Plant Mapping Potassium in Rice Tissue: What Part to Sample When?

First Year (2003) Progress report

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Objectives

(1) Develop critical levels of K concentrations within rice plants during the growing season.
(2) Define which plant parts are most appropriate for plant tissue K analysis.
(3) Evaluate current University of Missouri soil test recommendations for K fertilization of rice.

Introduction

Proper potassium (K) nutrition is critical for maximizing rice grain yields. K is very mobile within the rice plant. Older leaves are scavenged for the K needed by younger leaves. Recent studies at the Missouri Rice Research Farm have shown that supplemental K can be supplied to the rice plant as late as Internode Elongation (IE) and still increase rice grain yields. In this same study whole plant K analysis at IE was better correlated to yield than flag leaf analysis at early boot. Profitable rice production hinges on accurate, reliable, and relevant information about plant-soil interactions. A review of the available literature shows that no consistent methodology has been developed correlating K determinations in rice plants to rice grain yields. This study will attempt to determine which part of the rice plant and at which growth stage tissue samples should be collected.

Research Methods:

Reference plots for potassium fertilization were established at the Missouri Rice Research Farm at Qulin, MO on a soil testing low in available K. These plots received one of three levels of K fertilization, deficient (0 lb K/a), adequate (50 lbK/a), and excessive (200 lbK/a). Plant tissue samples were collected from each plot every two weeks during the growing season beginning at first tiller and continuing through harvest. These samples were then divided into plant components i.e. upper leaf, lower leaf, stalk, and whole plant. These tissue samples were analyzed for K%. Each plot was mechanically harvested for yield and the grain milled for quality determination. Correlation will be made between yield and plant tissue K levels.

Two additional studies were conducted on these reference plots. In one study a Cardy meter was used to determine plant K status. Cardy meter determinations for K were collected three times during the growing season. The results were then compared to traditional plant analysis values. In the second study basal stalk breaking strength was determined and compared to plant tissue K levels. Following harvest 12-inch long basal stalk samples were collected from each plot. These samples were evaluated for breaking strength by progressively adding weights to a cup suspended by a string from the stalk. The weight at which each stalk failed was recorded. These stalks were then dried, ground, and analyzed for K concentration

Statistical analyses of the data were preformed with SAS (1990) using General Linear Modeling procedures. Fisher's Protected Least Significant Difference (LSD) was calculated at the 0.05 probability level for making treatment mean comparisons. Regression and correlation analysis were performed in accordance with procedures outlined by the SAS Institute (SAS, 1997)

Project Accomplishments 2003:

Data collected during 2003 is presented in Tables 1, 2, and 3 and Figures 1and 2. In 2003 grain yields were significantly increased by both levels of K fertilization (Table 1). Grain yields for the 50 and 200 lbsK/a treatments were statistically equivalent. This indicted that the University of Missouri's revised soil test recommendations for K on rice appear to be appropriate. Flag leaf K levels were greater than lower leaf levels (Table 2). This difference was greater at 10% heading than at internode elongation. Table 3. shows the relationship between tissue K levels and rice grain yields. The best correlation between yields and tissue K levels were found at the first tiller growth stage Tissue K levels of lower leaves were better correlated with yield than flag leaves. Cardy meter determinations were found to compare well with traditional lab tissue analysis (Figure 1). Rice stalk breaking strength was correlated to lower stalk tissue K levels (Figure 2).

This data was presented to 175 rice producers at the 2003 Rice Farm Field Day held 8-27-03 in Qulin, MO and 900 interested parties at the Delta Center Field Day held 9-2-03 in Portageville MO. Results were also presented to 55 crops researchers at the Southern Plant Nutrition Conference held 10-6,7-03 in Olive Branch, MS and to 2,400 crops researchers at the American Society of Agronomy Annual meeting in Denver, CO held 11-3,4,5,6-2003(Appendix 1). Additionally two abstracts for presentations at the 2004 Rice Technical Working Group Conference held in New Orleans, LA have been accepted (Appendix 2 and 3).

