OHIO

Adequate Soil Potassium Increases Nitrogen Use Efficiency by Corn

By J.W. Johnson and H.F. Reetz

Developing sound nutrient management plans for crop production requires understanding of the response relationships to the various nutrients. Response curves for N, phosphorus (P), and K are readily available for many situations to help with this understanding. But the interactions among the nutrients are also important considerations. Adequate data sets are more difficult to find. A detailed study at the Ohio State University Western Research Center, Springfield, OH, is providing valuable information on the interactions of K and N.

> Higher soil test potassium (K) levels resulted in significant yield response, higher optimum applied nitrogen (N) rates, more efficient use of the applied N and less nitrate-N remaining in the soil after harvest.

Interaction

The experiment was designed to determine the interaction between applied N and residual soil K on corn yield and on the efficiency of N use by corn. The study is being conducted on a Crosby silt loam soil, representative of a large part of the eastern Corn Belt. The soil has a cation exchange capacity (CEC) of 12 milliequivalents/100g. October 1994 soil tests showed an average pH of 6.5 and an average Bray-P_1 soil test of 39 lb/A. All plots received annual preplant broadcast applications of 50 lb P_2O_5/A. In 1992, five K treatments were established as the main plots in a split plot design and annual soil tests were used to monitor K levels. Six different N treatments were established as the split plots. Annual N applications in 80 lb/A increments ranged from 0 to 320 lb/A, with all except the check plot receiving 40 lb N/A as starter and the rest applied as preplant broadcast ammonium nitrate.

Figure 1 shows the interaction between N rate and soil test K level on corn yield. There was a positive yield response to at least 160 lb N/A and to soil test K levels of up to 232 lb K/A. When no N was applied, the optimum soil test K was below 200 lb K/A. However, when soil test K was above 200 lb K/A, the optimum N rate was between 160 and 240 lb N/A.

The concentration of N in the corn grain increased as N rate and soil test K level increased. The combination of higher yield and higher percent N in the grain resulted in significantly higher total N removed in the grain (**Table 1**). As N rate increased, the percent of total applied N removed in the grain decreased (data not

Table 1. *Nitrogen in grain as influenced by applied N and soil K level.*

N rate, lb/A	Soil test K, lb/A 160	200	232	269	278
	N in grain, lb/A				
0	68	74	65	55	60
80	91	107	114	105	105
160	101	120	141	137	139
240	114	127	138	145	147
320	125	136	144	151	147

Ohio, 1992-1994, 3-yr. average

shown). But, at all N rates, higher soil test K levels resulted in a higher percentage of the total applied N being removed in the grain. That means higher N use efficiency. Similarly, increasing soil test K levels resulted in increased uptake of applied N in the total plant (**Table 2**).

Table 2. *Increasing soil test K levels resulted in increased uptake of applied N in the total plant.*

N rate, lb/A	Soil test K, lb/A 160	200	232	269	278
	Percent of applied N in total plant				
80	60	88	73	97	103
160	44	57	70	80	89
240	27	36	40	57	58
320	30	37	31	52	45

Post-harvest soil sampling revealed that increasing N application rates resulted in a higher percentage of the total applied N being left in the soil (0-3 ft.) at the end of the season (**Figure 2**). As soil K test level increased, more of the N was taken up by the crop, and significantly less remained in the soil. When soil K levels were above 232 lb K/A, the crop utilized fertilizer N more efficiently, resulting in less nitrate-N remaining in the soil after harvest.

Summary

The interaction between soil test K and N use efficiency demonstrates that K soil test should be maintained at high levels for higher yields and to make best use of available N. Any on-farm studies to determine optimum N rates should be conducted with high levels of available K. Otherwise, optimum yields and optimum N use efficiency will not be obtained.

When interpreting N response data to be used in formulating nutrient recommendations, it is critical to know that soil test K levels are high enough to optimize the interaction effects demonstrated in this study. If soil test K levels are below optimum, the full benefit of applied N cannot be realized, and more of the applied N may be left in the soil after harvest, resulting in lower profitability and creating greater potential for a negative environmental impact. BC

Dr. Johnson is Professor of Soil Fertility, School of Natural Resources, The Ohio State University, Columbus, OH. Dr. Reetz is Midwest Director, PPI, Monticello, IL.

