

Soil ameliorant gypsum can improve pod yield of groundnut (*Arachis hypogaea*)

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Gypsum was initially introduced as heavily subsidized ameliorant for treating alkaline soils in India. Over a period of time, gypsum being a cheap source of calcium and sulphur, farmers began to use it as a fertiliser in oilseeds production. Moderate solubility of gypsum helps in the ready availability of both the nutrients (calcium and sulphur) syncing with the critical growth stages of the plant. Many research trials proved that in groundnut, application of gypsum during the flowering stage enhances pod filling eventually increasing the pod yield along with improved seed quality. The application of right dose of gypsum at the right time not only improves the productivity but also minimizes environmental pollution. This study provides an overview of gypsum's role in the improvement of pod yield, its advantages and absorption of gypsum by roots and pods from the soil in groundnut crop.

Keywords: Calcium, Groundnut, Gypsum, Pod yield, Sulphur

INDIA is one of the largest producers of oilseeds in the world and occupies an important position in the Indian agricultural economy. It is estimated that nine oilseeds namely groundnut, rapeseed-mustard, soybean, sunflower, safflower, sesame, niger, castor and linseed, accounted for an area of 23.44 million hectares with the production of 25.14 million tonnes. Groundnut is one of the leading oilseed crops after soybean, rapeseed and sunflower with a production of 45.95 million metric tonnes at the global level. Among the leading countries, India ranks second after China in global groundnut production. The high edible oil content (48-50%) and protein content (25-28%) in groundnut make it a major part of the human diet. It is also a rich source of vitamins, minerals and antioxidants. The major production constraints in groundnut are abiotic stresses, biotic stresses, use of low-yielding varieties and poor soil fertility. The poor soil fertility results from soil erosion, nutrient imbalances/deficiencies, acidification and soil compaction.

Among several agronomic practices followed in groundnut, nutrient management plays a prominent role to overcome soil fertility issues and also improves the pod yield. The recommended dosage of nutrients to produce one tonne of pods/ha in groundnut is 11 kg of calcium, 4 kg of sulphur, 58 kg of nitrogen, 5 kg of phosphorus, 18 kg of potassium and 9 kg of magnesium. Being an oilseed crop, groundnut requires sulphur for oil synthesis and calcium for pod filling and shell formation.

Effects of calcium and sulphur deficiency

The secondary nutrients viz. calcium and sulphur plays an important role in enhancing production and productivity of groundnut. Calcium is an important macronutrient, which plays a vital role in the structural and functional aspects of plants. It is the key component of the cell wall, cell membrane, as a secondary messenger in various metabolic processes, and also involved in different pathways of resistance against biotic and abiotic stresses. In

groundnut, deficiency of calcium in the soil leads to the high incidence of pod rot, improper filling of pods called 'pops', poor germination and thereby affecting the crop yield. The calcium has no direct toxic effect on crops when present in excess amount but it reduces the uptake of other cation nutrients such as phosphorus, potassium, magnesium, copper, boron, iron and zinc. In general, calcium is applied to the field either for reclamation of acidic soils or as a fertilizer to overcome the deficiency of element. The important sources of calcium fertilizers are calcium oxide (CaO), calcium carbonate (CaCO₃), calcium hydroxide (Ca(OH)₂) and calcium sulphate (CaSO₄). Meanwhile, sulphur (S) is also one of the vital plant nutrients and plays a prominent role in the synthesis pathways of oil, protein, chlorophyll and sulphur containing amino acids like cysteine and methionine. Sulphur deficiency disrupts nitrogen metabolism, induces carbohydrate accumulation, reduces protein quality and also disturbs chlorophyll

synthesis. Lack of sulphur limits the efficiency of added nitrogen (N) therefore, S addition becomes necessary to achieve maximum efficiency of applied nitrogenous fertilizer. A shortage in the S supply to the crops lowers the utilization of the available soil nitrogen, thereby increasing nitrate leaching. The N: S ratio ensures optimum yield and quality of the crop, and unbalanced fertilizer use adversely affects crop production. Sulphur deficiency causes profound changes in N metabolism with reduced protein synthesis and accumulation of soluble organic and inorganic nitrogenous compounds. The various forms of sulphur fertilizers are elemental sulphur and thiosulphates in combination with other nutrients such as calcium, ammonium, nitrogen and potassium. Sulphur toxicity does not exist practically but the excessive application of sulphur leads to a decrease in soil pH and the crop faces problems associated with low pH. Calcium nutrition is also considered a yield limiting factor for groundnut production. Calcium absorbed by the roots is not translocated to the developing pod whereas calcium required for pod formation is absorbed directly from soil solution.

Importance of gypsum

Among different types of calcium and sulphur fertilizers available, the most routinely used fertilizer is gypsum. A gypsum is a pure form of calcium sulphate dihydrate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and comprises of 23.3% calcium and 18.6% sulphur whereas lime ($\text{Ca}(\text{OH})_2$) contains 54% calcium. The calcium present in gypsum is far more mobile than lime and is moderately soluble in water with ~ 200 times greater solubility than lime. Unlike lime, gypsum does not alter the pH of the soil and thus acts as a neutral salt. Gypsum also improves soil structure by reducing bulk density, increasing infiltration rate and water retention as well as reduces soil erosion. In groundnut, application of gypsum during the flowering stage at pegging zone enhances pod yield with premium quality pods.

