Evaluation of Combination Phosphorus - Sulfur Fertilizer Products for Corn Production

John Sawyer and Daniel Barker
Professor and Assistant Scientist
Department of Agronomy
Iowa State University

Introduction

Previously conducted research (40+ years before 2005) in Iowa had indicated few crop responses to sulfur (S) fertilizer application across major soil areas (Sawyer and Barker, 2002; Sawyer et al., 2009). Recent research in northeast Iowa (2005 and later) documented S deficiency in alfalfa and yield increases to S application on specific areas within fields (lower organic matter, side-slope landscape position, silt loam and loam textured soils) (Lang et al., 2006). On similar soils (and coarse-textured soils) in central to northeast Iowa, research has documented corn growth response and yield increase to S application. That research indicates S containing fertilizer products are becoming more important for crop production. In conjunction with phosphorus (P) application needs when soils are deficient in available P or applications are made to replace harvested nutrients, co-application of S with a P fertilizer product would enhance efficiency and consistency of the nutrient applications by meeting both fertilization requirements.

The objective of this study was to evaluate combination P and S fertilizer products for corn production. The combination fertilizer sources varied somewhat, but was consistent in the product makeup. In 2006, the first year of this work, the product evaluated was the Simplot 13-33-0-15S fertilizer (SEF). No studies were conducted in 2007. In 2008 the Mosaic 13-33-0-15S (MicroEssentials MES15) product was evaluated, and in 2009-2010 the Mosaic 12-40-0-10S (MES10) and Mosaic 12-40-0-10S-1Zn (MESZ) products were evaluated. These products are comprised of monoammonium phosphate (MAP), with S as sulfate and elemental S in equal proportions. The MESZ product includes Zn as zinc oxide. Since these products were similar in nutrient makeup, a combined analysis was performed across site years. The sites were grouped for statistical analysis by fertilizer product, that is, if the product did or did not include Zn. For 2006-2010, there were a total of seven sites, with four sites having the Zn product.

Materials and Methods

Sites were located on producer fields, with site selection for potential response to P and S. There were two sites in 2006, one site in 2008, and two sites each in 2009 and 2010. Details regarding the sites, soils, soil tests, and tillage are contained in the individual year reports and are not repeated here. Soil test P ranged from Very Low to Very High (one site Very Low, one Low, three Optimum, and two Very High); and soil test Zn ranged from Low to Adequate (one site Low, two Marginal, and one Adequate) – using ISU soil test interpretations (0-6 inch depth) for Mehlich-3 P and DTPA Zn (Sawyer et al., 2008). Extractable soil sulfate-S in the 0-6 inch depth ranged from 4 to 8 ppm (two sites at 8 ppm, one site at 5 ppm, and 4 sites at 4 ppm) – concentrations are low, however, there are no ISU test interpretations for S. Soil organic matter ranged from 1.9 to 5.5% (five sites < 3% and two sites at 5.5%). Soil pH was less than 6.6 at all sites except one with a pH of 7.4.

The following P and S treatment combinations were used at all locations. Details of the specific fertilizer rates are given in the individual year reports. The product rates were set by the desired rate of S application, 10 and 30 lb S/acre. The P application rate was set by the highest rate of the combination product at 30 lb S/acre (66 lb P_2O_5/acre with SEF and MES15 evaluation, and 120 lb P_2O_5/acre with MES10 evaluation). For correct comparisons, rates of P were equalized when required by the specific treatment with triple superphosphate (TSP). The P rate was constant for all treatments except the S & P control where no S or P was applied. The N rate was constant across all treatments as needed for the rotation, and K was applied at 60 lb K_2O/acre as potassium chloride to all plots. Fertilizer treatments were broadcast applied in the spring, prior to tillage and/or planting depending on the tillage system.

- SP-CON: S & P control, zero P and zero S (equalize N).
- S-CON: S control, zero S (equalize N; add P at the highest P rate).
- MES/SEF-10: 10 lb S/acre from the MES/SEF product (equalize N; equalize P to highest P rate).
- AMS-10: 10 lb S/acre from ammonium sulfate (AMS) (equalize N; equalize P to highest P rate).
- MES/SEF-30: 30 lb S/acre from the MES/SEF product (equalize N; no additional P as this is the highest P rate).
- AMS-30: 30 lb S/acre from AMS (equalize N; equalize P to highest P rate).
- MAP-30: P rate used in the MES/SEF 30 lb S/acre rate applied from MAP (equalize N; apply AMS at highest S rate).
- MESZ-30: 30 lb S/acre and 3 lb Zn/acre from MESZ product (equalize N; no additional P as this is the highest P rate). This treatment only used at four sites in two years.

Ear leaf samples were collected at the VT (tassel) corn growth stage from all plots and analyzed for total S, P, and Zn concentration (four sites only for Zn). Grain yield was determined for each plot and reported at 15.5% moisture.