Budget for 2004:

Expenses		**Year**	
	2003	**2004**	2005
Res. Specialist salary (0.25)	6,750	**6,953**	7,162
Fringe benefits	1,688	**1,739**	1,791
Student Labor (.125)	2,000	**2,060**	2,122
Fringe benefits	160	**165**	170
Supplies	2,000	**2,060**	2,122
Plant and soil analysis	5,600	**5,678**	5,758
Travel	1,800	**1,836**	1,873
Total	$19,998	**$20,491**	$20,998

Table 1. Average rice grain yield, moisture %, and milling quality for K treatments 2003.

Treatment	Yield (bu/a)	Moisture %	Milling Head%/Whole%
O lbs K/a	95a	14a	57a/65a
50 lbs K/a	112b	13.5a	57a/66a
200 lbsK/a	117b	13.3a	56a/66a

Table 2. Average tissue K levels for rice plant parts at growth stages for K treatments, 2003.

Growth Stage	Plant Part	Tissue K %		
		0 lbs K/a	50 lbs K/a	200 lbs K/a
First tiller	Whole	2.93	3.15	3.43
Internode elongation	Whole	2.17	2.24	2.42
Internode elongation	Flag leaf	1.78	2.08	2.25
Internode elongation	Lowest leaf	1.49	1.80	1.94
Internode elongation	Stem	2.40	2.92	3.25
10% Heading	Whole	1.36	1.39	1.44
10% Heading	Flag leaf	1.43	1.85	1.93
10% Heading	Lowest leaf	1.26	1.43	1.44
10% Heading	Stem	0.88	1.57	1.64
10% Heading	Head	0.95	1.11	0.69

Table 3. Correlation of plant tissue K levels with grain yields, 2003.

Growth Stage	Plant Part	R^2 value	Equation
First tiller	Whole	0.54	y = 0.03x-0.30
Internode elongation	Whole	0.37	y = 0.02x-0.18
Internode elongation	Flag leaf	0.23	y = 0.17x+0.24
Internode elongation	Lowest leaf	0.39	y = 0.15x-0.22
Internode elongation	Stem	0.30	y = 0.036x-1.03
10% Heading	Whole	0.32	y = 0.01x+0.18
10% Heading	Flag leaf	0.07	y = 0.007x+0.75
10% Heading	Lowest leaf	0.39	y = 0.015x-0.22
10% Heading	Stem	0.41	y = 0.03x-0.30
10% Heading	Head	.003	y = -0.001x+0.80

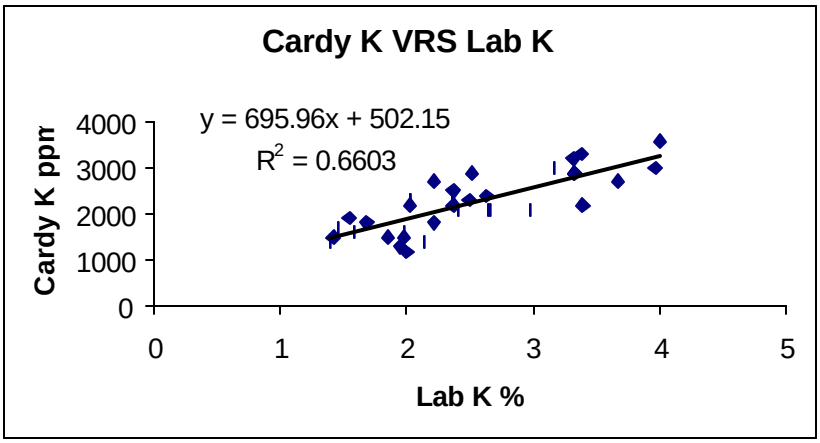

Figure 1. Relationship between Cardy meter K determinations and traditional Lab tissue analysis for rice plants at midseason, 2003.

