

# Rice Production in the United States – An Overview

By C.S. Snyder and N.A. Slaton

**The combined effects of higher-yielding varieties, better fertility management, threshold-based pest management, and intensive irrigation management have enabled rice producers in the United States (U.S.) to continuously increase national average rice yields since the early 1980s.**

Rice is the staple food of more than one-half of the world's population. Archeologists suggest that rice cultivation began in China more

than 5,000 years ago. Rice culture in the U.S. began in the Carolinas and Georgia about 300 years ago and is one of the nation's oldest agri-businesses. After the Civil War, cultivation shifted westward to the lowlands of Louisiana and Texas.

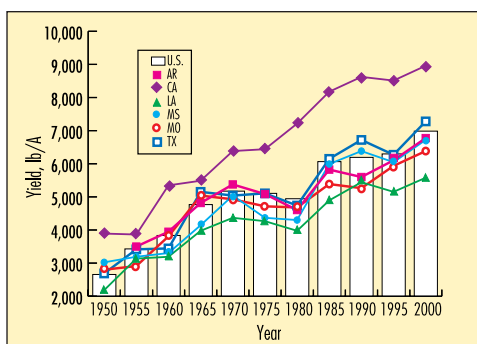
Modern rice production in the U.S. is concentrated in Arkansas, California, Louisiana, Mississippi, Missouri, and Texas, using different cultural production practices. The first U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) records for rice indicate 118,300 hectares (ha) were harvested in

1895 with an average yield of 1,280 kg/ha. Harvested area increased to more than 0.41 million (M) ha in 1919, 0.81 M ha in 1959, and 1.22 M ha in 1980. The greatest harvested area to date was 1.5 M ha in 1981, with an average yield of 5,400 kg/ha.

State and national rice yields are shown in **Figure 1**, for 1950 and every five years since. The highest national average yield was reported in 2000 at 6,990 kg/ha for 1.25 M ha.

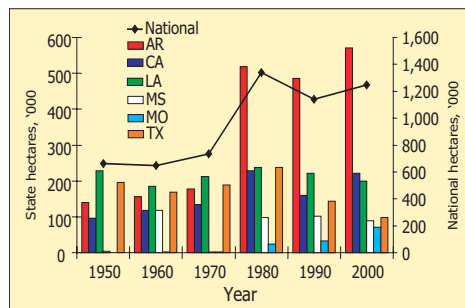
Seventy-three percent of the rice hectareage grown in 2000 was long grain, 26 percent was medium grain, and about one percent was short grain rice. California has the highest average yields (**Figure 1**), while Arkansas has the greatest hectareage (**Figure 2**). In general, a single crop is harvested from most U.S. rice fields each year. In Texas and southwest Louisiana, a second or ratoon crop may be harvested from a single planting because of the longer growing season.

U.S. rice hectareage has shifted from year to

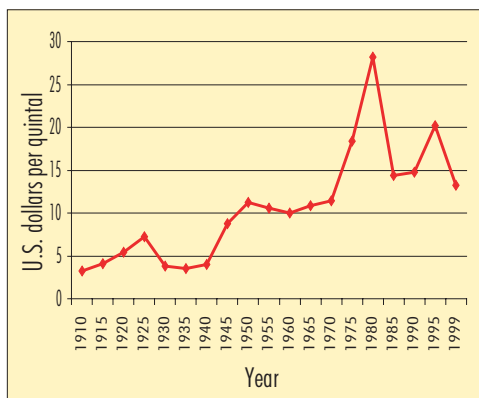


**Figure 1.** U.S. national and state average rice yields—1950 to current. Source: USDA-NASS.

**Figure 2.** State and U.S. national rice hectareage harvested—selected years. Source: USDA-NASS.



year depending on many factors: marketing quotas, government hectare allotments, export demand, production deficiency payments, hectare reduction programs, water availability, and the government “freedom-to-farm” policy. Production costs vary among the rice producing states and are influenced by factors such as seeding method, soil type, and variety-dependent nitrogen (N) rate. Average U.S. price per quintal ranged from US\$4.40 in the early 1920s to a high of over US\$28.22 in 1980. It is currently around US\$13.22 (Figure 3). Total direct production costs (excluding fixed expenses: tractors, implements, self-propelled equipment, and irrigation systems) have ranged from about US\$716 to US\$958/ha/year. Fertilizer costs have ranged from about US\$109/ha for N-only programs to US\$163/ha for N, phosphorus (P), potassium (K), sulfur (S), and zinc (Zn) programs in the Midsouth, to US\$212 for N and P programs in California. Fertilization costs account for about 13 to 26 percent of the annual direct production costs.



