POTASSIUM RESPONSES IN CALIFORNIA RICE FIELDS AS AFFECTED BY STRAW MANAGEMENT PRACTICES

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OBJECTIVES

1. Re-evaluate the effect of K fertilization response of rice yield and its interaction with N.
2. Determine on how adequate level of available K affects the occurrence of rice diseases.
3. Reassess the accuracy of the soil K test on predicting plants available K.

INTRODUCTION

California legislation (AB 1378) leads to a phase down of rice straw burning over a 10-year period which will change the way farmers manage rice straw. Although various options are available, it is likely that the incorporation of rice straw; i.e., on-site disposal, will remain a major option for rice straw disposal. The average concentration of K in rice straw is around 1.4 % but its range can be as low as 0.6 % or as high as 1.8 %. The amount of straw removed by baling for off-site use is approximately 6 tons/acre and hence the amount of K removed in the straw after harvest in Californian rice fields can exceed 90 lb/acre. When straw is continually removed, available K levels in the soil will be profoundly affected. Some preliminary data gathered from the long-term straw rotation studies at the Rice Experiment Station showed that the extractable K levels in the soil in the top 6 inches declined significantly to less than 60 ppm when straw was baled for 3 years. The current fertility guideline for rice is that about 87 ppm of extractable K should be present at time of seeding; otherwise K fertilization is recommended.

DESCRIPTION

As part of the first field season activities of this three-year field study, a field at Mathew Farm near Marysville, CA which has historically shown a potassium (K) deficiency was selected. From half of the selected area (about 7 acres), the rice straw was removed whereas for the other half of the field, the rice straw was incorporated in the fall of 1998. The same location will be used for the next three years and straw will be removed or incorporated for the duration of the experiment.

In the spring of 1999, 15 soil samples were collected from the site where straw was removed or where straw was incorporated. After one year of straw removal, a significant difference in plant available K concentration was detected: 59 ppm when the straw was removed versus 88 ppm soil in the straw-incorporated plot. In the spring of 1999, an N by K rate trial was established on both straw management treatments. A split plot factorial design replicated 4 times with 5 rates of N (0, 45, 90, 135, 180 lb/acre) as ammonium sulfate and 6 rates of K (0, 22, 44, 66, 88, 110 lb/acre) as KCl for each straw management treatment (total of 240 plots) was used. Midseason concentration of N and K in the leaves was conducted for all treatments. A disease rating was carried out a few weeks prior to harvest for the following rates: 0, 45 and 90 lb N/acre. Straw and grain yield were determined and both plant components were analyzed for total N.

RESULTS AND CONCLUSIONS

Midseason N and K

During the summer, the concentration of N and K in the youngest expanded leaf increased significantly following N and K application, respectively (Figs. 1 and 2). However, the concentrations of K in the leaves increased when straw was incorporated under all rates of K application compared to straw removal. The difference in K concentration in the leaves when straw was removed or incorporated remained similar across all K levels. This is a surprising result for which no clear explanation is presently available. If the incorporation of straw led to an increase in plant available K, this response would become most apparent when no K was applied and would disappear at higher rates of K fertilization. This would suggest that the increase in the concentration of K in the leaves when straw is incorporated is not induced by an increase in plant available K. An argument could be made that the growth stage of rice was different when where straw was incorporated or removed, leading to a so-called dilution effect. Such a dilution effect is unlikely as the concentration of N in the leaves was not different when straw was removed or incorporated (Fig. 2). A small increase in the cation exchange capacity when straw is incorporated might also account for more plant available K by preventing leaching and runoff losses.

As anticipated, an increase in the rate of N fertilizer led to an increase in leaf issue N (Fig. 2). High rates of N doubled the concentration of N and leveled off at about 4%. There was no impact on straw removal or incorporation on tissue N, suggesting that straw did not immobilize or increase plant available N.