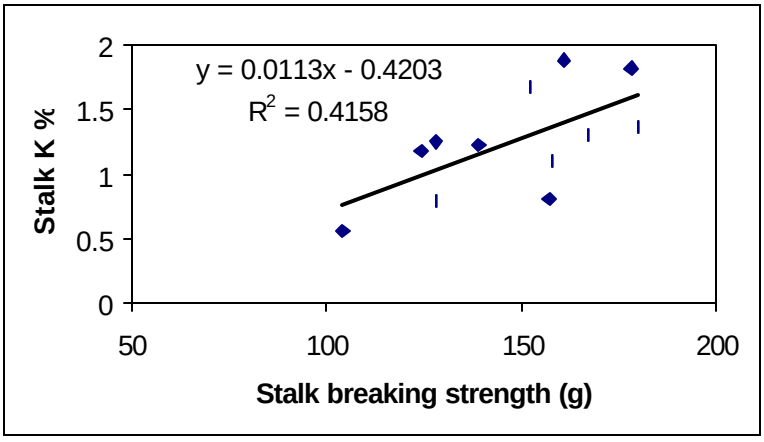

Figure 2. Relationship between rice stalk breaking strength and tissue K levels, 2003.

Appendix 1. Abstract of poster presented at 2003 American Society of Angonomy Annual meeting, Denver CO, 11-6-2003.

Potassium Nutrition of Rice

David J. Dunn and William E. Stevens

Proper potassium (K) nutrition is critical for maximizing rice grain yields. K is mobile within the rice plant. If the developing rice plant is unable to obtain sufficient K from the soil, older leaves are scavenged for the K needed by younger leaves. Profitable rice production hinges on accurate and relevant information about plant-soil interactions. The objective of this study is to correlate rice tissue K levels with grain yields. Reference plots for potassium fertilization were established at the Missouri Rice Research Farm at Qulin, MO. The plots received one of three levels of K fertilization, deficient (0 kg/ha), adequate (56 kg/ha), and excessive (224 kg/ha). Plant tissue samples were collected from each plot every two weeks during the growing season beginning at first tiller and continuing through harvest. These samples were divided into plant components i.e. upper leaf, lower leaf, stalk, and whole plant. These tissue samples were dried, ground, digested and analyzed for K%. Each plot was mechanically harvested for yield. Correlations were then made between yield and plant tissue K levels. Potassium fertilization significantly increased rice grain yields (0 kg/ha K = 95 kg/ha grain, 65 kg/ha K = 119 kg/ha grain, and 224 kg/ha K = 140 kg/ha grain). The K content of older leaves was a better indicator of yield limiting K status than younger leaves.

Appendix 2. Abstract of oral presentation to be given at Rice Technical Working Group meeting, New Orleans, LA, 3-1-2003

Potassium and Rice Production: Missouri Update

Dunn, D.J, Stevens, W.E. and Beighley, D

Proper potassium (K) nutrition is critical for ma ximizing rice grain yields. Incidences of K deficiency in rice have been increasing in Missouri. A 170 kg-ha-1 rice crop removes over 11 kg K_2O ha-1 each year. K is very mobile within the rice plant. Older leaves are scavenged for the K needed by younger leaves. Profitable rice production hinges on accurate, reliable, and relevant information about plant-soil interactions. A review of the available literature shows that no consistent methodology has been developed correlating K determinations in rice plants to rice grain yields. The objective of this study was correlate rice tissue K levels with grain yields.

