# Evaluation of Sulfur Fertilizers in Corn Production

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Extension and Outreach

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## Introduction

- Sulfur fertilization is an important nutrient management practice in Iowa corn production.
- Many S fertilizers are available for use in correcting S deficiencies.
- New products need evaluation as sources for plant available S, with polyhalite a new mineral S fertilizer source ($K_2SO_4$•$MgSO_4$•$2CaSO_4$•$2H_2O$).

## Objectives

- Evaluate multiple S fertilizers, including elemental and sulfate forms.
- Measure response in corn grain yield and plant tissue S concentration.

## Materials and Methods

- Field trials conducted in 2017-2018 at 12 sites in Central to Northcentral Iowa.
- Tillage was fall chisel plow in continuous corn, with spring field cultivation in both rotations.
- Four S treatments: no-S control, elemental S (0-0-0-90S), calcium sulfate (0-0-0-17S), ammonium sulfate (21-0-0-24S), polyhalite (Polysulfate, 0-0-13-19S).
- Urea and potash applied to equalize N and K application with treatments.
- Fertilizers broadcast applied in spring before tillage, except two sites after planting.
- Sulfur rates were 10 lb S/acre on fine-textured soils and 15 lb S/acre on coarse-textured soils.
- Randomized complete block with four replicates.
- Soil (0-6 inch depth) analyzed for extractable S with the monocalcium phosphate (MCP) and Mehlich-3 (M-3) extractants (ICP determination).
- Total S determined for small plants at the V6 corn development stage and ear leaves at R1.
- Corn grain yield reported at 15.5% moisture.
- Statistical treatment differences ($P \leq 0.10$, PROC GLIMMIX, SAS Institute) determined by site and across sites, and contrasts for control vs sulfate fertilizers, elemental S vs sulfate fertilizers, and Polysulfate vs other sulfate fertilizers.

Table 1. Research site characteristics for 2017-2018 and 0-6 inch depth routine soil and extractable soil sulfate tests for samples collected preplant.

| Site | Soil Series | Soil Texture | Previous Crop | pH | STP | STK | OM | MCP‡ | M-3‡ |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | - - - ppm - - - | | % | Sulfate-S - - - ppm - - - | |
| 2017 | | | | | | | | | |
| Bo17 | Clarion | l | soybean | 5.2 | 29 | 165 | 3.1 | 10.4 | 21.9 |
| Ka17 | Clarion | l | corn | 5.8 | 37 | 256 | 3.6 | 7.2 | 12.5 |
| Be17 | Kossuth | sicl | corn | 6.4 | 117 | 221 | 4.0 | 7.6 | 13.5 |
| Am17 | Coland | cl | corn | 7.3 | 90 | 296 | 4.5 | 7.1 | 13.8 |
| Ro17† | Dickinson | fsl | corn | 6.5 | 175 | 345 | 2.3 | 5.2 | 12.5 |
| Wa17† | Sparta | lfs | soybean | 5.8 | 57 | 114 | 1.2 | 4.4 | 12.5 |
| 2018 | | | | | | | | | |
| Bo18 | Clarion | l | corn | 6.1 | 11 | 122 | 2.9 | 3.8 | 9.6 |
| Ka18 | Nicollet | cl | corn | 5.4 | 35 | 176 | 5.1 | 3.4 | 8.8 |
| Be18 | Bode | cl | corn | 6.4 | 52 | 186 | 2.4 | 2.6 | 6.4 |
| Am18 | Coland | cl | corn | 7.7 | 24 | 180 | 4.6 | 3.8 | 9.6 |
| Ro18† | Dickinson | fsl | soybean | 6.7 | 79 | 214 | 2.6 | 2.5 | 6.7 |
| Wa18† | Bertram | fsl | soybean | 5.7 | 79 | 356 | 1.7 | 3.8 | 9.3 |

† Sites considered to be coarse texture for higher S application rate.
‡ MCP, monocalcium phosphate extraction; M-3, Mehlich-3 extraction.

Table 2. Corn grain yield at each site and mean across sites, 2017 and 2018.

