Nitrogen & The Thiosulfate Factor

How growers can gain agronomic, economic, and environmental benefits by using thiosulfate-based fertlizer.

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Farmers know that adding nitrogen to croplands is critical to sustain soil fertility and crop production.

They also know they must implement nutrient management plans based on reputable scientific information to achieve the most effective use of nutrients applied. After all, it is only through sound science that growers can reap agronomic, economic, and environmental benefits from their operations.

"Farmers know they must be good stewards of the land because their livelihoods depend on it," says Zack Ogles, Ph.D., Manager of Agronomy at Crop Vitality, which offers a range of Tessenderlo Kerley's liquid, soluble, and solid fertilizers.

Sound science is helping farmers solve tremendous challenges, including those with nitrogen fertilizer. While nitrogen fertilizer has enabled modern agriculture to produce sufficient food for a growing population, it can pose problems when lost to the environment through leaching, volatilization, or denitrification. These losses not only contribute to environmental damage, but they also often result in lower crop yield and quality at the grower level. With these factors in mind, the need to protect and enhance the availability of applied nitrogen is clear.

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By and large, plants take up two forms of nitrogen: ammonium and nitrate. By maintaining a higher percentage of the available nitrogen in the more stable ammonium form, growers can reduce the risk of nitrogen loss through both leaching and denitrification, Ogles says. Because when ammonium is converted into nitrate – a process called nitrification – it can leach out of the soil profile and possibly into groundwater.

Crop Vitality's Research Farm revealed in a recent study with Auburn University that Tessenderlo Kerley's thiosulfates are highly effective nitrification inhibitors. The study, conducted between 2017-2022, reinforces the agronomic, economic, and environmental benefits of thiosulfates.

Crop Vitality, which has offered Tessenderlo Kerley products that combine essential nutrients to improve soil health, increase water filtration, and maximize nutrient uptake for more than 100 years, is recognized as the leading brand of thiosulfate-based fertilizers.

"When farmers make nitrogen applications, there's a percentage of that nitrogen that will ultimately be lost through nitrate leaching and denitrification," Ogles says. "Ammonium thiosulfates, such as Crop Vitality's Thio-Sul®, have been historically shown to slow down the nitrification process and are listed as such with the Association of American Plant Food Control Officials (AAPFCO). When they are blended with a nitrogen source like UAN 32% and applied in a concentrated fashion, such as a banded fertilizer application, the concentrations are sufficiently high to have a strong impact on the nitrification process. And by stopping or slowing down the first steps of nitrification, you can maintain more of the nitrogen in the stable ammonium form as well as reduce several pathways in which nitrous oxide (N_2O), a potent greenhouse gas, can be generated through the process."

In collaboration with Auburn university from 2017-2020, Crop Vitality conducted a study revealing that thiosulfates are highly effective nitrification inhibitors, further reinforcing the environmental, agronomic, and economic benefits of thiosulfates.

ENVIRONMENTAL IMPACT

Nitrate leaching can be a major issue for both farmers and the environment. Nitrates that are moved beyond the reach of plant roots represent a monetary loss for the farmer and a potential ground water contaminant. Thiosulfate fertilizers work with the soil to slow the formation of nitrate and allow more of the applied nitrogen to be used to grow and nurture crops. This can result in less environmental impact and improved crop quality.

The fraction of nitrogen lost through nitrous oxide emissions is minor when considering pounds per acre, but that loss can't be underestimated when considering its environmental consequences, Ogles explains. While total N_2O emissions are much lower than carbon dioxide (CO_2) emissions, N_2O is nearly 300 times more powerful than CO_2 at trapping heat in the atmosphere over a 100-year time frame, according to the Intergovernmental Panel on Climate Change (IPCC). Since 1750, the IPCC and the National Oceanic and Atmospheric Administration (NOAA) estimate that the global atmospheric concentration of N_2O has risen by about 23%.

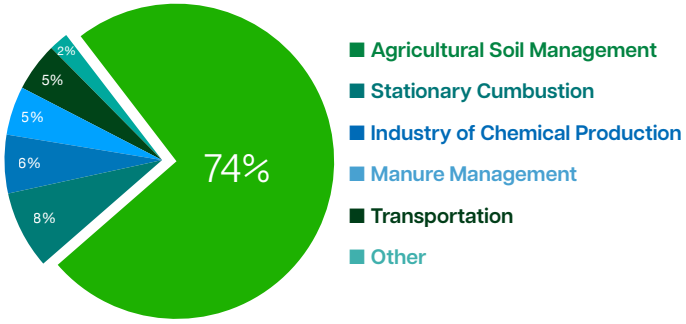
Agricultural soils accounted for 75.4% of N_2O emissions and 5.3% of total greenhouse gas emissions in the United States in 2019. Annual N_2O emissions from agricultural soils fluctuated between 1990 and 2019, although overall emissions were 9.1% higher in 2019 than in 1990. Year-to-year fluctuations are largely a reflection of annual variation in weather patterns, synthetic fertilizer use, and crop production.

