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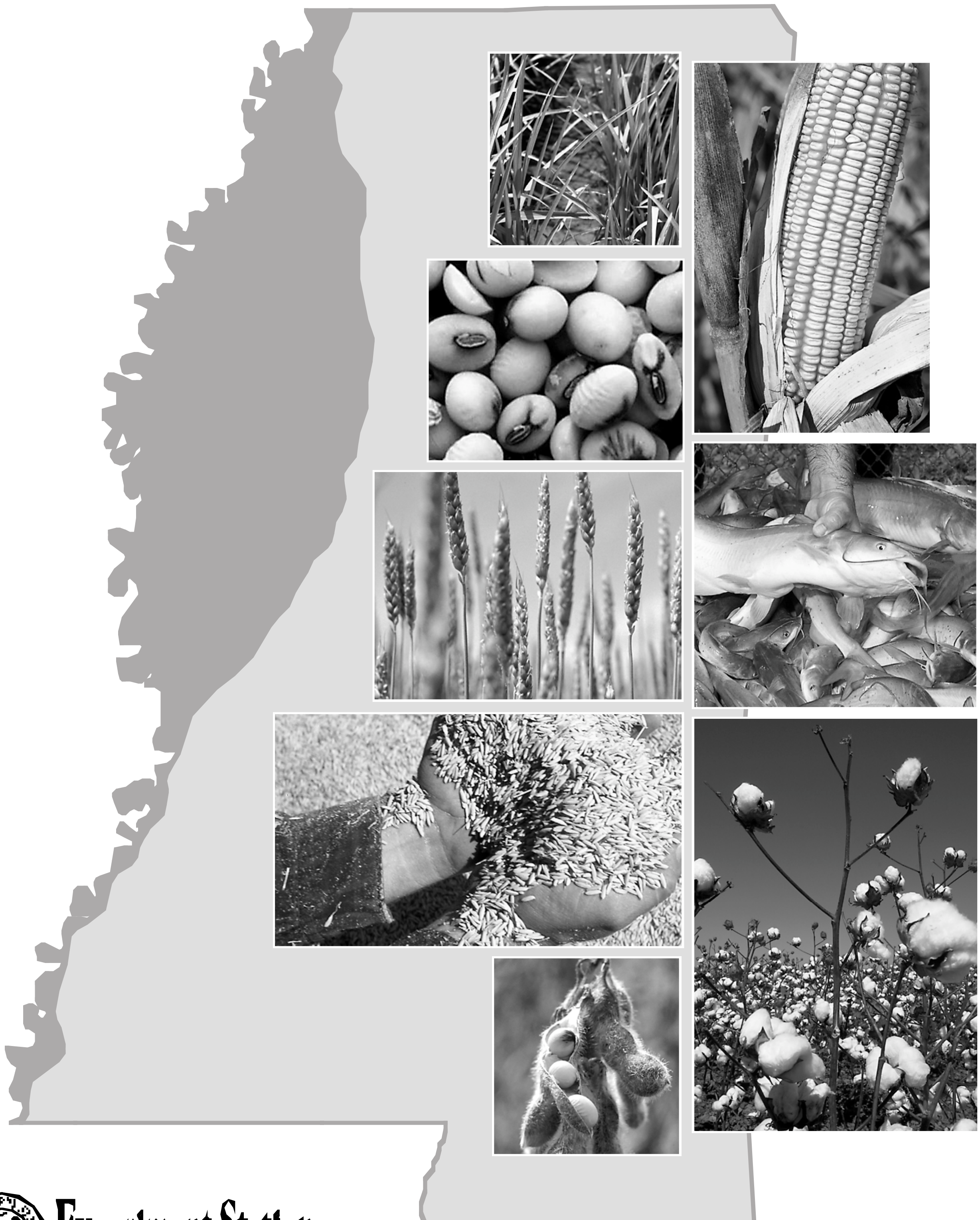
Current Agricultural Practices of the Mississippi Delta



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Current Agricultural Practices of the Mississippi Delta

Abstract

The Mississippi Delta is one of the largest contiguous agricultural areas in the United States with an area of more than 4 million acres. With deep, alluvial soils, 220 to 260 frost-free days per year, average annual soil temperatures greater than 59°F at a 20-inch depth, and annual precipitation ranging from about 45 inches in the northern Delta to 60 inches in the southern Delta, this region is agronomically very productive under proper management. In addition, its near level topography is well suited for large-scale mechanized agriculture. Major agricultural enterprises of the Mississippi Delta include cotton, soybean, rice, corn, small grain, forage, vegetables, and catfish. The following is a general overview of production practices of major crops grown in the Mississippi Delta.

Overview of the Mississippi Delta Ecosystem

The Mississippi Delta has many advantages for commercial crop production. Its topography is well suited for large-scale mechanized agriculture. Typical of large flood plains, the area ranges from nearly flat to undulating, gentle slopes (1). Elevations range from about 49 to 200 feet above sea level. There are extensive surface water resources with more than 99,000 acres of perennial streams and lakes. Oxbow lakes, created from past stream and river meandering, are prevalent throughout the region. These lakes serve as water sources for irrigation and recreation, as well as a natural filtering and flood control system.

Delta soils are largely alluvial and very deep, having developed over many years of deposition from seasonal flooding of the Mississippi River and its tributaries. Delta soils are nutrient rich, but they vary widely in texture, structure, depth, and frequency of overflow from rivers and bayous. At a modest cost, most Delta soils can be satisfactorily land formed and adequate water supplies obtained from relatively shallow depths for irrigation. Coarser, sandier materials tend to be deposited adjacent to or in close proximity to rivers and bayous, while finer textured silts and clays are deposited farther away in slack water areas. Many clayey soils contain 2:1 expandable montmorillonite clay, which swells when wet and shrinks when dry. These clayey soils are commonly referred to as “gumbo” or “buckshot.” During prolonged summer dry periods, soil cracks may develop up to 3 inches wide and more than 30 inches deep. Because these clayey soils have low permeability to water, they are difficult to manage when wet and slow to dry in the spring. The dominant soils are Aquepts, Aqualfs, Aquents, Udolls, and Udalfs. They are deep, medium- and fine-textured soils that have an udic or aquic moisture regime, a thermic temperature regime, and mostly smectitic or mixed mineralogy. Fine-textured Epiaquerts (Alligator and Sharkey series) and medium-textured Fluvaquents (Commerce and Mhoon series), Endoaqualfs (Dundee and Forestdale series), and Hapludalfs (Dubbs and Bosket series) occupy back swamp areas and older natural levees. Other soils, although less common, include moderately coarse-textured Dystrochrepts (Beulah series) and Udifluvents (Robinsonville series) (2).

Many crops may be produced in the Mississippi

Delta. Agronomic management practices will vary with soil type, crops grown, time of planting, and recent prevailing weather conditions. Surface drainage and proper soil management are critical for optimum production. Levees and flood control measures, many constructed by the United States Army Corp of Engineers, have reduced the incidence of major flooding in inhabitable and crop production areas.

Average yields over a period of years for major crops on highly managed soils typical of the Delta are listed in Table 1. Crops requiring good drainage, such as cotton (*Gossypium hirsutum*), corn (*Zea mays*), and most vegetables, are suited for the well-drained soils. These are predominately sandy loam, silt loam, or loamy soils and include Bosket, Commerce, Dubbs, Dundee, and Robinsville series. They compact easily under equipment traffic, generally respond to subsoiling, and can be planted soon after a rain. Many of these soils are low in organic matter content, ranging from 0.5% to 2%, while 0.9% to 1.5% is most typical. Organic matter is closely related to clay content; generally, as clay content increases, organic matter increases.

