IMPACT OF FOLIAR K SOURCE ON CROP RESPONSE AND WEED CONTROL IN A NO-TILL GLYPHOSATE-RESISTANT SOYBEAN PRODUCTION SYSTEM

Kelly Nelson
Research Agronomist

Peter Motavalli
Assistant Professor

Gene Stevens
Extension Associate Professor

Andy Kendig
Extension Associate Professor

Manjula Nathan
Extension Associate Professor

David Dunn
Supervisor Soil Test Lab

Summary:
An increased incidence of K deficiency in soybeans and the potential for lowering application costs by mixing foliar nutrient sources with herbicides or other agrochemicals can make fluid fertilizer applications more cost-effective. Research was conducted in 2004 and 2005 to determine the effects of foliar-applied K fertilizer sources and refine product application rate on glyphosate-resistant soybean response and weed control. Field trials were conducted in Northeast (Novelty) and Southeast (Portageville) Missouri on soils with low and high soil test K and a diverse, high population of weeds to evaluate crop response and weed control. Soybean injury resulting from foliar applications of up to 19.2 lb K_2O/acre from several K fertilizer sources (i.e. potassium chloride, potassium thiosulfate, and 3-18-18) was generally less than 10%. K fertilizer sources such as 3-18-18 at 2.4 and 9.6 lb/a, 5-0-20-13 at 2.4 lb/a, and 0-0-62 at 9.6 and 19.2 lb/a tank mixed with glyphosate controlled weeds greater than 90% and had grain yields similar to diammonium sulfate (DAS) while providing additional K fertilizer to the soybean plant in a single-pass weed management system in Northern Missouri. However, the two-pass weed management system in Southern Missouri provided excellent weed control for all additives and grain yields were greater than or similar to glyphosate plus DAS. The results of this study indicate that foliar K applications can be mixed with glyphosate with minimal crop injury and reduction in weed control depending product selection and application rate.

Introduction:
Soybeans were produced on over 5 million acres in Missouri and 83% of the soybean varieties were Roundup Ready® or contained another form of transgenic herbicide resistance in 2003 (MASS, 2003). Roundup Ready® varieties allow farmers to apply glyphosate-based products for broad spectrum post-emergence weed control. The incidence of K deficiency has increased in recent years due to reduced K availability under drought and areas with soil compaction, reduced applications for soybean due to low commodity prices, and higher corn grain yields and increased soybean acreage in rotation with corn increasing K fertilizer requirements (Fixen, 2000; Reetz and Murrell, 1998). Soil test K data from the University of Missouri Soil and Plant Testing Lab indicates that over 50% of the soil samples tested in the low to medium range for K (Fixen, 2002). This situation indicates that nearly 2.5 million soybean acres in Missouri could be at risk or are currently experiencing yield loss due to inadequate K soil test levels.

Several studies have evaluated response of soybean to foliar fertilizer mixtures (Garcia and Hanway, 1976; Haq and Mallarino, 1998; Parker and Boswell, 1980); however, no research has evaluated the interaction between macronutrient foliar fertilizers and weed control with postemergence herbicides. Potassium is an essential nutrient that increases drought tolerance, stem strength, and improves plant growth. Uptake of K is primarily by diffusion through roots and under drought conditions limited uptake may occur.

Previous research on a farm field in Northeast Missouri on crop response to a foliar application of K sulfate at the V4, R1-R2, or R3-R4 stages of development demonstrated that soybean grain yield increased over 10 bu/acre when compared to a non-treated or $MgSO_4$ control (Nelson et al., 2005). The calculated increase in profit due to this yield increase from foliar K applications was approximately $50/acre. However, possible limitations for the use of K sulfate combined with a post-emergence herbicide application are the large carrier volume required for an optimum foliar K application and the possible incompatibility that the K fertilizer source may have when mixed with a glyphosate-based herbicide. In addition, the K source and herbicide mixture must result in minimal crop injury and not affect weed control. The objectives of this research were to: determine soybean yield response and salt injury from different foliar-applied potassium (K) fertilizer sources and rates of application and determine the impact of K fertilizer source and rate of application on weed control when mixed with a glyphosate-based herbicide.

