

Use of Pre-plant or Foliar-Applied Potassium Chloride with Fungicides to Improve Soybean Response and Disease Resistance

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Introduction:

An increased occurrence of K deficiency in soybeans and the potential widespread onset of Asian rust (SBR) (*Phakopsora pachyrhiza*) in soybeans have stimulated interest in new management practices that may improve K nutrition and lower incidence of disease. In 2004, SBR was reported in nine states including Louisiana, other Gulf-coast and southeastern states, and Missouri (APHIS, 2005). Yield loss estimates for this fungal disease range from 10 to 80% in areas where rust is established and could result in economic losses between \$640 to \$1,341 million the first year of infestation (Sweets et al., 2004). Since current soybean varieties grown in the U.S. have little or no resistance to SBR, a primary method of controlling the spread of the disease has been to use fungicides. Currently, four families of fungicides are available for SBR management: triazoles, strobilurins, chloronitriles, and carboxamides. In addition, extensive research has established a link between plant nutrition and disease incidence including the disease suppressing effects of K, Cl, Mn, B and P (Fixen et al, 2004). Therefore, combining K, Cl and other nutrients either as a pre-plant or foliar application with a fungicide may improve disease management. Recent research by Bradley and Sweets (2005) in Missouri indicates that several fungicides can be tank mixed with glyphosate without significant injury or reduction in yields of soybeans, but the limited penetration of the combined spray into the plant canopy may reduce potential SBR control. Nelson et al. (2004) has also established the KCl and several other K fertilizer sources can be combined with glyphosate without reducing weed control or causing significant foliar injury. This “weed and feed” system could also serve as an example for a system that combines disease control and nutrient management. The possible benefits of this approach include reduction in application costs, improved disease suppression and nutrient response, and flexibility in management response to environmental conditions during the growing season.

The objectives of this study were:

1. Determine soybean yield response, disease incidence and K and Cl tissue concentrations from application of KCl alone or in combination with several fungicides.
2. Examine the effects of application timing of KCl or the fungicides on crop response and disease incidence.

Materials and Methods:

This study evaluated the effects of either pre-plant or foliar-applied KCl fertilizer sources and rates of application on glyphosate-resistant soybean response. Field trials were established at the Greenley and Delta Centers on soils with medium to low soil test K. Roundup-Ready[®] soybeans were no-till planted at 180,000 seeds/acre in 15 inch rows at Novelty and 30 inch rows at Portageville. The study was arranged as a randomized complete block design with four replications. Treatments consisted of a non-treated control, a recommended pre-plant rate of K₂O as KCl based on soil test (455 and 505 lbs K₂O/acre at Novelty in 2006 and 2007, respectively; 203 and 216 lbs K₂O/acre at Portageville in 2006 and 2007, respectively), or a foliar application of 16 lb K/acre (as KCl) in a factorial arrangement combined with and without fungicide

applications of 6 oz/acre of pyraclostrobin (Headline[®]), 6.4 oz/acre of azoxystrobin (Quadris[®]) or 6.4 oz/acre Quadris[®] + 2.6 oz/acre of Warrior[®] (lambda-cyhalothrin insecticide) applied either at V4 or R4 growth stages.

Foliar injury was rated 3, 7, 10, 14, or 28 days after foliar application. Treatments were evaluated for the incidence of Septoria brown spot (*Septoria glycines*), frogeye leaf spot (*Cercospora sojina*), sudden death syndrome (*Fusarium solani*), and Asian rust. Soybeans were harvested and data analyzed to determine the influence of the treatments on crop response and grain yield. Data were subjected to an analysis of variance and means separated at $p=0.05$ unless otherwise specified. Main effects were generally presented in the absence of interactions.

Results and Discussion:

Injury. Soybean injury was primarily temporary necrosis that was less than 3% at Novelty 3 and 7 days after treatment (DAT) (Table 1). Foliar applied KCl at the R4 stage of development injured soybean up to 30% at Portageville, but plants had recovered by 14 DAT (data not presented).

Table 1. Soybean response to preplant and foliar applied KCl averaged over application timing, fungicide treatment, and year at Novelty, and averaged over fungicide treatment and year at Portageville.

Treatment	Novelty		Portageville			
			3 DAT		10 DAT	
	3 DAT	7 DAT	V4	R4	V4	R4
	----- % -----					
Non-treated	0	0	0	0	0	0
Preplant KCl	0	0	1	0	0	0
Foliar KCl	3	2	1	30	1	12
LSD ($p=0.05$)	---1---	---1---	-----3-----		-----2-----	

Abbreviations: DAT, days after treatment; LSD, least significant difference.

