Purdue University Department of Agronomy
Soil Fertility Update

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Yield Response of Corn to Sulfur Fertilizer Research Update

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Summary

We conducted 20 field scale trials at 9 locations over the past 3 years to examine corn yield response to sulfur (S) applied as ammonium thiosulfate (ATS) in starter and/or sidedress nitrogen fertilizers. Grain yield increased with sidedress S in 9 of 20 trials. At responsive sites, yield increases ranged from 4 to 24 bu/acre and averaged 14 bu/acre. Sulfur applied in starter fertilizer at 5 lb S/acre had little impact on grain yield.

Sulfur deficiency

Sulfur (S) deficiency has become more common in Indiana crops because S emissions from coal-fired power plants have decreased over the past few decades (Camberato and Casteel, 2017). Consequently, atmospheric S deposition to soils has also decreased.

Figure 1. Sulfur deficiency symptoms in corn. Image © RLNielsen, Purdue Univ.

Sulfur deficient corn plants exhibit a general yellow-green color from top to bottom of the plant, often also with visible leaf striping (Fig. 1). Other nutrient deficiencies can cause striping and can sometimes be confused with S deficiency (Camberato, 2013). Other nutrient deficiencies can also cause yellow-green coloration symptoms, but the position on the plant usually varies. Nitrogen deficiency, for example, will usually have green leaves emerging from

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the whorl, while the lower leaves turn yellow from the tip through the mid-rib, then turn brown, and quickly wither away. Tissue S levels less than 0.15 – 0.18% and N:S ratios greater than 15:1 – 20:1 are reasonably good indicators of S deficiency in corn.

Response of corn to starter S fertilizer

Yield response of corn to S added to starter was investigated in 10 field scale trials in 2017 and 2018. Due to the limited planting windows available in 2019, no starter S treatments were examined in 2019. Ammonium thiosulfate (ATS) was mixed with urea ammonium nitrate (UAN-32% or 28%) and ammonium polyphosphate (10-34-0) and applied in 2x2 fertilizer placement. An application rate of ATS at 1.7 gal/acre provided about 5 lb S/acre.

Sulfur in the starter fertilizer increased yield in only 1 of 10 trials by about 4 bu/acre. At this location, there was no additional benefit from sidedress applications of S.

Response of corn to sidedress sulfur fertilizer

Yield increases from sidedress S application occurred in 9 of 20 trials, ranging from 4 to 24 bu/acre (Fig. 2). We observed spatial variability for yield response to applied S in several trials. For example, in one trial the yield response to S varied from only 5 bu/acre in some areas of the field to as high as 41 bu/acre in other areas of the field. In another trial, yield response to S in higher yielding areas (206 bu/acre) of the field averaged 11 bu/acre, while in lower yielding areas of the field (179 bu/acre) the yield response to S averaged 17 bu/acre.

Sidedress S treatments consisted of ATS mixed with UAN and applied in the row middle at V5 – V7 in all but one trial. A split application timing (V5 and V12) was used in one trial. Sulfur rates varied by trial, ranging from as little as 7.5 to as much as 30 lb S/acre. In each trial, the maximum grain yield response occurred with the lowest S rate used. The results suggest that a sidedress rate of 10 lb S/acre may be sufficient where S

