ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 2004 - December 31, 2004

PROJECT TITLE: Soil fertility and fertilizer use in rice.

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LEVEL OF 2003 FUNDING: $ 44,403

OVERALL OBJECTIVE:

The focus of the RM-4 project is to evaluate the impact of grower management practices on nutrient cycling, and to work in association with cooperative extension to develop improved fertility management guidelines for rice growers.

SPECIFIC OBJECTIVES AND RESERCH CONDUCTED:

Objective 1: To evaluate current fertilizer use by growers and identify changes in fertility management following legislated reductions in straw burning.

In 2004, we expanded the N-rate fertility trials initiated in 2003 to include 26 growers and 71 fields located throughout the major rice growing areas of the Sacramento Valley. Within each field, test plots were established to determine the impact of 25 lb N ac^{-1} increases and reductions in pre-plant aqua-ammonia fertilizer application rates on mid-season fertility indicators and yield. In addition, we conducted extensive soil and plant sampling to identify trends in overall fertility across a variety of soils under different straw management practices. To date, the research has provided substantial insights into grower fertility management practices, the impact they have on nutrient availability, and the potential for improvements in current fertility management guidelines.

As in 2003, mid-season N-fertility indicators including color, height, vigor, and tissue N levels significantly increased ($P<0.05$) with increasing pre-plant N fertilizer application rates in 2004. These indicators, either alone or in combination, are the basis by which growers determine whether or not to apply additional N fertilizer during the course of the season. Interestingly, in 2003, despite maximum tillering tissue N concentrations below the recommended critical level (4.0 %) in all treatments, higher N application rates did not result increased yields, suggesting that it was necessary to re-evaluate the mid-season tissue N critical level guidelines. In 2004, we increased the number of sampling dates to include mid-tillering and panicle initiation and did observe a significant yield reduction under the reduced fertility treatment (Figure 1.). The small plot yield results were in agreement with observations from field length N-rate trial strips established in key locations throughout the Valley.

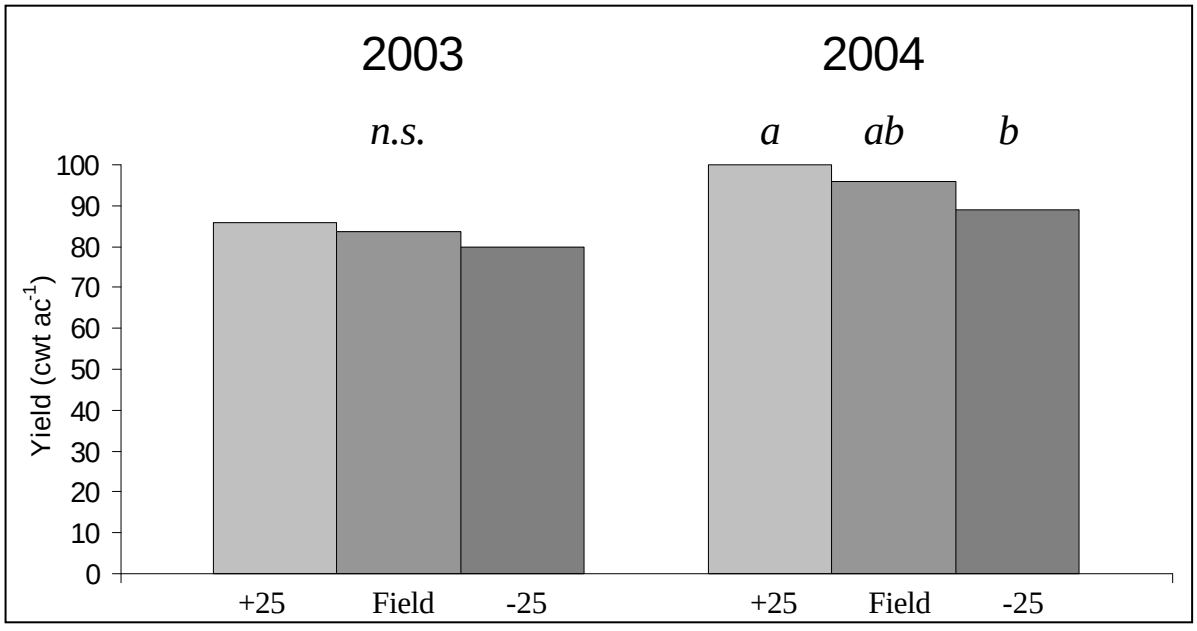

Figure 1. Impact of N fertilizer treatment on yield for 2003 and 2004 ($P<0.05$).

