CALIFORNIA

Correcting Potassium Deficiency Can Reduce Rice Stem Diseases

By Jack Williams and Sara Goldman Smith

Research in the Sacramento Valley of California shows that potassium (K) fertilization of soils deficient in available K will not only increase rice yields, but may also reduce pressure from such diseases as stem rot and aggregate sheath spot (AgSS).

Mineral nutrition is a key management tool for maximizing yield and promoting good market quality of rice. In California's Sacramento Valley, home to about 95 percent of the state's rice production, fertilizer nitrogen (N) and phosphorus (P) are nearly universally applied each year, averaging 140 lb N/A and 45 lb P_2O_5/A. Potassium fertilizer, however, is less generally used. Soils along the eastern slope of the valley frequently have low available K, in the range of 20 to 80 parts per million (ppm) ammonium acetate extractable. These shallow, coarse textured, hardpan or claypan soils were formed on alluvial fan terraces and are continuously cropped to rice, with many fields producing 30 or more consecutive crops. Cropping removes about 35 or 40 lb K/A/yr (42 to 48 lb K_2O equivalent) in the grain, slowly reducing the available soil supply. In recent years, response to K application in trials has become more common, and many growers in the area have begun to apply K annually, at rates of 60 to 120 lb K_2O/A. Straw removal from these low K soils, necessary because of reduced burning, will likely increase in the next few years, which will accelerate the rate of K removal.

Late season K deficiency symptoms on foliage of rice in California.

Important rice diseases in California include stem rot (*Sclerotium oryzae*) and AgSS. (*Rhizoctonia oryzae-sativae*). Either or both may appear in virtually any field.

Several researchers have confirmed in many previous studies that stem rot increases at higher N rates, and AgSS either decreases or does not respond to N. However, since California rice fields have not historically had widespread K deficiency, we have not studied the effect of K on rice diseases until recently. Occasionally, we have observed K-deficient rice fields that also have had very high disease levels, particularly stem rot. Interaction of K deficiency and disease has been reported elsewhere, but never in California. In addition, new rice residue management practices, including rice straw removal, make it important to increase our understanding of how K nutrition interacts with rice diseases.

Field Study

In 1996, we established a N x K interaction study in a rice field that had a history of very high disease and low yield. We suspected K deficiency was part of the problem because soil samples from the final seedbed in 1996 tested 23 ppm exchangeable K. The established critical K value for California rice is 60 ppm. The trial compared two rates of N and six K treatments. The K treatments, consisting of rates and timing of potassium chloride (KCl), were superimposed over the N rates in a split plot design with four replications. We evaluated leaf N and K at 45 and 63 days after planting (DAP), rated diseases at 114 DAP, and measured height, lodging and yield. Since there were no appreciable interactions between N and K in most cases, the results for N are averaged across K treatments and those for K across N treatments.

Results

At 45 DAP, we saw plant growth effects typical of K deficiency in the low K treatments, including reduced height, tillering and leafiness. Lower leaves had brown spots on the upper portion of the leaf blade and occasional leaf tip necrosis. Leaf samples taken at 45 and 63 DAP showed K percent increasing with rates and decreasing with time with several treatments falling below established critical values (**Figure 1**). Therefore, we expected a yield response in some of these treatments. There was no effect of increased N on leaf K concentration at 45 DAP. At 63 DAP, leaves from the lower N plots had a slightly higher K concentration (data not shown).

Increasing K rates decreased stem rot incidence and AgSS severity **(Table 1).** Stem rot severity and incidence increased with higher N, while AgSS incidence decreased marginally. There was also significant interaction of N and K for incidence of stem rot which tended to be higher at high N and low K (data not shown). Percent K in leaf blades at 63 DAP correlated negatively with severity for both diseases (**Figure 2**). In other words, higher leaf K was associated with lower disease incidence.

Increasing K rates resulted in increased plant height, delayed maturity (measured as higher moisture content at harvest), and more yield (**Table 2**). While K did increase plant height, lodging was not correspondingly increased. The effect of K on lodging appeared to be related to timing, rather than rate at which delayed K application resulted in increased lodging. Estimated maximum yield with preplant K rates occurred between 120 and 180 lb K_2O/A. Topdressing 120 lb K_2O/A at 45 DAP appeared to increase yield slightly over the same rate applied preplant, although the difference was not statistically significant.

The higher N rate increased plant height and lodging, delayed maturity, and decreased yield (**Table 2**). This suggests that the grower's N program (lower N rate) was near optimum.

Summary

Potassium deficiency can contribute to stem diseases of rice.