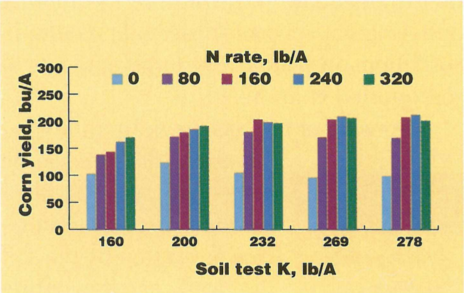

Figure 1. *Effects of applied N and soil test K on average corn yields. Springfield, OH, 1992-1995*

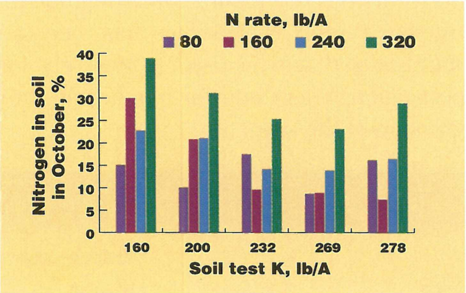

Figure 2. *Percent of applied N remaining in soil in October, related to soil test K level.*

CALIFORNIA

Foliar Applied Potassium Benefits Cotton in the San Joaquin Valley

By Bill L. Weir, Robert Miller and Bruce Roberts

California produces about 20 percent of U.S. upland cotton annually on 1.25 million acres. There are currently 11 different varieties available for growers to choose from. They are grown on a wide variety of soil types and with diverse management practices.

> Studies in California indicate that mid-season potassium (K) deficiency in cotton can be avoided with foliar sprays. Rates of less than 10 lb/A of K_2O can produce a highly economical return.

Along with new varieties have come new technologies and changes in cultural practices. Plant growth regulators such as PIX (mepiquat chloride) and PGR IV (gibberellic acid and indobuteric acid) may improve yields by aiding in setting and retaining more bolls. Earlier application of the first irrigation to avoid moisture stress has also been beneficial to yields and has enhanced the positive response derived from the plant growth regulators. Intensive crop monitoring has become standardized and is used extensively for pest management and for monitoring progression of the crop.

The application of foliar nitrogen (N) and K at or near the early bloom stage of growth, when these nutrients are in peak demand, is a recent practice that is gaining in popularity. Since 1983, such innovations in fertilization and other inputs, cultural practices, and overall management have resulted in an average annual cotton yield increase of 32 lb lint/A in California.

Cotton plants require K at a rate of 1.9 to 3.0 lb/A/day during boll fill. Previous studies by University of California researchers (Dr. Ken Cassman and others) have demonstrated that these levels of K uptake can be difficult to maintain, especially on vermiculitic soils in the San Joaquin Valley. After years of K depletion (inadequate fertilization), the high K buffering capacity of these soils results in conditions in which very large amounts of soil applied K are fixed.

Growers of the San Joaquin Valley are aware of the need to be efficient with fertilizer in the sense of minimizing K fixation by the soil as well as preventing losses of nutrients, primarily N, to the groundwater and to the atmosphere. Innovative methods of fertilizer applications such as split side-dress, water run, and

TABLE 1. *Test site characteristics.*

Test	Variety	Exchangeable K[1], ppm	Release rate[2], ppm/day
Merced 1992	Royale	160	2
Kings 1992	Pima S-6	159	–
Merced 1993	Maxxa	145	2

[1] In ammonium acetate.
[2] Unocal procedure.

foliar applications are becoming common. The increasing interest in supplemental applications of N and K by foliar applications is creating many questions that must be answered by researchers.

San Joaquin Valley Studies

Field tests were conducted in 1992 and 1993 in Merced and Kings counties in which K was applied in foliar sprays at various times during the growing season. All treatments were replicated four times. In Merced County, one test was conducted with potassium sulfate (K_2SO_4) and two with potassium nitrate (KNO_3).

Treatments were applied by a tractor sprayer set up for foliar plot work. Plots were eight rows wide (30-inch centers) by one-fourth mile long. Five treatments consisted of foliar applications initiated after first flower at timings of: 1 and 2 weeks; 3 and 4 weeks; 5 and 6 weeks; 7 and 8 weeks; and a control. Each of the two applications consisted of materials applied at the rate of 4.5 lb/A of K_2O, so that each treatment received a total of 9 lb/A. Acala Royale and Acala Maxxa were evaluated in the study. Plots were harvested with the grower's straddle row 30-inch picker and weighed with a research scale.

