UNITED STATES

Rice Production in the United States – an Overview

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

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. has 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 292,000 acres were harvested in 1895 with a yield of 1,140 lb/A. Harvested area increased to more than 1 million acres in 1919, 2 million in 1959, and 3 million in 1980. The greatest harvested acreage to date was 3.79 million acres in 1981, with an average yield of 4,820 lb/A.

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

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 6,240 lb/A for 3.08 million acres. Seventy-three percent of the rice acreage grown in 2000 was long grain, 26 percent was medium grain, and about 1 percent was short grain rice. California has the highest average yields (**Figure 1**), while Arkansas has the greatest acreage (**Figure 2**). 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 acreage has shifted from year to

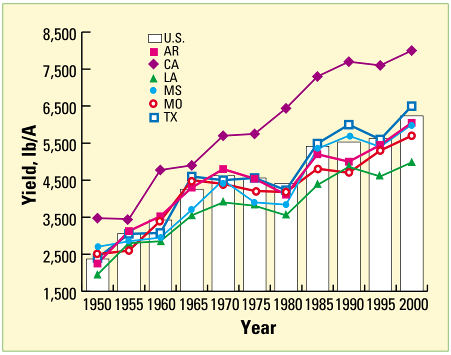

Figure 1. U.S. and state average rice yields – 1950 to current. Source: USDA-NASS

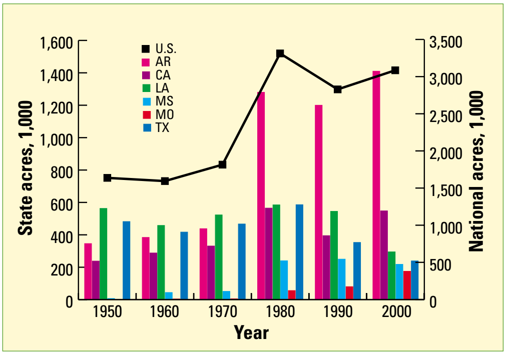

Figure 2. State and U.S. rice acreage harvested – selected years. Source: USDA-NASS

year depending on many factors: marketing quotas, government acreage allotments, export demand, production deficiency payments, acreage reduction programs, water availability, and the 'freedom-to-farm' government 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 hundred weight (cwt) ranged from \$2.00 in the early 1920s to a high of over \$12.80 in 1980. It is currently around \$6.00/cwt (**Figure 3**). Total direct production costs (excluding fixed expenses: tractors, implements, self-propelled equipment, and irrigation systems) have varied from about \$290 to \$388/A/year. Fertilizer costs have ranged from about \$44/A for N-only programs to \$66/A for N, phosphorus (P), potassium (K), sulfur (S), and zinc (Zn) programs in the Midsouth to \$86/A for N and P programs in California. Fertilization costs account for about 13 to 26 percent of the annual direct production costs.

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 pound of N. Only ammonium-N (NH_4-N) fertilizer sources are recommended because the NH_4 is

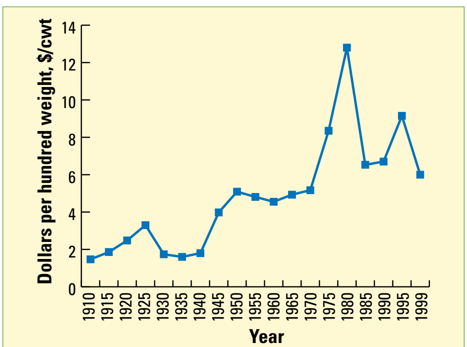

Figure 3. Average U.S. rice price.
Source: USDA-NASS

stable under flooded soil conditions. Nitrate-N (NO_3-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 is applied at preflood, 15 to 25 percent at $^1/_2$-in. internode elongation (IE), and 15 to 25 percent at 10 to 14 days after $^1/_2$-in. 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 preflood 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 preflood 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 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 runoff 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 (preflood 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. Straw must either be incorporated or removed from fields. Many rice farmers in California and the Midsouth reflood fields in the winter months to create a more favorable habitat for waterfowl. The impact of these practices on nutrient cycling, especially N, K, and carbon (C), and management of pre- 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 preflood 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: 60 to 120 lb N/A (depending on variety) preflood with the remainder (about 60 lb N/A) applied at midseason, beginning at IE to 1/2-in. IE. The N rate on clay soils is generally 20 to 30 lb N/A greater than that recommended for silt loam soils. The need for a midseason N application in the Midsouth is increasingly 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-50 (degrees Fahrenheit)] accumulation. The DD-50 program is used extensively in Arkansas and some adjacent states to assist growers in making up to 26 management decisions. In Texas, and 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 an effort to reduce weed pressure from red rice, water-seeded systems are sometimes used, especially in Louisiana. In water-seeded, permanently flooded systems, the maximum response to N is achieved by NH_4-N preplant incorporated 2- to 4-in. deep into a dry seedbed before flooding. Additional N is applied at midseason as needed. It is sometimes beneficial to broadcast some of the N during the pin-point drain (after water seeding to ensure anchoring of roots) and prior to reflooding.

