ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 2005 - December 31, 2005

PROJECT TITLE: Soil fertility and fertilizer use in rice.

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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.

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

2005 was the final year of the aqua-ammonia N-rate fertility experiment. Since 2003 we have been working with growers in the Sacramento Valley to evaluate 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 2005 we worked with 20 growers in 44 fields located throughout the major rice growing areas of the Sacramento Valley. In addition, a zero N plot (0 lb N ac^{-1}) was established in each field to determine N-use efficiency of the different fertilizer rates. Extensive soil and plant sampling to identify trends in overall fertility across a variety of soils under different straw management practices was conducted throughout the season. 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.

2005 was generally a poor year for rice with yields down 10 to 15% from average. Yield differences among the different aqua-ammonia fertilizer N treatments in 2005 (with 93% of fields sampled reported) were similar to 2003, where no significant yield differences were detected although there was a small trend toward increased yield with increased N fertilizer application (Figure 1). These data suggest that in good years, where the yield potential is high, that there is a better response to higher N fertility rates.

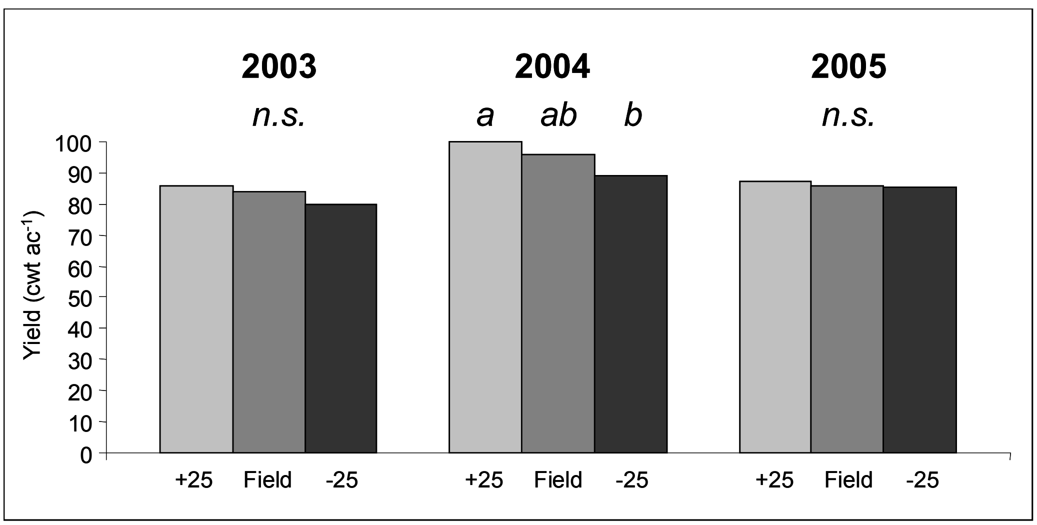


Figure 1. Impact of aqua-ammonia N fertilizer treatment on yield for 2003 – 2005 ($P<0.05$).

In 2003 and 2004, 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. 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. We are still awaiting 2005 tissue N concentration results from mid-tillering (MT) and panicle initiation (PI) sampling dates to compare with the critical value levels at those growth stages. These 2005 data will be combined with data from 2003 and 2004 to determine if current critical tissue N concentration levels are higher than they should be, as the data from 2003 and 2004 have suggested.

In addition to tissue N concentration, each of the 2005 samples will be examined for P and K concentration and. In 2004, K levels were largely well above the current critical concentrations. We are awaiting results from 2005 to provide an additional year of K data to compare the 2004 findings with. Findings for P in 2004 were quite different than those of K in that 18% of MT tissue samples were P deficient according to current guidelines (<1000 ppm), though only 2% had concentrations indicating deficiency at PI (<800 ppm). Soil P analysis (Bray-P) showed that 50% and 80% of the fields from 2003 and 2004, respectively, were below critical available soil P levels. The high percentage of soils found deficient in available P with virtually no detected tissue P deficiency suggests critical soil P availability levels may be too high. Alternatively, the commonly used Bray-P test, which only measures inorganic P, may not be a reliable test to use as a measure of soil P availability. With high amounts of annual straw incorporation, a substantial quantity of P may cycling through organic fractions (not measured by Bray-P) in the early season, but may become available as inorganic P later in the season.

