Information Sheet

6.6 Gypsum ameliorants and their use

Gypsum ($CaSO_4.2H_20$) is a commonly available mineral with wide-ranging uses in agriculture. Beneficial use of gypsum in agriculture includes the supply of nutrients calcium (Ca) and sulphur (S) in deficient soils, amelioration of subsoil acidity (excess aluminium (Al)) and sodicity (excess sodium (Na)). In some parts of the world, it is used to alleviate excess magnesium (Mg). The main types and properties of gypsum and their practical use for different agricultural applications are outlined here.

Key benefits of gypsum in soils:

- Adds readily plant-available Ca and S (in the plant-available form of sulphate (SO_4)).
- Ca can alleviate excess acidity (Al) or sodicity (Na).
- SO_4 can complex with Al to reduce its toxicity.
- SO_4 can form ion pairs with Na to help leach these from the soil profile.
- Ca improves aggregate stability and infiltration and reduces crusting in dispersive soils.
- Will dissolve over a wide range of pH conditions.
- Does not alter the soil pH greatly which improves Ca leaching through the profile (when compares to alkalising Ca products such as lime)

Risks associated with gypsum use:

- High rates of gypsum can lead to leaching of Mg and K in sandier soils.
- At very high application rates, it can lead to excess Ca suppressing the uptake of K and Mg.
- In salt-affected soils without adequate drainage and flushing with clean water, high application rates can increase soil salinity levels.

▲ Gypsum can be topdressed or broadcast and incorporated depending on the crop cycle. Regardless of the application method, uniform application is typically advised for optimal benefit. It is usually advised to co-apply gypsum with at least 1 ton of dolomitic lime to prevent Mg leaching (especially if soil Mg levels are low and in sandy soils).

Types and properties of gypsum

There are two main sources of gypsum: geological sediments and industrial by-products, both of which are available in the local market. Geological gypsum is a relatively common mineral typically formed by the evaporation of saline water rich in calcium and sulphate (sedimentary deposits). Industrial forms of gypsum are derived as by-products from industrial processes, the most common being phosphogypsum (a by-product from the production of phosphoric acid that contains small amount of P). Other sources of industrial gypsum include those formed from treating waste sulphuric acid with lime and from collecting and neutralising sulphur-rich products produced from coal-fired boilers in power stations (flue-gas desulphurisation). There are also several chemical forms of gypsum, the most commonly used is the hydrated form - $CaSO_4.2H_2O$. Others include dehydrated annhydrite ($CaSO_4$) or the partially hydrated hemi-hydrite ($CaSO_4.½ H_2O$).

In South Africa gypsum materials must conform to the regulations stipulated in the *Fertilizers, farm feeds, agricultural remedies and stock remedies act, 1947* (Act No. 36 of 1947).
Main criteria include:

- Ca content ≥ 18% (180 g/kg)
- S content ≥ 12% (120 g/kg)
- ≥ 50% of particles ≤ 0.25 mm
- ≥ 90% of particles ≤ 2 mm

Phosphogypsum has similar composition to mined gypsum, though it also contains small amounts of phosphorus (P) that can range from as low as 0.3% and up to 3%. It may also contain fluoride and other trace elements. The moisture content of industrial gypsum (up to 35%) tends to be much higher than that of mineral gypsums (typically < 2%), which must be considered when adjusting application rates, choosing handling methods and calculating transport costs. Industrial sources of gypsum should always be evaluated for quality and possible contamination with toxic elements (e.g. heavy metals) before use.

▲ Gypsum is either sourced from mined minerals or produced as a by-product from industrial process. Always ensure that the gypsum product meets the legal requirements and does not contain toxic elements. Also consider the moisture content as this can affect transport costs and handling characteristics.

Gypsum is 100 to 200 times more soluble than carbonate limes with a solubility of about 2.4 g/L of water (depending on particle size and hardness). Particle size plays a role in the effectiveness of gypsum, where fine particles react faster and more completely than large particles. This means the larger particles do not immediately and completely dissolve when applied, but rather dissolve over several weeks (with adequate moisture). Gypsum will also dissolve over a wide range of pH values, thus making it a useful amendment for a wide range of soil conditions. Gypsum is considered a "neutral salt", as it has relatively little direct impact on the soil pH where it is used.

