Evaluation of Polyhalite as a Source of Potassium and Sulfur for a Corn-Soybean Rotation in Minnesota

UNIVERSITY OF MINNESOTA EXTENSION

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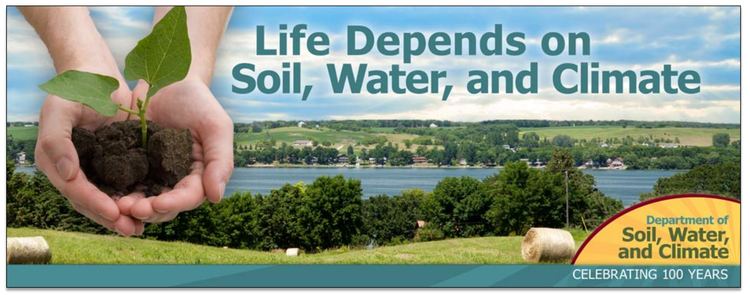

Background

Polyhalite [$K_2MgCa_2(SO_4)_4 \cdot 2H_2O$] contains four essential plant nutrients (140 g kg^{-1} K, 190 g kg^{-1} S, 60 g kg^{-1} Mg, and 120 g kg^{-1} Ca) and can be used for corn and soybean production to replace the need for separate application of KCl and S.

Objectives

Evaluate the use of polyhalite alone and in a blend with KCl to supply K or S for a corn-soybean rotation.

Methods

- A two-year corn soybean rotation was established at two locations in Minnesota (Table 1).
- Two factors were studied. Factor 1 consisted of K and S sources consisting of polyhalite alone, KCl alone, $CaSO_4$ + KCl, and a blend of polyhalite + KCl broadcast and incorporated before planting. Factor 2 consisted of K or S application rate which varied by source (Table 2).
- Corn ear leaf and soybean trifoliate samples were sampled when plants were at approximately the R2 growth stage.
- Corn grain yield was adjusted to 155 g kg^{-1} moisture. Soybean grain yield was to 130 g kg^{-1} moisture.
- All tissue samples were analyzed by ICP for K, S, Mg, and Ca.
- Statistical analysis was conducted using SAS.

Table 1. Soil test P, K, pH, soil organic matter (SOM), Ca, Mg, and SO_4-S from composite samples (10) cores taken before treatment application.

Site	P†	K	pH	SOM	Ca	Mg	SO_4-S
	--- mg kg^{-1} ---			g kg^{-1}	-----mg kg^{-1}-----		
St. Charles	9	71	6.9	27	1504	300	5
Staples	33	86	7.0	23	1411	122	5

† P, Bray-P1; K, ammonium acetate; pH, 1:1 soil to water; SOM, soil organic matter by dry combustion; Ca and Mg by ammonium acetate; SO_4-S, sulfate-S by mono-calcium phosphate.

Table 2. Fertilizer treatments and K and S applied for the two-year corn-soybean study in Minnesota. Fertilizers were not applied in 2016 before soybean planting.

		Rate / Code			
Source	K/ S rate	1	2	3	4
		---------- kg ha^{-1}----------			
Gypsum	K	112	112	112	112
	S	0	15	31	46
MOP	K	0	37	75	112
	S	0	0	0	0
Polyhalite	K	0	37	75	112
	S	0	60	122	183
Poly + MOP	K	0	37	75	112
	S	0	15	31	46

Results

Table 3. Summary of corn grain yield and concentration of K, and S in a composite sample consisting of ten corn ear leaves and twenty soybean trifoliate samples collected at R2 at Saint Charles. Data summarized by main effect of four fertilizer sources applied at four rates. Numbers followed by different lower case letters are significantly different at P≤0.10.

Sources of Variation	Corn, 2015 Ear Leaf K	Ear Leaf S	Ear Leaf Yield	Soybean, 2016 Trifoliate K	Trifoliate S	Trifoliate Yield
	g kg^{-1}	g kg^{-1}	Mg ha^{-1}	g kg^{-1}	g kg^{-1}	Mg ha^{-1}
	Main Effects					
Fert. Source						
Gypsum	15 a	14 b	12.5	18	2.6 a	3.79
MOP	14 b	12 c	12.2	17	2.4 b	3.71
Poly	14 b	15 a	12.7	16	2.6 a	3.79
Poly/MOP	14 b	14 b	12.6	17	2.5 ab	3.67
Fert. Rate						
1	13 c	13 c	12.0 b	15 b	2.5 b	3.54b
2	13 c	14 b	12.5 ab	17 ab	2.5 b	3.79a
3	15 b	15 a	12.9 a	18 a	2.5 b	3.74a
4	16 a	14 b	12.8 a	18 a	2.6 a	3.89a
Statistics	----------P>F----------					
Source	0.08	<0.01	0.33	0.28	<0.01	0.40
Rate	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Source x Rate	<0.01	0.37	0.26	0.30	<0.01	0.83

Table 4. Summary of concentration of K, and S in a composite sample consisting of ten corn ear leaves and twenty soybean trifoliate samples collected at R2 at Staples. Data summarized by main effects of four fertilizer sources applied at four rates. Numbers followed by different lower case letters are significantly different at P≤0.10.