Incidence of disease. Asian soybean rust spores were detected at physiological maturity in Northeast and Southeast Missouri in 2007. Asian soybean rust was monitored in this research, but spores were not detected in either of these locations. The incidence of Septoria brown spot, frogeye leaf spot, or sudden death syndrome (SDS) was less than 10% in 2006 and 2007 at both locations. Preplant KCl reduced the incidence of Septoria brown spot and frogeye leaf spot 4 and 6%, respectively, at Novelty (Table 2).

There was an interaction between application timing and fungicide treatment at Novelty (Table 3). Quadris, Quadris plus Warrior, or Headline applied at R4 reduced the incidence of Septoria brown spot and frogeye leaf spot when compared to the non-treated or V4 application timing.

There was an interaction between KCl fertility, fungicide treatment, and application timing at Portageville (Table 4). At the R4 application timing, there was a greater incidence of Septoria brown spot while there was a lower incidence of SDS when fungicides were combined with KCl. In general, the incidence of Septoria brown spot, frogeye leaf spot, and SDS was similar for preplant KCl and non-treated KCl.

Table 2. Effect of KCl fertility on the incidence of Septoria brown spot and Frogeye leaf spot at Novelty in 2006 and 2007.

KCl fertility	Septoria brown spot		Frogeye leaf spot	
	----- % -----			
Non-treated	7		8	
Preplant KCl	3		2	
Foliar KCl	7		6	
LSD (p=0.05)	----- 1 -----		----- 1 -----	

Table 3. Effect of fungicide and timing on the incidence of Septoria brown spot and Frogeye leaf spot at Novelty in 2006 and 2007.

Fungicide treatment	Septoria brown spot		Frogeye leaf spot	
	V4	R4	V4	R4
----- % -----				
Non-treated	7	7	6	6
Quadris at 6.4 oz/a	7	6	6	4
Quadris at 6.4 oz/a + Warrior at 2.6 oz/a	6	5	6	4
Headline at 6 oz/a	6	4	6	4
LSD (p=0.05)	----- 1 -----		----- 1 -----	

Table 4. Effect of KCl fertility, fungicide, and application timing on the incidence of Septoria brown spot, frogeye leaf spot, and sudden death syndrome at Portageville in 2006 and 2007.

Treatment	Septoria brown spot		Frogeye leaf spot		Sudden death syndrome	
	V4	R4	V4	R4	V4	R4
----- % -----						
Non-treated						
Non-treated	7	3	4	2	2	5
Quadris at 6.4 oz/a	0	6	3	1	8	3
Quadris at 6.4 oz/a + Warrior at 2.6 oz/a	6	4	0	2	3	3
Headline at 6 oz/a	4	4	3	3	3	4
Preplant KCl						
Non-treated	5	5	1	2	2	4
Quadris at 6.4 oz/a	6	5	2	5	5	3
Quadris at 6.4 oz/a + Warrior at 2.6 oz/a	5	6	0	1	1	2
Headline at 6 oz/a	3	5	0	2	3	1
Foliar KCl						
Non-treated	8	8	2	3	5	1
Quadris at 6.4 oz/a	6	10	1	3	6	1
Quadris at 6.4 oz/a + Warrior at 2.6 oz/a	4	9	0	1	4	1
Headline at 6 oz/a	2	8	4	0	3	14
LSD (p=0.05)	----- 4 -----		----- 2 -----		----- 6 -----	

Leaf tissue analysis. Leaves were removed approximately 10 days after the R4 application timing and evaluated for P, N, K, and Cl concentration. There was no effect of fungicides or KCl fertility on leaf P concentration (data not presented).

Quadris and Headline treated plants had lower leaf N concentrations at Portageville (Table 5). However, Quadris and Headline had no effect on leaf N concentration when compared to the non-treated check at Novelty. Quadris plus Warrior treated plants at the R4 application timing had increased leaf N concentrations when compared to the non-treated check and the V4 application timing of Quadris plus Warrior. Differences in leaf N concentrations may be related to a low infestation of soybean aphids (<80/plant). The Quadris plus Warrior treated plants at the R4 timing averaged less than 14 aphids/plant up to 29 DAT while the non-treated or Quadris only treated plants averaged 35-72 aphids/plant up to 29 DAT (data not presented). Control of soybean aphids with Quadris plus Warrior may have resulted in increased leaf tissue N concentrations at Novelty. There was no effect of KCl fertility on soybean aphid populations.