Once all of the 2005 data for the N-rate trials is amalgamated and grower management surveys are returned, a more complete analysis of the results from 2003-2005 will be conducted. Analyses will include identifying regional fertility trends, correlating overall fertility status with management practices, and the developing specific fertility management recommendations for growers.

Objective 2: To determine starter fertilizer N uptake and its influence on total N uptake under differing N and straw management practices.

Starter fertilizers are used by 95% of growers (2003 Fertility Management Survey) and are an important tool in rice fertility management, providing the seedlings with a readily available source of nutrients to help insure rapid early growth, improving competitiveness with weeds and increasing pest and disease resistance. Strong early uptake of N through the use of starter fertilizer may increase the overall N uptake capacity of rice plants throughout season. That is, starter N uptake may give rice plants the necessary jumpstart to increase total N uptake from aqua-ammonia and indigenous soil N sources. Nonetheless, there are currently no standard recommendations for the selection, timing or rate of application of starter fertilizer materials. Consequently, rice growers have expressed the need for better information on starter N management, particularly under varying straw and water management practices.

Achieving optimal starter N availability and uptake efficiency in rice fields requires an understanding of early season N uptake and N loss under differing straw and water management practices. Starter N is either surface applied or lightly incorporated, making it readily available to newly emerged rice plants. However, because starter N is applied near the soil surface, it is susceptible to loss resulting from changes in soil-water status.

To begin addressing the uncertainties around starter N management, we set up on-farm starter N trials across the Sacramento Valley in 2005. The starter N trials were nested within the larger aqua ammonia fertilizer-N experiment discussed above (Objective 1). The design used for this starter N experiment allowed us to group the data by straw / crop management the previous year, region, or by individual starter N treatments. The vast majority of rice growers rotate between burning and incorporating straw in a given field from season to season.

Five sites (10 fields) were chosen in the Richvale and Princeton rice growing areas which had side by side straw burned and incorporated fields or checks, allowing us to compare the interaction between starter N and straw management. An additional trial was conducted near Arbuckle where rice is rotated with other crops (in this case tomatoes were planted the previous year). This site in Arbuckle allowed us to evaluate the interaction of starter N with crop rotations, however only one site was established for this comparison, so results need to be evaluated with caution.

In microplots, starter fertilizer tracer N was used to directly measure starter fertilizer N uptake and its effect on total N uptake, biomass production, and yield. The effects of different starter N rates were examined under a range of aqua rates (those of the aqua ammonia N-fertility experiment) with a straw burning, straw incorporating, or crop rotation management regime (Table 1).

Table 1. 2005 starter N experimental treatments with comparisons across straw / cropping management and regions. N = Nitrogen, A = Aqua, S = Starter, SP = Standard Practice.

