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Sulfur uptake from a co-granulated phosphate fertilizer differed across three climate zones

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A lab-produced phosphate fertilizer fortified with two forms of sulfur (S) and labeled with ^{34}S was created by the University of Adelaide to simulate MicroEssentials fertilizer and to obtain a better understand of S recovery and uptake. Micro-plot trials were carried out at three sites, including Indian Head, Saskatchewan, and in Argentina and Brazil.

Common sulfur (S) fertilizers are ammonium sulfate (AS) and elemental S (ES). Sulfate (SO_4-S) is readily available to plants, but is also susceptible to leaching. Elemental sulfur, on the other hand, is immobile in the soil, and must be oxidized to become plant-available. This oxidation is dependent on total ES concentration in the fertilizer granule, ES particle size, and availability of moisture, and proceeds faster in warmer soils with higher soil pH and organic matter content.

In this study, stable isotopic tracers (^{34}S) were used to compare crop uptake of SO_4-S and ES at three sites with dramatically different climates and soils in Canada, Argentina, and Brazil. The object was to determine the direct contribution and residual value of SO_4-S and ES to crop uptake under different climatic conditions. The use of isotopic tracers does not rely on a yield response, but allows direct measurement of the amount of fertilizer taken up by the plant. Given the complexities and costs of isotope studies, micro-plots (0.61 m^2 in this study) are better suited for isotope tracer work, compared to small-plot trials that are better suited for yield measurements and treatment comparisons.

The three sites were Indian Head, Saskatchewan (Humid continental; 16 inches of annual rainfall); Lujan, Buenos Aires, Argentina (Humid subtropical; 40 inches annual rainfall); and Itiquira, Mato Grosso, Brazil (Tropical; 60 inches of annual rainfall).

Labeled fertilizer granules were produced in the lab from powdered MAP, AS and ES in ratios to obtain the same nutrient composition as MicroEssentials (MES) fertilizer from The Mosaic Company. The concentration of SO_4-S and ES forms varied by country. The sulfur forms in MES were labeled with a stable isotope ^{34}S. In each field trial, two types of labeled treatments were compared. In one treatment, SO_4-S was enriched with ^{34}S, while the other treatment had ^{34}S labeled ES. These treatments were replicated 4 times. Control plots of unlabeled MES fertilizer and MAP fertilizer were included on each side of the labeled plots.

Fertilizer was broadcast applied at the start of the growing season. The S rate applied was 20 kg/ha (17.8 lbs/ac) in Argentina, 28 kg/ha (25 lbs/ac) in Brazil, and 32 kg/ha (28.5 lbs/ac) in Canada.

Plants were collected at an early stage and at maturity to determine the amount of SO_4-S and ES uptake. Sulfur uptake from the labeled S was also calculated in the second year after application to assess residual S from fertilizer.

Soil test results showed 4.2 ppm SO_4-S at Argentina, 5.8 ppm at Brazil, and 4.0 ppm at Indian Head.

The crops grown in Canada were canola followed by wheat; in Argentina corn followed by soybean; and in Brazil, two rotations of soybean-corn were grown each year.

ES oxidation slower in cooler, drier areas; and higher in warmer wetter climates
In Canada, the climatic zone is cooler and drier than the other two study sites, which slows ES oxidation. At Indian Head, the percentage of added S recovered in the aboveground portion of the canola plant at maturity was much higher for SO_4-S (59.1%) than for ES (5.8%). In the second year wheat crop at maturity, fertilizer recovery was 6.5% for SO_4-S and 13.4% for ES. The cumulative recovery of S fertilizer over 2 years was greater than 65% for SO_4-S and 19% for ES.

By comparison, at the warmer and wetter Brazilian site, the ES recovery in the crop at maturity was similar or greater than that of SO_4-S. In the first year, 4.3% (SO_4-S) and 4.2% (ES) of the fertilizer S was recovered in the soybean crop, while the safrinha corn crop had 2.5% (SO_4-S) and 4.0% (ES) recovery. In the second year, the first crop soybeans had a recovery of 1.2% (SO_4-S) and 3.5% (ES), while the same year corn crop had a 1.3% (SO_4-S) and 4.2% (ES) fertilizer S recovery. Over the 2 years, the cumulative recovery of fertilizer-applied S in the harvested biomass was 16% for ES compared to 9% for SO_4-S. The greater recovery of ES relative to SO_4-S was attributed to faster oxidation of ES and leaching of SO_4-S.

Overall, the researchers concluded that in warm, humid climates with high rainfall, higher inclusions of ES within the fertilizer source would help reduce leaching of SO_4-S. In colder, drier climates, including a higher proportion of SO_4-S in the fertilizer source would provide better first-year plant-available S. In these cooler drier climates, multiple years of co-granulated phosphate containing two forms of sulfur may be needed to provide an adequate equilibrium of plant available sulfate-sulfur to match crop uptake and removal.

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