Materials and Methods:
Research was conducted in 2003 and 2004 at the University of Missouri Greenley Center near Novelty on a Putnam silt loam with a high soil test K and the Delta Center near Portageville on a Portageville sandy loam in locations with a high and low soil test K. Plots were 7.5 by 25 ft to 10 by 35 ft. Soybeans were planted in 15 in. rows at Novelty and 30 in. rows at Portageville. All treatments were applied with a CO_2 propelled hand sprayer calibrated to deliver 15 and 20 GPA at Novelty and Portageville, respectively. Treatments were applied at four rates (0, 2.4, 9.6, and 19.2 lb K_2O/acre) of foliar K fertilizer sources (potassium chloride, potassium thiosulfate, potassium phosphate, Trisert K+) and diammonium sulfate (2.6 lb/acre) either sprayed separately on plots maintained weed-free or sprayed as a mixture with a glyphosate at 0.75 lb ae/acre on plots with weeds.

Foliar salt injury and weed control was rated on a scale of 0 (no effect) to 100 (complete crop or weed death). Weed control for individual weed species was visually evaluated at both locations. Leaf samples were collected at initial bloom to determine crop K status in treated and non-treated plants. A biomass harvest of soybean and weeds was collected 28 days after application to determine total weed control at Novelty. Percent dry weight reduction was calculated as 100[1-(total weed dry weight/untreated weed dry weight)]. Grain was harvested and moisture adjusted to 13% prior to analysis.

All data were subjected to analysis of variance using PROC ANOVA (SAS Inst., 1999) and subjected to an *F Max* test for homogeneity (Kuehl 1994). Data were combined over years and locations when variances were homogenous. Injury and weed control data were transformed to the arc sine prior ANOVA. This transformation did not affect conclusions; therefore, original means were reported. Means were separated using Fisher's Protected LSD at p=0.01.

Results and Discussion:
Soybean injury was less than 10% three days after treatment at Novelty (Table 1). Similarly, all treatments except 5-0-20-13 at 19.2 lbs/a injured soybean less than 10% 22 days after treatment at Portageville (Table 2). Glyphosate plus 3-18-18 at 2.4 and 9.6 lb/a, 5-0-20-13 at 2.4 lb/a, and 0-0-62 at 9.6 and 19.2 lb/a controlled weeds greater than 90% at Novelty 28 days after treatment (Table 1). All treatments except glyphosate plus DAS controlled palmer amaranth, morningglory spp., and large crabgrass greater than 90% 21 days after treatment at Portageville (Table 2).

K concentration in leaves at Novelty in the non-treated, weedy check was similar to all glyphosate tank mixtures except glyphosate plus 0-0-25-17 at 9.6 and 19.2 lb/a (Table 1). Leaf K concentration 14 days after application was similar among K treatments at the low soil test K site at Portageville, and no grain yield differences were detected at this site (Table 3).

No grain yield increase over the weed-free control was observed at Novelty (Table 1). Glyphosate plus 0-0-62 at 19.2 lb/a reduced grain yield 5 bu/a when compared to 0-0-62 applied in the weed-free check in 2004. K fertilizer additives applied alone to weed-free checks had grain yields 5 to 14 bu/a greater than a single application of glyphosate plus the fertilizer additive in 2005 due primarily to reduced weed control. Soybean grain yield was reduced 6 bu/a when glyphosate was tank mixed with 5-0-20-13 at 19.2 lb/a when compared to glyphosate plus NIS in 2005. Similarly, 0-0-25-17 at 9.6 and 19.2 lb/a reduced grain yields 7 and 6 bu/a, respectively. All weed-free treatments had grain yields similar to tank mixtures with glyphosate at Portageville (Table 2). All K additives increased soybean grain yield compared to glyphosate plus DAS except 5-0-20-13 at 9.6 and 19.2 lb/a, and KTS at 19.2 lb/a. This was probably due to increased soybean injury caused by these treatments.

K-based fertilizer sources such as 3-18-18 at 2.4 and 9.6 lb/a, 5-0-20-13 at 2.4 lb/a, and 0-0-62 at 9.6 and 19.2 lb/a tank mixed with glyphosate controlled weeds greater than 90% and had grain yields similar to DAS while providing additional K fertilizer to the soybean plant in a single-pass weed management system in Northern Missouri. However, the two-pass weed management system in Southern Missouri provided excellent weed control for all additives and grain yields were greater than or similar to glyphosate plus DAS.

References:

Fixen, P. 2000. A national perspective on nutrient management guidelines and regulations. Symposium on the Status and Basis for Mandating Nutrient Management Guidelines, ASA Annual Meetings, Nov. 6, 2000, Amer. Soc. Agron., Madison, WI.