**Figure 3.** Average U.S. rice price. Source: USDA-NASS.

## Fertilization

Nitrogen is the fertilizer nutrient required in the greatest amount for maximizing rice yields. Fertilizer N use efficiency (NUE) is usually greatest in dry-seeded production systems when it is applied to dry soil, just prior to permanent flood establishment. Urea is the most common N source because of its high analysis and relatively low cost per kilogram of N. Only ammonium-N ( $\text{NH}_4\text{-N}$ ) fertilizer sources are recommended because the  $\text{NH}_4$  is stable under flooded soil conditions. Nitrate-N ( $\text{NO}_3\text{-N}$ ) sources are subject to denitrification losses after flooding and are not recommended for use. Nitrogen is often applied up to three times during the season: approximately 50 to 70 percent of the total N rate at pre-flood, 15 to 25 percent at 1.25 cm internode elongation (IE), and 15 to 25 percent at 10 to 14 days after 1.25 cm IE. Isotopic N studies have shown that plant recovery of urea-N fertilizer can approach 70 to 75 percent when applied in a three-way split.

Grain yield and NUE are reduced when: flood establishment is delayed after the pre-flood fertilizer N application; fertilizer N is applied to a wet soil; and/or N fertilizer is applied into the floodwater for seedling rice uptake. The goal with the pre-flood application is to incorporate fertilizer N into the soil with the floodwater. This positions N in the root zone, below the oxygenated soil-water interface, limiting nitrification and the potential for subsequent denitrification. According to research and monitoring of water quality in Texas and Arkansas, N and P concentrations in surface runoff from flooded commercial

rice fields are frequently lower than groundwater pumped onto the fields. The rapid nutrient uptake and filtering effects of rice make run-off N and P losses negligible under recommended fertilizer and irrigation management practices.

The appropriate agronomic N rates and best times of application are determined by each state based on variety and cultural management-specific research. Prior to 1995, a three-way split application of N fertilizer was common in the Midsouth. A two-way split (pre-flood and at IE) has recently replaced the three-way split in the Midsouth states because of more precise irrigation management and increased planting of short-season, stiff-strawed cultivars.

Recent legislation in California is phasing out the common practice of rice straw burning. Therefore, straw must be incorporated or removed from fields. Many rice farmers in California and the Midsouth re-flood fields in the winter months to create a more favorable habitat for waterfowl. The impact of these practices on nutrient cycling...especially N, carbon (C), and K...and how to manage both pre-plant and post-plant nutrients is currently being studied.

Research suggests that maximum rice yields can be obtained using less total seasonal fertilizer N when the majority of N is applied immediately before flooding during vegetative growth. Thus, recommendations are shifting towards the use of a single, large pre-flood N rate with fertilizer NUE monitored at midseason growth stages. Where it is difficult to establish or maintain a permanent flood in a timely manner, many farmers continue to use a two-way split: 65 to 135 kg N/ha (depending on variety) pre-flood with the remainder (about 65 kg N/ha) applied at midseason, beginning at IE to 1.25 cm IE. The N rate on clay soils is generally 20 to 35 kg N/ha greater than those recommended for silt loam soils.

The need for a midseason N application in the Midsouth is increasingly being based on plant biomass estimates of total N uptake using a plant area reference board, calibrated and specific for the variety and growing degree unit [DD-10 (°C)] accumulation. The DD-10 program is used extensively in Arkansas and some adjacent states to assist growers in making up to 26 management decisions. In Texas and some other areas, midseason N requirements are sometimes based on chlorophyll meter readings from recently matured leaves. In California and other states, laboratory N analysis of sampled flag leaf or Y-leaf tissue determines the need for midseason N. Midseason fertilizer applications are typically made by airplane or helicopter.