Drawing from the results of 2003 and 2004, the current critical tissue N concentration levels are likely higher than they should be. Our results suggest that the critical levels should be reduced to 4.3% at mid-tillering, between 3.4% and 3.7% at maximum tillering and between 3.0% and 3.2% at PI (Figure 2); however, additional verification of the levels will be sought in 2005.

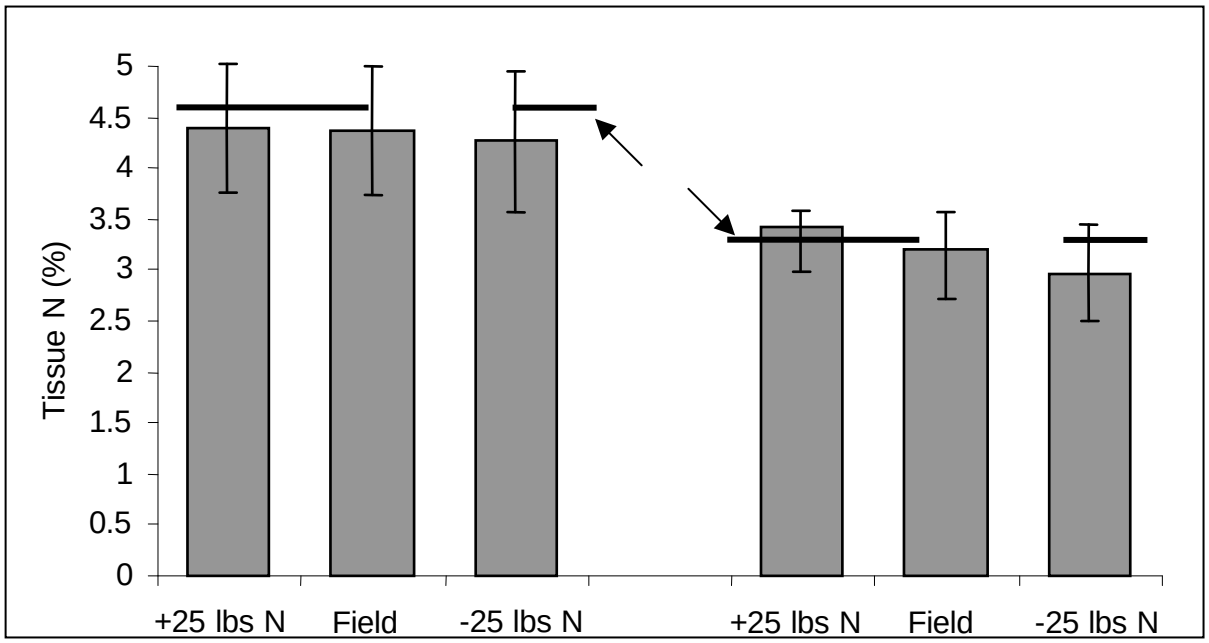

Figure 2. Impact of N fertilizer level on tissue N concentration in 2004.

In addition to tissue N concentration, each of the samples was examined for P and K concentration (Table 1.).

Table 1. 2004 N, P and K concentrations measured at mid-tillering and panicle initiation under grower standard practice (field) treatment.

	Mid-Tillering			**Panicle Initiation**		
	Observed Average	Critical Value	% Fields Below	Observed Average	Critical Value	% Fields Below
N (%)	4.4	4.6	61	3.2	3.3	56
P (ppm)	1447	1000	18	1502	800	2
K (%)	2.16	1.4	1	2.16	1.0	1

On the whole, K levels were well above the current critical concentrations. Conversely, eighteen percent of mid-tillering tissue samples were P deficient according to current guidelines

(<1000 ppm), though only 2% had concentrations indicating deficiency at PI (<800 ppm). While the soil analyses for 2004 are still under way, it should be noted that greater than 50% of those soils studied in 2003 were P-deficient (Bray-P <2.5 lbs available P per acre). In 2003, the most severe soil deficiencies were observed in Willows clays on the west side of the valley; conversely, the greatest soil P availability was observed in areas where rotation between rice and non-rice crops was practiced. The tissue results from 2004 follow a similar distribution.
In 2005, we anticipate continuing our current N-rate trials in grower managed fields and undertaking a more complete analysis of the results, including identifying regional fertility trends, correlating overall fertility status with management practices, and the development of specific fertility management recommendations for growers.

Objective 2. To determine if lime application improves rice production.

