Rice Potassium Nutrition Research Progress

By David Dunn and Gene Stevens

Recent Missouri research has shown significant rice response to potassium (K) fertilization applied pre-plant or at mid-season on silt loam soils. Soil test K interpretations and fertilizer recommendations for rice were increased.

Missouri has a long history of rice production, going back to 1910 when the crop was first grown in the southeast region of the state. From this 40-acre start, rice acreage has increased steadily over the years to over 200,000 acres currently. The statewide average yield was 110 bu/A in 1997 and increased to over 141 bu/A in 2004. Traditionally, nitrogen (N) management has been given top priority by farmers. But with increased yields and rotations with soybeans, K fertility is increasingly being recognized as a yield limitation in some Missouri rice fields.

Research conducted by the University of Missouri is now highlighting the importance of K in rice production. Historically, soil test-based fertilizer recommendations for rice grown in Missouri were adapted from work in the surrounding states of Arkansas and Mississippi. As production increased, a need for soil test recommendations specific to Missouri soils was recognized. Missouri uses a 1 N ammonium acetate (NH_4OAc) extraction for K, while Arkansas uses the Mehlich-3 extractant and Mississippi uses the Lancaster extractant. Initial soil testing and soil fertility research in Missouri focused on improving soil test recommendations for K and has now expanded to the diagnosis and correction of K deficiency at mid-season.

Rice production in the Bootheel region of southeast Missouri is on silt loam soils west of Crowley's Ridge, and clayey soils generally found to the east of Crowley's Ridge. The Sharkey clay soils (Vertic Haplaquepts) generally have high native available K levels (500 to 600 lb K/A) and do not require K fertilization. Many of these clayey soils have been recently land leveled and have a limited history of rice production. If intensive rice and soybean production continues on these soils, they will eventually require K fertilization. The silt loam to silty clay loam soils with a longer history of rice production often require K fertilization. This article focuses on drill-seeded rice grown on silt loams using the delayed-flood management system (i.e., flooded at the 5-leaf stage, 20 to 30 days after emergence, after urea is applied to a dry soil surface).

Soil test K management. Potassium deficiency in rice can reduce grain yields and increase lodging. Visual symptoms of K deficiency in rice first appear in older leaves (**Figure 1**). These symptoms include

Figure 1. Brown areas on leaf margins and tips in rice are a visual indicator of K deficiency.

a yellowing of leaf tips, decreased disease resistance, and reduced yields. Increased stalk strength and decreased lodging are associated with proper K nutrition. When this study began, the University of Missouri soil test critical level for K (lb/A) was 5 x cation exchange capacity (CEC) based on a 1 *N* NH_4OAc extraction. During the late 1990s, Missouri rice producers began growing Baldo, a variety grown for a specialized Mediterranean and west Asian market. This variety is much taller than the semi-dwarf varieties typically grown. Agronomists from Italy recommended applying mid-season K applications on Baldo to increase stalk strength and reduce lodging.

To test this management strategy under Missouri conditions, a 2-year evaluation of pre-plant and midseason K fertilization strategies was undertaken on a Crowley silt loam soil (Typic Albaqualf) having 110 lb NH_4OAc extractable K/A. A single pre-plant (48 lb K_2O/A) application was compared to two 24 lb K_2O/A applications at mid-season, using potassium chloride (KCl) as the K source. Two foliar treatments were also evaluated: 1) two applications of 12 lb K_2O/A as potassium nitrate (KNO_3), and 2) two foliar applications of urea (1.3 lb N/A). The urea treatment was included to allow separation of the effects of N and K in the KNO_3 treatment. The results for the foliar urea treatment were identical to that of the untreated check and will not be discussed further. Response of Baldo was compared to Bengal, which is considered susceptible to K deficiency.

The results of these investigations were: 1) pre-plant and mid-season K applications increased rice yields on a soil where K fertilization was not expected to increase yields (**Figure 2**), 2) Visual deficiency symptoms were sometimes observed at mid-season. Tissue K analysis of flag leaves at mid-season did not reveal significant differences between treatments (data not shown) and was not an effective tool for diagnosing K deficiency in rice, and 3) Lodging of Baldo was significantly reduced by foliar applications of KNO_3 at midseason (**Figure 3**). No lodging of Bengal was observed.

These findings prompted a more detailed K rate study beginning in 2001. Methods to diagnose mid-season K deficiency were also evaluated as part of the study. Three rates of pre-plant K fertilization were compared (0, 50, and 200 lb K_2O/A). When relative yields were compared, the 50 lb K_2O/A rate provided 95% of the maximum yield (**Figure 4**). As a result of this study, the critical level for soil test recommendations was increased to 125 lb of available K/A + (5 x CEC) in 2003. Comparison of our results with those in Arkansas, Louisiana, and Mississippi indicate that this new soil test K interpretation level is similar to the interpretations in those states.