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 30 to 60 lb P_2O_5/A, 60 to 90 lb K_2O/A, and from 10 to 20 lb S/A. 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 10 lb Zn/A, depending on the Zn source and time/method of application. Deficiencies 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 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. Now, many rice fields 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

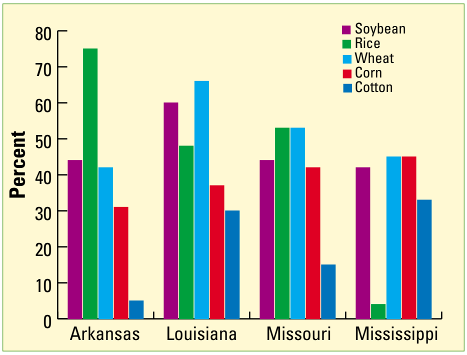

Figure 4. Crop acreage (%) with medium or lower soil test P in selected states (1995-96).

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 10 to 50 bu/A on alkaline silt loams testing medium or lower in Mehlich 3 P [<15 to 25 parts per million (ppm)]. Responses to K typically range from 10 to 30 bu/A on soils testing medium or lower in Mehlich 3 K (<88 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 (0.29 lb P_2O_5/bu and 0.18 lb K_2O/bu). 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, Irrigation

The majority of U.S. rice has typically been planted with seed drills on prepared seedbeds following several tillage and smoothing operations. Seed are usually drilled at about 40 seed/ft^2 under ideal conditions, to provide a uniform stand of about 15 to 20

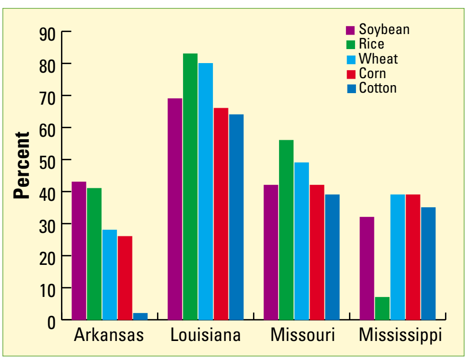

Figure 5. Crop acreage (%) with medium or lower soil test K in selected states (1995-96).

plants/ft^2. 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 locations are laser surveyed and marked. After planting in dry-seeded systems, levees (soil burms) are established at 0.1- to 0.2-ft. 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 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 2- to 4-in. 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 (40 to 160 acres) 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 practices. Plant protectants are applied in-season based on research-based treatment thresholds 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 spot (*Cochliobolus miyabeanus*), brown leaf spot, (*Bipolaris oryzae*), scab (*Fusarium graninearum*), Fusarium sheath rot (*Fusarium proliferatum*), and other diseases are managed/controlled through 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. 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. are 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.

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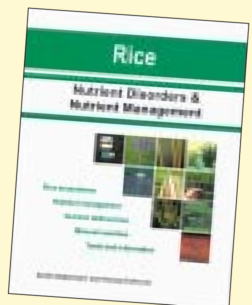
New Handbook on Rice Nutrient Management Now Available



The International Rice Research Institute (IRRI) in the Philippines has forecast that rice yields must increase by 30 percent by 2020 to keep pace with growing demand due to population increases.

A new handbook published by IRRI and PPI/PPIC describes site-specific nutrient management methods and provides a reference to assist with the identification and management of nutrient disorders. Titled *Rice: Nutrient Disorders & Nutrient Management*, the 191 page book is authored by Dr. Achim Dobermann, formerly with IRRI and now with the University of Nebraska, and Dr. Thomas H. Fairhurst, Deputy Director, PPI/PPIC East and Southeast Asia Program, Singapore.

Oriented to production in tropical and subtropical regions, topics include rice ecosystems, nutrient management, nutrient deficiencies, and mineral toxicities. Estimates of nutrient removal in grain and straw are included to help researchers and extension workers calculate the amount of nutrients lost from the field under various management systems. The publication will improve understanding of new approaches to nutrient management at the farm level.

The book with CD-ROM is available for purchase. The price (including shipping/ handling) is US$32.00 in less developed countries and US$77.00 in highly developed countries. For more details, check the website at **www.eseap.org**, or contact Doris Tan, PPI/PPIC (ESEAP), 126 Watten Estate Road, Singapore 287599. E-mail: dtan@ppi-ppic.org, phone: 65 468 1143, or fax: 65 467 0416.