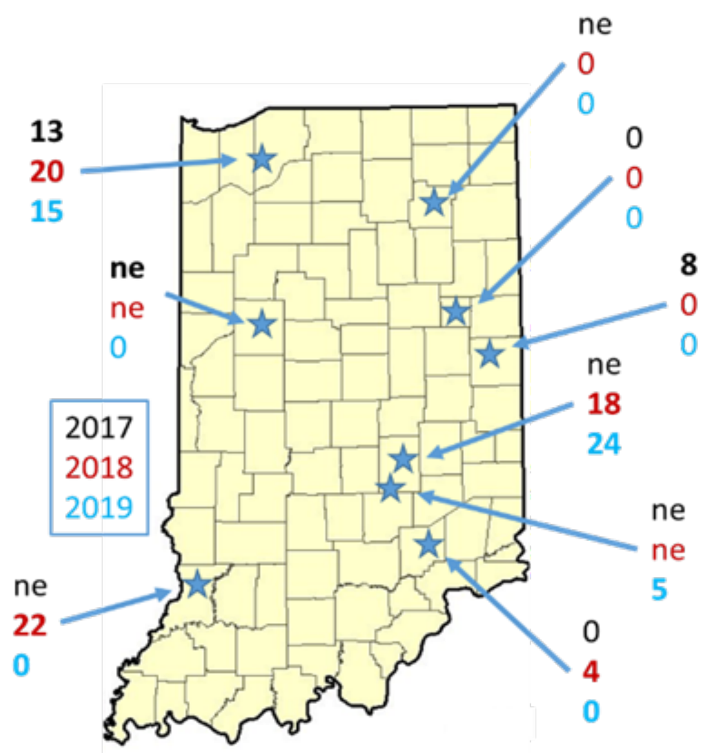

Figure 2. Significant (P ≤ 0.10) grain yield increases (bu/ac) with sidedress sulfur fertilizer application at 9 locations over 3 years. “No experiment” at a location for a given year is indicated by "ne" and “non-significant” yield response is indicated by "0".

availability from the soil is inadequate. Higher S rates in our trials were neither beneficial nor detrimental. Splitting the application between V5 and V12 in one trial was not beneficial versus applying all the S in one application at V5.

It is difficult to identify fields needing sulfur fertilization

Based on the studies conducted to date we have seen substantial yield increases to sidedress S at some locations, but not at all locations. There was little justification for low rates of S in 2x2 starter fertilizer at any location, but this was only based on 10 trials over 2 growing seasons. The locations where sidedress S increased yield differed substantially for soil texture and organic matter (OM) levels, ranging from a loam with 1 – 2% OM to a silty clay loam with 2 – 3% OM. Typically, we would more often expect sandy low organic matter soils to be potentially S deficient, but not clayey high organic matter soils. Soil testing for S is also not a good indicator of S deficiency for several reasons; (1) sulfate sulfur (SO_4-S) found in soil sampled in the fall leach from the root zone by spring, (2) SO_4-S that accumulates in some subsoils is overlooked with the usual 8-inch sampling depth, and (3) organic-S that may become plant available during the growing season is not measured by commonly used soil testing procedures. Therefore, it is hard to predict where S deficiency will occur based on soil properties and soil analysis.

Another factor confounding our ability to predict S deficiency is a recent discovery that phosphorus fertilizers, mono-ammonium phosphate (MAP), di-ammonium phosphate, and triple superphosphate (TSP) contain SO_4-S. Analysis of fertilizers collected in the fall of 2019 by the Office of the Indiana State Chemist revealed SO_4-S concentrations of 1.3 – 2.4% (MAP-65 samples), 1.4 – 3.3% (DAP-46 samples), and 1.4 – 1.9% (TSP-7 samples). Routine applications of these fertilizers to supply 75 pounds of P_2O_5 per acre (common crop removal rates) would therefore supply 2 to 5 pounds of SO_4-S. This seems like a small amount of S, but combined with 4 – 5 lb S/acre from mineralization of soil OM and 4 – 5 lb S/acre deposited from the atmosphere each year, the total S available to crops may be enough to prevent or minimize S deficiency. However, whether SO_4-S from fall or winter applications of P fertilizers remains in the root zone in the spring is difficult to predict.

Approaches to sulfur fertilization

Given that soil testing is not an effective tool for predicting S deficient soils, alternative approaches to determine if S fertilization is needed include (1) tissue testing to identify deficient fields or (2) scouting for S deficiency symptoms prior to sidedress N applications. Otherwise, we cannot tell with much certainty the likelihood of S deficiency in any particular situation.

Applying small amounts of S (e.g., 5 lbs S/acre) in starter fertilizer, though inexpensive, is probably not a wise investment of fertilizer dollars because the yield responses to starter S in our trials were infrequent and small. The absence of starter S benefits occurred even in fields which had large responses to late-applied sidedress S and may be a result of the small amount of added S and/or the starter timing of application.

Despite S deficiency symptoms occurring in some fields prior to sidedressing when no starter S was applied, we found that sidedress S alone always produced the same yield as starter S plus sidedress S. Thus, our research suggests that sidedress applications of S are adequate to maximize yield response to S. Full yield responses were obtained with sidedress rates of 7.5 to 15 pounds of S per acre with no benefit to higher rates.

Although all our studies used ATS mixed with liquid N fertilizers, similar results should be found with granular sulfate fertilizers, such as ammonium sulfate (21-0-0-24S), calcium sulfate (gypsum, about 20% S), K-mag (0-0-22-23S-11Mg), and potassium sulfate (0-0-50-18S). Most likely applications around the time of planting up to sidedress time should be similarly effective. Since sulfate is highly mobile in the soil, some sulfate may be lost from the root zone if applied well before planting.

Related References

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