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Gypsum: As Soil Amendment

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It has been a long time since calcium sulphate otherwise known as gypsum is being used in multipurpose. Calcium sulphate, ($CaSO4.2H_2O$) is a mineral that occurs naturally and is used in a variety of industrial applications. When heated over 120 °C, a portion of the chemically bound water is released, resulting in the formation of different mineral calcium sulphates such as hemihydrate (CaSO4.5H2O; created at 130-160 °C) and anhydrite (CaSO4; formed at 290-900 °C). Gypsum is most commonly used as a binder in gypsum plaster boards, gypsum fibre boards, and plaster blocks in the construction industry, followed by dry mortar applications such as gypsum renders and plasters; gypsum trowelling, repair, and patching mortars; anhydrite screeds and self-levelling compounds; and gypsum-based adhesive mortars and bedding mortars. In agriculture, It's full availability, relatively lower price; that is makes it an excellent agronomic and environmental tool to improve physical and chemical property. The primary utility of gypsum is a means to overcome the physicochemical problem in sodic soils as well as a nutrient source of calcium and sulphur to the plants. The most recent scientific trends are also suggesting a just opposite turn, i.e., using it to reduce the high level of soil acidity as well as soil dispersion problems. Along with reclaiming sodic soils; the other most common utilities of gypsum are reducing soil crusting in arid and semi areas where it can increase infiltration rate despite scarce rainfall and improving seed germination. In high aluminium- rich soil, gypsum can suppress the Al ions from damaging the root system by replacing it with Ca ions thus helps to establish a sound root system. On the strict sense of plant nutritional point of view; it might seem unnecessary to apply gypsum as a source of calcium in low rainfall areas where the calcium is already present in the soil in plentiful quantity to suppress Phyto- toxic aluminium ions; however; the problem lies somewhere else. The high rate of ammonia-based fertiliser often responsible for the localised or even widespread soil acidification, which causes a sharp increase of Al^{+3} ions. However, the effectiveness of the lime application is limited to the depth of its incorporation which often results in the formation of a shallow and deep acid subsoil especially in zero tillage situation where lime can only reduce acidity of the middle layer; the layer of lime incorporation. In this scenario, Gypsum has some advantages over lime such as higher rate of ion mobility, solubility and replacing the Al3+ from the exchange medium with calcium and sulphate. In this article potential and uses of gypsum in agriculture are discussed

Sources and Properties of Gypsum:

Gypsum (CaSO4) from natural and non-natural sources is most frequently used for sodic soil treatment. To make recommendations for gypsum use in agriculture, it is important that we have a good understanding of its composition and properties. Composition of pure gypsum ($CaSO_4 \cdot 2H_2O$) is 79% calcium sulfate ($CaSO_4$) and 21% water (H_2O). Pure gypsum contains 23.3% calcium (Ca) and 18.6% sulfur (S). Gypsum is moderately soluble in water (2.5 g per L) or approximately 200 times greater than lime ($CaCO_3$). This makes the calcium in gypsum more mobile than the calcium in lime and allows it to more easily move through the soil profile. It is most popular chemical treatment mainly because of its low cost, good solubility, and easy availability. By increasing EC and cation exchange effect of sodic soil, gypsum can increase soil permeability. The efficiency of gypsum will depend on the fineness as well as purity of the material. Usually, a fineness with particle size of 2mm or 0.59mm (10 or 30 mesh sieve)has been found optimum for the purpose of amelioration. Thorough incorporation and mixing of the amendment in the soil is an another important factor in determining beneficial effect. Gypsum amendments can also improve the physical properties of some soils (especially heavy clay soils). Such amendments promote soil aggregation and thus can help prevent dispersion of soil particles, reduce surface crust formation, promote seedling emergence, and increase water infiltration rates and movement through the soil profile. It can also reduce erosion losses of soils and nutrients and reduce concentrations of soluble phosphorus in surface water runoff. Chemical properties improved by application of gypsum include the mitigation of subsoil acidity and aluminum toxicity. This enhances deep rooting and the ability of plants to take up adequate supplies of water and nutrients during drought periods. Gypsum is the most commonly used amendment for sodic soil reclamation and can also be included as a component in synthetic soils for nursery, greenhouse, and landscape use.

