadleaf weeds and sedges. However, its residual activity is above average, it is convenient to use, and it is currently among the lowest-cost rice herbicides to be applied conveniently in an immediate-post-plant, true-preemergence application. Clomazone has been widely adopted by rice producers, and weed control strategies have shifted largely to preemergence clomazone followed by an appropriate broadleaf-controlling herbicide. Clomazone’s weakness on nutsedges has increased the use of halosulfuron andbensulfuron as preflood cleanup treatments. On occasion, clomazone will provide incomplete grass control, and for that reason, propanil is often applied and is retaining its status as a key rice herbicide.

- **Glyphosate + Pendimethalin (Prowl)** Recommended rate of 0.37-2 lb ai/A + 0.75-1.0 lb/A. Glyphosate + Prowl 3.3EC is applied delayed pre at 12-64 oz/A + 1.8-2.4 pt/A. It controls winter annual weeds and has residual grass control.

- **Imazethapyr (NewPath)** Imazethapyr is currently being developed along with imazethapyr-resistant rice that was produced via mutation breeding techniques. Imazethapyr is best known as the soybean herbicide Pursuit; however, Newpath is the name for this herbicide in imazethapyr-resistant (or Clearfield) rice. As with glufosinate and glufosinate-resistant rice, selective red rice control is a highlight. Current results indicate that on silt-loam soils, an incorporated or preemergence application followed by a postemergence application will be needed for acceptable red rice and grass control. On some clay soils, soil applications may provide poor results, thus the postemergence application is needed. Imazethapyr provides poor control of hemp sesbania and jointvetch species, and consequently, an additional herbicide will be added to the overall weed control program for control of those weeds.

- **Pendimethalin (Prowl 3.3EC)** Recommended rate range of 0.75 to 1 lb ai/A. Prowl is applied at 1.8 to 2.4 pt/A. It controls annual grasses including sprangletop and broadleaf signalgrass for up to 3 weeks.

- **Thiobencarb (Bolero)** Recommended rate of 4 lb ai/A. Bolero should be applied at 4 pt/A delayed Pre. (1-5 days before rice and weed emergence). It controls barnyardgrass, sprangletop, ducksalad, redstem, water hyssop, false pimpernel, annual umbrella plant, and spikerush.

- **Quinclorac (Facet 75 DF)** Recommended rate of 0.25 to 0.5 lb ai/A. Facet 75 DF should be applied at 0.33 to 0.67 lb/A Pre/Delayed Pre. It controls annual grasses except sprangletop. It also controls morningglory, sesbania and eclipta.

- **Quinclorac + Pendimethalin (Facet 75 WP+ Prowl 3.3 EC)** Recommended rate of 0.25-0.5 lb ai/A + 0.75 –1 lb ai/A Facet + Prowl should be applied at 0.33-0.67 lb/A + 1.8-2.4 pt/A delayed Pre. It controls annual grasses, including sprangletop. Also controls morningglory and sesbania.

Postemergence: [6]
• **Propanil** Recommended rate of 3 to 4 lb ai/A. It should be applied at 3 to 4 qt/A of 4 lb/gal formulation in 10 gal water for aerial application and 15 to 20 gal water for ground application. It should be applied when barnyardgrass is in the 1 to 4 leaf stage. It controls barnyardgrass and many other grasses and broadleaf weeds common in rice fields.

• **Fenoxaprop (Whip 360 0.67 WE)** Recommended rate range of 0.06 to 0.067 lb ai/A. Whip should be applied at 0.7 to 0.8 pt/A. It should be applied to 4-leaf to late tillering rice. It controls barnyardgrass, sprangletop, broadleaf signalgrass, johnsongrass, and other grasses in rice. Fenoxaprop should not be applied within three days following cloudy weather or within 14 days following fertilizer.

• **Quinclorac (Facet 75DF)** Should be applied at 0.25 to 0.5 lb ai/A. Facet should be applied at 0.33 to 0.67 lb/A at early postemergence. It controls 1 to 2 leaf barnyardgrass, broadleaf signalgrass, crabgrass, junglerice, sesbania, and eclipta. It also controls 2 to 6 leaf morningglory. Facet will not control sprangletop.