Silty clay loams, loamy clays, and clay soils, such as Forestdale, Alligator, and Sharkey series, typically have high clay content and are mostly found on flats or in depressions. They have somewhat poor to very poor internal drainage and require special treatment to improve surface drainage. Many of these soils are well suited to flood culture rice. Forestdale silty clay loams can be utilized for cotton production because they have comparatively better drainage. This soil may respond to subsoiling. Fall plowing, subsoiling, and bedding are often necessary for satisfactory production (2).

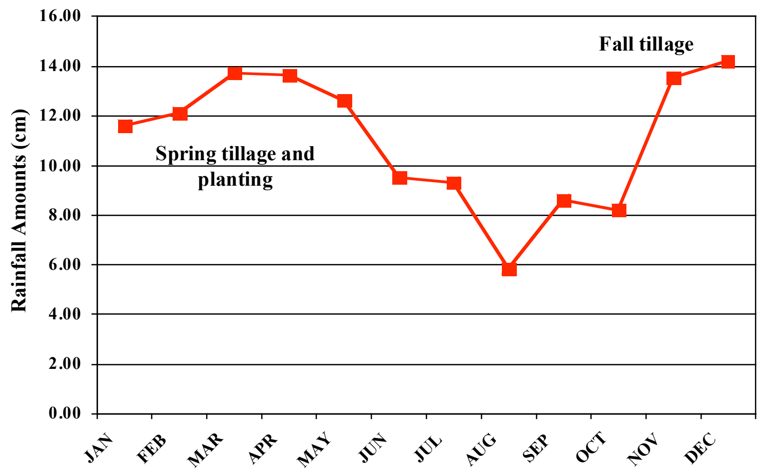

Figure 1. Thirty-year rainfall patterns (1964-1993) for Stoneville, Mississippi. SOURCE: Mississippi Agricultural and Forestry Experiment Station, 1995.

Yearly rainfall amounts in the Mississippi Delta range from approximately 45 inches per year in the northern areas of the region to 60 inches per year in the more southern portions (3). Although rainfall seems plentiful, much of it occurs during months in which the major crops are not produced and production surface areas have their greatest exposure. This leaves the soil surface most vulnerable to erosion during winter and early spring months (4) when crops are not being grown. Data collected at the Delta Research and Extension Center in Stoneville, Mississippi, over a 30-year period showed that 72% of the yearly rainfall occurred from September to April, whereas only 28% occurred during May, June, July, and August (Figure 1) (5). Due to the rainfall distribution, irrigation is often necessary to meet crop needs and provide a measure of risk management against crop loss due to drought.

Table 1. Yields of major crops on typical Delta soils. [1]

Soil type	Cotton	Soybean	Rice	Corn	Wheat
	lb/A	*lb/A*	*lb/A*	*lb/A*	*lb/A*
Dundee	749	2,096	—	5,588	2,395
Forestdale	599	2,096	5,838	3,493	2,095
Sharkey	599	2,096	5,838	—	1,796
Alligator	599	2,096	5,838	—	1,497
Commerce	823	2,359	—	5,938	2,994
Tunica	599	2,096	—	3,493	1,796
Dubbs	798	2,096	—	5,938	2,395
Robinsville	823	2,395	—	8,033	—
Tutwiler	798	2,096	—	4,191	1,796

[1]SOURCE: Adapted from Anderson and Pettry, 1978.

Historical Agronomic Production Practices

For more than two centuries, agriculture has been the mainstay of the Mississippi Delta economy. Early agriculture was limited to tobacco production in the Natchez area and indigo in the lower Mississippi Valley Region. Though settlers had crowded into other parts of Mississippi by the early 1800s, the Delta region was avoided due to dense, almost impenetrable cypress swamps (6). By the early 1800s, however, eastern cotton planters, whose land was worn out by continuous agriculture production, began to move into the Delta in search of fertile soils. Agriculture quickly developed into a labor-intensive plantation-system based on African slave labor. Cotton had become the Delta's major crop and remained so until the Civil War.

Following the Civil War, sharecropping and tenant farming replaced the slave-based plantation system. During the late 19th century and early 20th century, no fundamental changes were made in agricultural production of major Mississippi crops (7). Crop production was still a process of hand labor with a hoe, a mule, and a few small tillage implements. With the exception of having more workers, labor methods for large farming operations were the same as for small ones. In the Delta region, the almost annual flooding of the Mississippi River hindered access to its fertile soils. Intensive development of its fertile agricultural lands was not possible until the early 20th century, when systems of levees were constructed to control flooding from the Mississippi River.

Throughout the 20th century, agriculture in much of the Mississippi Delta evolved into large, mechanized, low-labor, and capital-intensive farms. The 20th century also saw an increase in diversification of commodities from cotton to commodities such as catfish (*Ictalurus punctatus*), rice (*Oryza sativa*), corn, and soybean (*Glycine max*).

Agriculture continues to be the major contributor to the economy of Mississippi, and the Delta is pre-eminent in the state, as well as the nation. In 2002, as a percent of total harvested acres in the state, the Delta accounted for 97% of the rice, 81% of the cotton, 79% of the soybean, 67% of the corn, and 88% of the acres of water surface in catfish production (Table 2) (8). Though more acres of soybeans are harvested in the Mississippi Delta, cotton represents the major dollar value to the region, followed by soybean, catfish, corn, and rice.

Table 2. Major agricultural commodities and their value — Mississippi Delta (including part Delta) counties, 2002.[1]

Crop	Harvested area[2] (x 1,000 acres)	Percent of Mississippi total	Value (x $1,000)
Cotton	931	81	370,591
Catfish[3]	98	88	240,030
Soybeans	1,086	79	243,312
Rice	246	97	62,339
Corn	357	67	154,363
Total			1,070,635

[1]Part Delta counties include Tallahatchie, Grenada, Panola, Tate, Carroll, Holmes, and Warren.
[2]SOURCE: USDA – NASS.
[3]Water surface area used for production.

The major components that characterize production systems in the Mississippi Delta include proper selection of crop cultivar, pest control, cropping system, tillage methods, nutrient management, and water management. Each component must be selected according to individual farm and/or crop situation.

Crop Cultivar Selection

Crop cultivar selection is a critical step a producer must consider when planting the crop. Cultivar selection impacts numerous aspects of crop production, including maturity dates, commodity quality, yield potential, pest tolerance, and growth characteristics. Development of new cultivars for the region has increased over the last several years. This has been largely due to integration of transgenic crops into cotton, corn, and soybean production systems. Transgenic crops provide new opportunities in the region to help combat major insect and weed pests.

Crops carrying herbicide-tolerant genes have been developed to survive application of specific herbicides that would normally injure the crop. The most common herbicide-tolerant crops are resistant to glyphosate (*N*-phosphonomethylglycine), an herbicide effective on many species of grass, broadleaf weeds, and sedges. Glyphosate tolerance has been incorporated into cotton, corn, soybean, and canola.

Some cultivars have been genetically modified to include a gene from the soil bacterium, *Bacillus thuringienesis* var. *Kurstaki* (Bt). The bacteria produce a protein toxin within the plant that kills certain Lepidoptera (caterpillar) insects when they feed on the plant. The Bt gene has been incorporated into several crops including corn and cotton.