Nitrification inhibitors have been shown to reduce N_2O emission when applied with ammonium and urea fertilizers. Through inhibiting nitrification, thiosulfates may provide an additional way to cut out potential pathways of N_2O production in the soil. "Preliminary studies have yielded promising results that support the use of thiosulfates for this purpose," said Ogles. Thiosulfate fertilizers provide a sound method of protecting nitrogen and the environment while providing a unique form of sulfur nutrition.

Crop Vitality's study with Auburn showed that thiosulfates effectively maintain nitrogen in the stable ammonium cation form longer, which improves nitrogen-use efficiency.

N_2O Emissions

Agricultural soils accounted for 75.4% of N_2O emissions and 5.3% of total greenhouse gas emissions in in 2019, according to the Environmental Protection Agency. But thiosulfates cut out the potential pathways of N_2O production in the soil such as ammonia oxidation denitrification.



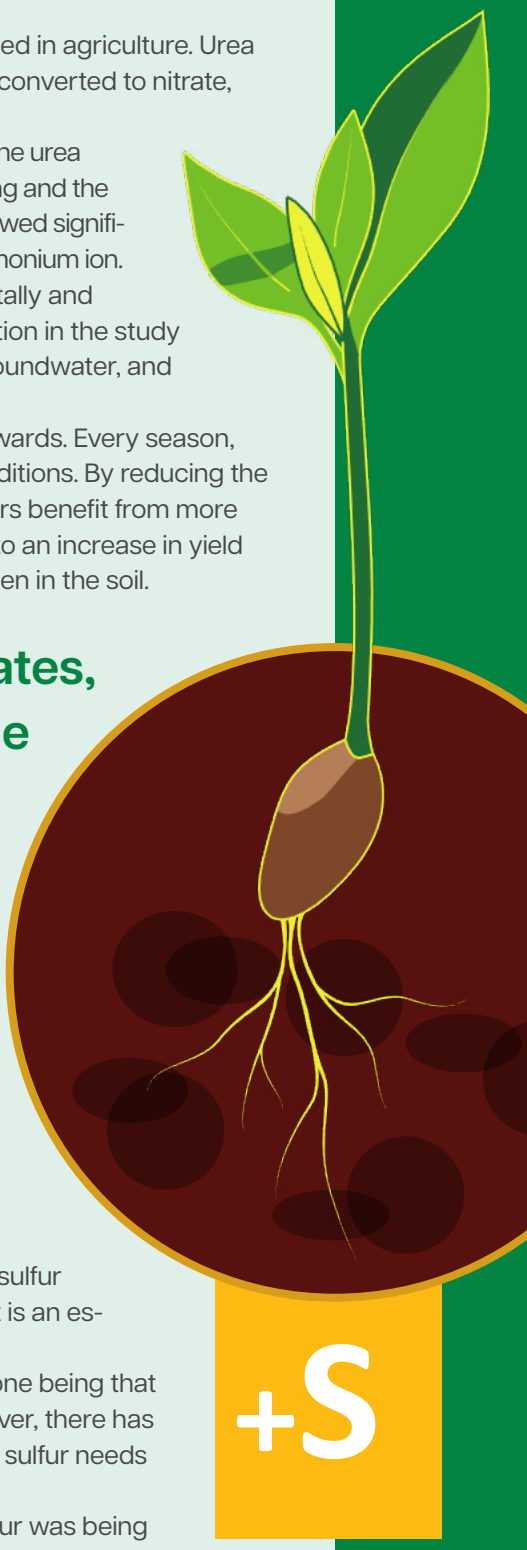
Consider urea, which is one of the most common sources of nitrogen used in agriculture. Urea can lose nitrogen through ammonia volatilization as well as leaching once converted to nitrate, which leads to growers potentially missing their crops' yield potential.

The study revealed that when urea solution is applied without thiosulfates, the urea converts to nitrate rapidly in the soil, which is subject to losses through leaching and the atmosphere. But when urea is applied with thiosulfates, nitrate formation is slowed significantly resulting in lower nitrate levels and higher levels of the more stable ammonium ion.