• **Propanil** Recommended rate of 6 to 8 lb ai/A for split application where flooding is delayed. It should be applied as total of 6 to 8 qt/A of 4 lb/gal formulation in two applications. It should be applied in split applications of 3 to 4 lb/A when weeds are in 1 to 3 leaf stage and the second application should be made when needed using the same rate as the first application. It controls barnyardgrass, and many other grass and broadleaf weeds common in rice fields.

• **Propanil + Molinate (Propanil 4 EC + Ordram 8EC or Arrosolo)** Recommended rate of 3.0 lb ai/A + 3 lb ai/A. Propanil + Ordram should be applied at 3 qt/A + 1.5 qt/A or Arrosolo should be applied at 4 qt/A. It should be applied when amazon sprangletop is less than 0.5 inches in height and dayflower is less than 2 in. It controls amazon sprangletop. It also controls 3 to 4 leaf barnyardgrass and many other common grass and broadleaf weeds.

• **Fenoxaprop-p-ethyl (Ricestar)** Recommended rate of 13 fluid oz/acre in the 1 to 2 leaf stage and 17 fluid oz/acre for the 3 to 4 leaf stage. Ricestar controls barnyardgrass, spangletop, and signalgrass.

• **Quinclorac + Propanil (Facet 75 DF + Propanil)** Recommended rate of 0.25-0.5 lb ai/A + 3-5 lb ai/A. Facet should be applied at 0.33 to 0.67 lb/A in combination with propanil 3-5 lb/A early postemergence. It controls a broad spectrum of grasses and broadleaf weeds.

• **Quinclorac + Bentazon (Facet 75DF + Basagran)** Recommended rate of 0.25 to 0.5 lb ai/A + 0.75-1 lb ai/A. Facet + Basagran should be applied at 0.33 to 0.67 lb/A + 1.5 to 2 pt/A at early postemergence. This mixture controls the same weeds controlled by Facet with addition of redstem, ducksalad, and cocklebur.

• **Quinclorac + Propanil + Molinate (Facet + Arrosolo)** Recommended rate of 0.25 to 0.5 lb ai/A + 2.25 to 3 lb ai/A. Facet + Arrosolo should be applied at 0.33 to 0.67 + 3-4 qt/A early postemergence. It controls a broad spectrum of grasses, especially amazon sprangletop and broadleaf weeds.

• **Thiobencarb + Propanil (Bolero + Propanil 4EC)** Recommended rate of 3-4 lb ai/A + 3-4 lb ai/A. Bolero + Propanil should be applied at 3-4 pt/A + 3-4 qt/A of 4EC or equivalent dry flowable formulation. It should be applied early postemergence. Grasses should be in 1 to 3 leaf stage or less, aquatics should be less than 0.5 in tall, and broadleaf weeds less than 2 in. tall. It controls many grass and broadleaf weeds common in rice fields.

• **Propanil + Pendimethalin (Propanil 4EC + Prowl 3.3 EC)** Recommended rate of 3 to 4 lb ai/A
Propanil + Prowl should be applied at 6-8 pt/A + 1.8 to 2.4 pt/A in 10 gal of water for aerial application. It should be applied after rice emerges and barnyardgrass is in 1 to 3 leaf stage. This mixture is applied postemergence to control barnyardgrass and many other grasses and broadleaf weeds common in rice fields. Preemergence control of barnyardgrass, sprangletop, broadleaf signalgrass, and crabgrass.

- **Bentazon (Basagran)** Recommended rate range of 0.75 to 1 lb ai/A. Basagran should be applied at 0.75 to 1 qt/A in 10 gal water for aerial application. It should be applied at least 24 hours before permanent flooding. On flooded fields, lower flood or drain before application. It controls dayflower, smartweed, redstem, cocklebur, and yellow nutsedge.