Fertility

Nitrogen (N) is the most important macronutrient necessary for crop production in the Delta (Table 3). Nitrogen is very mobile in soils and undergoes rapid transformation. In warm, humid climates such as in Mississippi, soil-based N transformations occur throughout the year. Nitrogen source utilized for fertilizer is predominately based on price, availability, ease of application, and potential for volatilization. All N sources are equally effective as a plant nutrient if they are properly applied in appropriate situations. However, some crops such as rice preferentially use the ammonium form of nitrogen.

After N, potassium (K) is the second most important macronutrient needed for crop production in the Delta. Plant K needs are typically two to four times greater than phosphorus (P) needs. Higher soil K concentrations are required in soils as clay content increases to meet crop demands. Soybean, corn, and wheat (*Triticum aestivum*) have lower requirements for K than cotton and produce lower economic returns from applied potash fertilizers. Soils in the Mississippi Delta typically have high levels of P for crop production. Plant P needs are relatively small for most crops produced in the Delta, so care must be taken not to overuse P fertilizers. Crops most sensitive, in descending order, to low-P soil levels are wheat, oats (*Avena sativa*), corn, grain sorghum (*Sorghum bicolor*), cotton, soybean, and rice (9). Phosphorus deficiency symptoms may be more pronounced during cool, wet seasons when plants are small (10).

Crop Tillage Practices

Soil tillage varies widely in the Delta and is based primarily on the intended crop and soil type. Tillage may be performed prior to planting the crop, during the

Table 3. Plant nutrients removed in the harvested crops.[1]

Crop	Harvested yield	Nitrogen	Phosphorus	Potassium
		lb/A	*lb/A*	*lb/A*
Cotton	1 bale (480 lb)	32	14	20
Corn	1 bushel (70 lb)	0.7	0.4	0.3
Soybean	1 bushel (60 lb)	4.0	0.8	1.4
Rice	1 bushel (45 lb)	0.5	0.3	0.2
Wheat	1 bushel (60 lb)	1.2	0.5	0.4

[1]SOURCE: Potash and Phosphate Institute.

growing season, or after harvest. It promotes crop emergence by creating a uniform seedbed, eliminates competition from weeds for moisture, sunlight, and nutrients, and can improve physical conditions. Postharvest tillage, especially in cotton, is important for disease, insect, and weed management. By disturbing the soil surface after crop harvest, over-wintering sites of important cotton insect pests within crop residues are destroyed. In addition, food sources and reproduction sites for microorganisms responsible for disease are reduced or eliminated.

High clay content of some soils, combined with excessive moisture levels during the winter and early spring months, can limit the use of tillage during the early spring in the Mississippi Delta. Seedbed preparation often begins for the following year's crop after harvest in the fall or early winter. This practice leaves the soil disturbed and without cover through periods when the region receives the majority of its rainfall. Under these conditions, the potential for erosion is high.

To reduce the number of tillage operations and maintain cover crops or crop residues on the soil surface for much of the year, some producers utilize conservation tillage practices. According to the Natural Resources Conservation Service, conservation tillage systems can reduce soil erosion, increase water infiltration into the soil profile, improve soil aggregate stability, and increase soil organic matter content.

The Conservation Technology Information Center classifies any tillage or planting system that maintains at least 30% of the soil surface covered with plant residue after planting as a conservation tillage system (11). Types of conservation tillage include no-till, strip-till, and mulch-till. In 1998, 26% of the major row crops in Mississippi were planted in some type of conservation tillage system (11). Though this has increased from an average of 14.8% during the 4-year period from 1985 to 1988 (12), it is still below the national percentage of 38%. The use of conservation tillage practices in the 18 counties that make up the Mississippi Delta was similar to the rest of the state in 1998 at 28%. Corn and soybean represented the highest percentages at 36% and 35%, respectively, followed by grain sorghum at 20% and cotton at 11%.

Irrigation

The amount of rainfall in the Mississippi Delta is generally adequate for crop production; however, the yearly distribution of this rainfall makes supplemental irrigation desirable. A high level of management is needed to make an irrigation system successful, especially with regard to decisions of when to apply supplemental water and how much to apply. Irrigation should be applied to ensure that most of the water is used by the crop and not lost to surface runoff, evaporation, or deep percolation (water that moves below the root zone) through the soil profile. Approximately 25% of the cotton, 30% of the soybean, and 64% of the corn acres in Mississippi are irrigated. All of the rice acreage is irrigated, since rice is grown under a flood culture system. Yield response depends on the management and timeliness of the irrigation, as well as rainfall and environmental demand.

Furrow and sprinkler irrigation are the two predominant systems utilized in the Mississippi Delta. With furrow irrigation, evenly spaced, shallow channels that run parallel to the row direction are formed during tillage operations, typically created by plowing, down or across the slope of the field to be irrigated. It is the lowest capital cost system, but it requires formed land, has high water demands, and is 30% to 90% efficient, depending on crop and soil properties (13). Sprinkler irrigation systems are designed to simulate rainfall during dry periods. They require major capital expenditures and higher levels of management, but less labor requirements.

In 2003, Mississippi ranked third in the nation in cotton production after Texas and Georgia, with 504,000 tons produced (14). Mississippi farmers harvested 1.1 million acres of cotton with an average yield of 807 pounds per acre. Of the five top cotton-producing counties, all were located in the Delta (15).

The 1960s saw the establishment of full mechanization in cotton production. The transition to advanced levels of production technology has had a marked effect on cotton production in the Mississippi Delta, characterized by improved cultivars, high levels of fertilization, chemical weed control, intensive insect control, supplemental irrigation, mechanical harvesting, and careful management.

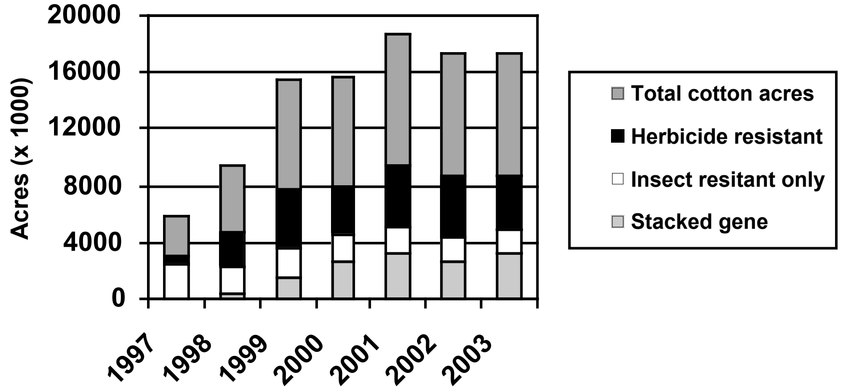

Figure 2: Adoption of transgenic upland cotton cultivars, 1997-2003. SOURCE: Compiled from NASS, USDA Agricultural Statistics Board.

Cultivars

Development of new cotton cultivars tends to focus on improving lint yield and fiber quality. Other traits include plant maturity, smooth leaves (hairy leaves can be a source of trash in the cotton lint), and pest resistance. The recent introduction of genetically modified cotton cultivars — those that are insect resistant because they contain the Bt gene or that are tolerant to certain herbicides — has significantly impacted the cotton industry. Adoption of herbicide-tolerant crops has been rapid since their introduction in 1995 as seen in Figure 2. Transgenic cultivars used on cotton acres grew from 22.5% in 1997 to 73% in 2003 (16). Mississippi has surpassed this national trend with 92% of the cotton acres planted in 2003 with a transgenic cultivar containing the Bt gene, herbicide tolerance genes, or both (stacked genes).