This field research confirmed what we had speculated – that stem diseases of rice may be more severe in K-deficient soils. While correcting the deficiency did not eliminate the diseases, they were generally less damaging when K was adequately supplied. This is the first such confirmed report for rice in

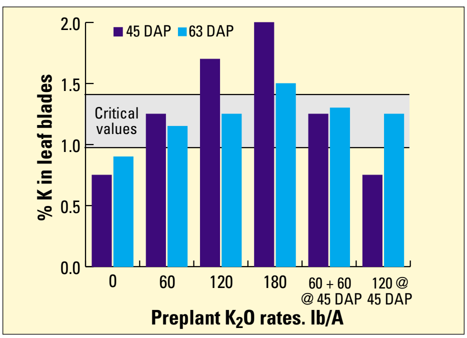

Figure 1. Percent K in leaf blades at 45 and 63 days after planting, at different levels and timing of KCl fertilizer, averaged across N treatments.

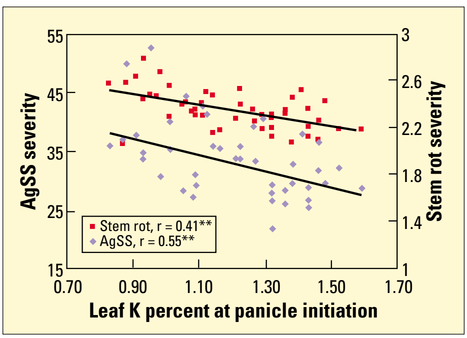

Figure 2. Correlation of leaf K percent at 63 days after planting (approximately panicle initiation growth stage) to stem rot and AgSS severity ratings. (**regression is significant at the 99 percent probability level).

California. The combination of high N and low K was particularly important in enhancing stem rot incidence; hence, a balance of N and K is an important consideration when managing rice fields with high disease potential and low K.

TABLE 1. Effect of N and K treatments on disease severity and incidence.

N treatments[1]	Stem rot severity, 1-5[3]	Stem rot incidence, %	AgSS severity, %	AgSS incidence, %
Low N	1.75	35.5	41.5	96.5
High N	2.06	45.0	42.9	94.2
Significance, %	>99.9	>99.0	ns	>95.0
K treatments, lb K_2O/A				
0	2.0	50.3	45.2	95.0
60 preplant	2.0	43.9	42.8	94.9
120 preplant	1.8	38.6	41.1	96.8
180 preplant	1.9	39.3	40.5	96.5
60 + 60[2]	1.8	33.6	40.7	94.3
120 @ 45 DAP	1.9	35.9	42.8	94.8
$LSD_{0.5}$	ns	12.0	3.2	ns

[1]Low = grower rate of 147 lb N/A. High = grower rate + 40 lb N/A.
[2]60 lb preplant + 60 lb 45 days after planting.
[3]Higher number indicates increased stem rot severity.

Potassium is a fertilizer, not a fungicide.

The research also suggests that K had a significant role in both plant nutrition and the course of disease on this K-deficient soil. However, it is important to recognize that the role of K fertilization is primarily plant nutrition, not disease prevention. To confirm this, we did follow-up work in 1997. We established K and zero K sites in 10 rice fields that represented a diversity of rice soils in the Sacramento Valley. None of these soils were deficient in K, averaging 189 ppm over a range of 82 to 246 ppm. Application of 120 lb K_2O/A as KCl did not affect yield, leaf K, or N percent at any of three sample dates. In addition, stem rot and AgSS...incidence or severity... were not affected by the addition of K fertilizer. Clearly, K must first be deficient before effects of K application on yield and disease can be expected.

TABLE 2. Effect of N and K treatments on lodging, height, grain moisture, and grain yield.

N treatments[1]	Lodging, %	Height, inches	Grain moisture, %	Yield, lb/A
Low N	12.5	37.3	21.3	8,068
High N	51.9	38.3	21.9	7,673
Significance, %	>99.9	>99.9	>99.0	>99.0
K treatments, lb K_2O/A				
0	31.3	35.2	21.0	7,155
60 preplant	30.0	37.5	21.2	7,725
120 preplant	30.0	39.0	21.9	7,803
180 preplant	26.3	39.2	22.0	8,292
60 + 60[2]	43.8	38.3	21.9	8,039
120 @ 45 DAP	31.9	37.2	21.6	8,208
$LSD_{0.05}$	15.2	0.9	0.6	423

[1]Low = grower rate of 147 lb N/A. High = grower rate + 40 lb N/A.
[2]60 lb preplant + 60 lb 45 days after planting.

Rice straw removal will induce K deficiency on some soils.

The role of K in rice crop nutrition in California may change in the near future as rice straw management practices change. When rice residue is burned, the historical practice, 93 to 98 percent of the K in the residue is returned to the soil in the ash. Currently, growers are soil-incorporating most of their rice straw as new regulations phase down burning. This practice also returns essentially 100 percent of the mineral nutrients to the soil. Straw removal, however, would greatly increase the amount of K exported from these soils. BC

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