- **Bensulfuron (Londax 60DF)** Recommended rate of 0.6 to 1 oz/A. Londax should be applied at 1 to 1.6 oz/A in 10 gal water for aerial application. It should be applied to flooded field preemergence to weeds or very early postemergence to submerged aquatic weeds. Red stem and yellow nutsedge should be 3 to 4 inches above water application. It controls aquatic weeds and yellow nutsedge.

- **Bispyribac (Regiment)** A key feature of bispyribac is that it controls relatively large barnyardgrass and hemp sesbania. It is anticipated that bispyribac will become an option for pre- or postflood control of weeds that escaped earlier applications. Regiment is recommended at 0.4 – 0.6 oz/acre for control of barnyardgrass.

- **Carfentrazone (Aim)** Aim 2EC is recommended at a rate of 1.6 – 3.2 oz/acre. Carfentrazone is sold as Aim in the mid-south and as Shark in California. In the mid-south, carfentrazone is used primarily in pre- and postflood applications for control of common broadleaf weeds. Carfentrazone provides fairly good control of smartweed, which can be difficult to control with other herbicides.

- **Cyhalofop (Clincher)** Clincher 2.38 EC is recommended at a rate of 13.5 – 15 oz/acre and is a postemergence herbicide that only controls grass species. Cyhalofop is a good herbicide for grass control in rice fields that are adjacent to broadleaf crops such as cotton. Cotton and soybeans are sensitive to a number of rice herbicides, most notably propanil and quinclorac. Research has also shown promise for cyhalofop to be used for postflood salvage of large barnyardgrass.

- **Halosulfuron (Permit)** Permit 75 DF is recommended at a rate of 1 – 1.6 oz/acre. Halosulfuron is a broadleaf and nutsedge herbicide that is typically applied shortly before flooding in delayed-flood, drill-seeded rice. Nutsedge activity has been excellent, and general broadleaf weed control has also been good.

- **Quinclorac + bensulfuron (Facet 75 DF + Londax 60 DF)** Recommended rate of 0.25 to 0.5 lb ai/A + 0.6 to 1 oz/A. Facet + Londax should be applied at 0.33 to 0.67 lb ai/A + 1 to 1.6 oz/A. It should be applied postemergence 1-2 days prior to permanent flood. This mixture controls grasses, broadleaf weeds and yellow nutsedge.

- **Molinate (Ordram 15G)** Recommended rate of 3 to 3.75 lb ai/A. Ordram should be applied at 20-25 lb/A. It should be applied in first flood water on dry seeded rice when barnyardgrass is less than 12 inches tall. It controls barnyardgrass specifically. Also suppression of sprangletop and spikerush. Most broadleaf and aquatic weeds are not controlled.

- **Acifluorfen + bentazon (Storm)** Recommended rate of 0.25 + 0.5 lb ai/A. Storm should be applied at 1.5 pt/A. It should be applied after rice tillering to early boot. This mixture controls cocklebur, dayflower, hemp sesbania, redstem, smartweed and yellow nutsedge.
• **Propanil + triclopyr (Propanil 4EC + Grandstand)** Recommended rate of 3 to 4 lb ai/A + 0.19 to 0.25 lb ai/A. Propanil + Grandstand should be applied at 3-4 qt/A + 0.5 to 0.67 pt/A. It should be applied after rice is past the 3 leaf stage. Grandstand (0.5 pt) should be used for 2 leaf rice. It controls many grasses and broadleaf weeds common in rice fields.

• **Propanil + Molinate + Triclopyr (Arrosolo + Grandstand)** Recommended rate of 3 lb ai/A + 3 lb ai/A + 0.19 to 0.25 lb ai/A. Arrosolo + Grandstand should be applied at 4 qt/A + 0.5 to 0.67 pt/A. It should be applied after rice is past the 3-leaf stage. Grandstand (0.5 pt) should be used for 2 leaf rice. It controls most grasses to include sprangletop species and broadleaf weeds common in rice fields.