Gypsum: from where it comes?

Several possible sources of gypsum for agricultural use are mined gypsum from geologic deposits, phosphor-gypsum from wet-acid production of phosphoric acid from rock phosphate, recycled casting gypsum from various manufacturing processes, recycled wallboard gypsum, lacto-gypsum and flue gas desulfurization (FGD) gypsum from power plants.

A. Natural gypsum: the gypsum used in soils is typically natural gypsum, which is mined or quarried (calcium sulfate dihydrate in dry powder form containing 80–98% product as particles <150 μm). The traditional natural source of gypsum is the geologic depositions which are often excavated, collected, and used for a long time. When brine marine water is evaporated, the first mineral which gets precipitated is gypsum which is often found beneath the rock salt deposit of salt domes (Murray, 1964). If the temperature is higher, (>42°C) anhydrite (Angelite) may precipitate before gypsum, but upon rehydration, it easily converts back to gypsum

B.Synthetic gypsum: Other commercial sources of gypsum (synthetic) as a by-product from the food, construction waste and glass crystal industries, and flue gas desulfurization gypsum are also available

a. Phosphogypsum: it is nongeogenic in nature, is a by-product of phosphoric acid production, which is a part of high analysis phosphetic fertiliser production. As compared to the natural gypsum, it is much finer in quality and higher purity.

b. Flue gas desulfurization (FGD): FGD gypsum is created in limestone-forced oxidation scrubbers that remove sulphur dioxide from the flue gas stream after coal combustion.

c. Lacto-gypsum: As a part of lactic acid downstream purification process in whey making process in dairy industry, bacterial cells are removed after complete fermentation using centrifuge from calcium lactate fermentation broth. In the recovery phase, the fermentation broth containing calcium lactate is neutralized with 96% sulphuric acid to produce calcium sulfate (gypsum) and a free form of lactic acid is obtained. The gypsum precipitates in fermentation broth due to sulphuric acid neutralization reaction and this insoluble gypsum is separated by belt filtration method. In this process, the calcium sulfate is recovered as an additional by-product called lacto-gypsum.




1.**Pulverized gypsum 2.Granular gypsum 3. Pelleted gypsum 4. Pulverized organic gypsum**

Benefits of Gypsum Application in Agriculture

1. Source of calcium and sulphur for plant nutrition: Plants are becoming more deficient for sulphur and the soil is not supplying enough it. Gypsum is an excellent source of sulphur for plant nutrition and improving crop yield. Meanwhile, calcium is essential for most nutrients to be absorbed by plants roots. Without adequate calcium, uptake mechanisms would fail. Calcium helps stimulate root growth. Research found that the sulfur is available not only in the year applied, but can continue to supply sulfur for one or two years after, depending on the initial application rate. Gypsum as a sulfur fertilizer has benefitted corn, soybean, canola, and alfalfa. Scientists also reported that gypsum induced yield improvement is more prominent in the year when the deficit of rainfall has been observed.

2. Improves acid soils and treats aluminium toxicity: One of gypsum's main advantages is its ability to reduce aluminium toxicity, which often accompanies soil acidity, particularly in subsoils. Gypsum can improve some acid soils even beyond what lime can do for them, which makes it possible to have deeper rooting with resulting benefits to the crops. This can inhibit aluminum uptake at depth and promote deeper rooting of plants. Surface-applied gypsum leaches down to the subsoil and results in increased root growth.

3. Impact of gypsum application on overall soil pH : Gypsum is not an acid neutralising or acid-forming agent hence the impact of gypsum on overall soil pH is minimal. It can although slightly change the pH, but that totally depends upon the sophisticated soil mineralogy, CEC, and other competing anions. The range of pH change is often ranged between 0.2-0.3 pH units

4. Effect on base cations base saturation: Gypsum has a high potential to increase the soil fertility especially in the sub-soil due to high solubility of Ca, and S. Gypsum directly improves base saturation, exchangeable Ca and S content in soil moreover; gypsum also increases the leaching loss of Mg and K due to thermodynamics of ion exchange

5. Improves soil structure: Excess sodium ions in the soil cause deflocculation, or the loss of soil structure by dispersing soil colloids. This detrimental effect can be mitigated by the presence of calcium ions, which flocculate the soil by binding the soil aggregates together.