| Fertilizer treatment | 2017 Sites Bo17 | Ka17 | Be17 | Am17 | Ro17 | Wa17 | 2018 Sites Bo18 | Ka18 | Be18 | Am18 | Ro18 | Wa18 | Across Sites |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | bu/acre | | | | | | | | | | | | |
| No-S (Con) | 191 | 226ab | 212b | 229 | 197 | 198 | 206 | 172c | 105c | 194 | 217 | 262 | 201c |
| Gypsum (Gyp) | 187 | 225b | 237a | 239 | 203 | 192 | 199 | 191ab | 213a | 198 | 219 | 266 | 214ab |
| Elemental (Elm) | 198 | 219c | 230ab | 221 | 185 | 191 | 195 | 167c | 157b | 197 | 234 | 255 | 204bc |
| Am Sulfate (Ams) | 195 | 224bc | 245a | 224 | 213 | 185 | 212 | 192ab | 215a | 199 | 231 | 264 | 216a |
| Polysulfate (Poly) | 189 | 232a | 238a | 227 | 196 | 199 | 212 | 193a | 206a | 191 | 226 | 256 | 214ab |
| | (*P*>*F*) | | | | | | | | | | | | |
| Treatment Statistics | 0.423 | 0.033 | 0.087 | 0.538 | 0.509 | 0.738 | 0.833 | 0.024 | <0.001 | 0.722 | 0.600 | 0.733 | 0.047 |
| Contrasts | | | | | | | | | | | | | |
| Con vs (Ams+Gyp+Poly) | 0.854 | 0.853 | 0.009 | 0.946 | 0.606 | 0.500 | 0.903 | 0.011 | <0.001 | 0.666 | 0.360 | 0.982 | 0.007 |
| Elm vs (Ams+Gyp+Poly) | 0.151 | 0.014 | 0.271 | 0.335 | 0.161 | 0.948 | 0.311 | 0.003 | 0.002 | 0.931 | 0.333 | 0.306 | 0.034 |
| Poly vs (Ams+Gyp) | 0.723 | 0.027 | 0.788 | 0.654 | 0.369 | 0.314 | 0.611 | 0.920 | 0.629 | 0.232 | 0.908 | 0.287 | 0.772 |

† Am Sulfate, ammonium sulfate.
Letters within a column indicate significant difference ($P$<0.10).

Table 3. Corn small plant (V6 stage) S concentration at each site and mean across sites, 2017 and 2018.

| Fertilizer treatment | 2017 Sites Bo17 | Ka17 | Be17 | Am17 | Ro17 | Wa17 | 2018 Sites Bo18 | Ka18 | Be18 | Am18 | Ro18 | Wa18 | Across Sites |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % S | | | | | | | | | | | | |
| No-S (Con) | 0.22 | 0.21b | 0.20cd | 0.20c | 0.17c | 0.18 | 0.23 | --- | 0.15bc | 0.18 | 0.15c | 0.16b | 0.19b |
| Gypsum (Gyp) | 0.23 | 0.24a | 0.21bc | 0.24a | 0.20b | 0.19 | 0.23 | --- | 0.16bc | 0.19 | 0.22ab | 0.23a | 0.21a |
| Elemental (Elm) | 0.23 | 0.21b | 0.19d | 0.21bc | 0.17c | 0.18 | 0.22 | --- | 0.14c | 0.18 | 0.16c | 0.15b | 0.19b |
| Am Sulfate (Ams) | 0.23 | 0.26a | 0.22ab | 0.23ab | 0.23a | 0.19 | 0.24 | --- | 0.19a | 0.20 | 0.24a | 0.23a | 0.22a |
| Polysulfate (Poly) | 0.23 | 0.25a | 0.22ab | 0.23ab | 0.21ab | 0.20 | 0.25 | --- | 0.16b | 0.20 | 0.21b | 0.21a | 0.22a |
| | (*P*>*F*) | | | | | | | | | | | | |
| Treatment Statistics | 0.751 | 0.018 | 0.008 | 0.037 | <0.001 | 0.111 | 0.257 | --- | 0.001 | 0.349 | <0.001 | <0.001 | <0.001 |
| Contrasts | | | | | | | | | | | | | |
| Con vs (Ams+Gyp+Poly) | 0.303 | 0.010 | 0.019 | 0.006 | <0.001 | 0.044 | 0.348 | --- | 0.031 | 0.059 | <0.001 | <0.001 | <0.001 |
| Elm vs (Ams+Gyp+Poly) | 0.895 | 0.005 | 0.002 | 0.047 | <0.001 | 0.044 | 0.098 | --- | 0.002 | 0.129 | <0.001 | <0.001 | <0.001 |
| Poly vs (Ams+Gyp) | 0.710 | 0.845 | 0.206 | 0.702 | 0.791 | 0.269 | 0.232 | --- | 0.169 | 0.839 | 0.055 | 0.088 | 0.628 |

† Am Sulfate, ammonium sulfate.
Letters within a column indicate significant difference ($P$<0.10).

