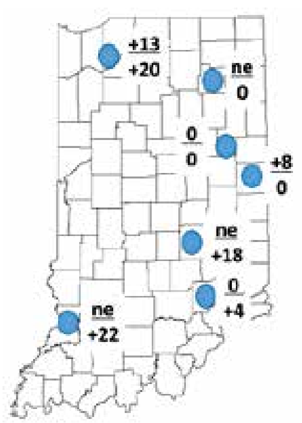
NEED FOR APPLIED SULFUR IN CORN IS INCREASING IN INDIANA AND ELSEWHERE

A two-year Purdue study illustrates the growing need for applied sulfur (S) in many fields across Indiana, says extension soil fertility specialist Jim Camberato of Purdue University, one of the investigators in the large-plot research. Camberato and Purdue agronomy professor Bob Nielsen studied corn yield response to S applications in 11 plots in seven locations around the state in 2017 and 2018.

Shelby county sulfur (S) response trial in 2018. 16-row strips of light green corn can be seen where no S was applied to the corn crop. Where S was applied, the corn has a darker green color.

The Purdue scientists referenced above observed an average yield increase of 14 bushels per acre in six of the 11 plots following sidedress applications of S, says Camberato. The yield benefit from S ranged from four to 22 bushels per acre at responsive sites, as shown in Figure 1.

Figure 1: Yield Benefit



Yield benefit to sidedress S in Indiana in 2017 (above line) and 2018 (below line); "ne" indicates no trial that year.

Source: Camberato and Nielsen (2018), Sulfur Fertilizer Response of Corn — background and research update.

Camberato notes that the study was prompted by a growing number of observations of S deficiency in corn around the state. In a 2005-2007 survey, fewer than five percent of Indiana soil samples tested less than eight parts per million (ppm) sulfate-S. By 2016, approximately 70 percent of the state's soil samples tested below that threshold.

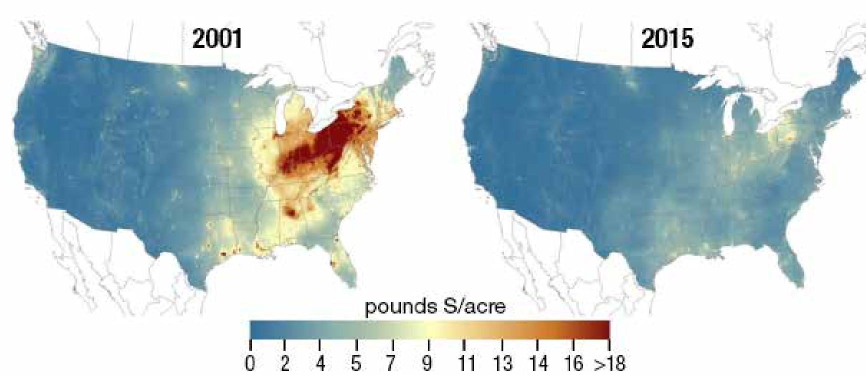
"A combination of factors led Dr. Bob Nielsen and me to explore corn response to fertilizer S," Camberato explains. "We saw more symptoms of S deficiency in corn from farmers' fields that were confirmed by plant sampling. Atmospheric data from the EPA showed continued lessening of S deposition, and soil summaries by A&L Great Lakes Laboratories showed a higher percentage of soil samples testing low in S."

Less Airborne Deposition

The impact of the Clean Air Act on airborne deposition of S has been profound. In a 2017 paper, Camberato and Purdue soybean extension specialist Dr. Shaun Casteel reported that as recently as 2001, soils in most of Indiana received more than 13 pounds of S per acre annually from smokestack emissions, and deposition in many areas of southern Indiana totaled as much as 18 pounds of S per acre each year. By 2015, the annual average was less than 10 pounds per acre across the state, a trend shown in Figure 2.