Pests

Insects and weeds are the major pests of cotton in the Mississippi Delta. Cotton has a long growing season (April to October), and crop yield is very sensitive to weed and insect pressure. This, combined with the subtropical climate of the Mississippi Delta, creates intense pest pressure on the crop, resulting in a high dependency on agricultural pesticides.

The potential for loss to insect pests is greater in cotton than any other field crop (17). More than a dozen different species of insect pests attack cotton, each of which is capable of causing severe economic yield loss. In 2000, the major economic losses occurred due to bollworms (*Helicoverpa zea*), tobacco budworms (*Heliothis virescens*), and plant bugs (*Lygus lesperus*) (18). Insect feeding can seriously damage cotton by causing leaf malformation or abscission, increasing the shedding of squares and bolls, damaging the seed and lint, or a combination of these problems (19). In 1999, the total cost of management and loss to insects was approximately $93 per acre, of which controlling insects accounted for $50 per acre (18). Though significant dollars are spent on insect management, it was reported in 2000 that 4.5% of Mississippi cotton production (121,000 bales) was lost to insects (20). The boll weevil (*Anthonomus grandis grandis*) eradication program, implemented in the Delta counties in 1999, has allowed producers in the boll-weevil-free area to receive higher profits per acre (21).

Integrated pest management (IPM) is practiced on all of Mississippi's cotton acreage to control insects. This includes a number of noninsecticide management tools to prevent insect populations from exceeding economic thresholds that may require insecticide treatment. These methods include cultivar selection, crop rotation, destruction of over-wintering sites by tillage and other means, and careful monitoring of insect pest populations throughout the growing season. Timely and judicious use of insecticides is an important component of cotton IPM.

Cotton does not compete well against weeds, especially during the early stages of growth. If weeds are allowed to emerge and compete for a minimum of 5 weeks after cotton emergence, yield may be reduced, even if the cotton crop is weed-free the remainder of the season. Buchanan and Burns (22) showed that if a healthy stand of cotton were kept free of weeds for 8–10 weeks after planting, it would be sufficiently competitive to suppress further weed growth and achieve maximum yield. Loss from weed interference with harvesting equipment was not considered and is an additional factor in cotton production. In 2000, an estimated 9% of the Mississippi cotton crop was lost due to weed competition (23). Predominate species contributing to this loss included morningglory (*Ipomoea sp.*), pigweed (*Amaranthus sp.*), common cocklebur (*Xanthium strumarium*), and johnsongrass (*Sorghum halapense*). Respective losses were 27%, 15%, 10%, and 9% of the total loss. Economic losses due to weeds typically exceed $40 million annually in Mississippi (23).

Herbicides are used to minimize economic loss from weeds. Control systems vary according to weed spectra and cropping system. Typically, judicious use of soil residual herbicides is followed by timely application of various postemergence herbicides. In conventional-tillage systems, cultivation supplements these systems. Predominate soil residual herbicides include trifluralin (α,α,α-trifluoro-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine), pendimethalin (N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine), fluometuron (1,1-dimethyl-3-(α,α,α-trifluoro-*m*-tolyl)urea), and pyrithiobac (sodium 2-chloro-6-[(4,6-dimethoxy prymidin-2-yl)thio] benzoate). Postemergence materials include glyphosate in glyphosate-tolerant cotton and pyrithiobac in conventional cultivars of cotton.

Seedling diseases are the most prevalent pathogens of cotton. Soilborne fungi, including *Rhizoctonia solani*, *Fusarium spp.*, *Pythium ultimum*, and *Thielaviopsis basicola,* are the primary cause of seedling diseases of cotton. It was estimated in 1998 that 3% of the Mississippi cotton crop was lost to seedling disease, a loss of $19.2 million (23). Loss can occur directly by death of newly planted seedlings or indirectly through weakened plants that are more susceptible to drought and other pests, such as nematodes. Less vigorous plants take longer to mature and generally produce lower yields. Cool, wet soils favor seedling disease development. Because conservation tillage leaves crop residues on the soil surface, soil warming in the spring is delayed and the incidence of disease increases. To minimize the incidence of seedling diseases, producers plant on raised seedbeds to promote good drainage and warming of soils in the spring. Other ways to reduce the extent of yield loss due to soilborne pathogens are to avoid fields with a history of severe seedling diseases and to rotate crops with small grains and corn.

Fertility

Nitrogen fertilization of cotton is complicated; either too much or too little can be detrimental to cotton lint production. Inadequate N limits yield and quality, whereas excessive N delays maturity, increases attractiveness to insects, increases the incidence of boll rot, and makes harvesting more difficult. Optimum N fertilizer rates vary from farm to farm and from field to field within a farm. Nitrogen rate is generally based on yield potential, history of rank growth in a field, soil type, and level of management.

Nitrogen requirements by the cotton plant are not constant throughout the growing season. Less than one-third of the total seasonal N uptake occurs during its early vegetative growth phase prior to bloom. As the plant begins to set fruit, the rate of N uptake significantly increases (25% to 40% of the seasonal N accumulation may occur during the first 2 weeks of bloom). As the plant matures, the need for N gradually decreases.

Approximately 50 to 60 pounds per acre of N fertilizer are needed to produce a bale (500 pounds) of cotton on light-textured soils; 60 to 69 pounds per acre of N fertilizer are needed to produce a bale of cotton on medium-textured soils; and 69 to 79 pounds per acre of N are needed to produce a bale of cotton on clay and clay-loam soils (24). Nitrogen rates are reduced if a field has been in soybean production, has a history of rank growth, or is on nonirrigated fields.

Most new cotton cultivars have a greater daily requirement for potassium (K) than other crops. Uptake of K increases during early boll set with some 70% of total uptake occurring after first bloom (24). Supplemental P is less needed for cotton due to the naturally high levels of soil test P in most areas of the Mississippi Delta.

Cotton grows best in soil with a pH between 5.8 and 7.0. When the soil pH falls below 5.2 on clay soils and 5.5 on loam soils, limestone application is recommended (24). The irrigation water from wells in the Mississippi Delta typically contains 1,996 to 2,495 pounds per acre of limestone equivalent per 6 acre-feet of water. Thus, less limestone is usually needed on irrigated fields used for row crops.

Tillage Practices

The majority of cotton grown in the Mississippi Delta is produced on conventionally tilled fields, defined as fall stalk shredding followed by fall and/or spring disking, subsoiling, and listing. This is largely due to the cotton crops' vulnerability to both wet and cool soils. Plant residues on the soil surface increase soil moisture levels and slow the soil from warming in the spring. If not managed properly, this can cause a number of problems for the cotton plant. Cottonseed will not readily germinate and develop unless soil temperature at a 5-inch depth is at least 64°F. Seedling diseases also become a greater problem when soils are cool and wet.

Interest in conservation-tillage practices has increased over the past several years largely due to economics and the development of better herbicides. Stale seedbed is a modified conservation-tillage system used in the Mississippi Delta, practiced primarily to save time during the planting season. In stale-seedbed systems, field preparation operations are limited to stalk shredding and listing, which are performed as soon after cotton harvest in the fall as possible. The next spring, herbicides are applied prior to planting to control winter weeds, and then cotton is planted with minimal tillage. Because stale-seedbed systems are more dependent on preplant herbicides, pesticide input costs can increase but may be offset by a reduction in certain types of tillage. Specialized equipment and a higher level of management are necessary to insure success.

