4 nutrient stewardship

DECISION-MAKING GUIDE SULFUR

The 4R Nutrient Stewardship Framework provides a comprehensive approach of managing plant nutrients to increase food production while improving the ecological integrity of farms. When correct decisions are made regarding the 4R's (using the right nutrient source, at the right rate, at the right time, and in the right place) there are many benefits, including better crop growth, decreased nutrient leakage to the environment, and the protection of natural areas and wildlife.

Implementing 4R principles is challenging because there is no single set of correct practices that can be universally adopted. Each farmer and crop adviser makes decisions best suited to local conditions and crops—adjusting practices for each field and soil, production targets, weather conditions, economic objectives, environmental concerns, and regulations—to meet the overall goals. Because local conditions determine the appropriate 4R practices, nutrient management decisions are best made at a local level, rather than with centralized regulations.

Sulfur (S) is one of the essential plant nutrients and is required in relatively large quantities. A lack of S limits crop growth and yield, as well as affecting crop quality. Sulfur deficiency has become more common over the past few decades due to less atmospheric S deposition as air quality improves.

Soluble sulfate is the primary source of S nutrition for plants, although the vast majority of S in soils is stored in organic matter. In the soil, microbial communities continually convert small amounts of organic S-containing molecules to sulfate. The conversion of inorganic S to sulfate is also a microbial process carried out by common soil bacteria. The 4R principles provide the best approach to getting the maximum amount of this important nutrient into the plant.

Some of the fertilizer S that is not recovered in the crop is incorporated into organic compounds, where it can help build soil organic matter and tie up carbon dioxide. Sulfate can be leached below the rootzone, but generally the environmental impact of this loss is minimal. Under extreme soil conditions, S is lost as sulfur dioxide or hydrogen sulfide gas.

The principles of 4R Nutrient Stewardship provide a scientific basis for a farmer to make fertilizer decisions to achieve production goals in an environmentally acceptable manner that meet social objectives.

Right Source

Provide a balance of essential plant nutrients, considering the use of all available nutrient sources. Plant roots only take up nutrients in a soluble form and these must be present when the plant needs them. Sulfur fertilizer sources should be selected based on soil properties, the crop requirement, and potential leaching losses below the rootzone.

Examples of Right Source

- Use a S source that provides sulfate-S when an immediate crop response is required.
- Fluid S sources (e.g., thiosulfates) are rapidly converted to sulfate. Elemental S needs to be oxidized to sulfate before plant uptake. The S oxidation rate depends on particle size, soil conditions and temperature.
- Where leaching losses are likely, consider a fertilizer source that has some sulfate for immediate use and some elemental S to meet later crop demands.
- Excessive sulfate can be damaging to germinating seeds, so in-furrow applications need to consider soil properties, machinery set-up, and crop tolerance.
- Many S fertilizers also contain other plant nutrients. Select a specific S fertilizer to assist with meeting the demand for those additional nutrients.

IPNI International Plant Nutrition Institute
3500 Parkway Lane, Suite 550
Peachtree Corners, GA 30092-2844
USA | www.ipni.net | Ref # 16023

Add fertilizer based on the soil nutrient supply and the plant demand. *Application rates may be adjusted based on soil nutrient analyses to account for the existing nutrient supply. Realistically attainable predictions of crop performance and yield should be used to estimate crop requirements and nutrient removal. Nutrient application rates should also account for fertilizer use efficiency. Nutrient applications should provide a balance of all the essential plant nutrients to optimize crop nutrition and performance.*

Examples of Right Rate

- Adjust S fertilizer application rates for expected crop yields from individual fields based on soil texture, soil organic matter content, and soil tests where appropriate.
- Account for variable weather conditions before making decisions on fertilizer application rate.
- Recognize that S application beyond the capacity of the crop to use it may result in greater risk of unwanted losses to water or air.

Fertilizer decisions should account for the nutrient demands of the crop, the soil nutrient supply, potential losses, and the ability to get application equipment into the field. *In general, it is preferable to add fertilizer as close to the time of plant uptake as possible. For some S Sources (e.g., elemental S), fertilizer application can precede crop uptake by many months. However, the risk of sulfate loss from the root zone increases the longer it remains in the root zone before plant uptake.*

Examples of Right Time

- Understand the time of peak S demand by the plant and then apply fertilizer in advance of that time as closely as possible.
- Be aware of forecasted weather events and drainage conditions that can move applied S fertilizer—as well as native sulfate—below the root zone.
- Recognize that the rate of sulfate formation from some elemental S sources may be insufficient to match the timing of the peak S demand of crops.

Plant nutrients need to be in a soluble form before roots can acquire them. *Some forms of S are not very soluble and do not move in the soil. Soluble S in soil is largely in the form of sulfate, which moves freely with soil water. Sulfur-containing fertilizer can be applied to the soil surface, incorporated by tillage, or banded in concentrated zones in the soil to help maximize plant recovery. The concept of "right place" also refers to applying fertilizer only in field zones where crops will positively respond to nutrient additions. In consistently low-yielding areas, reduce fertilizer applications to match crop needs to avoid risk of excessive loss.*

Examples of Right Place

- Place S fertilizer near the crop root zone or where it will move into the root zone based on root development and architecture.
- Take care with in-furrow fertilizer placement near germinating seedlings for susceptible crops.
- Adjust S fertilizer application rates for field zones based on soil conditions and the potential productivity of the crop. Crops growing in soils with low organic matter levels and a coarse-texture are more likely to be responsive to S applications.
- Avoid broadcast applications of S fertilizer onto the soil surface if there is little likelihood of irrigation or rainfall to move sulfate into the root zone.

Further Reading

Mikkelsen, R., and R. Norton. 2013. Better Crops 97(2):7-9.

Norton, R., R. Mikkelsen, and T. Jensen. 2013. Better Crops 97(2):10-12.

Till, R. 2010. Sulphur and Sustainable Agriculture. International Fertilizer Association, Paris. 70 p.