Dr. P. Motavalli, Dr. K. Nelson, Dr. G. Stevens, and S. Phurahong

What About Foliar K On Soybeans?

Despite a relatively inconsistent soybean response to foliar K, studies show an opportunity may exist to provide growers with a cost-effective method of applying foliar K.

Summary: *Among the conclusions reached by this research is that foliar potassium (K) fertilization may be a supplemental practice to longterm K fertilization practices that build up and maintain soil test K levels. However, foliar K fertilization may become a more useful management tool if further research determines what soil and environmental conditions promote soybean crop response to foliar K fertilization. In addition, methods must be developed to assist growers in making more rapid assessment of soil K availability during the growing season to decide when foliar K fertilization may be profi table. Our ongoing research also has been examining mixing foliar K sources with glyphosate, since combining foliar fertilizer with post-emergence weed control may make foliar fertilization more cost-effective.*

Soybean response to foliar fertilization applied several times during the growing season has been extensively examined by researchers, starting in the 1970s. Most of the reported responses to foliar fertilization have been variable and inconsistent, especially when tested over a wide range of locations. However, recent changes in agricultural management practices and other developments justify additional research into use of foliar K applications for improved soybean production.

The incidence of K deficiency in agronomic crops has increased in recent years in Missouri and other Midwestern states due to 1) the effects of drought conditions and soil compaction resulting in decreased K availability, 2) reduced amounts of applied K fertilizer, 3) lower frequency of soil testing by producers due to low commodity prices, and 4) higher K fertilizer requirements because of increasing crop yields and larger soybean acreage. Moreover, 83 percent of soybean varieties produced on over five million acres in Missouri were Roundup Ready® or contained another form of transgenic herbicide resistance in 2003. Widespread use of glyphosate for post-emergent weed control in soybeans opens the possibility of making foliar K fertilization more cost-effective by combining foliar fertilization with post-emergent herbicide applications.

Finally, the goal of recent developments in soil fertility management practices, such as the practices being developed for site-specific nitrogen (N) management of corn, has been to provide growers with tools that allow them the flexibility of assessing and responding to changes in and spatial variation of soil nutrient availability over a longer portion of the growing season. If effective, post-emergent application of foliar K would have the advantage of increased flexibility for growers to more rapidly respond to observed K deficiency owing to the effects of variable soil properties, management practices, or climatic conditions.

Objectives of our 2001 to 2002 experiments conducted on a farmer's field, with low to medium soil test K, were to 1) compare how soybeans respond to foliar K applied at several growth stages versus a preplant application, and 2) evaluate the cost-effectiveness of different timings and application methods on soybean growth in claypan soils.

Objectives of our 2003 experiments, with both low to medium and high soil test K, were to 1) determine soybean yield response and salt injury from different foliar-applied K sources, 2) assess if the K source affects weed control when mixed with a glyphosate-based herbicide, and 3) evaluate the cost-effectiveness of applying K with glyphosate-based herbicides for soybean production.

2001 to 2002 results

Salt injury is common with foliar fertilizer applications. However, no foliar crop injury was observed 3 or 7 days after the V4, R1 to R2, and R3 to R4 application timings of K_2SO_4 or the foliar control, $MgSO_4$ (data not presented).

Grain yields were generally higher in 2001 (Figure 1) compared to 2002 (Figure 2), which was probably due to better rainfall distribution in 2001. Soybean yields in both 2001 and 2002 were also 14 to 15 bu/A greater with preplant K compared to foliar-applied treatments. Foliar-applied K at 20 or 39 lbs/A of K_2O increased average grain yield 6 to 10 bu/A across all foliar application dates when compared to the untreated or sulfur control in 2001 (Figure 1). However, soybean yields were more responsive to foliar K applications from 10 to 39 lbs/A of K_2O under relatively drier conditions in 2002. Grain yields increased 8 to 11 bu/A when compared to the untreated or sulfur control (Figure 2).

Soybean grain yield was maximized (an increase of 11 bu/A compared to the control) at a foliar K rate of 39 lbs/A of K_2O applied at the R1 to R2 stages of development in 2001 when drought stress conditions were minimal.

In contrast, the maximum grain yield increase observed in 2002 was 12 bu/A at the V4 application timing. A foliar K application may be more effective when applied from the V4 to the R1 to R2 stages of development to obtain optimal yields in years with good rainfall distribution. However, substantial yield increases were observed at low rates when conditions were less optimal. Differences in soybean response to foliar K may be affected by climate, since lower soil water content may reduce K uptake through the roots and thereby increase the relative crop response to foliar applications.