Sources of Variation	Corn, 2015 Ear Leaf K	Ear Leaf S	Ear Leaf Yield	Soybean, 2016 Trifoliate K	Trifoliate S	Trifoliate Yield
	g kg^{-1}	g kg^{-1}	Mg ha^{-1}	g kg^{-1}	g kg^{-1}	Mg ha^{-1}
	Main Effects					
Fert. Source						
Gypsum	21 b	18 b	12.9 a	25	2.4	3.08
MOP	22 a	16 c	11.1 b	25	2.5	3.14
Poly	20 b	20 a	12.5 a	25	2.5	3.16
Poly/MOP	19 c	19 ab	12.8 a	25	2.5	3.07
Fert. Rate						
1	21 a	17 b	11.4 b	25	2.5	3.09
2	20 b	19 a	12.3 a	26	2.5	3.10
3	20 b	18 a	12.8 a	26	2.5	3.13
4	20 b	19 a	12.8 a	25	2.5	3.12
Statistics	----------P>F----------					
Source	<0.01	<0.01	<0.01	0.79	0.23	0.46
Rate	<0.01	<0.01	<0.01	0.60	0.86	0.94
Source x Rate	<0.01	<0.01	<0.01	0.81	0.40	0.60

Discussion

- At Saint Charles, fertilizer source and rate affected corn ear leaf K and S concentration and soybean trifoliate S concentration. Rate affected corn and soybean grain yield and soybean trifoliate K concentration (Table 3). Since rate significantly affected grain yield and not source, both K and S may have increased yield.
- At Staples, fertilizer source and rate affected corn ear leaf K and S concentration and corn grain yield but did not affect soybean (Table 4).
- A significant source x rate interaction at Saint Charles indicated that ear leaf K and trifoliate S were increased by increasing K or S rate, respectively (Figure 1).
- A significant source x rate interaction at Staples (Figure 1) indicated that fertilizer sources containing S increase ear leaf S and corn grain yield and decreased ear leaf K. MOP applied without S had no impact on yield indicating S was responsible for increasing corn grain yield.
- Corn and soybean grain yield decreased as K concentration in the ear leaf or soybean trifoliate increased. Corn grain yield decreased as ear leaf S increased while soybean yield increased when S concentration in the trifoliate tissue increased (Figure 2).

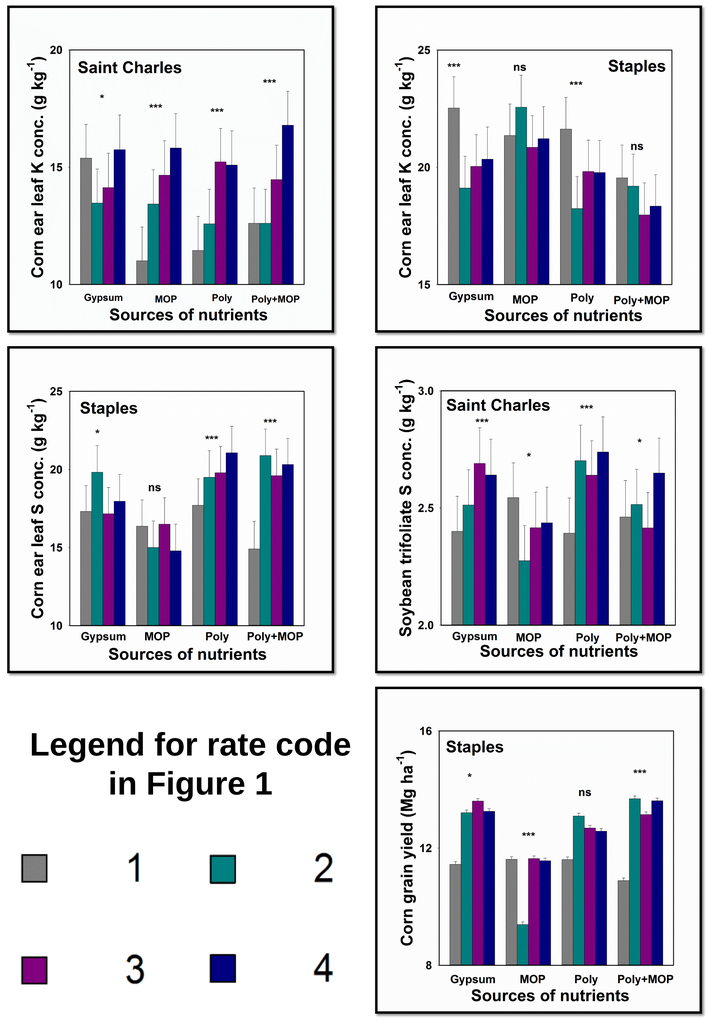

Figure 1. Summary of significant interaction effects at both locations.

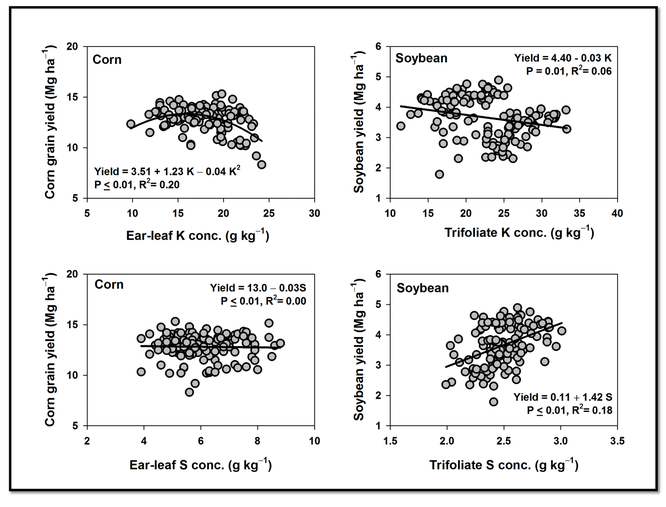

Figure 2. Relationships between grain yield and tissue K and S concentration at R2 growth stage.

Conclusion

Nutrients (K and S) in polyhalite are available for uptake for corn and soybean. Depending on product cost, polyhalite can be substituted for KCl or gypsum to supply K and S to crops. Application of polyhalite should be based on S rate due to both crops potential response to S and the greater concentration of S compared to K in polyhalite.