General guidelines for gypsum use

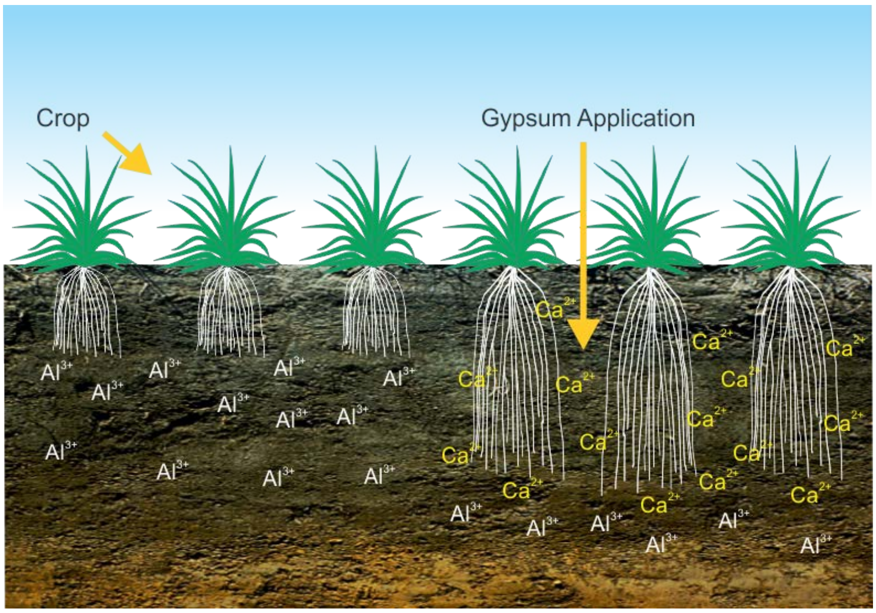
Gypsum as a Ca and S nutrient source

In non-acidic soils where Ca is deficient (< 300 mg/L exchangeable Ca), gypsum is an effective supply of the nutrient. In general, 1000 to 2000 kg/ha can be applied to overcome the deficiency for several seasons, while still being practical from a handling perspective. Due to the risk of Mg leaching where gypsum is applied (particularly sandy soils), it is advisable to co-apply the gypsum with 1000 kg/ha dolomitic lime (to supply Mg).

Gypsum is perhaps the most used amendment for S deficiencies. SASRI advises that if soil test values are <15 mg/L, supplemental S should be applied. In general, 500 to 1000 kg gypsum/ha will overcome the deficiency for 3 – 4 seasons. Because S can be easily leached in sandy soils or taken into orgainc matter by microorganism, regular monitoring is necessary to evaluate changes in the availability. Leaf testing should be periodically undertaken to ensure the crop is taking up sufficient Ca and S. For more information on managing Ca, see *Information Sheet 7.7: Calcium and magnesium management* and for S, see *Information Sheet 7.6: Sulphur management.*

Gypsum as an ameliorant for subsoil acidity

Gypsum has been recognised as an effective management tool to alleviate aluminium toxicity in subsoils by supplying Ca to roots at depth. Recent work in Brazil in well-weathered deep soils, with acidic subsoils, have clearly demonstrated the long-term benefits of gypsum applications over the plant and several ratoon cycles. These studies have shown that gypsum is effective in promoting root growth to much greater depth than without amelioration. This allows the crop to access soil moisture in a greater volume of soil and at greater depth, this providing crop resilience through short-term droughts and dry spells. Similar beneficial responses have also been noted in local studies.



▲ Gypsum provides soluble Ca that can readily leach to depth to alleviate the negative effects of Al on roots. The SO_4 will also complex with the Al and reduce its toxicity.

To date, no definitive method to determine gypsum rates to alleviate subsoil acidity has been developed. At SASRI, the recommended gypsum rate is based on the assessment of a subsoil sample, where the acid saturation level and soil texture are considered in estimating the required application rate. Periodic reassessment is advised to ensure acidity is controlled.

Notes:

- Gypsum applications are advised in addition to any lime requirements for alleviation of topsoil acidity.
- In plant crops, the gypsum should be uniformly broadcast and tilled into the soil, while in ratoon or no-till crops, broadcast surface application is acceptable (ideally to be followed by rainfall).
- Banding for acidity alleviation is not recommended.
- Due to the risk of Mg leaching where gypsum is used, co-application with dolomitic lime is typically advised to ensure Mg levels are maintained in the topsoil.
- Gypsum can be co-applied with lime for topdress liming situation (ratoon or no-till) as this provides alleviation of topsoil acidity more quickly than lime alone.

For further details on soil acidity and its management practices see Information Sheet *6.4 Managing Soil acidity.*

Gypsum used to remediate sodic soils

Gypsum has become one of the most important ameliorants to treat sodic soils. Sodic soils are typified by an excess of exchangeable and soluble Na (relative to Ca and Mg) and high pH (typically >7.5 and as high as 9). This causes dispersion of clay leading to the disintegration of soil aggregates. The consequence is reduced infiltration, crusting and run-off. High Na levels can also interfere with uptake of other plant essential nutrients. Gypsum provides an excellent source of readily available Ca that can displace the excess Na, which will complex with SO_4 and can be leached from the soil profile. This improves the soil structure and alleviates nutrient imbalances caused by the Na.

The SASRI gypsum recommendations are determined after the analysis of a soil profile for salinity and sodicity status. Gypsum will only be advised if the soil is sodic and above the target threshold. The rate is calculated based on the requirement to exchange the excess Na with Ca. However, remediating sodicity requires more than just gypsum application, where drainage and leaching are essential steps.

For more information on sodicity and its management, see *Information Sheet 5.11: Properties of saline/sodic soils and their reclamation.*

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