Diseases

Leaf diseases and the occurrence of aggregate sheath spot and rice stem rot was assessed at the end of the growing season. Only aggregate sheath spot was observed and rated for severity. Aggregate sheath spot, rated on a scale between 1 and 4, was prominent in all treatments and an overall rating of 3 was observed across all treatments whether straw was incorporated or removed. The severity of aggregate sheath spot declined slightly with higher rates of N fertilization for both straw management practices (Fig. 3) but was unaffected by the application of K (Fig. 4). Straw management practices had no significant impact on aggregate sheath spot.

It is likely that incorporating straw for one growing season may not yet show the severity of aggregate sheath spot occurrence. How aggregate sheath spot severity will be affected over time following several years of residue incorporation will be assessed during the duration of this project.

Straw and Grain Yield

Rice yield was affected by rate of N application (Fig. 5). Whereas unfertilized rice achieved an average yield of 5500 lb/acre, increasing the rate of N fertilizer increased the grain yield to 9100 lb/acre. However, the removal or incorporating of the straw did not significantly affect the yield. In addition, applications of N above 90 lb/acre did not further increase the grain yield, whether residue was incorporated or removed. The often observed N benefit on grain yield following residue incorporation did not occur. The most likely explanation is that the duration of residue incorporation has been too short to show any significant impact on the overall N supply power of the soil and therefore an effect on total grain yield was not observed.

Medium rates of K fertilization had a small but significant effect on total grain yield when straw was removed but not when straw was incorporated (Fig. 6). Evidently, the amount of K removed in the straw was sufficient to induce a K deficiency. It is of interest to note that just one year of straw removal led already to such a significant increase in grain yield. It is anticipated that a stronger K response on yield will manifest itself in years 2 and 3 of the experiment.

The total amount of rice straw residue produced, however, was not only affected by N rate application but also by straw management (Fig. 7). There was no effect of K application on straw yield. Incorporation of straw led to higher straw production and because yield was not affected, to a lower harvest index (Fig. 8). Harvest index is here defined as the total amount of grain yield divided by the total amount of aboveground biomass produced multiplied by 100. The increase in straw production without an increase in grain production would suggest that the additional nutrients that became available following the incorporation of straw were not used by the crop to produce additional grain. Or in other words, the crop became less efficient in its nutrient use (in particular N) once the N was taken up in the production of grain following straw incorporation. As K rate had no effect on straw production and the harvest index, the production of straw and subsequently the lower harvest index appears to be mainly controlled by N which becomes accentuated following the incorporating the residue. Of interest would be to determine how to manage the rice straw differently and whether an increase in nutrients leads to an increase in grain rather than in straw production.

Nitrogen Use Efficiency

For the 1999 season, the concentration of N in the grain at final harvest showed that removing straw led to an increase in the concentration of N in the grain at all levels of N applications (Fig. 9). The K fertilizer had no effect on N concentration in the straw (Fig. 10). As anticipated, the concentration of N in the grain increased with increasing rates of N application and the increase was more pronounced when straw was removed. The application of N fertilizer increased the concentration of N in the straw but neither straw management nor K fertilization had a significant impact on the concentration of N. The increase in the concentration of N in the seed when straw is removed compared to straw incorporation can be explained by a principle of plant physiology. Stressed plants are known to show higher concentrations of nutrients in their seed, a phenomenon that may have occurred in this study.

The N requirement (amount of N in lb/acre to produce a ton of grain), increased significantly under higher rates of N (Fig. 11). Higher rates of K application had no effect on the N requirement (Fig. 12). However, the N requirement for rice under low N and K rates of fertilizers improved when straw was incorporated: i.e., less N was needed to produce a ton of grain (Figs. 11 and 12).

Although increased levels of N application decreased the recovery of the applied fertilizer-N (N-use efficiency or NFUE) and the lowest N recoveries occurred when straw was incorporated (Fig. 13), the decline was not significant. The impact of K fertilization on N fertilizer use efficiency remains unclear and is non-significant (Fig. 14).