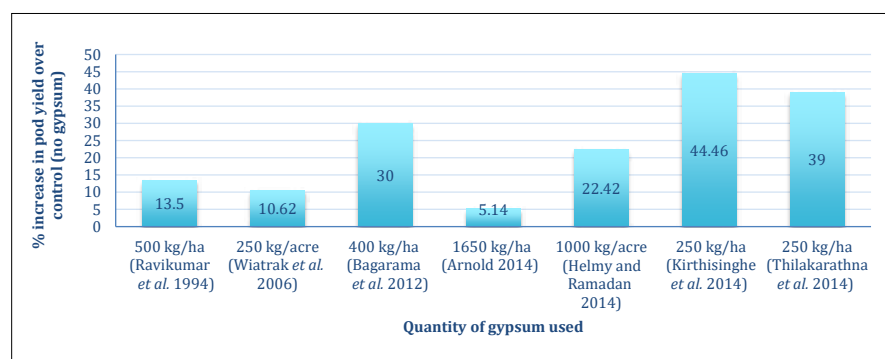
Effect of gypsum on groundnut yield

Groundnut has a special feature, where the pods develop inside the soil. The nutrients absorbed by roots are transported to the upper parts of the plant through the xylem due to transpiration pull. In general, the developing fruits in plants receive nutrients from the shoot, in contrast calcium is accumulated as crystals in groundnut leaves and is not transported to the developing pods. Pods absorb nutrients especially calcium directly from the soil. Hence, the application of calcium at the flowering stage enables the availability of calcium in the pod-zone and thus enhances proper pod growth and development in groundnut. Sulphur is very crucial for the formation of sulphur containing amino acids and oil synthesis and it also improves both yield and quality of crops. The gypsum application also results in an increased number of nodules, protein, oil content and reduces aflatoxin contamination, and improves germination capacity. The gypsum application may help to increase peanut yields in years with high potential yield by increasing Ca

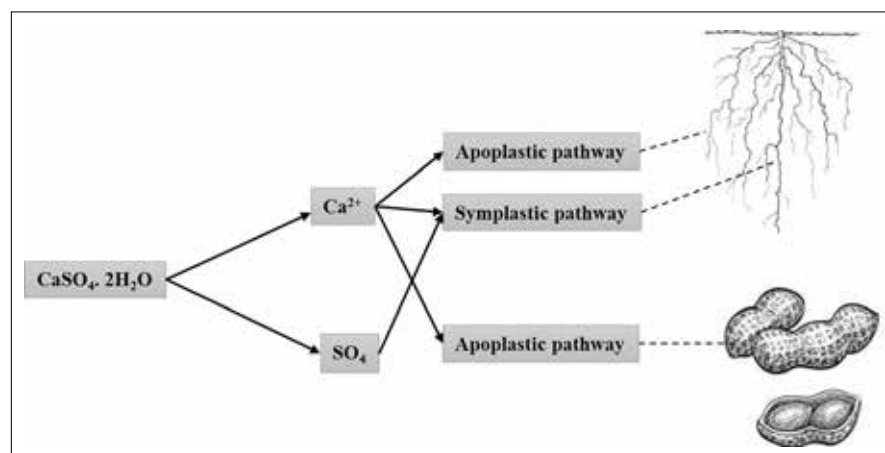
availability in the fruiting zone. The variation in pod yield of groundnut concerning gypsum application was reported by various researchers and observed percentage increments due to differences in dosage, original soil profile, genotypes used in the study alongside other environmental factors (Fig. 1). The highest nitrogen uptake was recorded with the application of 60 kg S/ha at all the growth stages and by seeds. The interaction between N and S was synergistic and hence application of sulphur increases the concentration and uptake of nitrogen. Some of the researchers also observed that the high amount of Ca reduces production. Therefore, the application of gypsum in the recommended dosage at an appropriate time optimizes the yield of groundnut.

Transport of calcium and sulphur into plant

The mineral elements enter into roots either through the symplastic or apoplastic pathway (Fig. 2) and participate in various metabolic processes. An apoplastic pathway is



Meta-analysis of gypsum effect on pod yield of groundnut



Overview of transport of gypsum in the form of calcium and sulphur into roots and pods of groundnut

a form of nutrient transport through the concentration gradient between xylem and soil solution without any energy consumption whereas the symplastic pathway requires ATP for the transport of ions across the concentration gradient. Very less literature is available on the transportation of calcium into pod walls. It is assumed that due to the absence of casparian bands in pod walls, the transport of calcium into the pod might be through the apoplastic pathway (Fig. 2). Calcium in the soil solution enters into roots through both apoplastic and symplastic pathways and into pod walls through diffusion based on

an apoplastic pathway. The sulphur enters into roots from the soil driven by proton gradient by consuming ATP through proton/sulphate co-transport as a symplastic pathway.

CONCLUSION

As compared to other calcium and sulphur fertilizers, gypsum is the best source as it viz. provides both mineral components calcium and sulphur at the same time. Gypsum is a cheap source of fertilizers and is provided to farmers under a government scheme with support from the National Food Security Mission - Oilseeds & Palm (50% of the cost + transportation).

The Indian Council of Agriculture Research (ICAR) (<https://kvk.icar.gov.in/>) and the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) recommended gypsum at the rate of 500 kg/ha if calcium is below the critical level of 1000 ppm in the soil. From different studies, it is clear that the external application of gypsum improves pod yield in groundnut. Therefore, appropriate application of gypsum is recommended to reduce calcium deficiency and also to enhance pod yield in groundnut.

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