Cost-effectiveness. The cost-effectiveness of treatments evaluated in this study was ranked preplant K at 300 lbs/A of K_2O = preplant K at 150 lbs/A of K_2O > preplant K at 600 lbs/A of K_2O = foliar K applied at the V4 and R1 to R2 stages at 39 lbs/A of K_2O followed by additional foliar treatments and the untreated control. All treatments except the V4 at 10 lbs/A of K_2O and R3 to R4 timing at 10, 20, and 39 lbs/A of K_2O increased gross margins when compared to the untreated control.

Conclusions. A couple of conclusions were reached from this preliminary research at a low-to-medium soil test K site with a claypan soil.

First, foliar K applications in soybeans may be a possible management tool to mitigate reduced yields caused by K deficiency. However, optimal soybean grain yields and gross margins were obtained with preplant K fertilizer application timings and foliar treatments

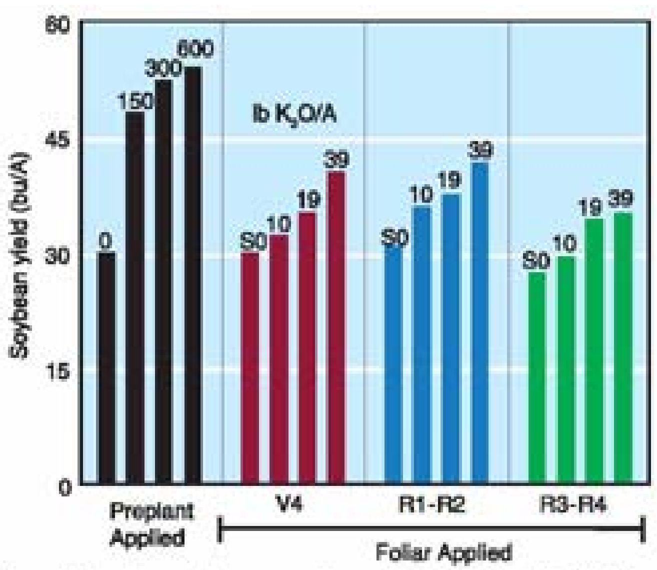

Figure 1. Soybean grain response to preplant and foliar K fertilization at different soybean growth stages, 2001. S0 = sulfur control; 10, 19, and 39 = lbs/A of K_2O.

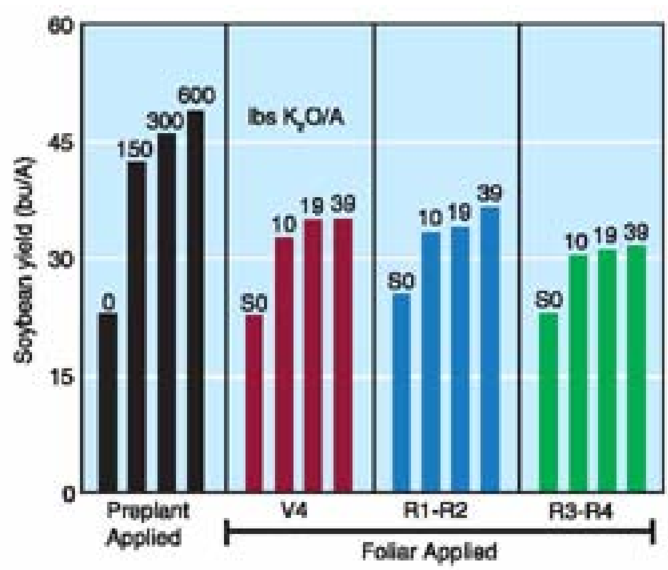

Figure 2. Soybean grain response to preplant and foliar K fertilization at different soybean growth stages, 2002. S0 = sulfur control; 10, 19, and 39 = lbs/A of K_2O.

did not substitute for a preplant K application for optimal soybean production in this research. Foliar K may be a supplemental nutrient management practice when conditions reduce plant K uptake from soil.

Second, carrier volumes required for foliar application of K_2SO_4 at rates shown to be effective in this research are generally impractical for most farm operations. Additional research was needed to evaluate crop response from more soluble K fertilizer sources that would have relatively lower salt indexes and possible compatibility with glyphosate.

Table 1. Soybean injury and grain yields with K sources in the presence and absence of glyphosate (formulated as Roundup WeatherMAX) in 2003 at high soil test K site.