Fixen, P.E. 2002. Soil test levels in North America. Better Crops with Plant Food 86:12-15.

Garcia, R.L. and J.J. Hanway. 1976. Foliar fertilization of soybeans during the seed-filling period. Agron. J. 68:653-657.

Haq, M.U. and A.P. Mallarino. 1998. Foliar fertilization of soybean at early vegetative stages. Agron. J. 90:763-769.

Kuehl, R. O. 1994. Statistical Principles of Research Design and Analysis. Duxbury Press, Belmont, CA. pp. 686.

MASS. 2003. Missouri Agriculture Statistics Service. http://agebb.missouri.edu/mass/farmfact/index.htm. Accessed 20 November 2004.

Nelson, K.A., P.P. Motavalli, and M. Nathan. 2005. Response of no-till soybean to timing of pre-plant and foliar potassium applications in a claypan soil. Agron. J. 97:832-838.

Parker, M.B. and F.C. Boswell. 1980. Foliage injury, nutrient intake, and yield of soybean as influenced by foliar fertilization. Agron. J. 72:110-113.
Reetz, H.F. and T.S. Murrell. 1998. Negligence of potassium in corn/soybean systems: Are you guilty? News & Views, December issue, Potash & Phosphate Institute, Norcross, GA.
SAS Institute. 1999. SAS user's guide. SAS Inst., Cary, NC.

Table 1. The effect of fertilizer additive on soybean injury, leaf tissue nutrient levels 14 days after application, total weed dry weight reduction and grain yield applied alone as a weed-free treatment and tank mixed with glyphosate in 2004 and 2005 at Novelty.[a]

		Injury 3 DAT		Tissue K		Total weed[b] dry weight reduction	Yield 2004		Yield 2005	
Fertilizer additive[c]	Rate	Weed-free	Glyphosate tank mixture	Weed-free	Glyphosate tank mixture	Glyphosate tank mixture	Weed-free	Glyphosate tank mixture	Weed-free	Glyphosate tank mixture
	lb K_2O/a	%		%		%	bu/a			
Non-treated		0		2.61		0	9.6		15.9	
Weed-free		0	—[d]	2.75	—	100	66.3	—	47.6	—
NIS		—	1	—	2.67	93	—	68.1	—	42.5
NIS + DAS		—	1	—	2.57	93	—	69.9	—	40.9
3-18-18	2.4	0	0	2.90	2.75	96	66.7	67.1	47.5	41.5
3-18-18	9.6	1	3	2.72	2.60	96	70.4	66.8	46.5	40.1
3-18-18	19.2	4	3	2.76	2.60	88	66.8	68.9	46.7	38.5
0-0-25-17 KTS	2.4	1	1	2.69	2.53	88	68.6	65.1	48.1	39.1
0-0-25-17 KTS	9.6	3	5	2.77	2.50	86	68.2	65.1	48.7	35.1
0-0-25-17 KTS	19.2	5	6	2.72	2.77	84	66.6	66.0	47.5	36.6
5-0-20-13	2.4	0	1	2.71	2.77	96	67.7	66.4	47.2	40.5
5-0-20-13	9.6	4	6	2.77	2.58	87	70.2	66.6	46.9	40.7
5-0-20-13	19.2	6	4	2.83	2.66	85	65.1	67.3	46.8	36.9
0-0-62	2.4	0	1	2.73	2.66	88	70.3	67.1	46.3	41.2
0-0-62	9.6	2	3	2.68	2.57	91	67.5	67.7	47.5	40.3
0-0-62	19.2	6	6	2.79	2.59	90	69.4	64.1	49.4	38.9
LSD (p=0.01)		1		0.15		11	4.9		4.7	

[a]Abbreviations: DAS, diammonium sulfate; DAT, days after treatment; KTS, potassium thiosulfate; NIS, non-ionic surfactant.
[b]Weeds included common lambsquarters in 2004, common ragweed in 2005, common waterhemp in 2004 and 2005, and giant foxtail in 2004 and 2005. Total dry weight reduction was calculated as 100[1-(total weed dry weight/untreated weed dry weight)].
[c]Fertilizer additives included 3-18-18, K phosphate + urea (NA-CHURS/ALPINE); 0-0-25-17, K thiosulfate; 5-0-20-13, K thiosulfate + urea-triazone (Trisert-K+, Tessenderlo Kerley); and 0-0-62, potassium chloride. All tank mixtures with glyphosate included non-ionic surfactant unless stated otherwise.
[d]Treatment was not included.