Calcium is a macro-nutrient that accounts for up to 1.0 % plant tissue, and is important in the processes of cell elongation and division, N uptake and root development. Furthermore, there have been numerous anecdotal reports that increasing soil calcium levels may increase yields, improve soil tilth and bring about changes in weed pressure. However, there has been little scientific research to evaluate the claims in California rice production systems and a great deal of skepticism whether it is economically viable. Nonetheless, according to the results of our 2003 fertility management survey, nearly one fifth of growers report using either lime ($CaCO_3$) or gypsum ($CaSO_4$) to increase calcium availability in some portion of their fields.
In 2004, we completed 3-year liming trials at grower-managed sites in Princeton and Richvale in the Sacramento Valley. The trials incorporated extensive pre-application sampling and multiple liming rates applied at different points in time to reflect current grower practices. Our findings suggest that lime application does impact the production environment, but does not provide sufficient benefits to justify material and application costs.

There were no significant effects on yield (Figure 3.) at either site in any of the three years. Likewise, under standard fertilizer and herbicide management practices, there were no changes in head rice, biomass production, or any of the mid-season plant indicators. However, in the year immediately following lime application there was an increase in soil available N of between 10 and 20lbs ac^{-1}, which resulted in a reduction in fertilizer uptake efficiency. Similarly, in 2003, tissue samples displayed reductions in Zn and P uptake following liming, although there were no deficiencies symptoms apparent. From a management standpoint, growers that decide to apply lime should reduce N fertilizer rates following initial lime application, particularly for varieties that are susceptible to excess N fertilization, and consider other nutrient applications, particularly P and Zn.

In an effort to evaluate the impact of liming on tillage requirements, we measured the tillage force requirement in the spring of 2003 and 2004 at the Princeton site. The results indicate that liming increased the amount of force required by 25%. Subsequent laboratory tests suggested that the increase was a result of reductions in soil cracking following lime application. An analysis of soil structure in the limed and un-limed treatments did not detect any difference in the distribution of water stable aggregates.

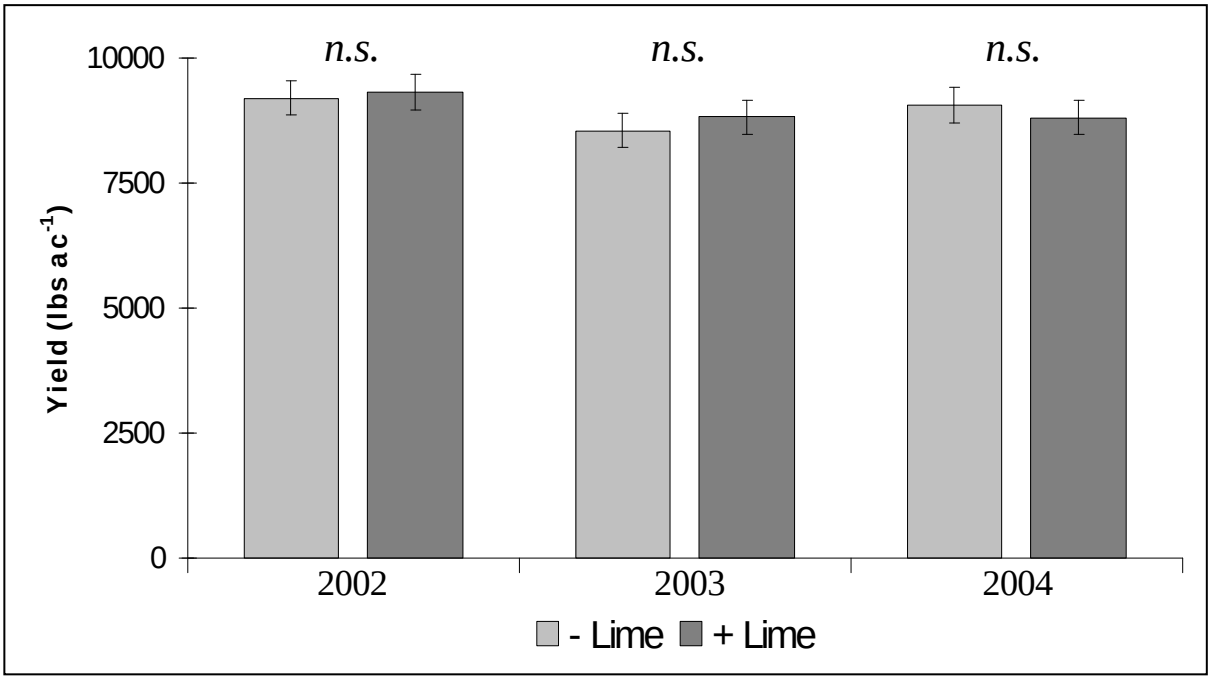

Figure 3. Liming trial yield data for 2002, 2003 and 2004.