Glyphosate K source[a]	Rate	Injury 3 DAT glyphosate - [b]	Injury 3 DAT glyphosate +	Injury 7 DAT glyphosate -	Injury 7 DAT glyphosate +	Injury 21 DAT glyphosate -	Injury 21 DAT glyphosate +	Grain Yield glyphosate -	Grain Yield glyphosate +
	lbs/A K_2O	%						bu/A	
Untreated		0	0[c]	0	0	0	0	21	43
Weed-free		0	0	0	0	0	0	44	45
3-18-18	32	5	11	2	10	0	7	45	45
0-0-30	55	23	19	15	14	5	13	49	38
0-0-25-17	46	7	7	4	4	1	3	46	33
5-0-20-13	35	9	15	7	11	0	10	47	40
5-0-20-13	22	4	12	3	8	0	8	47	43
5-0-20-13	12	2	6	1	2	1	3	46	46
0-0-50	2	0	1	0	1	0	1	44	43
0-0-62	19	3	4	2	2	1	2	46	46
14-0-44	2	0	0	0	0	0	0	45	45
DAS	0	0	0	0	0	0	0	45	47

[a]K sources: 3-18-18, potassium phosphate; 0-0-30, potassium carbonate; 0-0-25-17, potassium thiosulfate; 5-0-20-13, Triset K+; 0-0-50, potassium sulfate; 0-0-62, potassium chloride; 14-0-44, potassium nitrate; and DAS, diammonium sulfate.
[b]All treatments except the untreated control were maintained weed-free with glyphosate (formulated as Roundup UltraMAX).
[c]No additive was included.

K with glyphosate

Spray pattern. Compatibility tests of tank mixing K sources with glyphosate were conducted in 2003 with the highest rate of foliar fertilizer that could be mixed with glyphosate. Therefore, not all K sources were mixed at uniform K rates. A slight precipitate was formed when fluid 3-18-18 was tank mixed with Roundup WeatherMAX, while potassium thiosulfate (KTS) formed a viscous solid with Roundup WeatherMAX that was removed prior to the tank mixture application. A poor spray pattern was observed when 0-0-30 (potassium carbonate) was applied with Roundup WeatherMAX and the spray boom height was adjusted to compensate.

Visual injury was primarily necrosis of leaves exposed to foliar application. For the high soil test K site located at the Greenley Center, all treatments except 0-0-30 had less than 10 percent soybean injury 3 and 7 days after treatment (DAT) with almost complete recovery 21 DAT (Table 1). Tank mixtures of 3-18-18 and 5-0-20-30 at rates of 12, 23, and 35 lbs/A of K_2O with glyphosate injured soybeans more than the foliar fertilizer applied alone 3 DAT. This injury was still evident up to 21 DAT for some treatments and plant height late in the season was shorter than the untreated control (data not shown). The adjuvants present in Roundup WeatherMAX probably increased uptake of the foliar K causing increased injury.

Grain yield. The weed-free soybean grain yield was 44 bu/A (Table 1). In the absence of Roundup WeatherMAX, 0-0-30 increased soybean grain yield 5 bu/A when compared to the weed-free control at the high soil test K site located at the Greenley Center. At the low-to-medium soil test K site, foliar-applied 0-0-62 significantly increased soybean grain yield by 2 bu/A when compared to the weedfree control (data not shown).

Conclusions. The first year results of these fi eld trials indicated the potential viability of mixing K sources with glyphosate, but also highlighted the importance of evaluating both crop K response and weed control to ensure grower acceptance of the practice. Potential concerns will be the initial foliar injury observed after spraying some of the foliar K sources, and the solubility limitations of certain K sources such as potassium nitrate and potassium sulfate, which would reduce flexibility in increasing foliar K application rates. In addition, soybean yield response to foliar K varied among the K sources and was much lower at both the high and low-to-medium soil test K field sites compared to the initial field site tested in 2001 and 2002. Our current research is comparing K sources for foliar fertilization at uniform K application rates with and without mixing with glyphosate at several field sites in the state of Missouri.

Dr. Motavalli is assistant professor in the Department of Soil, Environmental, and Atmospheric Sciences, Dr. Nelson is research agronomist and assistant professor in the Department of Agronomy, Dr. Stevens is extension associate professor in the Department of Agronomy, and Mr. Phurahong is a research assistant in the Department of Soil, Environmental, and Atmospheric Sciences at the University of Missouri. ❑