• **Quinclorac + Acifluorfen + Bentazon (Facet 75DF + Storm)** Recommended rate of 0.25 to 0.5 lb ai/A + 0.25 to 0.5 lb ai/A. Facet + Storm should be applied at 0.33 to 0.67 lb/A + 1.5 pt/A. It should be applied after rice is past the 3-leaf stage. This mixture controls grasses and broadleaf weeds such as cocklebur, dayflower, hemp sesbania, redstem, smartweed, and yellow nutsedge.

**Midseason:** [6]

• **2,4-D (2,4-D amine 4EC)** Recommended rate of 0.75 to 1.25 lb ai/A. It should be applied at 0.75 to 1.25 qt/A in 5 to 10 gal of water for aerial application by helicopter or ground applicator. It should be applied at late tillering stage but before first elongated internode exceeds 0.5 in. in length. It controls hemp sesbania, curly indigo, redstem, ducksalad, gooseweed, smartweed, spikerush, umbrellasedge, water hyacinth, morningglory, and dayflower.

• **Triclopyr (Grandstand)** Recommended rate of 0.25 to 0.38 lb ai/A. Grandstand should be applied at 0.67 to 1 pt/A. It should be applied from 3-leaf to midseason. It controls many midseason broadleaf weeds.

• **Acifluorfen (Blazer Ultra)** Recommended rate range of 0.125 to 0.25 lb ai/A. Blazer should be applied at 0.5 to 1 pt in 5 to 10 gal water/A. Apply to actively growing sesbania before it flowers. Apply to rice prior to early boot stage. It controls hemp sesbania.

• **Propanil** Recommended rate range of 2 to 3 lb ai/A. It should be applied at 2-3 qt/A of 4 EC. It should be applied at midseason when the first elongating internode of rice is less than 0.5 inches in length. It controls hemp sesbania less than 5 feet tall. Lower rates may be used on weeds 3 feet or less.

**Salvage:** [6]

• **Molinate (Ordram 15G)** Recommended rate of 3.75 to 5 lb ai/A. Ordram should be applied at 25 to 33 lb/A. It should be applied to 12 to 24 in. barnyardgrass or up to 8 in. sprangletop. It controls large barnyardgrass and sprangletop.

• **Propanil + 32% N solution at 4 lb + 9 gal/A.** It should be applied at 4 qt/A of 4 EC + 9 gallons of 32% nitrogen solution/A. It should be applied to heading barnyardgrass and before rice flag leaf appears. This mixture burndowns large grasses.

• **Fenoxaprop (Whip 360 0.67 WE)** Recommended rate of 0.067 lb ai/A. Whip should be applied prior to midseason at 0.8 pt/A postflood to grass with more than 2 tillers. It suppresses grasses.
Preharvest: [6]

- **Sodium chlorate** Recommended rate of 4.5 lb ai/A. It should be applied as a 1.5 gal of a 3 lb/gal formulation in 10 gallons of spray solution. It should be applied 7 days before harvest. It produces desiccation of weeds and "down" rice.

Red rice control: Steps should be taken to prevent the introduction of this weed into rice fields. These steps include use of rice seed free of red rice, cleaning equipment before entering uninfested fields, and hand roguing of light infestations. Where severe infestations occur, several cycles of a 2-year soybean or a 1-year sorghum - 1 year soybean rotation with rice are suggested. During the years out of rice, strive for 100% red rice control. Use a combination of preemergence and postemergence herbicides recommended for the control of red rice. A combination of shallow spring and fall disking in conjunction with clod disruption also should be used reduce the soil reserves of red rice by stimulating germination and destroying germinated seed. When rice is planted, an early season variety should be used. It should be planted late to allow for additional spring tillage and seeded at a rate that allows a good competitive stand. The early season varieties mature earlier, thereby limiting the amount of red rice that shatters before harvesting as well as extending the time interval for additional fall tillage. [9]

Herbicide Development

Two genetically altered rice varieties that are resistant to various herbicides are getting closer to being available. Seed of varieties containing Liberty-resistant genes could be available in 2006. Such rice plants would withstand applications of the herbicide glufosinate, providing effective control of a board spectrum of weeds including red rice. [6]