Reference plots for potassium fertilization were established at the Missouri Rice Research Farm at Qulin, MO in 2002 and 2003. These plots received one of three levels of K fertilization, deficient (0 kg K_20 ha^{-1}), adequate (56 kg K_20 ha^{-1}), and excessive (224 kg K_20 ha^{-1}). Soil testing at this site indicated that a K fertilization rate of 56 kg K_20 ha^{-1} K was required for optimum rice production. Plant tissue samples were collected from each plot three times during the growing season, first tiller, internode-elongation, and 10% heading. These samples were divided into plant components i.e. flag leaf, lower leaf, stem, and whole plant. These tissue samples were dried, ground, digested using H_2SO_4-H_2O_2 and analyzed for K% by atomic absorption. Each plot was mechanically harvested for yield. Statistical analyses of the data were preformed with SAS (1990) using General Linear Modeling procedures. Fisher's Protected Least Significant Difference (LSD) was calculated at the 0.05 probability level for making treatment mean comparisons. Regression and correlation analysis were performed in accordance with procedures outlined by the SAS Institute (SAS, 1997)

Flag leaves were found to have greater tissue levels than lower leaves for each K fertilization level. This difference was greater at 10% heading than at internode- elongation. The tissue K levels of lower leaves were better correlated to yield than flag leaves. The two-year average r^2 value between K level and yield at 10% heading for lower leaves was 0.42 vrs 0.07 for flag leaves. Potassium fertilization significantly increased rice grain yields (0 kg/ha K = 4536 kg/ha grain, 56 kg/ha K = 5494 kg/ha grain, and 224 kg/ha K = 6098 kg/ha grain).

Appendix 3. Abstract of poster to be presented at the Rice Technical Working Group meeting, New Orleans, LA, 3-1-2003.

Using a Cardy Meter to Determine Rice Potassium Status at Mid-season

Dunn, D.J., Stevens, W.E., Kenty, M and Beighley, D.

The increased cost of rice production paired with low commodity prices necessitates more efficient nutrient management for the crop. The ability to monitor nutrient levels throughout the growing season is critical. This allows detected deficiencies to be corrected on a timely basis and improves the possibility of achieving optimal yields. Plant tissue analysis is available to the producer from university and independent labs. A common problem of traditional lab analysis is the time lag between sample collection and results returned to the crop advisor. Sampling and conducting the tissue analysis the same day can eliminate this time lag.

One method of same day analyses is the Cardy portable electrode-based ion meters (Horiba, Ltd., Kyoto, Japan). The Cardy K ion meter offer crop advisors the ability to quickly evaluate crop K levels. Cardy meters have been widely used in vegetable production with NO_3-N and K thresholds established for several crops.

This study evaluates the Cardy meter as a tool for determining in-season rice plant K status. Plots with one of three levels of K fertilization were established. Three times during the growing season tissue samples were collected from each plot. These times were internode-elongation (IE), IE + 7 days, and IE + 14 days. These tissue samples were then analyzed for K content by two different methods. Approximately 30 cm of row from each plot was collected. The above ground portion of this sample was separated from the roots using a garden pruning shear. The remaining portion of the lower stem was washed of soil and algae using tap water. The basal 10 cm of the plants were separated from the leaves and retained for analysis. These stems sections were dried with paper towels. Half the stems were then placed oriented up and the other half oriented down. Five cm from each sample was cut into one cm pieces. These pieces were frozen over night and sap was extracted using a sap press. The extracted sap was then analyzed for K content using the Cardy meter. The remaining five cm of sample was dried and ground, digested using H_2SO_4 and H_2O_2. The results of these two analyses were then compared.

It was difficult to extract sap from the rice stems. At growth stages before IE there was not enough stem tissue available to extract the sap. As the sampling occurred after establishment of a permanent flood several problems were encountered. Algae were some times present on the basal stem. Washing with tap water was necessary to remove the algae. Drying of the stems with paper towels was then necessary to remove the tap water. If the water was not removed before sap extraction the Cardy meter determinations were quite variable. Freezing the stems overnight served to rupture the cell walls within the stems and allow more sap to be extracted.

The Cardy meter determinations were well correlated to traditional lab K analysis, with an r^2 value of 0.66.