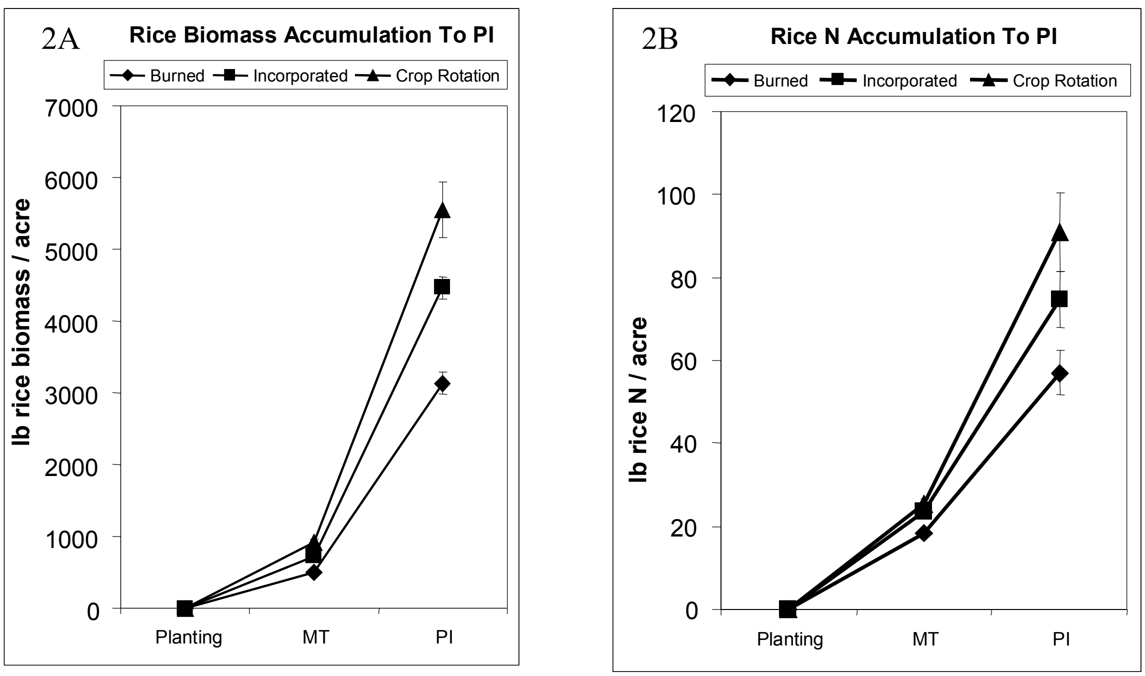
Total N the same

Total N the same

Aqua N Rate (lb/acre)	Starter N Rate (lb/acre)	Straw/Cropping Management Comparisons	Regional Comparisons
0N-A	0N-S	Burned vs. Incorporated vs. Crop Rotation	Arbuckle vs. Princeton vs. Richvale
SPN-A	0N-S		
- 25N-A	+ 25N-S		
+ 25N-A	0N-S		
SPN-A	+ 25N-S		
- 25-A	+ 50N-S		

Whole plants were sampled from the starter N treatments at MT, PI, and harvest to measure yield, and starter and total N accumulation in biomass and grain. At each plant sampling date, soil cores were also taken to evaluate soil N dynamics in relation to starter N application rate and uptake, and calculate total starter N recovery. The harvest plant samples and soil samples are still being processed, but we hope to have those data available to present at the Cooperative Extension winter meetings. In this report only preliminary starter N data from MT and PI plant sampling will be discussed.

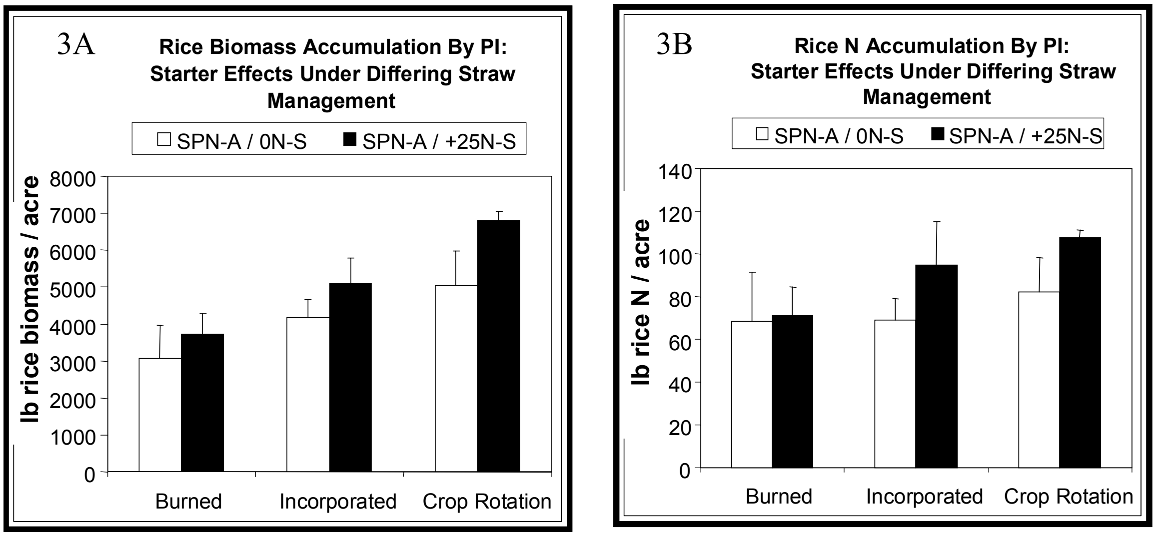
When data were grouped by straw / crop management the previous year, differences in rice biomass and N accumulation were noticeable by MT and obvious by PI. The crop rotation site, where tomatoes were produced in 2004 and rice was grown in 2005, had the highest biomass and N accumulation (Figures 2A & 2B). Again, this finding is based on data from one site only, and we were not able to identify comparable burned and incorporated fields or checks in the area. The straw burned vs. incorporated comparison, however, is based on five paired side by side fields or checks in Richvale and Princeton. This pairing provides robust data to compare the effects of straw burning or incorporation on biomass and N accumulation. By PI, in fields where straw was incorporated the previous year, biomass and N were 1300 lb / acre and 18 lb /acre higher, respectively, than in fields where straw was burned the previous year. This data confirms findings from previous research (i.e. from Maxwell and the Rice Research Station) suggesting that N rates could be reduced by up to 25 lb/ac when rice straw is incorporated. However, it also suggests that the benefit from rice straw incorporation may be negated following a straw burn year. A more complete understanding of this phenomenon is needed to develop robust and efficient N fertility recommendations which will allow growers to adjust their N fertilizer rates based on straw management. When grower surveys from 2005 are available, results from the 2003 to 2005 will be analyzed to more robustly determine the effect of straw management (particularly effect of previous years) on crop N response.



