SO_2 Pollution May Be Good for Plants

As man has reduced the amount of sulfur applied as fertilizer, sulfur-starved plants have adapted by extracting it from the air

Agricultural crops throughout the United States have become dependent on air pollution, according to J C Noggle of the Tennessee Valley Authority (TVA). Without their daily dose of sulfur compounds from the atmosphere, he says, many common agricultural species would be markedly less productive. And if sulfur emission from coal-burning power plants and other facilities are curbed by new pollution abatement procedures, he contends, the plants' withdrawal symptoms could reduce the total value of crops in the Tennessee Valley by more than $300 million per year unless steps are taken to incorporate sulfur compounds into fertilizers.

Atmospheric sulfur dioxide is, of course, toxic to plants above certain concentrations. Experiments at TVA and other laboratories have shown that exposure to as little as 0.5 part per million for 3 hours can cause visible injury to the foliage of sensitive vegetation. The importance of such damage is still a matter of some dispute, but it is clear that exposure to higher concentrations for longer periods of time can stunt plant growth. The toxicity is believed to be due to the accumulation of either sulfur trioxide or sulfates within plant tissues. Acid rain, produced when relatively high concentrations of sulfur dioxide and sulfates are washed out of the atmosphere by rain, damages forests, crops, and even fish. But at concentrations below those at which toxicity develops, sulfur in the air can apparently be beneficial to plants. The importance of this pollutant to plants has arisen from a combination of technological changes in farming and the adaptability of plants.

Sulfur, says Noggle, a plant nutritionist, is the fourth most important plant nutrient, ranking behind only nitrogen, phosphorus, and potassium. It has a major role in the synthesis of both proteins and chlorophyll. Historically, plants received more than adequate amounts of sulfur from the degradation of manure and other organic matter in the soil. Later, farmers shifted to fertilization with ammonium sulfate, potassium sulfate, and superphosphates, all of which supplied sufficient quantities of sulfur. Since the 1950's, though, the trend has been toward fertilizers with high nitrogen, phosphorus, and potassium contents, but little or no sulfur. While farmers have been reducing the amount of sulfur applied to their fields, however, power plants have been burning increased amounts of sulfur-containing fuels. Many types of plants have apparently compensated for the decreased quantity of sulfur in the soil by increasing their intake of sulfur dioxide and hydrogen sulfide from the air.

In the early 1950's, Maurice Fried, now with the International Atomic Energy Agency, used isotopically labeled sulfur dioxide to show that plants can absorb the gas directly from the atmosphere and incorporate it into organic compounds in the plant tissues. Several other investigators have subsequently demonstrated that plants exposed to small concentrations of sulfur dioxide incorporate more sulfur than those not so exposed. But no one had measured the amount of atmospheric sulfur accumulated by plants under field conditions, Noggle says, or determined the importance of the absorption to the growth of plants.

> Coal-burning plants in Tennessee Valley emit enough sulfur to nourish crops in the region.

Noggle performed two main types of experiments. In one, he used an elaborate filtration apparatus to remove all the sulfur from the air in a greenhouse. In the second, he used radioactive sulfur-35 as a tracer to monitor the uptake of sulfur compounds in soybeans, cotton, and fescue. In this way, he was able to separate the amount of sulfur taken up by the plants from the soil from that absorbed from the atmosphere. His primary conclusion was that plants absorb increasing amounts of sulfur from the air as the amount of sulfur in the soil decreases. Plants grown at locations distant from urban and industrial pollution, furthermore, produced less biomass and accumulated less sulfur than plants grown in identical low-sulfur soil close to a coal-burning power plant. His results showed that as much as 40 percent of the plants' accumulated sulfur was derived from sulfur dioxide absorbed directly from the air. Sulfur compounds that are washed from the air by rain or that settle out as particulates are an additional source.

The amounts of sulfur involved can be quite large. Cabbage, turnips, alfalfa, and cotton can require as much as 45 pounds of sulfur per acre (40 kilograms per hectare) per year, while corn and wheat can require as little as 11 pounds per acre (10 kilograms per hectare). Forests require even less. Calculations show, Noggle says, that coal-burning plants in the Tennessee Valley are emitting an amount of sulfur that is roughly equivalent to the amount required by crops in the region. If the output of sulfur is reduced by installation of emission controls, he argues, sulfur supply in the soils will be a limiting factor in crop growth. Cotton will be the first to be affected, but even those crops with relatively low sulfur requirements will eventually feel the pinch. After a period of several years, during which output would decrease slowly unless additional sulfur is added to the soil, crop production could decrease by a minimum of 10 percent, which amounts to about $306.8 million per year in the seven Tennessee Valley states. Application of sufficient amounts of sulfur to maintain present crop yields could increase fertilizer bills in the region by $6.7 million per year, he calculates.

Noggle makes it clear that he does not intend that his research be used as part of the argument against cleaning up emissions from TVA's own plants and from others in the area. He does think it important, though, that the cost of supplying additional fertilizer be considered in estimating the costs of the cleanup. It is also crucial, he says, that farmers in the region be alerted to the need for sulfur fertilizers before crop production falls off significantly and earnings drop. If crops in the region do not get their fix, he says, farmers could find themselves in one.—THOMAS H. MAUGH II

0036-8075/79/0727-0383$00.50/0