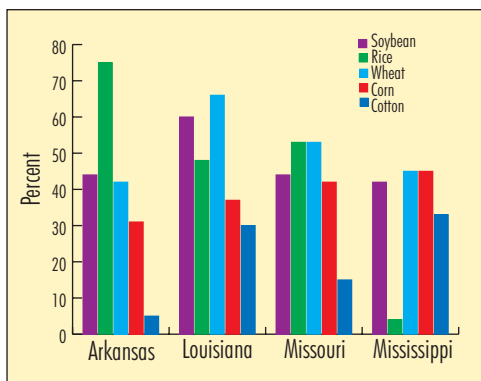
In water-seeded, permanently flooded systems, the maximum response to N is achieved by  $\text{NH}_4\text{-N}$  pre-plant incorporated 5 to 10 cm deep into a dry seedbed before flooding. Additional N is applied at midseason as needed. In an effort to reduce weed pressure from red rice,

water-seeded systems are sometimes used, especially in Louisiana. It is usually beneficial to broadcast some of the N during the pin-point drain (after water seeding to ensure anchoring of roots) and prior to re-flooding.

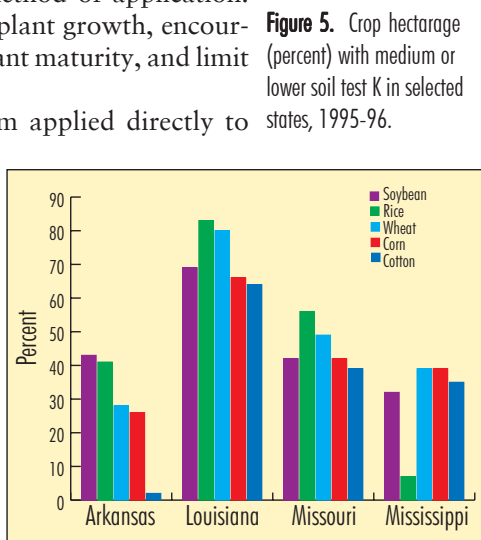
Balanced fertilization with P, K, S, and Zn in many rice fields is essential for production of high yielding rice and to attain maximum NUE. These nutrients are usually applied to silt and sandy loam soils based on soil test recommendations. Rice farmers commonly use 35 to 65 kg  $P_2O_5$ /ha, 65 to 100 kg  $K_2O$ /ha, and from 10 to 20 kg S/ha. Although infrequent, silty clay and clay soils may also receive P, K, and S fertilizers. Zinc is often applied on many alkaline silt loam soils (pH >7.0) and occasionally to clays at rates from 1 to 11 kg Zn/ha, depending on the Zn source and time/method of application. Deficiencies of any of these nutrients can reduce plant growth, encourage disease development, interfere with normal plant maturity, and limit yield.

Historically, P and K fertilizers were seldom applied directly to rice. Rice relied on residual P and K from fertilizer applied directly to other crops in the rotation. Early research indicated that rice yield responses to P fertilization were infrequent because P was released from iron (Fe) and aluminum (Al) compounds in the soil upon flooding. However, many rice fields now have a long history of irrigation with well water (groundwater), and significant amounts of calcium bicarbonate have been deposited. Soil pH has risen to the alkaline range, and forms of soil P have shifted to include calcium phosphates, which are not as affected by reduction upon flooding.

Recent research suggests that economic rice yield responses to P fertilization are most likely to occur on alkaline soils or where land-forming has removed topsoil. Soil test summaries from several Midsouth states reveal that soils used for rice production generally have some of the lowest P and K soil test levels compared to those used for the production of other major field crops (**Figures 4 and 5**). Most of the soils used for rice production in Texas and Mississippi are acid to strongly alkaline silty clays and clays that do not test as low in P and K as the silt loam soils in other states. Soil test P levels for these clayey soils in Mississippi and Texas range from low to high, and K levels often test in the high range. In Arkansas, the responses to recommended rates of P have ranged from 500 to 2,500 kg/ha on alkaline silt