In 2002 and 2003, common ricefield weeds were monitored at both sites prior to mid-season herbicide applications. While most weeds were unaffected by liming, there was a significant reduction in ricefield bulrush (*Scirpus mucronatus*) at both sites, in both years. (Figure 4.), but did not appear to interfere with perennial plants. Interestingly, the effect appeared to be additive over time. Efforts to quantify changes in the seed bank at the Princeton site were obscured by the high residual seed populations, which averaged 7,500 seeds sq ft^{-1} in the top four inches of soil. Subsequent laboratory tests indicated that overall germination rates were quite low (5%) and that there were no significant differences in germination between seeds collected directly from the plant and those from the field soils after over wintering. Soil lime concentration reduced the germination rate of the seed at levels comparable to those observed in the field trials (Figure 5.), indicating that the reduction in *Scirpus* pressure may be entirely due to reductions in germination. Although, the effect that liming has on *Scirpus* is intriguing, the potential for lime as an alternative to other herbicide applications appears limited.

In conclusion, given the lack of any observed economic benefit, lime application does not appear to be cost effective.

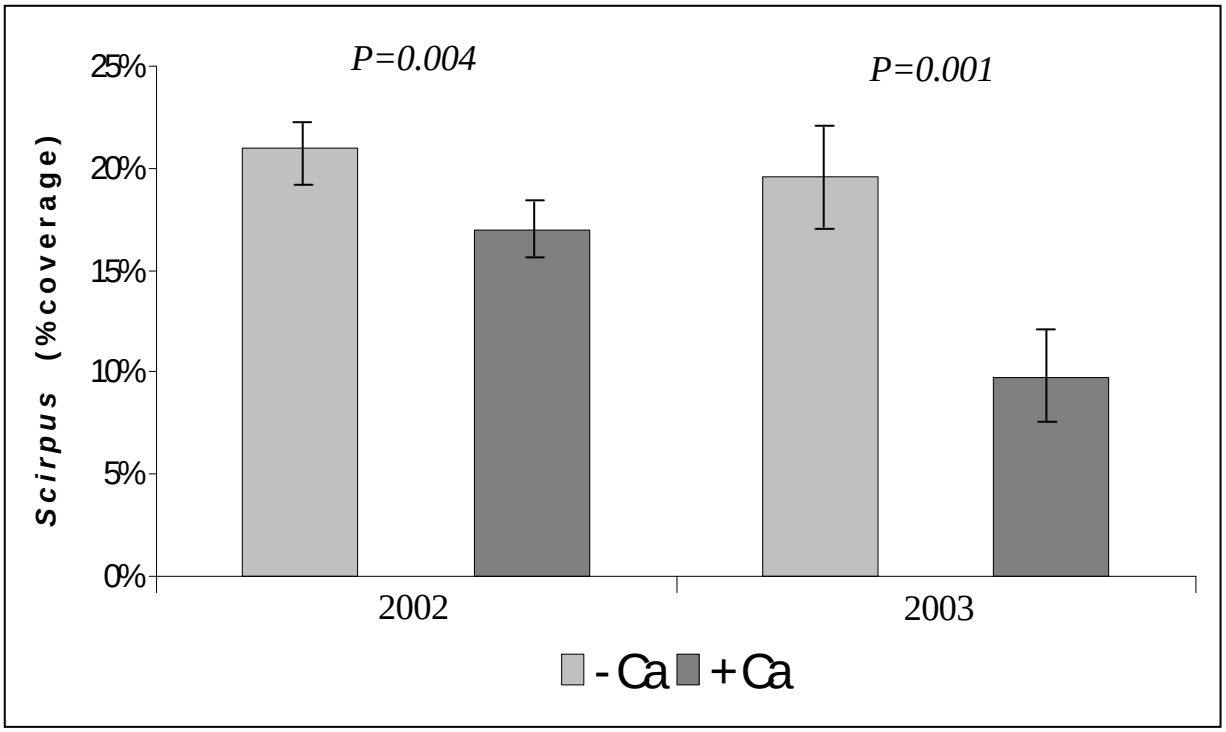

Figure 4. Mid-season *Scirpus* measurements 2002 and 2003, Princeton site.