Table 4. Corn ear leaf (R1 stage) S concentration at each site and mean across sites, 2017 and 2018.

| Fertilizer treatment | 2017 Sites Bo17 | Ka17 | Be17 | Am17 | Ro17 | Wa17 | 2018 Sites Bo18 | Ka18 | Be18 | Am18 | Ro18 | Wa18 | Across Sites |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % S | | | | | | | | | | | | |
| No-S (Con) | 0.17 | 0.14 | 0.14bc | 0.16 | 0.15b | 0.18 | 0.13 | 0.11c | 0.09c | 0.14 | 0.13b | 0.13b | 0.14c |
| Gypsum (Gyp) | 0.19 | 0.15 | 0.15ab | 0.17 | 0.17a | 0.18 | 0.14 | 0.12ab | 0.12b | 0.15 | 0.14b | 0.15a | 0.15b |
| Elemental (Elm) | 0.18 | 0.14 | 0.13c | 0.17 | 0.14b | 0.18 | 0.15 | 0.12ab | 0.12b | 0.14 | 0.14b | 0.13b | 0.14c |
| Am Sulfate (Ams) | 0.19 | 0.16 | 0.16a | 0.18 | 0.17a | 0.19 | 0.15 | 0.12ab | 0.14a | 0.15 | 0.17a | 0.15a | 0.16a |
| Polysulfate (Poly) | 0.18 | 0.16 | 0.16a | 0.16 | 0.17a | 0.18 | 0.15 | 0.14a | 0.13ab | 0.15 | 0.18a | 0.16a | 0.16a |
| | (*P*>*F*) | | | | | | | | | | | | |
| Treatment Statistics | 0.298 | 0.167 | 0.044 | 0.173 | 0.002 | 0.930 | 0.503 | 0.069 | 0.001 | 0.117 | 0.007 | 0.005 | <0.001 |
| Contrasts | | | | | | | | | | | | | |
| Con vs (Ams+Gyp+Poly) | 0.056 | 0.057 | 0.032 | 0.060 | 0.002 | 0.815 | 0.150 | 0.008 | <0.001 | 0.078 | 0.003 | 0.002 | <0.001 |
| Elm vs (Ams+Gyp+Poly) | 0.229 | 0.099 | 0.008 | 0.423 | <0.001 | 0.560 | 0.541 | 0.216 | 0.190 | 0.018 | 0.020 | 0.004 | <0.001 |
| Poly vs (Ams+Gyp) | 0.561 | 0.884 | 0.867 | 0.103 | 0.620 | 0.740 | 0.804 | 0.118 | 0.769 | 1.000 | 0.045 | 0.230 | 0.325 |

† Am Sulfate, ammonium sulfate.
Letters within a column indicate significant difference ($P$<0.10).

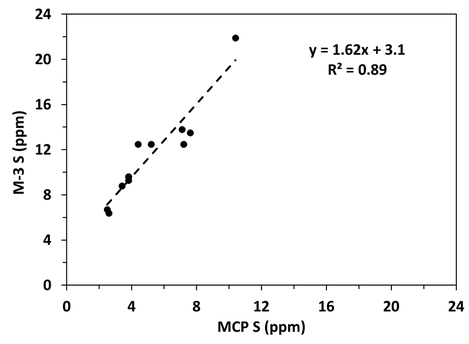
## Conclusions

- Of the S fertilizers evaluated, only the sulfate containing fertilizers consistently increased corn plant/leaf S concentration and grain yield.
- With the spring preplant application, elemental S was substantially less effective than the sulfate containing fertilizers.
- The Polysulfate fertilizer was equally effective as the other two sulfate containing fertilizers.
- Soil and plant tests did not differentiate between responsive and non-responsive sites.
- The M-3, while linearly related to the MCP concentrations, extracted a mean 2.2 times more S than the MCP.
- The results of this study highlight the need for new tests/tools for determining potential S deficiency in corn production.

## Results and Discussion

- Three of 12 sites had a grain yield increase from application sulfate-S fertilizers, with a quite large response at Be18 (an eroded side-slope).
- The yield increase with the sulfate-S fertilizer applications was significant across all sites, average 14 bu/acre.
- There was no yield response difference between the three sulfate fertilizers.
- Elemental S was considerably less effective, and inconsistent response, compared to the sulfate fertilizers.
- Sulfate-S fertilizers increased small plant (V6) S concentration at 9 sites, including sites with grain yield response. Six sites had small plant S concentration increase, but no yield response. At 8 sites, elemental S had lower plant S concentration than the sulfate fertilizers, and no site or across sites had higher concentration than the control with elemental S. The plant S concentration was the same with Polysulfate as the other sulfate fertilizers.
- Sulfate-S fertilizers increased leaf S concentration at 10 sites, including the sites with yield response. Seven sites had leaf S concentration increase, but no yield response. At 6 sites leaf S concentration was lower with elemental S than the sulfate fertilizers. The leaf S concentration was the same with Polysulfate as the other sulfate fertilizers.
- There was no differentiation of site grain yield S responsiveness with the soil or plant tissue tests.
- The M-3 was linearly related to the MCP, but extracted approximately 2.2 times more S than the MCP.

Figure 1. Comparison of site mean monocalcium phosphate (MCP) and Mehlich-3 (M-3) soil extractions.

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