**Figure 4.** Crop hectareage (percent) with medium or lower soil test P in selected states, 1995-96.



**Figure 5.** Crop hectareage (percent) with medium or lower soil test K in selected states, 1995-96.

loams testing medium or lower in Mehlich 3 P (less than 15 to 25 parts per million [ppm]). Responses to K typically range from 500 to 1,500 kg/ha on soils testing medium or lower in Mehlich 3 K (less than 90 ppm). In response to the increased frequency of P and K deficiencies in rice, university research efforts and industry and extension educational programs concerning crop nutritional requirements have intensified. More Midsouth farmers have begun to apply maintenance rates of P and K to silt loam soils, equivalent to the rate of harvest removal (0.64 kg P<sub>2</sub>O<sub>5</sub> and 0.40 kg K<sub>2</sub>O/quintal). Failure to increase or at least maintain soil test P and K levels on soils used for rice production has been blamed for compromising Midsouth soil fertility management and lowering the yield potential of rotational crops such as wheat, soybeans, corn, and grain sorghum.

### Land Preparation, Planting, and Irrigation

The majority of U.S. rice has typically been planted with grain drills on prepared seedbeds following several tillage and smoothing operations. Seed are usually drilled at about 430 seed/m<sup>2</sup> under ideal conditions, to provide a uniform stand of about 160 to 215 plants/m<sup>2</sup>. Adjustments from the standard seeding rate are made for different varieties, tillage systems, seeding methods, and environmental conditions.

Many fields are shaped to a uniform grade to facilitate efficient flood irrigation and field drainage prior to harvest. Either before or after planting, levee (soil burm) locations are laser surveyed and marked. After planting in dry-seeded systems, levees are established at 3- to 6-cm elevation intervals using levee discs or squeezers. The levees are established on the contour, except where precision leveling has been conducted to facilitate straight levees. Rice seeds are usually broadcast on the levees, from the tractor, and incorporated during the last trip(s) over the levee in the forming process.

Levee gates, or spills, are established in each levee using metal and/or vinyl frames, to permit maintenance of a shallow 5- to 10-cm flood depth in each paddy throughout the growing season. Desirable irrigation pumping capacities from wells, surface reservoirs and streams enable farmers to flush water across an entire field (15 to 65 ha) in three to four days and to flood a field in three to five days. Precise flood irrigation management is one of the most important factors affecting NUE and integrated pest management practices. Irrigation is stopped, and fields are drained about 14 and 25 days after heading, respectively.

### Pest Management

Field scouting is used to detect weed, disease, and insect infestations and to time pest management control practices. Plant protectants are applied in-season according to research-based treatment thresholds



**Rice harvest** near  
Jonesboro, Arkansas.

in integrated pest management programs. Plant nutritional status, as affected by nutrient management, may impact rice response to pests and pest management strategies. The relative level of soil fertility most dramatically affects disease reaction. Inadequate or excessive fertilization, especially with N, may increase the frequency and severity of many rice diseases. Ensuring adequate K nutrition has reduced the incidence of brown leaf spot, stem rot, and some other diseases. Sheath blight (*Rhizoctonia solani*), blast (*Pyricularia oryzae*), straighthead (physiological disorder), stem rot (*Sclerotium oryzae*), kernel smut (*Neovossia barclayana*), black sheath rot (*Gaeumannomyces graminis* var. *graminis*), brown leaf spot (*Bipolaris oryzae*), scab (*Fusarium graminearum*), *Fusarium* sheath rot (*Fusarium proliferatum*), and other diseases are managed/controlled through appropriate selection of tolerant/resistant varieties, balanced fertilization, rice stubble management, and rotation to non-host crops.

## Summary

Rice grower support of public breeding and management research programs has led to the release of high-yielding short-statured and semi-dwarf varieties. The combined effects of higher-yielding varieties, better fertility management, threshold-based pest management, and intensive irrigation management have enabled U.S. rice producers to continuously increase the national average rice yields since the early 1980s (Figure 1). The adoption and use of site-specific management technologies...such as global positioning system (GPS)-referenced yield monitoring, variable rate or management-zone application of nutrients and soil amendments, remote sensing, etc...is increasing, especially where significant precision land leveling has been performed to improve irrigation water use efficiency. The trend toward improved management and higher U.S. rice yields is likely to continue as the world demand for rice grows. **BCI**

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