Similar effects have been recorded in Pennsylvania. At the American Society of Agronomy meetings in Baltimore in November 2018, a team from Penn State University and Ag Analytical Services Lab

Figure 2: Total Deposition of Sulfur



Deposition of airborne S dropped dramatically between 2000 and 2015 due to regulations limiting air pollution, reducing the amount of "free" sulfur provided by the atmosphere.

Source: CASTNET/CMAQ/NTN/AMON/SEARCH, USEPA 09/14/16

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reported that a three-year survey of corn S status revealed that 75 percent of the corn ear leaf tissue samples were below the optimum range for S in Pennsylvania — a state where a 2001 survey found **no** evidence of S deficiency.

Like Camberato, the Pennsylvania team was concerned that clean air regulations had limited airborne deposition of sulfur to such levels that applied S might be required in many fields. Crop trials conducted in Pennsylvania from 2015 through 2017 demonstrated significant yield responses to applied S in corn — averaging 14 percent — at about 20 percent of the sites.

Other Factors

Other factors contribute to growing S deficiency, notes Camberato, namely:

- **Steadily increasing crop yields remove more S than ever from soil reserves.** Ten bushels of corn contain approximately 0.5 pounds of S, so a 200-bushel crop removes about 10 pounds of S per acre.
- **High-organic-matter soils can be S-deficient in the spring.** While soil organic matter can contribute S to crops after the sulfur it contains is mineralized by microorganisms (typically about three pounds of S per acre per percentage point of organic matter), those microorganisms do not function optimally in cold or wet soils.
- **Reduced tillage contributes to reduced S availability.** Wet spring weather and cool, wet conditions in reduced-tillage fields exacerbate the slowdown in conversion of S from soil organic matter (or applied elemental forms of S). Camberato notes that reduced tillage is not uncommon in Indiana, decreasing springtime soil temperatures and challenging soil biota to break down high levels of crop residue. This increases the chance of S immobilization by those same microbes.

In summary, decreased S deposition, increased sulfur removal at harvest and delayed springtime mineralization put the burden of building S levels in the soil on farmers, now more than ever.

Soil Tests vs. Tissue Tests

Camberato points out that although soil tests can shed light on trends in S levels, they are not a reliable predictor of whether a crop will respond to applications of S. He notes that soil tests can **overestimate** available S levels by measuring them too early, before winter or spring rains leach the sulfate deep into the soil. At the same time, soil test results can **underestimate** S reserves by not measuring root-available sulfate-S below the six- to eight-inch sampling depth. Conventional soil tests also do not account for organic S that can be mineralized and made available to the crop.

Instead of relying on soil tests, Camberato recommends conducting strip trials with 15 pounds of applied sulfate-S to evaluate the need for S applications. He advises farmers to keep a close eye on their fields and watch for the yellowing or striping that can be a telltale sign of S deficiency, and take tissue samples for a more accurate prediction of S needs.

Tissue tests also highlight another important aspect of S management: maintaining a proper ratio between S and nitrogen (N). Corn tissue S levels lower than 0.15 percent and an N:S ratio greater than 20:1 are indications of a likely S deficiency, while corn tissue S levels greater than 0.20 percent and an N:S ratio less than 12:1 probably indicate adequate S supplies, Camberato notes.

"N and S are primary components of protein so the N:S ratio tends to be fairly constant in healthy plants," he explains, adding that a deficiency of S can limit the plant's utilization of N.

Applied S

Camberato points out that S deficiency and crop response to sulfur can vary widely within a single field. "In one case," he says, "yield increase in areas of the field showing the most visual symptoms of S deficiency was 44 bushels per acre with added S, while the yield increases in other areas with the least yellowing was five bushels per acre. Reducing S deficiency is definitely something we need to keep working on."

See these Purdue University *Soil Fertility Update* articles for more details:

- Sulfur Fertilizer Response of Corn – Background and Research Update
- Sulfur Deficiency

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