CALIFORNIA

# *Nutrient Requirements of Rice with Alternative Straw Management*

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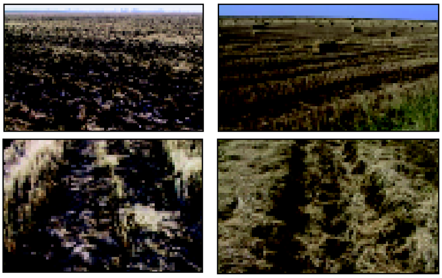
**As the burning of rice straw was phased out in California, a 3-year research project was conducted to determine the effect of straw management on rice nutrient requirements, especially nitrogen (N) and potassium (K). Removal of rice straw from the field exports an additional 50 lb N/A and 140 lb $K_2O$/A beyond the nutrients harvested in the grain. When the straw is left in the field during winter flooding, most of these nutrients will be available for the following crop. Soil extraction with ammonium acetate was a good predictor of K deficiency.**

Over 550,000 acres of rice are currently grown in California, mainly in the Sacramento Valley. These rice growers produce some of the highest yields in the world, as a result of finely-tuned management practices developed by close cooperation between public and industry-supported researchers. Grain yields frequently exceed 8,500 lb/A, with research plots exceeding 13,000 lb/A.

After harvest, rice straw has traditionally been burned to facilitate tillage and reduce potential pest problems. Due to air quality concerns, this practice has been greatly eliminated. Farmers now manage the straw in several alternative ways...incorporation of straw is used on about 75 to 80% of the acreage, burning on about 15 to 20%, and removal on less than 5% of the rice acreage. Each of these practices has a different effect on the nutrient balance and the fertility requirement for the following crop. Rice straw has a high ash content (>20%) and does not decompose as quickly as straw from many other grain crops, such as wheat or barley (5 to 10% ash).



**Methods** of managing rice straw include incorporation, burning, baling, and spreading.

When rice straw and stubble are incorporated into the soil following harvest and then flooded during the winter, it can improve soil properties and serve as a source of nutrients for the following crop. Since many of the plant nutrients remain in the straw following harvest [approximately 35% of the N, 30% of the phosphorus (P), 85% of the K, and 40 to 50% of the sulfur (S)], much of this can be recycled for subsequent crop growth following decomposition. As rice straw contains most of the accumulated plant K, how this resource is managed has a large impact on its long-term availability, particularly on soils with relatively low native K concentrations.

A 3-year field experiment was conducted to determine the effect of straw management and nutrient application rate on rice productivity. In the fall of 1998, 1999, and 2000, straw was either chopped and incorporated or removed from rice fields following grain harvest. The following spring, N fertilizer [as $(NH_4)_2SO_4$)] was added at five application rates (0, 45, 90, 135, or 180 lb N/A) in factorial combination with six rates of K as KCl (0, 26, 53, 80, 108, and 132 lb $K_2O$/A). Soil and plant parameters were measured each season.

**Nitrogen management.** Addition of fertilizer N significantly increased grain yield all 3 years, regardless of straw management practices (**Figure 1**). However, an increase in the soil N supply was noted when straw was regularly returned to the soil, reducing the need for N fertilizer. Since straw contains an average of 50 lb N/A, we currently recommend that when straw has been incorporated for at least 5 years, that the N fertilizer rate be decreased by 25 lb N/A. This N fertilizer savings has the potential advantages of lowering production costs and reducing off-site loss.

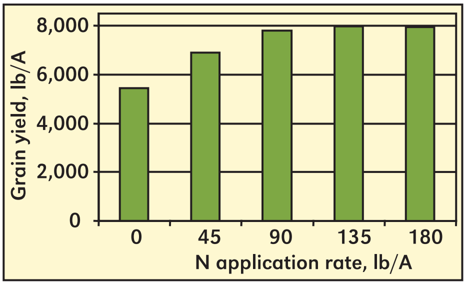



Figure 1. Average rice grain yield response to applied N fertilizer averaged over K additions and straw management during the 3-year study.

**Potassium management.** When straw was removed from the field following harvest, there was a significant positive response in grain yield following application of K fertilizer each year (**Figure 2**). When straw was incorporated into the soil, there was no grain response to application of K in the first 2 years of the experiment. During the third year, there was a significant increase in grain yield with the application of K fertilizer when straw was incorporated. The concentration of exchangeable soil K (extracted with 1 mol/L ammonium acetate) was found to be an excellent predictor of tissue K concentrations and grain yields, especially when soil K was low. Whenever extractable soil K concentrations fall below 60 parts per million (ppm), a loss of grain yield is anticipated. When rice straw is incorporated into the soil, this critical value may need to be increased somewhat.