Table 2. Soybean injury 22 days after treatment (DAT), palmer amaranth control, ivyleaf and entireleaf morning glory control, large crabgrass control, and soybean yield at Portageville in 2004 and 2005.[a]

Deleted: 2

Fertilizer additive[b]	Rate	Injury 22 DAT 2004 Weed-free[c]	Injury 22 DAT 2004 Glyphosate tank mixture	Injury 22 DAT 2005 Weed-free[c]	Injury 22 DAT 2005 Glyphosate tank mixture	Palmer amaranth	Ivyleaf and entireleaf morningglory	Large crabgrass	Yield Weed-free	Yield Glyphosate tank mixture
		%							bu/a	
Non-treated		0		0		0	0	0	17.2	
NIS		—[c]	0	—	2	95	95	94	—	43.8
NIS + DAS		—	0	—	1	91	85	90	—	31.4
0-0-62	2.4	5	6	0	0	95	95	96	39.3	45.3
	9.6	5	5	2	0	94	96	95	38.2	48.8
	19.2	5	10	5	10	95	96	96	38.6	41.6
5-0-20-13	2.4	4	5	3	2	95	94	96	37.1	44.8
	9.6	3	10	1	3	95	94	92	38.1	40.0
	19.2	5	0	18	10	95	96	96	35.0	37.6
3-18-18	2.4	5	10	1	3	96	97	97	44.4	41.9
	9.6	0	4	1	1	96	96	97	41.5	41.3
	19.2	4	3	4	2	96	96	95	38.8	45.6
0-0-25-17 KTS	2.4	3	5	1	0	96	96	96	40.8	46.2
	9.6	0	3	7	3	95	96	95	38.8	43.0
	19.2	3	0	8	10	93	95	93	42.7	40.6
LSD (p=0.01)		8		7		5	5	6	10	

[a]Abbreviations: DAS, diammonium sulfate; DAT, days after treatment; KTS, potassium thiosulfate; NIS, non-ionic surfactant.

[b]Fertilizer additives included 3-18-18, K phosphate + urea (NA-CHURS/ALPINE); 0-0-25-17, K thiosulfate; 5-0-20-13, K thiosulfate + urea-triazone (Trisert-K, Tessenderlo Kerley); and 0-0-62, potassium chloride. All tank mixtures with glyphosate included non-ionic surfactant unless stated otherwise.

[c]Treatment was not included.

Table 3. Leaf tissue K and grain yield at Portageville with a low soil test K in 2004 and 2005.[a]

Deleted: ¶
¶
Section Break (Odd Page)

		Tissue K		Yield	
Fertilizer additive[b]	Rate	Weed-free	Glyphosate tank mixture	Weed-free	Glyphosate tank mixture
	lb K_2O/acre	-------- % --------		-------- bu/a --------	
Non-treated		1.7		48.0	
Weed-free		1.7	—[c]	54.4	—
NIS		—	1.8	—	49.9
NIS + DAS		—	1.7	—	53.1
3-18-18	2.4	1.6	1.8	44.5	52.1
3-18-18	9.6	1.7	1.7	53.3	57.5
3-18-18	19.2	1.8	1.7	54.4	54.9
0-0-25-17 KTS	2.4	1.8	1.6	51.2	51.1
0-0-25-17 KTS	9.6	1.6	1.8	50.3	53.5
0-0-25-17 KTS	19.2	1.7	1.8	52.7	55.8
5-0-20-13	2.4	1.8	1.8	51.8	52.1
5-0-20-13	9.6	1.9	1.7	54.3	47.9
5-0-20-13	19.2	1.8	1.6	53.4	53.0
0-0-62	2.4	1.6	1.7	53.7	55.8
0-0-62	9.6	1.6	1.7	59.7	52.1
0-0-62	19.2	1.8	1.7	51.8	53.9
LSD (p=0.01)		NS[d]		NS	

[a]Abbreviations: DAS, diammonium sulfate; KTS, potassium thiosulfate; NIS, non-ionic surfactant.

[b]Fertilizer additives included 3-18-18, K phosphate + urea (NA-CHURS/ALPINE); 0-0-25-17, K thiosulfate; 5-0-20-13, K thiosulfate + urea-triazone (Trisert-K, Tessenderlo Kerley); and 0-0-62, potassium chloride. All tank mixtures with glyphosate included non-ionic surfactant unless stated otherwise.

[c]Treatment was not included.

[d]NS = not statistically significant.