AGREEMENT NUMBER: **00-0651**

A. Long-term rice straw incorporation: Does it impact maximum yield?

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Introduction

Rice growers have faced a decade of reinventing some of the aspects of growing rice. Passage of the California Rice Straw Burning Reduction Act (AB 1378) in 1991 forced growers to contend with a tremendous amount of rice residue that was formally burned. The burning of the residue serves many functions including reducing the incidence of weeds and pathogens and to facilitate seedbed preparation. Burning also enhanced fertility, most likely by increasing the availability of phosphorus, potassium and micronutrients. There were basically two choices for rice growers to deal with the rice residue, either leaving in the field or removal. Many variations of leaving in the field have been done ranging from incorporation by tillage or cage rolling to leaving it on the surface. Additional flailing operations are usually done to speed up straw decomposition. The in-field approaches were thought to potentially immobilize nutrients leading to possible yield declines. Our long-term results have shown that winter flooding increases available soil nitrogen and leads to a significant yield gain over non-winter flooded fields regardless of the type of residue management employed. Other studies on lighter soils (i.e., San Joaquin series) also show a similar response. However, the response is higher on soils with higher clay or organic matter content. In addition, an additional yield gain is seen in fields with a minimum of 3 to 5 years of straw incorporation compared to where straw is burned or removed. These findings suggest that fertilizer rates can be reduced by to 50lbs N/A depending on soil type, residue management and use of winter flooding. The fertility status of other nutrients under in in-field residue management has not been as closely examined. The in-field straw management approach leads to soil organic build-up, a positive soil quality characteristic. However, the increased soil organic matter also has led to larger microbial biomass and immobilization of phosphorus and micronutrient metals in soil organic matter. The increase in yield in association with chicken manure application as seen by some growers suggests that phosphorus and possibly micronutrients may be responsible. For these reasons, a comprehensive fertility guide for rice growers in California must

include all macro and micronutrients.

Though we feel the nitrogen story is fairly complete, we have noticed as fertilizer N additions are increased the straw incorporated treatment reaches maximum yield potential at 100 lbs nitrogen/acre, while the burned treatment continues to rise with increasing fertilizer N addition. These results suggest that straw incorporation is yield limited, possibly from non-N limiting factors such as weed, disease or pathogen pressure. The long-term future of straw incorporation is uncertain as to its effect on the incidence of weeds and pathogens. What is certain is that herbicide use will become increasingly important in straw incorporated management approaches where weed seeds are protected from waterfowl foraging. In treatments such as cage rolling and flailing/leaving on soil surface approaches, we have shown that waterfowl can significantly reduce the incidence of weeds.

B. Objectives

1. **To determine if the maximum yield potential of rice under prolonged straw incorporation has been impaired.**

2. **To assess if the severity of weeds is a possible cause of a lower maximum yield in rice fields under prolonged straw incorporation.**

C. Executive summary

After 8 years of implementing alternative rice straw management practices, grain yield did not decline compared to burning rice straw. No further yield increase was observed when the rate of N application exceeded 100 lbsN/A under straw incorporation. Therefore, the rate of the amount of N fertilizer applied can be reduced to 100 lbsN/A when practicing straw incorporation. A similar but smaller effect of increased N availablity would be expected for rolling and surface residue management practices. The possible increase in weed and disease pressure when straw is incorporated or rolled was not severe enough that it would lead to a grain yield decline under current fertilizer practices. However, considerable awareness of weeds and application of herbicides is needed to attain these results. This represents an increased cost both for managing the residue and in application of herbicides. An increase in soil N availability could lead to an increase in weed and disease pressure as is suggested by the non-nitrogen limiting phenomenon seen in the N rate trials. Based on on-going research at other sites, other factors besides N and K are likely involved in controlling maximum yield potential. In the west side of the Sacramento value, magnesium, calcium and phosphorus levels are also related to yield.

Weed and disease pressure were not significant enough to be remarkable across all treatments. The incorporated and rolled plots showed a tendency for both higher weed and disease symptoms. This observation collaborates the non-nitrogen yield decline response seen in the incorporated high N plots. However, to achieve these results a diligent herbicide application

program was required to maintain rice yield in the incorporated plots. These represent additional costs to growers and must be considered when evaluating the sustainability of alternative rice residue management practices.

D. RESULTS, DISCUSSION, AND CONCLUSIONS:

OBJECTIVE **1. To determine the maximum** yield **potential of rice following prolonged straw incorporation or burning.**

N fertilization and straw management

For all the years, grain yield was strongly affected by N application, independent of straw management and, on average, yield increased by 50 % following an N application of 100 lbs N per acre. When straw was incorporated, grain yield was higher when no N fertilizer was applied compared to the zero N yield when the residue was removed (Fig. 1). Furthermore, the maximum yield was observed when 100 lbs N per acre

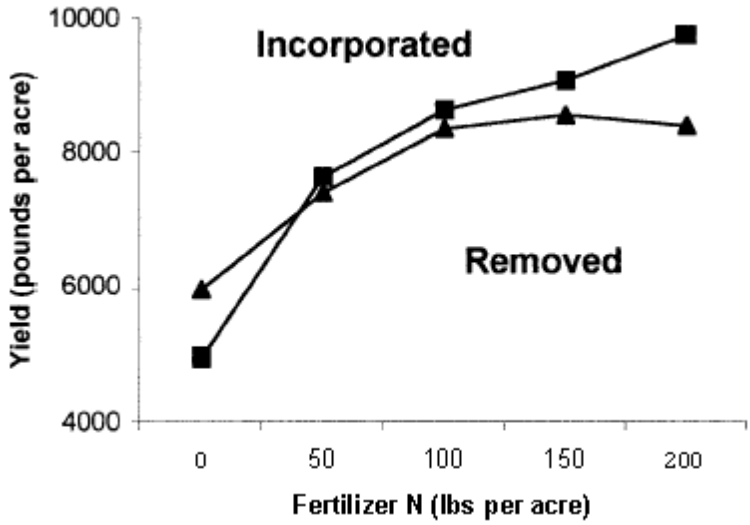

Fig. 1. Yield response of rice following N fertilizer following straw removal or incorporation.

