FACT SHEET

November 2021

SULFUR

SULFUR IN SOILS

Sulfur in the soil is derived from parent material, the weathering process and atmospheric inputs. Sulfur contained in parent material exists as sulfide minerals that can be oxidised during the early weathering process. Sulfate released during the weathering process are mobile ions susceptible to leaching unless contained in the soil organic matter. Sulfur consists in the soil predominantly in the organic matter accounting for up to 90% of all the sulfur in soils.

This sulfur is not available for plant uptake until it has been converted to sulfate (SO_4^{2-}) by soil bacteria, a process known as mineralization. Like the nitrogen cycle, the sulfur cycle is determined by the mineralisation/immobilisation process.

Mineralization occurs more rapidly when the soil is warm and moist and has been cultivated. Soil disturbance accelerates the decomposition of organic matter. Consequently, sulfur fertiliser is more likely to be needed in permanent pasture than in crops.

Some sulfur is also received in rain (near industrialised areas and the sea). In Australia, this can exceed 10 kg/ha/annum S; but in inland areas, e.g., the New England Tableland, it is often no more than 1 - 2 kg/ha S per year. The use of low sulfur fuels and added emphasis on air pollution control has reduced the amount of atmospheric sulfur reaching agricultural land through rainfall in many highly industrialized regions of the world.

Compared to phosphate and ammonium ions, sulfate is not as strongly adsorbed onto clay and organic colloids. Sorption is stronger in acid soils than in alkaline soils. Leaching losses can be appreciable in light textured soils in areas of high rainfall. In drier areas and in soils of a heavier texture, leaching is less significant. In semi-arid areas, crystalline calcium sulfate (gypsum) may accumulate in the sub-soil, e.g. the inland plains in the east Australian States. Where this occurs, sulfur is seldom limiting as a plant nutrient, provided it is accessible by plant roots.

SULFUR IN PLANTS

Sulfur (S) is taken up by plants in slightly smaller amounts than phosphorus. It is absorbed by plant roots almost exclusively as the sulfate ion (SO_4^{2-}). Sulfur is a constituent of protein and is necessary for the development of chloroplasts and in photosynthesis.

DEFICIENCY

With higher yielding crops being grown and greater use being made of high analysis fertilisers with a low sulfur content, the incidence of sulfur deficiency in plants has increased in recent decades, e.g., urea in place of sulfate of ammonia, and the ammonium phosphates (DAP and MAP) in place of single superphosphate (SSP). The adoption of reduced tillage practices has also resulted in less sulfur being mineralized in the soil. Responses to sulfur are most likely to occur on lighter textured (sandy) soils with a low organic matter content. In Australia,

deficiency most commonly occurs in legume-based pastures, and in canola which has a high requirement for sulfur.

Because nitrogen and sulfur are important in the formation of chlorophyll (the green pigment in plant leaves) and the synthesis of protein, deficiency symptoms of both are similar, i.e., poor growth, reduced tillering in cereals, and pale green to yellow foliage. Nitrogen, however, is more readily relocated from old to young leaves within the plant, so that with nitrogen deficiency, it is older leaves that will lose their dark green colour, whereas with sulfur deficiency it is usually the young leaves that will be pale green to yellow in colour. Sulfur deficient plants are often rigid and brittle, and the stems remain thin. As is the case with nitrogen deficiency, a shortage of sulfur will at first be reflected by a decline in protein in grain crops, before yield is affected. In legumes, the nitrogen-fixing root nodules are often reduced in both size and number in sulfur deficient plants.

SULFUR FERTILISERS

Sulfur can be applied in two ways, as elemental sulfur (S) or as a sulfate (SO_4^{2-}) compound in combination with another nutrient, e.g., ammonium sulfate, potassium sulfate or calcium sulfate. The latter (calcium sulfate) is a constituent of single superphosphate. It is also known as gypsum, which is mined at various localities throughout Australia. The sulfur content of gypsum varies depending on the number of impurities. Grade 1 gypsum contains > 15% S, Grade 2 > 12.5% S and Grade 3 > 10% S. Gypsum can be used as a sulfur fertiliser but is more commonly applied at higher rates as a soil ameliorant to improve the structure of sodic soils.

Sulfate is the form in which sulfur is taken up by plant roots. Elemental sulfur must first be converted to sulfate in the soil, a bacterial process which is dependent on the soil being warm and moist. The finer the particle size the greater the surface area and the more quickly oxidation occurs. Elemental sulfur can be impregnated into or coated onto fertiliser granules or formulated as a dispersible granule. Sulfur dust, which may be generated from some of these products, is flammable and potentially explosive in air. This may place some restrictions on how these products are handled, stored and applied.

Examples of sulfur containing fertilisers marketed by Incitec Pivot Fertilisers are listed in the following table and discussed in brief below.

Product	**Common Name**	**Analysis (%)**			
		N	**P**	**K**	**S**
Gran-am	Sulfate of Ammonia	20.2			24
SuPerfect	Single Superphosphate (SSP)		8.8		11
Sulfate of Potash	Potassium Sulfate			41	18
Granulock SS	NPS Compound	10	17.5		12
Sulfur Bentonite	Dispersible Sulfur Granules				90
Kieserite	Magnesium Sulfate Monohydrate				15-20

Gran-am (granulated ammonium sulfate) is manufactured in Brisbane. While it is used on its own, it is commonly used in combination with other nitrogen fertilisers to provide a better

balance of nitrogen to sulfur. Gran-am contains approximately equal parts of nitrogen and sulfur, whereas most plants take up ten or more times as much nitrogen as sulfur.

SuPerfect (Single Superphosphate) is manufactured in Victoria at Geelong and Portland. It is ideally suited for top-dressing perennial grass legume pastures where both phosphorus and sulfur are usually required. High analysis phosphorus fertilisers such as DAP and MAP contain very little sulfur. Legumes fix their own nitrogen from the soil air, so fertiliser nitrogen is generally not required.

Sulfate of Potash (potassium sulfate) is a more expensive source of sulfur than Gran-am or SuPerfect. It is not normally used to supply sulfur unless there is a reason to avoid using the more economically priced Muriate of Potash as a potassium fertiliser, e.g., where the chloride in Muriate of Potash may be detrimental.

NPS Compounds and Blends. Different fertiliser compounds are often mixed together in compounds and blends, so that several nutrients can be applied together in a single application. **Granulock SS** is an example. It is used at planting in oilseed, grain and forage crops to supply phosphorus and sulfur, and some starter nitrogen. The balance of the nitrogen can be applied at some other stage, e.g., pre-plant or as a side/top-dressing.

Sulfur Bentonite is a dispersible elemental sulfur fertiliser. The granules disperse on wetting after application to release fine sulfur particles. It is mainly used on legume-based pasture on soils high in phosphorus.

Kieserite (Magnesium Sulfate Monohydrate) is a naturally occurring mineral found in marine evaporites. Kieserite is water soluble fertiliser suitable for supplying sulfur and magnesium to range of horticultural and broadacre crops. Kieserite is not recommended for fertigation or foliar application.

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