Worker Activities

**Land Preparation, Seedbed Preparation, and Planting:** For the production of rice in Mississippi, worker activities are centered on land preparation, seedbed preparation and planting. Some of the land preparation is done in early spring of the year prior to the spring rains. Fields for growing rice should be relatively level but gently sloping toward drainage ditches. By gently sloping fields this will aid in necessary early drainage in the spring for early soil preparation which permits early seeding, uniform flood depth which reduces the amount of water needed for irrigation, and the need for fewer levees. Seedbed preparation is particularly critical in the coarser textured soils. The seedbed should be well pulverized and firm to maintain proper moisture conditions for drilling and to insure rapid germination and emergence of the rice plant. Although seedbed preparation is not as critical in areas where rice is not drilled, it is important to insure that the desired soil condition is achieved to allow rapid emergence of the rice plant. Planting methods depend on soil type, weather conditions, and producer preferences. The main factors to consider in selecting seeding methods are uniformity of seed distribution and seedling emergence.
In all these activities worker injuries are very few. Because most of the activities described above are accomplished with mechanical equipment, only a few bruises or cuts should occur.

**Cultivation** – Because the growth habit and flood culture of rice, mechanical cultivation after planting does not exist.

**Fertilization/Pesticide Application** – With the advent of Global Positioning System, flaggers are no longer used for the application of fertilizers and pesticides. In Mississippi, over 85% of the pesticides and fertilizers are applied by air. Some applications of fertilizers and pesticides are still applied by ground equipment, particularly during land preparation or seedbed preparation. During this time of using ground equipment a worker could be exposed to residue from either fertilizer dusts or pesticides, but with the proper Personal Protective Equipment the risk of exposure is greatly reduced.

**Irrigation** – Irrigation in rice is essentially managing or maintaining the floodwater on the rice plant. This is accomplished through pumping water from wells, coupled with ditch, canal, and levee management. Worker activity in this area involves the possible moving of pipe or the opening of levee openings, risk to the worker is minimal and injuries rarely occur.

**Scouting** – The only time workers are in the fields and not on a piece of heavy machinery usually involves pest monitoring. The producer or a hired consultant does most of the pest monitoring, if workers are used for scouting ATV’s (all terrain vehicles) are used to assist in the monitoring. Conceivably a worker could have an injury involving an ATV. However, the speed at which one travels in a rice field is so slow, injury rarely if ever happens.

**Harvesting** – Combine harvesters or “combines” are machines that do the cutting, threshing, and pre-cleaning of the rice in one operation. Self-propelled with an enclosed and often temperature regulated cab, combines have a cutting apparatus, a threshing chamber composed of a revolving threshing drum (with teeth), and a stationary counter-thresher. Two major types are used: a conventional setup and a stripper-header. There are variances among augers and feeding mechanisms among the two. Generally the stripper-header offers considerably faster harvesting, but it does have drawbacks. It is more expensive, heavier to operate, and is limited to small grains (rice, wheat, oats, etc.). This makes it difficult for a grower who wishes to use the same combine for another crop such as soybeans in rotation with rice.

Generally, a minimum of 4-5 people are involved in rice harvesting: one to operate the combine, one to drive a grain cart, and two or more to drive the trucks to the grain elevator for drying and storage in bins. Depending on the equipment used and field conditions, 25 –50 acres may be harvested in one day.

There are times when the combine will become clogged and require manual removal of debris from the header or cutter mechanism. Cuts, bruises, and abrasions can occur as a result. In rare cases, a fatality or loss of a limb can occur when an operator, who does not properly shut off the header mechanism,
attempts to remove debris from the header. This occurred more often in years past, but due to more safety features of the equipment, including automatic shutoff devices, fatalities or loss of limbs is rare. Institutions that gather agricultural statistics such as the USDA and NIOSH (The National Institute for Occupational Safety and Health) do not carry data specific to rice combine injuries and fatalities. However, state rice specialists agree the occurrence of fatalities and injuries involving rice combines is declining. [16]

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10. Ingram, Dr. David, Mississippi State University

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