Irrigation

Irrigation water is an important cotton production management practice just like fertilization and tillage. Cotton has the potential to use more water per day in the production of a harvestable product than any other field crop, with the possible exception of alfalfa (*Medicago sativa*) (25). Cotton is most sensitive to water stress at peak bloom (26). However, too much water applied at the wrong time can be detrimental. A successful irrigation program is highly dependent on precisely timed irrigations according to seasonal needs of the crop and periods when soil moisture is inadequate. Such a program requires close monitoring of the cotton crop and timely application of controlled amounts of water.

Crop Rotations

Historically in the Delta, cotton has been grown in a monoculture cropping system where cotton is grown year after year on the same land. The prime reason for this system has been economics, as cotton results in high net returns. In addition, cotton production requires higher capital investment in equipment used exclusively to grow and harvest the crop. For example, typical cotton production systems require wider row spacing than used for most grain crops. This creates incompatibility of equipment across cropping systems resulting in either greater capital investment to accommodate the additional system or underutilization of cotton equipment. Alternate field crops, such as soybean, corn, grain sorghum, or wheat, have not always generated as much income per acre as cotton.

There are a number of problems associated with cotton monoculture. It is well documented that crop rotations are successful in reducing the incidences of diseases, nematodes, and weeds in cotton (27, 28, 29). Recently, reniform nematodes (*Rotylenchulus reniformis*) have become a serious cotton pest and rotation to corn or grain sorghum are the primary means of reducing nematode populations.

More recently, crop diversification has been necessary to avoid market instability of various crop commodities. Production risks can be hedged by avoiding production of a single commodity.

Soybean Production

Mississippi ranks 15th in soybean production in the United States with approximately 1.4 million acres planted in 2003 (30). Soybean production in Mississippi peaked in the late 1970s at more than 9.9 million planted acres (31). Acres have decreased steadily since that time, and the 1.16 million acres planted in 2001 was the first time since 1964 that soybean production in Mississippi declined below 1.3 million acres. Soybean yields in Mississippi from 1999 to 2003 averaged 29.9 bushels per acre (32), which was low compared to the national average. Reflected in this 5-year average are 1998, 1999, and 2000, which were droughty years that negatively impacted soybean yield, especially on nonirrigated acreage. In addition, large portions of the 2001 and 2002 bumper crops were destroyed by extended wet periods during harvest. Soybean remains an economically important crop to Mississippi, especially in the Delta Region, where more than 70% of the state's soybean is grown (33). Acreage has increased slightly since the low in 2001 with 1.44 acres planted in 2002 and 1.36 million acres planted in 2003 (30). Approximately 55.8 million bushels of soybean were produced on 1.43 million harvested acres in 2003 (32). This record state yield estimate of 39 bushels per acre was the first time in history that the Mississippi state yield average exceeded the national average.

Soybean production in the Mississippi Delta emerged in conjunction with cotton production. Initially, traditional soybean production systems used much of the same equipment and cultural practices used in cotton production. Soybeans were grown using wide (38- to 40-inch) row spacings and cultivated. Weed control programs often included directed-herbicide treatments. More recently, cultivation use has decreased, and soybean row spacings have narrowed as adoption of the glyphosate-tolerant soybeans has increased and use of residual herbicides has decreased. Nearly 70% of recently surveyed producers (n=74) used narrow row spacings (15 to 20 inches) for some of their soybean acres (34). Nearly three-fourths (72%) of respondents grew soybean with no in-season cultivations. Soybean planters in the Delta are often set up to fit tractors with wide wheel spacings used to plant cotton. A typical soybean planter in the Delta may have three to four planter units located between tractor wheels spaced 80 inches apart and five or more planter units located on the outside of each tractor wheel. Planter units are generally spaced 15 to 20 inches apart, and wider spaces (often 30 inches) are left for tire tracks. Despite the fact that soybean row spacings have narrowed, this system allows the same tractors to be used in multiple crops. Recently, more modern grain drills with improved planter units and seed metering capability have increased in popularity. In addition, planting two soybean rows on top of a single raised bed (twin row) is becoming more popular. Corn, cotton, and soybeans can all be grown using the raised-bed system that improves drainage and facilitates furrow irrigation. Relative to soybean production, the twin-row system provides faster canopy closure than in single widerows. In narrow row patterns, fewer seed per row foot (often two to four seed) are utilized and adequate stands are often difficult to achieve because the inability of few seed to break the soil crust. With the twin-row system, approximately five to six seed per row foot are commonly planted, which increases the likelihood of emergence and adequate plant populations.

Traditional soybean production systems in the Mississippi Delta involved planting late-maturing cultivars (Maturity Group [MG] V, VI, and VII) in May and June (35). Unfortunately, this system has produced consistently low yields, which result from typical low rainfall during July through September. Water deficits coincided with the high-water-demanding soybean reproductive stages. The Early Soybean Production System (ESPS) was developed to remedy this problem for producers in the midsouthern United States and has improved soybean yields in Mississippi (36). This system focuses on planting early-maturing cultivars (MG IV and V) in April to avoid seasonal drought and maximize yields. Vegetative growth, flowering, and pod-fill occur earlier in the growing season when temperature and soil moisture are more favorable (37). Widespread adoption of this system is evident in Mississippi with 74% of all soybean acreage planted on or before the first week of May in 2001, 55% in 2002, 68% in 2003, and 78% in 2004 (38).

Early-planted soybean emerges before most summer annual weeds and therefore has a competitive advantage over weeds that appear several weeks after planting. Because weeds emerge several weeks after planting with the ESPS, the need for preemergence herbicides may be reduced compared with systems where soybean is planted later in May. Therefore, the potential of off-site movement of soil-applied herbicides is reduced with the ESPS. The ESPS may also reduce or eliminate the need for many late-season insecticide applications because soybean matures before the arrival of many fall insects.

Cultivar Selection

Cultivar selection remains one of the most critical decisions made by Delta soybean producers. Widespread adoption of glyphosate-tolerant soybean cultivars has resulted in rapid increases in the number of cultivars available to producers. Of 296 cultivars evaluated in the 2004 Mississippi State University official cultivars trials, more than 89% were glyphosate-tolerant cultivars. Maturity groups ranged from MG III to VI, with MG IV cultivars representing 42% of the entries and MG V cultivars representing 42%. MG III (4% of entries) cultivars are being evaluated as a potential means of drought avoidance, while grower interest in MG VI (less than 1% of entries) cultivars has declined in recent years. The large number of cultivars available to producers, combined with a wide range of maturity groups, tends to make cultivar selection a time-consuming task. Producers are encouraged to select cultivars for yield potential, disease resistance, and growth habit to match their production system.

Mississippi Delta soybean producers have widely adopted glyphosate-tolerant soybeans. Recent estimates suggest nearly complete grower adoption of this technology, with 89% of all soybean planted in Mississippi in 2003 being glyphosate-tolerant cultivars (30).

Pests

After drought stress, weeds are the most limiting factor in Mississippi Delta soybean production. Losses due to weeds in Mississippi soybean fields have been estimated at more than $68 million annually (39). Herbicides alone represent 16–48% of the direct costs of soybean production in Mississippi, depending on the production system utilized (40). Delta soybean producers, responding to a survey of the 1999 growing season, listed annual morningglories (*Ipomoea* spp.), hemp sesbania (*Sesbania exaltata*), Johnsongrass (*Sorghum halepense*), and prickly sida (*Sida spinosa*) as their four most troublesome weeds. Most (52%) acres in the survey received both preemergence and postemergence herbicide applications, compared with only 15% and 30% of the acres treated with only preemergence or postemergence herbicides, respectively (34). Widespread adoption of glyphosate-resistant varieties and the ESPS has occurred since the 1999 survey was conducted. Consequently, use of preemergence herbicides has decreased and dependence on glyphosate has increased. In the absence of residual herbicides, annual grasses, and to a lesser degree pigweeds, have emerged as some of the most troublesome weeds in soybean. In addition, glyphosate-resistant horseweed has been documented as far south as Greenville, Mississippi. Herbicides will continue to be the primary means of soybean weed control as fuel and labor costs continue to increase and the price of glyphosate continues to decrease.