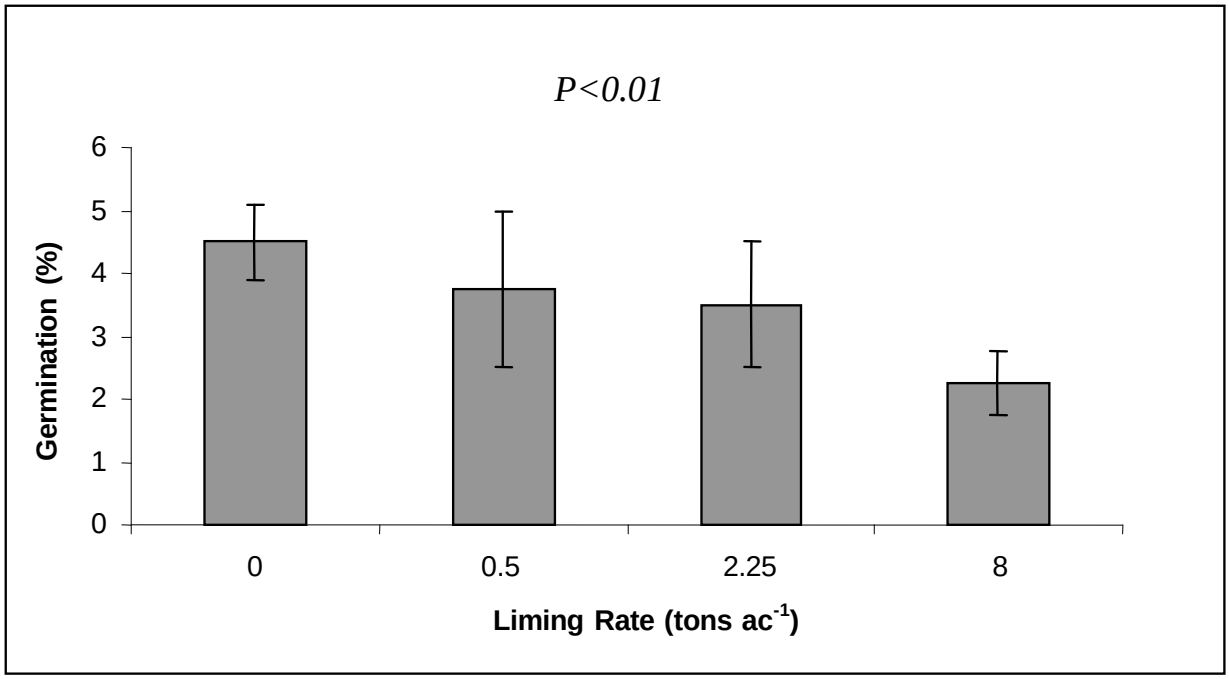

Figure 5. Percent laboratory germination of field collected *Scirpus* seed with liming treatments.

PUBLICATIONS AND REPORTS

Hartley, C. and C. van Kessel. (2005). **Residue Management, Soil Organic Matter and Fertility in California Rice Systems.** 2005 California Plant and Soil Conference Proceedings, California Chapter of the Agronomy Society of America.

Hartley, C., C. van Kessel, and R. C. Mutters (2004). **Evaluating Nitrogen Fertility Management in Rice**. Abstract and Oral presentation at ASA-SSSA-CSA Annual Meetings, Seattle, November 2004.

In addition, annual presentations have been made to California rice growers at the UCCE winter meetings, and the fertility management survey we conducted in 2003 was the basis for an article in March 2004 edition of Rice Farming magazine entitled "California rice growers re-examine crop fertility."

CONCISE GENERAL SUMMARY OF 2004 RESULTS

Objective 1: In 2004, we expanded the N-rate fertility trials to include 26 growers and 71 field sites located throughout the Sacramento Valley. The trials consisted of extensive soil and plant sampling and monitoring of three different N rates across a variety of soils, under different management practices. Contrary to 2003, there was a reduction in yield in the reduced fertility treatments. Mid-season tissue N concentrations were below the current critical limits for a majority of fields sampled at mid-tillering and PI; however, increased N application rates increased straw production but did not improve yields, suggesting that there is a need to re-evaluate the current guidelines. The applied nature of the research and its ability to address fertility as a function of straw management and fertilizer practices will facilitate the development and extension of recommendations to growers.

Objective 2: In 2004 we completed a 3-year evaluation of the impact of liming on rice production at two sites in the Sacramento Valley. The results indicate that liming has no appreciable effect on straw or grain yields, head rice production, or mid-season plant growth parameters under standard fertilizer and herbicide applications. While most weeds were unaffected by liming, there was a significant reduction in ricefield bulrush (*Scirpus mucronatus*) following liming and the effect is additive over time. Laboratory tests suggest that liming reduces bulrush germination. In addition, liming increases soil N availability from 10 to 20lbs N ac^{-1} in the year following application and increases the amount of force required for primary tillage by up to 25%. Given the lack of any observed economic benefit, lime application does not appear to be cost effective.