Monitoring rice tissue K. Plant tissue samples were collected for K analyses from

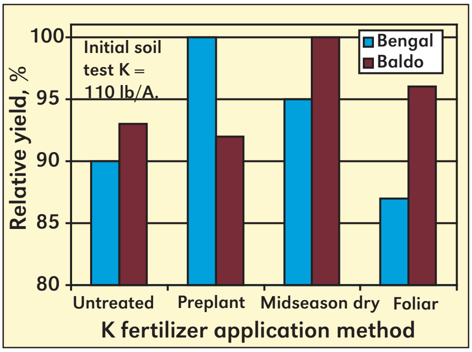

Figure 2. Relative yields for K treatments of Baldo and Bengal rice averaged across 1999 and 2000 at Qulin, Missouri.

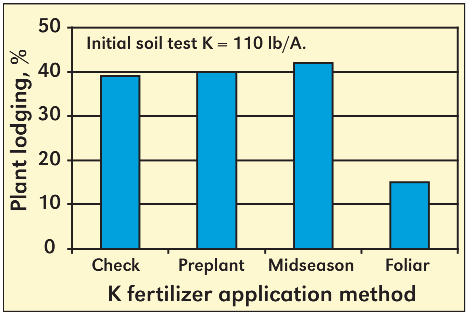

Figure 3. Effect of K treatments on lodging of Baldo rice variety averaged across 1999 and 2000 at Qulin, Missouri.

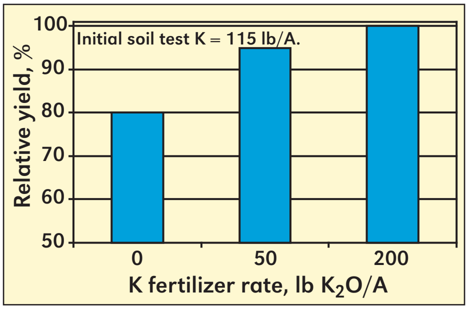

Figure 4. Effect of preplant K fertilizer rates on relative rice yields in tissue K monitoring experiments in 2002 and 2003 at Qulin, Missouri.

each plot every two weeks during the growing season beginning at first tiller and continued until harvest. Samples were divided into plant components (i.e. upper leaf, lower leaf, stalk, and whole above-ground plant). Correlation analyses were made between yields and plant tissue K levels (**Table 1**). Plant tissue testing clearly showed the effect of K fertilization. At first tiller, only the whole plant was analyzed. At this growth stage, untreated check plants (0 K) had lower K concentrations than plants that received 50 and 200 lb K_2O/A. At internode elongation, the rice plants were divided into the following plant parts: stem, flag leaf, lowest leaf, and whole plant.

Correlations between plant K and yield were generally better in 2003 than 2002 (**Table 1**). The best correlation in 2003 was for whole plant at first tiller growth stage. Tissue K levels of lower leaves were better correlated to grain yields than were K levels of flag leaves. Leaf K concentrations were greatest in the upper leaves, but the lowest leaves showed the most differences between K fertilizer treatments. At internode elongation, all of the leaves had K levels above the critical sufficiency level of 1.0%. Potassium content of stems also reflected K treatment differences at panicle initiation. Whole plant tissue K content increased with increasing K fertilization. Stem K content at 10% heading also closely reflected K treatment differences.

Table 1. Correlation of plant tissue K levels with grain yields in 2002 and 2003 at Qulin, Missouri.

		r^2 value	
Growth stage	Plant part	2002	2003
First tiller	Whole	0.22	0.54
Internode elongation	Whole	0.27	0.37
	Flag leaf	0.07	0.23
	Lowest leaf	0.38	0.39
	Stem	0.07	0.30
10% Heading	Whole	0.25	0.32
	Flag leaf	0.06	0.07
	Lowest leaf	0.45	0.39
	Stem	0.11	0.41
	Head	0.001	0.003

The K content of heads was affected erratically by K fertilization, and K levels of heads were poorly correlated to yields.

In summary, tests showed that preplant and mid-season K applications increased rice yields on soils where K fertilization was not previously expected to have that effect. This prompted the University of Missouri to increase critical soil test K (lb/A) from 5 x CEC to 125 lb extractable K/A + (5 x CEC). Tissue testing showed that K concentrations in lower rice leaves were better for measuring K status than tissue K in flag leaves. BC

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InfoAg 2005 Scheduled for July 19 to 21

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