Grasshoppers (*Melanoplus* spp.), bean leaf beetles (*Cerotoma trifurcata*), and soybean loopers (*Pseudoplusia includens*) are perhaps the most common foliage-feeding insects in Mississippi Delta soybean fields. Insect larvae that feed at or below the soil surface tend to be problems in no-till fields planted into heavy residue. Stinkbugs (*Nezara viridula*) have emerged as one of the most formidable pests for Mississippi Delta soybean producers, especially in late-planted and late-maturing soybean. Greater use of the ESPS has resulted in earlier soybean harvests, which coincides with cotton defoliation, corn harvest, and rice harvest. Consequently, stinkbugs leave cotton, corn, rice, and early-planted soybeans fields and infest late-maturing soybean fields, causing significant damage. Other insects of economic significance include three-cornered alfalfa hoppers (*Spissistilus festivus*), green cloverworms (*Plathypena scabra*), corn earworms (*Helicoverpa zea*), salt marsh caterpillars (*Estigmene acrea*), velvetbean caterpillars (*Anticarsia gemmatalis*), and beet armyworms (*Spodoptera exigua*).

Recent shifts toward the ESPS mean that soybean is often planted during periods of cool, wet weather, often in poorly drained soils. Consequently, seedling diseases caused by *Pythium* spp. and *Phytophthora* are major problems for soybean producers in the Mississippi Delta. As a result, most soybean seed planted are treated with materials that control soilborne diseases, especially diseases caused by *Pythium* spp. Charcoal rot (*Macrophomina phaseolina*) is considered by some to be the most limiting soybean disease in the Mississippi Delta. Research is ongoing to develop resistant cultivars. Foliar fungicide use has increased slightly in the Mississippi Delta since 1995, when only 3% of the acres in the state were treated (41). This increase has been associated with the introduction of products that provide excellent aerial web blight (*Rhizoctonia solani*) and good frogeye leafspot (*Cercospora sojae*) control at reasonably low rates. Yield responses to foliar fungicides have been more consistent in irrigated soybean fields or fields with high yield potential. Stem canker (*Diaporthe phaseolorum* var. *meridionalis*) and *Phytophthora* root rot have perhaps the greatest potential of causing total stand loss. Resistant varieties are recommended. However, some recently introduced varieties are not resistant to stem canker, or have not been screened for resistance. Soybean mosaic-bean-pod-mottle virus is prevalent in the region, but early-planted soybean often escapes virus infection, and cultivars resistant to soybean mosaic virus are available. Other major diseases of economic significance in the Mississippi Delta include purple seed stain (*Cercospora kikuchii*), *Phomopsis* seed decay, pod and stem blight (*Diaporthe phaseolorum* var. *sojae*), and sudden death syndrome (*Fusarium solani* f. sp. *glycines*).

Nematodes of economic significance to soybean are often problems only on lighter-textured soils. Consequently, nematodes are not a major problem in the Mississippi Delta because most soybean production occurs on mixed to heavy clay soils.

Tillage

Conventional tillage remains a commonly used tillage practice for soybean producers. However, no-till and reduced-tillage practices are becoming more popular. According to a recent survey, approximately 61% of growers use conventional tillage, 42% use no-till, 38% use stale-seedbed tillage, and 27% use deep tillage on their farms (34). Stale seedbed production involves one or more tillage events in the fall to incorporate residue and to remove ruts left by equipment (42). With this production system, no tillage occurs in the spring prior to planting, and winter vegetation is controlled chemically, thereby allowing farmers to plant earlier in the spring. This system is recommended for all producers that intend to use the ESPS. Consequently, stale seedbed production has increased dramatically as more producers choose to plant early. The popularity of no-till and reduced-tillage systems is likely to increase in Mississippi as the price of nonselective herbicides for spring weed removal decreases.

Crop Rotations

Most soybean grown in the Mississippi Delta is grown in rotation with rice or in soybean monoculture. In a recent survey, monoculture soybean and soybean grown in rotation with rice were produced by 72% and 50% of respondents, respectively (34). Soybean rotations with crops other than rice were practiced by less than 30% of the respondents. Interest in double cropping soybean with wheat is limited, with only 13% of the soybean acres planted following another crop. Soybean may be grown in rotation with wheat, but rarely in a double-crop production system unless irrigation is available.

Irrigation

Approximately 30% of Mississippi's soybean crop is irrigated (43). Many irrigated soybean fields are located in the Delta and are often planted in rotation with rice. Flood, furrow, and border irrigation systems are often used in these fields. Flood irrigation requires the construction of contour or straight levees throughout the field and is generally only 50–60% efficient on soybean. Getting water on and off fields in 48 hours is often difficult with this system. Additionally, large contour levees take land area out of production and require large amounts of time to construct and to remove after irrigation. Furrow irrigation is the most common system of irrigating soybeans in the Delta and is 50–70% efficient. This system involves pumping water into row middles that have slopes ranging from 0.05–0.5%. Border irrigation is increasing in popularity and includes aspects of furrow and flood irrigation. Border irrigation is a flush irrigation system that moves water downhill between small levees or dikes in a 12- to 24-hour period. Efficiency ranges from 60–80%. Border irrigation is best suited to straight-levee rice fields and fields with no side slope. As with rice, considerable water is lost as tailwater that exits the lower ends of fields with the methods described above. Producers have expressed interest in tailwater recovery systems, but the expense of establishing such systems is rarely cost-effective.

Sprinkler irrigation, including center pivots, traveling guns, and linear-move systems, are less popular in the Delta for soybean production. Disadvantages of sprinkler irrigation include deep rutting in wheel tracks on heavy clay soils and an inability to supply sufficient water to the crop during peak water usage periods.

Mississippi is a major producer of rice in the United States, ranking behind Arkansas, California, and Louisiana (44). Rice acreage in Mississippi over the 10-year period from 1995-2004 has fluctuated between 210,000 and 325,000 acres (Anonymous 2005). Yields have more than doubled since the early 1950s and averaged 6,900 pounds per acre in 2004 (46).

The Delta is ideal for rice production. High average temperatures during the growing season, a plentiful supply of irrigation water, and a smooth land surface with less than 1% slope to facilitate uniform flooding and drainage are available. Most rice fields have soils with an impervious subsoil layer that inhibits percolation of irrigation water from flooded fields.

A drill-seeded, delayed-flood culture system is used by most rice producers in Mississippi. This culture provides a favorable environment for rice growth, to help control weeds, and to stabilize soil ammonium N in the soil. If rain does not occur following planting, growers will flush (wet the soil in each field) one or two times to provide the necessary moisture for seed germination and early-season growth. A shallow (3-inch) permanent flood is established approximately 21 to 28 days after plant emergence, coinciding with a plant growth stage of 4- to 5-leaves.