applied and straw was incorporated whereas the highest yield was observed when 200 lbsN per acre was applied and straw was removed. Moreover, the maximum yield observed when straw was removed was higher than when straw was incorporated (Fig. 1). Apparently, a non-N effect occurred and its negative effect on yield was more pronounced when straw was incorporated. A similar yield response to straw management practices has been observed earlier in the Valley.

Objective 2. To assess if the severity of weeds is a possible cause of a lower **maximum** yield in rice fields under prolonged straw incorporation.

Changes in agronomic practices that impact crop yield often take up to 10 years or longer before they are realized. Furthermore, the direction of change, positive or negative, is difficult to ascertain during the transition to alternative practices such as from burning to straw incorporation. In addition, changes in soil fertility often affect other soil properties ranging from physiological stress from nutrient sufficiencies or deficiencies to plant competitive response to weeds and pathogens. These potential broad changes in soil properties often make diagnosing factors affecting yield potential problematic.

As part of the fertilizer nitrogen rate trials and rice yield determination done in 2001, we determined the severity of water grass under a wide range of N fertilizer application rates and long-term straw incorporation and burning. Only water grass was a problem in 2001most likely because of large amounts of herbicide used to control a serious total weed problem. Water grass was the main weed to escape the efficacy of the herbicides formulations used. Also no significant stem rust was found. Weeds and diseases are the most likely non-N factors that limit plant production. We were be able to remove one of the limiting growth factors, i.e., N.

Figures 2 and 3 show the incidence of water grass at the Maxwell site in 2001. Notably, the burned treatment regardless of winter flooding or not had considerably less or no water grass compared to both incorporated treatments (non- and winter flooded). The incidence of water grass is related to the fertilizer N rate increasing with increasing N.

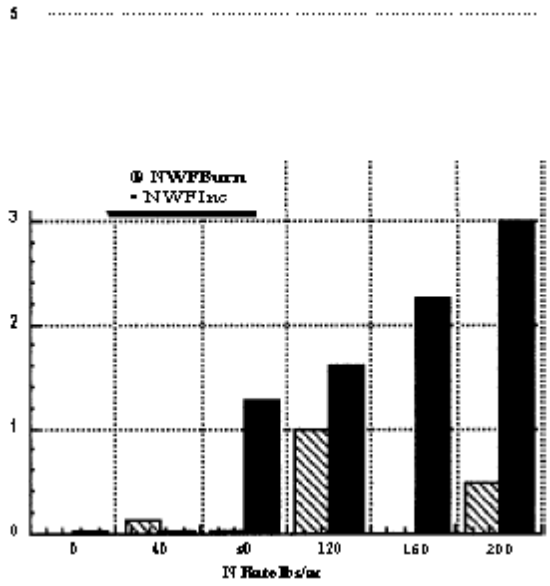

Figure 2. The incidence of water grass in the non-winter flooded burned (NWFBurn) and incorporated (NWFInc) treatments at Maxwell.

Based on our previous research, other factors besides N are likely involved in controlling maximum yield potential. Possible yield controlling factors that have to be investigated are weed and pests. It is often observed that the incorporation of residues leads to an increase in weed and disease pressure.

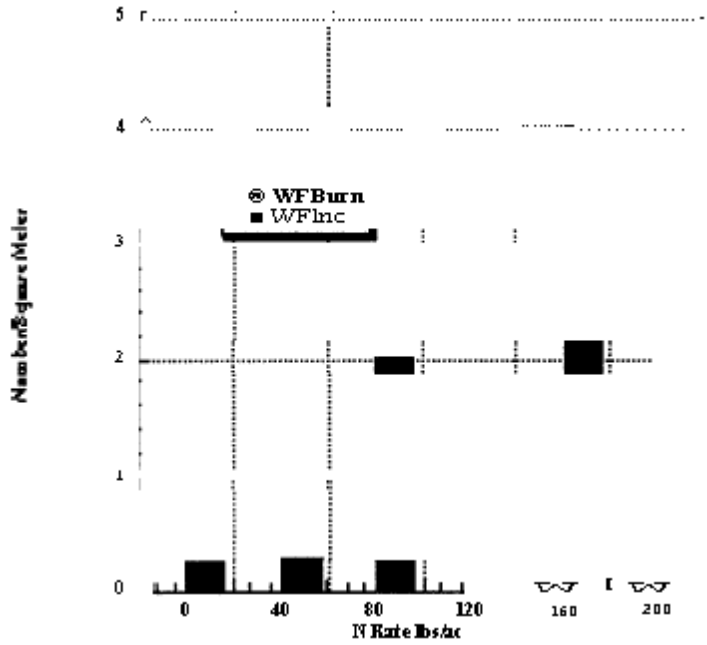

Figure 3. The incidence of water grass in the winter flooded burned (WFBurn) and incorporated (WFInc) treatments at Maxwell.

E. This annual report is also the final report for this one-year grant.

F. Results from experiments funded through this grant were presented at the annual FREP meeting. Results have also been discussed at the 4 winter meetings organized for rice farmers. An article in California Agriculture on this subject has been published in 2002.