Results and Discussion

Phosphorus and sulfur product evaluation

The across-site (all seven sites) combined analysis for P and S response evaluation is given in Table 1. Ear leaf P concentration was increased with all P fertilizers. The SP-CON did not have any P applied (true control), and all other treatments (including the S-CON) had P fertilizer applied. The P rate within a site was the same for all treatments where P was applied. The increase in ear leaf P concentration indicates that all P fertilizers (SEF, MES, MAP, TSP) were equally effective in supplying plant available P. Ear leaf S concentration was increased with S application from all fertilizer products. This indicates all S fertilizers (SEF, MES, AMS) were equally effective in supplying plant available S. The form of S in the SEF and MES was half sulfate and half elemental. That mix did not appear to detract from supplying plant available S. The SP-CON and S-CON treatments did not have S applied, and therefore had the lowest S concentrations. The higher rate of S resulted in greater ear leaf S concentration, reflecting the higher application rate. The ear leaf S concentration was increased slightly with P application in the S-CON (compared to the SP-CON treatment). The P source used in that treatment was TSP. The S concentration in TSP is expected to be low; therefore, that ear leaf S increase could be due a small amount of S applied in the TSP or to enhanced uptake due to response from the applied P.

The corn grain yield was increased with all P fertilizer product applications. Along with the leaf P concentration increase, this yield response indicates an overall response to P application. The uniformity in yield response also indicates all P fertilizers were equally effective in supplying plant available P. The S-CON treatment did not have S applied, and the yield with that treatment was the same as treatments where P and S was applied. Therefore, the across-site yield response appears to be due to P and not S.

Zinc product evaluation

The MESZ product was evaluated at four sites. The across-site combined analysis for Zn response is given in Table 2. That evaluation also gives an indication of the P and S response at those four sites; with the P and S response for leaf nutrient concentration and grain yield across the four sites being the same as for all seven sites (Table 1). There was no change in ear leaf Zn concentration with any fertilizer application, including the MESZ product. This indicates either no response to applied Zn, or the form of Zn in the MESZ was not plant available. The grain yield was the same for all P product applications, that is, no yield response to applied Zn in the MESZ product. This indicates either adequate soil Zn supply or Zn not being plant available in the product. Considering the potential for corn response to Zn due to the soil pH level at these sites (all but one with pH < 6.6), the lack of yield response is not surprising. At the site with high pH (pH 7.4), soil test Zn was low but there was no response to applied Zn.

Summary

The combined P and S products (SEF and MES) were able to supply plant available P and S, and performed as well as individual P or S nutrient products (TSP, AMS). In fields needing both P and S application, the co-application of S with the P fertilizer products could meet both fertilization requirements. Since there was no response to applied Zn, it was not possible to completely evaluate the combination fertilizer containing Zn. The ear leaf Zn concentrations were at the critical concentration, therefore it is likely the soil supplied adequate Zn.

References

Lang, B., J. Sawyer, and S. Barnhart. 2006. Dealing with sulfur deficiency in NE Iowa alfalfa production. p. 213-222. In Proc. 18th Annual Integrated Crop Manag. Conf. 29-30 Nov. 2006. Iowa State Univ., Ames.

Sawyer, J.E., and D.W. Barker. 2002. Sulfur application to corn and soybean crops in Iowa. p. 13-24. In Proc. 14th Annual Integrated Crop Manag. Conf. 4-5 Dec. 2002. Iowa State Univ., Ames.

Sawyer, J.E., B. Lang, D.W. Barker, and G. Cummins. 2009. Dealing with sulfur deficiency in crop production: the Iowa experience. p. 64-73. In Proc. Thirty-Ninth North Central Extension-Industry Soil Fertility Conf., Des Moines, IA. 18-19 Nov. 2009. Vol. 25. International Plant Nutrition Inst., Brookings, SD.

Sawyer, J.E., A.P. Mallarino, R. Killorn, and S.K. Barnhart. 2008. A general guide for crop nutrient and limestone recommendations in Iowa. pm 1688. Iowa State Univ. Extension, Ames.

Table 1. Evaluation of combination P and S fertilizers.

Treatment	Ear Leaf P	Ear Leaf S	Grain Yield
	%	%	bu/acre
SP-CON	0.24b	0.14d	194b
S-CON	0.28a	0.15c	209a
MES/SEF-10	0.28a	0.17b	213a
AMS-10	0.28a	0.16b	211a
MES/SEF-30	0.28a	0.19a	208a
AMS-30	0.28a	0.18a	212a
MAP-30	0.28a	0.18a	212a

Mean response across all seven sites, 2006-2010.
See the materials and methods for a description of the specific treatments.
The number behind the treatment code indicates the S rate.
Letters indicate significant difference at p=0.05.

Table 2. Evaluation of combination P, S, and Zn fertilizers.

	Ear Leaf			
Treatment	P	S	Zn	Grain Yield
	%	%	ppm	bu/acre
SP-CON	0.24b	0.14c	15a	202b
S-CON	0.28a	0.15b	14a	224a
MES-10	0.28a	0.16b	13a	223a
AMS-10	0.28a	0.15b	14a	220a
MES-30	0.29a	0.17a	15a	222a
AMS-30	0.28a	0.17a	14a	228a
MAP-30	0.28a	0.17a	13a	224a
MESZ-30	0.28a	0.17a	14a	232a

Mean response across four sites where the Zn treatment was included, 2009-2010.
See the materials and methods for a description of the specific treatments.
The number behind the treatment code indicates the S rate.
Letters indicate significant difference at p=0.05.