Cultivar

Rice cultivar selection involves consideration of such factors as length of growing season, grain type, availability of weed-free seed, disease susceptibility, processing characteristics, yield potential, and market demand. In 2004, the most popular rice cultivars grown in Mississippi where Cocodrie (58%), CL161 (20%), and Priscilla (12%). These are all semi-dwarf long-grain rice cultivars. Hybrid rice, commercialized in 2000 in the United States by RiceTec, Inc., was grown on approximately 5% of the acreage in Mississippi in 2004 (Walker, personal communication).

Pests

Weeds are the most serious pests affecting rice production in Mississippi. The economic impact of weeds in rice includes losses in yield and quality, added cost of herbicides, extra land preparation and cultivation, and increased cost of harvesting. It was estimated in 1999 that economic loss in rice to weeds in Mississippi was $18.7 million (47).

Since rice is grown in an aquatic system, the humid microclimate favors disease development, which can cause substantial losses in yield and quality. Certain diseases can be controlled by using resistant cultivars, fungicide seed treatments, and better cultural and management practices. However, the incidence of soilborne rice diseases in Mississippi is on the rise (48). This has been due to the expanded rice acreage in the state, the prolonged recropping of rice in certain fields, and the limited availability of suitable new land for long crop rotations. In addition, the recent adoption of short-stature, high-yielding cultivars that respond to high rates of N fertilizer has also contributed to disease increases. The benefit of high N application rates is that yields are increased; however, disease susceptibility also increases (48).

Fertility

Delta rice soils have native pH measurements that are slightly to moderately acid; however, long-term irrigation of row crops and rice in the Delta has caused pH to increase to neutral to slightly alkaline. Where soil pH is above 7 and soil test levels of phosphorus (P) are low, rice grain yield responses have been obtained when P-fertilizer is applied at the seedling stage prior to flood establishment. Potassium levels range from medium to very high in most rice soils, and thus yield responses to K-fertilizer has not been documented in Mississippi. Nitrogen (N) is the most-limiting nutrient for rice production in the United States. In Mississippi, N is recommended at rates of 150 to 180 pounds per acre, depending upon the cultivar and the soil type. Nitrogen fertilizer is applied in two to four applications. Often a small amount of N (20 pounds per acre) will be applied to rice that has one or two leaves to stimulate early-season vegetation. When rice reaches the 5-leaf stage, approximately 90 to 135 pounds of N will be applied immediately prior to establishing a permanent flood. The final 30 to 60 pounds of N per acre will be applied in one or two applications at the panicle initiation and/or panicle differentiation growth stages. Hybrids are an exception to this rule as the 30 to 60 pounds of N per acre are applied at panicle emergence (Walker, personal communication).

Tillage

Conventional tillage is the most common method used in rice production. The land is tilled in the fall or early spring, depending on the rotation crop planted prior to the rice. If decomposition of crop residues is not complete by planting, microorganisms that decompose crop residue will compete with rice plants for nutrients, particularly N, resulting in N deficiency in the rice plant.

Conservation tillage is a recent innovation in rice. It has the potential to lower production costs and improve timeliness in planting. Types of conservation-tillage practices used in rice include no-till and stale seedbeds. With no-till, rice is planted directly into the previous crop's residue, typically soybean or wheat. In stale-seedbed systems, tillage operations are performed in the fall, and the seedbeds remain idle while winter vegetation becomes established. Nonselective herbicides are used to control winter vegetation prior to planting. The introduction of improved no-till grain drills has greatly enhanced the capability to produce rice with reduced tillage. Planting rice into a stale-seedbed has given producers the opportunity to plant earlier, which has two important benefits. First of all, planting date studies have shown that rice planted in early April has larger yield potential than rice planted in mid to late May. Secondly, planting earlier allows the rice crop to be harvested in late August and early September, which is critical. Chances for hurricanes and tropical storms interrupting harvest are generally greater in mid to late fall.

Irrigation

All rice in the United States is irrigated. In the continuous flood system of irrigation used in the Delta, water depth is regulated in rice fields by construction of levees. Levees divide rice fields into subfields called bays or paddies. After a rice field is flooded, a considerable amount of water is required to maintain optimum water depth in the field. Water losses occur due to transpiration from the plant leaf surface, evaporation from the water surface, downward percolation movement through the soil profile, seepage losses through the levees, and runoff of excess water from the field (50). During a 4-year survey in Mississippi from 1991 to 1994, the overall annual water use averaged 29 inches per acre for straight-leveed rice fields and 31 inches per acre for contour-leveed rice fields (51).

Crop Rotations

Crop rotations in rice prevent buildup of soilborne disease pathogens, help control weeds, and improve soil structure for planting. Lower yields often result with continuous rice production.

In the Mississippi Delta, rice is typically rotated with soybean because both crops are adapted to the clay soils of the Delta. When soybean was grown behind 1 or 2 years of rice, the average soybean yield increased 557 pounds per acre compared with continuous soybeans (52). Clearly, rice makes a valuable rotation crop with soybean, and the economic returns exceed those for either crop grown in continuous monoculture.

Corn Production

Corn acres have declined since the 1930s, when there were more than 2.9 million acres grown in Mississippi. This decrease has been even more striking in the Delta, due in part to lack of need for local feed, competition with cotton for best soils, no development of local cash markets, and the need for irrigation to produce profitable corn yields. Most of the limited acres for corn in the Delta were produced under high levels of management and for silage for cattle feedlots.

In 1999, 340,000 acres of corn were grown in Mississippi, 45% of that in the Delta. In recent years, more acres of corn have been grown because producers are looking for good-yielding, profitable alternatives to cotton. This is especially true where irrigation is available to help maintain yield potential. In addition, corn is an excellent crop to rotate with cotton.

Mississippi corn production averages about 3.5 tons per acre (53). Typically, about one-third of the acres are irrigated. Yield from irrigated acres tend to average 4.4 to 7 tons per acre, whereas dryland corn yields range from 1.4 to 5.3 tons per acre.

Pests

Seedling diseases (favored by cool, wet weather following planting) and leaf, ear, and stalk diseases (favored by warm, wet midseason weather) are a problem for corn in Mississippi. Problems with aflatoxin, which is a toxic chemical by-product from the growth of the fungus *Aspergillus flavus*, can also be a serious problem in corn produced in Mississippi (54). Grain containing aflatoxin is toxic to animals in very low concentrations (20–300 ppb). Problems with aflatoxin are more likely in Mississippi than the Midwest Corn Belt because of hot, dry weather during the late growth stages that are conducive for fungal growth. Early planting, timely harvesting, and grain drying can avoid aflatoxin contamination of feed grain. Cultivar selection is also important since some cultivars have tight husks on the end that limit pathogen entry.

The economic threat from insects to corn will vary from year to year. Several insect species can cause damage to corn either by feeding on plant parts or by vectoring a plant virus such as maize dwarf mosaic. Fall armyworms (*Spodoptera frugiperda*), seedcorn maggots (*Delia platura*), cutworms (*Agrotis sp.*), corn earworms (*Helicoverpa zea*), and southern corn rootworms (*Diabrotica undecimpunctata*) are insect pests of corn in Mississippi (55).

Weed control is important to prevent yield and harvest losses. In Mississippi, it was estimated that economic loss due to weeds in 1999 equaled $5.5 million (47). Production practices such as crop rotation, early planting, and cultivation are used to control weeds. Where production practices cannot control problem weeds, herbicides are used.

Fertility

Nitrogen is typically the most limiting nutrient to high corn yields. Split applications of N fertilizer may substantially improve N use efficiency since corn extracts less than 15% of its seasonal N uptake before rapid vegetative growth begins. The maximum N use rate occurs just before pollination; however, during early growth stages, considerable N may be lost due to denitrification and leaching. It is recommended that growers apply one-third to one-half of the total N recommendation before corn emergence, with the remainder added as a split N application delayed until five to eight true leaves have emerged. In Mississippi, this occurs about 25 to 35 days after emergence (56).