Similarly, the Kings County trials tested the yield response of Pima S-6 to foliar KNO_3 applied after first bloom at: 1, 3, 5, and 7 weeks; 3 and 4 weeks; and 5 and 6 weeks. A fourth treatment consisted of foliar K applied at 3 and 4 weeks to plants growing on soil fertilized preplant at the rate of 360 lb/A of K_2O using potassium chloride (KCl). Foliar applications went on as KNO_3 at the rate of 4.5 lb/A of K_2O which totaled 9 lb/A after two applications and 18 lb/A after four applications. This test was conducted by hand spraying plots four rows wide (38-inch centers) and hand harvesting 13-foot lengths from the center two rows for yields.

The cotton varieties used and the available soil K values for each experimental site are presented in **Table 1**. All sites were adequate in exchangeable K according to present University of California guidelines. The K release test also suggests adequate release potential.

Results

The Merced and Kings counties tests in 1992 evaluated the importance of timing of foliar KNO_3 (unbuffered solution) on both upland and Pima varieties (**Table 2**). Data in **Figure 1** show that applica-

Table 2. *Foliar KNO_3 application effects on yields of Acala and Pima cottons, 1992.*

Application, weeks after first flower	Treatments dates 7/1	7/7	7/16	7/22	7/28	8/4	8/12	8/20	Lint yield, lb/A
Acala (Merced)									
Control	–	–	–	–	–	–	–	–	1,291
1 & 2	+	+	–	–	–	–	–	–	1,360
3 & 4	–	–	+	+	–	–	–	–	1,411
5 & 6	–	–	–	–	+	+	–	–	1,367
7 & 8	–	–	–	–	–	–	+	+	1,313
Pima (Kings)									
Control	–	–	–	–	–	–	–	–	1,310
1-7	–	+	–	+	–	+	–	+	1,371
4 & 6	–	–	–	–	+	–	+	–	1,332
5 & 7	–	–	–	–	–	+	–	+	1,255
360 lb K_2O/A soil	–	–	–	–	+	–	+	–	1,397

tions of KNO_3 at about three weeks after bloom resulted in greater yields than either earlier or later applications. The highest yield in the Pima test when there was no soil applied K treatment occurred with four sequential applications at 1, 3, 5, and 7 weeks after first bloom. The yields were not significantly different, but the trend supports the results from the upland tests.

The 1993 tests employed both KNO_3 and K_2SO_4 applied foliarly (unbuffered solutions) to Acala Maxxa cotton in Merced County and KNO_3 applied to Pima S-7 in Kings County. Results from these tests were very similar to those of the previous year. The greatest yield responses were measured from plots receiving foliar K at 2 to 3 weeks after bloom initiation. Yield response was less as foliar applications were made later in the season. The effect was similar whether the K fertilizer source was KNO_3 or K_2SO_4.

NEW COTTON *varieties which set a heavy boll load over a short period of time require larger amounts of K. High yield management of these varieties has led to widespread occurrence of K deficiency symptoms during mid and late season in the San Joaquin Valley.*

Summary

The results of these tests show that benefits can be obtained from foliar applications of K. New, more determinant cotton varieties which set the crop over a short period of time require larger amounts of some nutrients, such as K and N, during this critical stage of development. These varieties coupled with cultural practices aimed at obtaining high yields and which push the crop toward earlier termination also intensify nutrient demand. One result has been the widespread occurrence of K deficiency symptoms in cotton fields during mid- and late-season. Even though soil K levels are "adequate" according to present guidelines, foliar applications at 2 to 3 weeks after first bloom produce a positive yield response. BC

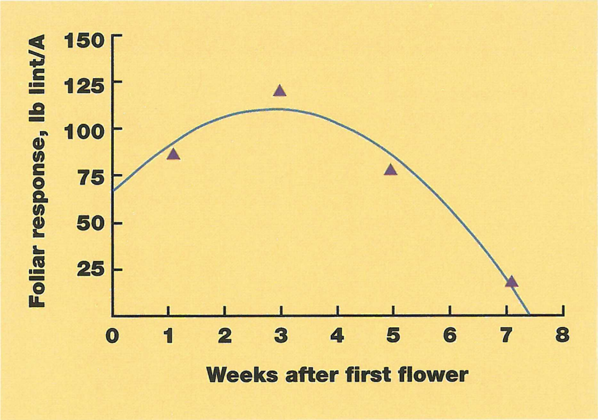

FIGURE 1. *Cotton response to foliar-applied K at various times after first flower.*

Dr. Weir is Extension Farm Advisor, Merced County, Dr. Miller is Extension Soils Specialist, University of California, Davis, and Mr. Roberts is Extension Farm Advisor, Kings County, California.