Gaseous nitrogen loss and nitrogen loss to leaching can be environmentally and economically unfavorable for growers. The result of the thiosulfate application in the study is improved nitrogen-use efficiency and protection of the environment, groundwater, and grower's nitrogen investment.

When plants utilize nitrogen more efficiently, growers reap economic rewards. Every season, growers apply nitrogen based on the crop's need and the existing soil conditions. By reducing the amount of nitrogen lost to leaching, volatilization and denitrification, growers benefit from more efficient and effective use of the nitrogen they are applying. This can lead to an increase in yield and improved crop quality via more available and effectively utilized nitrogen in the soil.

When urea is applied with thiosulfates, the result is low nitrate levels in the soil due to the nitrogen being kept in its stable ammonium ion form.



With fertilizer prices continuing to skyrocket, growers need to get the most out of their nitrogen budgets, Ogles points out.

"Any savings that can be afforded to growers are going to be valuable," Ogles says. "What we've seen is that just by adding thiosulfate, growers get the benefits of slowing down nitrification as well as providing a nutrient that they would supply anyway, which is sulfur."

AN ESSENTIAL NUTRIENT

Sulfur is a principal element in Crop Vitality's thiosulfate products. While sulfur is classified as a secondary element along with magnesium and calcium, it is an essential nutrient and often called "the fourth major nutrient."

Sulfur has become more important in recent years for several reasons, one being that more of it is required for higher crop yields. In the past several years, however, there has been a shortage of sulfur in the soil, which spurred a greater awareness of sulfur needs among farmers.

"Sulfur isn't available like it once was prior to the Clean Air Act, when sulfur was being deposited on the soil throughout the year in the form of acid rain and through atmospheric deposition," Ogles explains. "The amount of sulfur in the atmosphere was significantly reduced. After several years, what sulfur that was in the soil was mined up by the plants, and growers started seeing sulfur deficiencies."

Sulfur serves many functions in plants. It is used in the formation of amino acids, proteins, and oils. It is necessary for chlorophyll formation, promotes nodulation in legumes, helps develop and activate certain enzymes and vitamins, and is a structural component of two of the 21 amino acids that form protein.

Also, a crop's need for sulfur is strongly associated with nitrogen. The relationship between the two nutrients is not surprising since both are components of protein and are involved in chlorophyll formation. They are also linked by the role of sulfur in the conversion of nitrate to amino acids. Crops having high nitrogen needs will usually also have high sulfur needs.

Ogles says growers' perceptions of the importance of sulfur in their operations has "increased dramatically" in the last 20 years. "Growers today are aware of the value of sulfur and how essential it is," Ogles says. "Without sulfur, the plant can't properly utilize the nitrogen that it takes up."

CONTINUED RESEARCH

Ogles said the Crop Vitality Research Farm and Auburn University continue to research the impact of thiosulfates. One objective is to establish how thiosulfates inhibit nitrification, which includes determining the positive effects on soil bacteria.

In addition to the work surrounding nitrification inhibition, we plan to expand our scope and take a more comprehensive look at how thiosulfates can be used to further reduce N_2O emissions from nitrogen fertilizers.

Other objectives are to determine the optimal rate of thiosulfates required to achieve the desired effect on nitrification and investigating the effect of thiosulfates on reducing ammonia volatilization under laboratory conditions.

Greenhouse trials will also be conducted to evaluate the agronomic performance of thiosulfates under progressively less-controlled options.

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—ZACK OGLES, MANAGER OF AGRONOMY FOR CROP VITALITY, TESSENDERLO KERLEY

Three consecutive years of research between Auburn University and the Crop Vitality Research Farm has proven that concentrated applications of thiosulfates are strong inhibitors of nitrification.

Crop Vitality's Tessenderlo Kerley line of thiosulfates include:

Thio-Sul This ammonium thiosulfate (12-0-0-26S) helps improve nitrogen-use efficiency and provides quickly available and extended sulfur release. Thio-Sul can be applied through most irrigation systems.

KTS® This potassium thiosulfate (0-0-25-17S) is a highly soluble, chloride-free solution that improves the crop's ability to cope with drought stress and effectively utilize nitrogen. It is used to supplement fertility programs where only a defined amount of potassium and/or sulfur is needed per acre.

CaTs® This calcium thiosulfate (0-0-0-10S-6Ca) conditions soils by leaching harmful salts and improving water infiltration. It does not contain nitrogen or chlorides but can be tank mixed with liquid urea-ammonium nitrate (UAN) or liquid urea. It improves the density, firmness, and appearance of fruits, vegetables, and nuts.

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