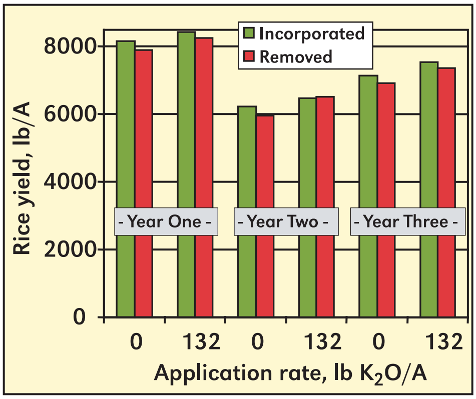



Figure 2. Average rice grain yield response to applied K fertilizer, as affected by K fertilization rate and straw management (averaged over N treatments) during the 3-year study.

**Nutrient budget.** Over the 3-year study, average K removal in the grain was 40 lb $K_2O$/A/year and averaged 140 lb $K_2O$/A/year in rice straw **(Table 1)**. When both grain and straw are removed from the field, K depletion occurs at a rate of 180 lb $K_2O$/A/year. Even at the highest rate of K application tested in this study, there was a steady depletion of nutrients over the 3 years (**Figure 3**). When grain is harvested and straw incorporated back into the soil, removal of harvested K is balanced with annual applications of 35 to 45 lb $K_2O$/A/year.

*(continued on page 11)*

**Symptoms** of K deficiency include firing (top of center leaf) and flecking (on leaf to right of center).

Table 1. Typical amounts of nutrients removed by rice.

| Nutrient | Content, lb/cwt | | Removal in 8,000 lb/A, lb | | Total nutrient removal when straw harvested, lb/A |
|---|---|---|---|---|---|
| | Straw | Grain | Straw | Grain | |
| N | 0.63 | 1.27 | 50 | 100 | 150 |
| $P_2O_5$ | 0.23 | 0.67 | 18 | 54 | 72 |
| $K_2O$ | 1.80 | 0.54 | 140 | 43 | 183 |
| Si | 11.0 | 2.1 | 880 | 170 | 1050 |

as a forage crop, increased 34% where P was surface-applied and 23% where P was knifed into the soil. In all cases, surface-applied P fertilizer was equal to or better than P knifed into the soil. A greater advantage to knifed P would be expected at very low soil test P levels and very low P application rates.

Although results from economic analyses of each treatment were not statistically different, surface-applied P produced the highest net returns in each system, averaging $44/A in the graze-plus-grain system and $16/A in the graze-out system. In addition to paying for the P fertilizer, surface-applied P returned $12/A and $8/A in the two management systems.

**Net returns to land, management, and other indirect costs were consistently higher in the graze-plus-grain than in the graze-out system, indicating that grain production is a major factor in profitability of wheat/stocker programs in the Texas Rolling Plains.** BC

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## *Straw Management...* *(continued from page 7)*

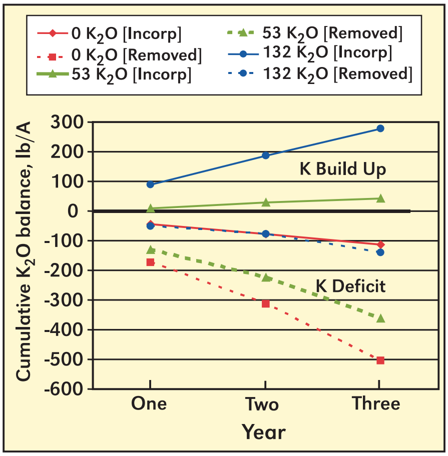


**Figure 3.** Potassium balance for 3 years of rice production, as affected by straw management (incorporated or removed) and K fertilizer addition (0, 53, or 132 lb $K_2O$/A).

Changes in straw management practices have an impact on a number of related issues. For example, an increase in methane production (a greenhouse gas) from rice fields occurs when straw is left in the field under flooded conditions. However, increases in soil carbon that follow from straw incorporation may reduce the amount of carbon dioxide emitted to the atmosphere. Additionally, winter flooding which increases the decomposition of rice straw also creates valuable habitat for millions of migratory and wetland-dependent birds along the Pacific Flyway in northern California.

Rice straw is a valuable source of plant nutrients and its management can make a significant impact on the following crop. The rice industry is working to develop off-field uses for rice straw with the goal of converting crop residues to a profitable resource. Current research shows that straw removal removes large amounts of nutrients which must be replaced to sustain yields. Careful management of rice straw will slow the export of nutrients from the soil, reduce production costs, and eliminate air quality concerns associated with burning...all while maintaining a high level of grain production. BC

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