Leaf tissue K was affected by KCl fertility (Table 6). Preplant KCl increased leaf tissue K 0.1 and 0.9% at Portageville and Novelty, respectively. No interactions between fungicide treatment, KCl, or fungicide treatment were observed.

Leaf Cl concentration was three times greater at Portageville than Novelty in 2006. There was an interaction between KCl fertility and application timing which was due to the foliar application of KCl. Preplant KCl increased Cl concentration in the leaves of soybean when compared to the non-treated check at Portageville, but had no effect at Novelty. Foliar applied KCl at the R4 application timing increased leaf Cl concentrations 2,770 to 3,740 ppm when compared to the non-treated check at both locations. The R4 foliar application also increased leaf Cl concentration 1,500 to 3,370 ppm when compared to preplant KCl at both locations.

Yield. Grain yield at Novelty and Portageville increased 3.5 to 5.8 bu/a with preplant KCl when compared with the non-treated control and foliar applied KCl (Table 7). Grain yield was ranked preplant KCl > foliar KCl > non-treated at Novelty and preplant KCl > foliar KCl = non-treated at Portageville. At Novelty, fungicide treatments applied at the R4 stage of development increased yields 3 to 5 bu/acre. However, there was no significant effect of fungicide treatments or application timing on soybean grain yield at Portageville.

Summary and Conclusions:

This research indicates that preplant KCl fertility reduced the incidence of Septoria brown spot and frogeye leaf spot at Novelty, and increased grain yield 3.5 to 5.1 bu/acre. Foliar applied KCl increased grain yield 1.6 bu/a at Novelty, and when KCl was foliar applied at the R4 stage of development leaf tissue Cl concentrations increased at both locations. An R4 application of fungicides increased grain yields 3 to 5 bu/acre when compared to a V4 application timing at Novelty. Since there was a light incidence of disease and multiple diseases present, the effects of these foliage diseases may be additive; however, the effects of KCl and fungicide treatments on these diseases and grain yield were also additive which may explain increased yields at the Novelty location.

Soybean grain yield increased 5.4 to 5.8 bu/a with a preplant application of KCl at Portageville. There were variable effects of fungicides on the incidence of disease and no yield response due to fungicides or foliar KCl at this location. This may be due to increased crop injury with foliar applied KCl which may provide infection locations for foliar diseases especially at the R4 application timing, or three fold greater Cl concentrations in soybean leaves when compared to Novelty. Crop injury and leaf Cl concentrations may interact with fungicide

treatments causing no additive yield benefit and variable effects on the incidence of foliage diseases.

References:

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Table 5. The effect of fungicide treatment on soybean leaf tissue N concentration at Portageville and Novelty in 2006.

Fungicide treatment	Portageville	Novelty	
		V4	R4
		----- % -----	
Non-treated	5.1	5	5
Quadris at 6.4 oz/a	4.5	5.2	5.1
Quadris at 6.4 oz/a + Warrior at 2.6 oz/a	5.1	4.7	5.5
Headline at 6 oz/a	4.4	5.2	5.1
LSD (p=0.1)	----0.3----	---0.5---	

Table 6. The effect of KCl fertilization on leaf tissue K and Cl concentrations at Portageville and Novelty in 2006.

KCl fertility	Leaf tissue K		Leaf tissue Cl			
	Portageville	Novelty	Portageville		Novelty	
			V4	R4	V4	R4
	----- % -----		----- ppm -----			
Non-treated	1.8	1.6	12,490	12,150	3,960	3,670
Preplant KCl	1.9	2.5	14,390	14,360	3,690	3,360
Foliar KCl	1.8	1.6	12,750	15,890	3,650	6,730
LSD (p=0.05)	--0.1--	--0.3--	-----810-----		----1,475----	

Table 7. Effect of KCl fertility and fungicide*application timing on yields at Novelty and Portageville in 2006 and 2007.

Treatment	Yield	
	Novelty	Portageville
	----- bu/acre -----	
KCl fertility		
Non-treated	57.3	45.4
Preplant at 455 lb K/a	62.4	51.2
Foliar at 16 lb K/a	58.9	45.8
LSD (p=0.01)	1.2	3.4
Fungicide*application timing		
V4		
Non-treated	58	47
Quadris at 6.4 oz/a	59	48
Quadris at 6.4 oz/a + Warrior at 2.6 oz/a	58	45
Headline at 6 oz/a	58	51
R4		
Non-treated	58	46
Quadris at 6.4 oz/a	61	47
Quadris at 6.4 oz/a + Warrior at 2.6 oz/a	63	48
Headline at 6 oz/a	62	49
LSD (p=0.01)	1.9	NS