Irrigation

Irrigation can significantly increase corn yields. Typically, corn needs 20 to 24 inches of water during the entire growing season and up to 1.5 inches per week during the peak growing period. Timing is critical, with water requirements of corn being greatest from tasseling through kernel filling. An ample moisture supply during pollination is critical for complete ear and kernel formation.

Tillage

Corn producers in the Delta use several types of tillage practices. Conventional tillage is the most common, though some type of conservation tillage is used on 36% of the acres, typically no-till or mulch till (11).

Grain Sorghum Production

The production of grain sorghum in the Mississippi Delta has increased somewhat during the past decade, largely due to the low commodity prices of the traditional Delta crops and the occurrence of drought. Sorghum is more drought tolerant than corn, has a relatively short growing season, and adapts well to rotations with soybean or cotton. In addition, grain sorghum can be grown on a wide variety of soil types. Though highest yields are obtained on deep, well-drained soil, good yields can occur on heavy clay, clay-loam soils, poorly drained soils, or soils that are subject to moderate drought stress (57).

Small Grain Production

Small grains are grown throughout Mississippi, with soft red winter wheat (*Triticum aestivum*) as the primary crop followed by oats (*Avena sativa*). Wheat continues to be grown on a relatively small number of acres. The number of acres fluctuates according to market price and the availability of cultivars resistant to wheat leaf rust. In 1999, approximately 138,000 acres of wheat were grown in the Delta — 83% of the total state acres. Wheat yields averaged from 1.1–3.8 tons per acre (58).

Forage Crop Production

In the 1950s, pastures were distributed throughout the Delta, predominately in low, flat areas. Many farmers planted small grains, sudangrass (*Sorghum sudan*), millet (*Panicum ramosum*), annual lespedeza (*Lespedeza stipulaces*), and other annuals for grazing. A permanent grazing program consisted of perennial winter and summer grasses with suitable legumes. In many cases, pastures were built by using perennial grasses and legumes in rotation with row crops. Thus, pastures were a part of a well-balanced cropping system to conserve the soils and maintain yields.

Pasture programs and cow-calf operations were gradually replaced in the Delta by row crops during the 1960s. The shift to row crops, mainly soybeans and rice, resulted in greater net returns per acre. Today, pastures are mostly limited to areas along the Mississippi River levee system that are not well suited for row crop production.

Fruit, Nut, and Vegetable Production

Commercial fruit, nut, and vegetable production annually contribute $76 million to Mississippi's economy. This number has gradually increased over the past 5 years mainly due to the growth in acres of sweetpotatoes (*Ipomoea batatas*). Sweetpotatoes accounted for approximately 45% of the total vegetable production in 2000. Other vegetables grown in Mississippi include southern peas (*Pisum sativum*), watermelons (*Passiflora laurifolia*), turnip (*Brassica rapa*) and mustard greens (*Brassica spp*.), and bush green beans (*Phaseolus* spp.). Top fruits are blueberries (*Vaccinium* spp.), muscadine grapes (*Vitis vinifera*), peaches (*Prunnus persica*), and strawberries (*Fragaria* sp.). Today, few fruits, nuts, and vegetables are produced in the Mississippi Delta. Pecans (*Carya illinoenisis*) and sweetpotatoes comprise the bulk of production.

Catfish Production

By the mid- to late 1970s, Mississippi had emerged as the leading producer of farm-raised catfish in the United States with nearly 23,000 acres of ponds (59). By 1985, production had expanded to more than 75,000 acres. Today, the area of water surface used for catfish production in Mississippi is estimated at nearly 109,000 acres with 88% of ponds located in the Delta (32). Sunflower, Humphreys, and Leflore counties account for 39% of the total national pond area (33). Mississippi catfish production in 2003 was estimated at 196,000 tons (60), generating nearly $220 million in sales (33). Total economic impact in Mississippi due to catfish production is estimated at nearly $2 billion annually (61).

Flat topography, alluvial clay soils, and availability of high-producing groundwater sources at shallow depths are characteristics of the Mississippi Delta. Collectively, these factors are ideal for constructing levee catfish ponds. Ponds are constructed by removing soil from areas that will become pond bottoms and using this soil to form levees around the pond. Catfish pond size in the lower Mississippi River Valley tends to be relatively uniform with rectangular ponds ranging in size from 8–15 acres of surface water area (62). Pond depths range from 40–60 inches with heights of levees generally 12–14 inches above water level. Drains are placed in levees at the deepest end of the pond to regulate water levels. Wells are normally drilled after pond construction and are generally located at the intersection of four pond levees, thereby servicing multiple ponds. Wells are designed to replace water losses due to evaporation and maintain water levels during periods of extreme drought.

Water is an essential input for catfish production, and the need for water conservation relative to catfish production has increased as the industry has expanded. Annual water use for catfish production is estimated at 20–40 inches, depending on production system (63). These values exceed water use for all major crops except rice and alfalfa. However, economic value per unit of water used in catfish production far exceeds that of other crops, with some ponds exceeding a $2 return for every 264 gallons of water used (64). Water losses in catfish ponds occur via evaporation, seepage, and overflow. After initial pond filling, water levels are maintained by rainfall and pumped groundwater. Most ponds are managed to efficiently capture rainfall, which significantly reduces the need for pumped groundwater and reduces the amount of effluent discharged (64). Catfish ponds in the Mississippi Delta are generally constructed in montmorillonitic clay soils. These soils swell when wet, becoming nearly impervious to water flow. Consequently, water losses due to seepage are minimal (65).

Water use varies greatly depending on pond type. Broodfish, fingerling, and food-fish ponds represent 3%, 13%, and 84% of the pond area used for catfish production in the United States, respectively (66). Water use by pond type varies depending on frequency of pond draining. Broodfish ponds are typically drained every 2–5 years. In contrast, the average life of a commercial food-fish pond is 6 years. Fingerling ponds are drained annually to ensure that all fish are removed. Consequently, they account for 30% of the total water used in catfish production, despite representing only 13% of the production area (64).

Food-fish pond stocking rates in the Mississippi Delta range from 11,000 to nearly 25,000 fish per acre, with yields normally ranging from 4,700 to more than 5,100 pounds per acre (61). Two factors negatively impacting the profitability of catfish production in the Delta include off-flavor and increasing competition from imported fish. Imports of foreign fish, primarily from Vietnam, continue to threaten the profitability of catfish production in Mississippi and other regions of the nation. Imports of foreign fish in June 2001 nearly reached 1,100 tons, an increase of 167% from June 2000 (60). Off-flavor is associated with secondary metabolites produced by several species of blue-green algae and often results in unmarketable fish or increases in the length of time needed to raise a crop (67). Costs associated with off-flavor range from $16–60 million annually. Copper-based products, including copper sulfate, have been commonly used as algicides in commercial ponds to reduce the incidence of algae-related off-flavor. Until recently, these products were the only algicides labeled for use in catfish ponds. Several herbicides (68) and ferulic acid (69) have also been evaluated for algae control in commercial ponds. Diuron, a photosynthesis-inhibiting herbicide used primarily in field crops, is now registered in the state of Mississippi for use in commercial catfish ponds via an emergency exemption label (Section 18) (70). At very low use rates, diuron is effective against the species of blue-green algae responsible for most off-flavor in Mississippi farm-raised catfish.

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