Figures 2A & 2B. Rice biomass (figure 2A) and rice N (figure 2B) accumulation up to PI. Data is grouped by straw / crop management and is pooled across starter N treatments and regions.

The effect of starter N on biomass and N uptake, and its interaction with straw / crop management practices were determined by comparing two of the starter N treatments, SPN-A / 0N-S and SPN-A / +25N-S, within straw / crop management type (Table 1). In these two treatments, the aqua-ammonia N application rate was held constant at the farmer's standard practice rate, but the starter N rate was manipulated with one treatment receiving no starter N and the other receiving 25 lb / acre of starter N.

Preliminary results show that by PI more starter N was taken up in fields where straw was incorporated or where rice was rotated with other crops than where straw was burned (Figures 3A & 3B). It is not clear why starter N fertilizer use efficiency is less following rice straw burning but it may result from rice straw buffering changes in soil redox potential. The effects of starter N on yields have yet to be determined as data was not available at the time of writing but these results will be presented at the grower meetings.



Figures 3A & 3B. Rice biomass (figure 3A) and rice N (figure 3B) accumulation up to PI. Two treatments, one with and one without starter N were compared within straw / crop management group, across regions.

Publications and Reports

Koffler, K., C. Hartley, B. Linquist, J. Six, R. Mutters, C. Greer, W. Horwath, and C. van Kessel. 2005. Determining starter fertilizer N uptake and its influence on total N uptake under differing N and straw management practices. Rice Field Day. Rice Experiment Station. Biggs, CA.

Concise General Summary of 2005 Results

1. In 2005 there was no difference in yields with varying N rates (+25 lb N/ac, -25 lbN/ac and farmer standard practice). There was a small increase in yields similar to what was observed in 2003. This suggests that in years where average California rice yields are low (2003 and 2005) there is less response to N fertilizer than in high yield years (2004). These data are averaged across 44 fields, however as is noted below, there is likely to be a difference in response to N depending on the previous years straw management. This will be analyzed once all the grower surveys are in.
2. In fields where straw is incorporated for three to four years and then burned (the most common straw management practice in California), N uptake and biomass are greater at PI in fields following where straw was incorporated than where it was burned. Nitrogen uptake is about 18 lb/ac higher, supporting findings from Maxwell and the Rice Experiment Station.

3. Also, in fields where straw is incorporated for three to four years and then burned, starter N uptake and efficiency (based on N accumulation by PI) is higher following a straw incorporated year than a burn year.
4. Based on limited data, N uptake and biomass accumulation in fields that are rotated with other crops is similar to straw incorporated fields.
5. Based on these preliminary results, growers need to manage their N differently in fields that are burned or straw incorporated in the previous year.