6. Improves water infiltration: Gypsum also improves the ability of soil to drain and not become waterlogged due to a combination of high sodium, swelling clay and excess water. Increased water-use efficiency of crops is extremely important during a drought. The key to helping crops survive a drought is to capture all the water you can when it does rain. Better soil structure allows all the positive benefits of soilwater relations to occur and gypsum helps to create and support good soil structure properties.

7. The environmental footprint of gypsum : Gypsum potentially can be used to increase water infiltration hence reducing runoff of water and nutrients. Gypsum is also used as phosphorus absorbing material. A higher dose application of high analysis phosphatic fertiliser or dumping off manure often leads to eutrophication. This is especially problematic in the case of poultry manure. Application of gypsum along with compost leads to up to 61% less runoff loss of soluble phosphorus (Endaleet al., 2014). Another critical environmental benefit of gypsum is that it can be used to trap pollutant heavy metals like mercury and lead.

Application of gypsum

Reclamation of sodic soils requires use of amendments such as gypsum or calcium chloride, that directly supply soluble calcium, or other substances, like sulphuric acid and sulphur that solubilise the relatively insoluble calcium carbonate commonly found in sodic soils. ICAR-Central Soil Salinity Research Institute, Karnal has standardized gypsum technology for reclamation of such sodic soils. Based on soil sodicity (pH), the gypsum requirement for light (10% clay), medium (15% clay) and heavy (20% clay) textured soil ranges from 0-10, 0-14 and 0-16 t ha^{-1} . After application of required quantity of gypsum, it needs be mixed in surface 10 cm soil and level graded plots are bunded properly. For effective leaching of gypsum reaction products, the reclamation process should be initiated before onset of monsoon with preferably rice as first crop. Farmers can take gypsum and apply it to the topsoil prior to planting or right after harvest. It can also be applied to hay fields after hay cutting. If tilling is needed (again, dependent on the soil conditions), gypsum can be worked into the soil with the tilling equipment.

The agronomic criterion under which gypsum should be applied are given below:

- When the subsurface layer is significantly high in aluminium and low in calcium
- which inhibiting the root growth When there is a high chance of periodic drought occurrence causing water stress to the plant.
- When magnesium level higher than usual and should be reduced.

Conclusion

Gypsum is the cheapest and widely available source for correcting S deficiency and improving physico-chemical properties of the soil. It is a moderately soluble source of the essential plant nutrients, calcium and sulphur and can improve overrall plant growth. It also reduces erosion losses of soils and nutrient concentrations (especially phosphorus) in surface water runoff. Using gypsum as a soil amendment is the most economical way to cut the non-point run-off pollution of phosphorus. Considering the facts stated above, we can conclude that gypsum, which can be used as a soil amendment or fertilizer, plays a critical role in improving the overall performance of agricultural systems.

References

1. Crusciol, C. A., Marques, R. R., Carmeis Filho, A. C., Soratto, R. P., Costa, C. H., Ferrari Neto, J., & Franzluebbers, A. J. (2019). Lime and gypsum combination improves crop and forage yields and estimated meat production and revenue in a variable charge tropical soil. Nutrient Cycling in Agroecosystems, 115(3), 347-372.
2. Dubrovina, T. A., Losev, A. A., Karpukhin, M. M., Vorobeichik, E. L., Dovletyarova, E. A., Brykov, V. A., & Neaman, A. (2021). Gypsum soil amendment in metal-polluted soils- an added environmental hazard. Chemosphere, 281, 130889.
3. Sumner, M. E., & Larrimore, L. (2006, September). Use of gypsum for crop production on southeastern soils. In Workshop on Research and Demonstration of Agricultural Uses of Gypsum and Other FGD Materials.
4. Wang, Y., Wang, Z., Liang, F., Jing, X., & Feng, W. (2021). Application of flue gas desulfurization gypsum improves multiple functions of saline-sodic soils across China. Chemosphere, 277, 130345.
5. Giulia B., Owen F., Parikshit, S., Hilda K. & David W.(2021) potential of lacto-gypsum as an amendments to build soil quality. *Fronteires in sustainability*. doi: 10.3389/frsus.2020.625727.