GYPSUM – A MULTITASKING AMENDMENT FOR NATURAL RESOURCE MANAGEMENT

[1]RASHMI I*, [1]S KALA, [1]ANITA KUMAWAT, [1]ASHOK KUMAR, [1]KULDEEP KUMAR, [2]RAMA PAL, [3]KARTHIKA KS, [4]ATHIFA M

[1]ICAR-Indian Institute of Soil and Water Conservation, RC Kota, Rajasthan; [2]ICAR-Indian Institute of Soil and Water Conservation, Dehradun, Uttarakhand; [3]ICAR-National Bureau of Soil Survey and Land Use Planning, RC Bengaluru, Karnataka, [4]Krishi Vigyan Kendra, Mandya, Karnataka

*Corresponding author, Email: rashmiuas25@gmail.com

Faulty land management practices, intensive agriculture, and erratic weather pattern created enormous pressure on land. Soil being integral part of land, bears the consequences of damages caused by these poor management approaches. Soil health deterioration is increasing at alarming rate, risking environment and human existence many ways. Faulty agriculture and land use practices augment the rate of soil erosion, salinity-sodicity, and environmental pollution. This eventually leads to decline in agricultural productivity and food shortage. Nearly 94 and 6.7 million hectares of land in India are severely affected by soil erosion and salinity problems respectively. It demands immediate interference like adopting appropriate management practices to reverse soil degradation and sustain crop production. Use of amendments is one of the efficient techniques to improve soil functions and productivity. Soil amendments are easily available, cost effective and environmentally safe in general. Gypsum is one such amendment that is commonly used in agriculture for improving soil properties. Gypsum mineral acts as nutrient source of Sulphur (S) for oilseeds, Calcium (Ca) source for legume and ameliorant for salt affected soils. Gypsum enhances crop yields and nutrient use efficiency in variety of soils and crops. Two types of gypsum are being used for agronomic purpose, one is naturally mined gypsum, and other one is synthetic gypsum produced as industrial by-product. Gypsum is recognized as multi-tasking amendment (Figure 1).

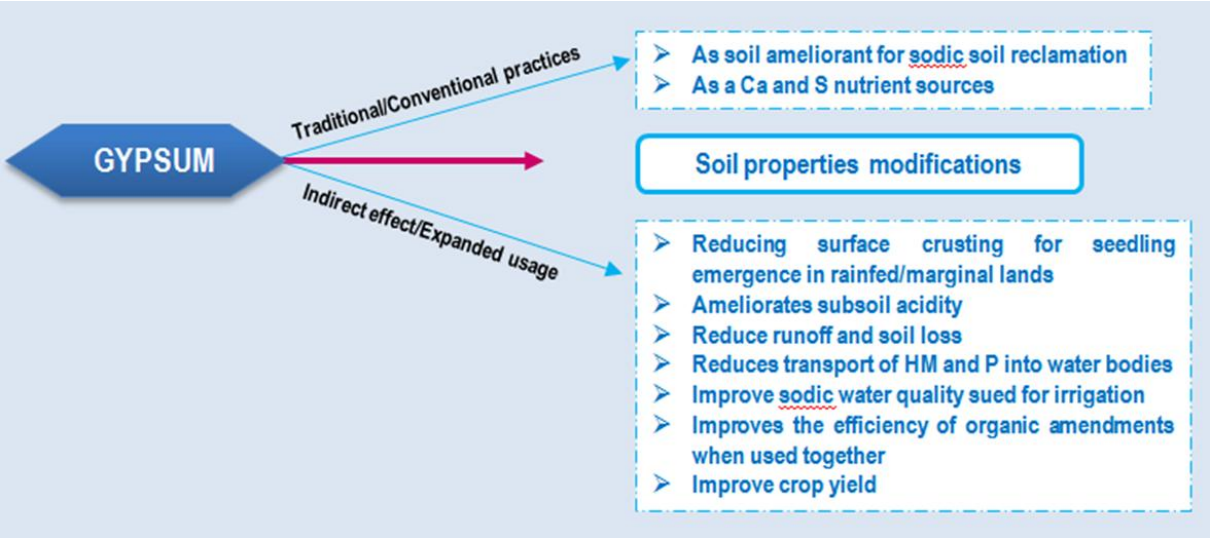

Figure 1. Multitude impact of gypsum on soil properties, crop and environment quality

SOME IMPORTANT FUNCTIONS OF GYPSUM

Sodic Soil Reclamation: Gypsum is the most common reclamation strategy for salt affected soils. In soils with high exchangeable sodium percentage (ESP), gypsum application replaces Sodium (Na) with Ca on soil colloidal surface. Ca supplied through gypsum acts as a stabilizing agent that further prevents dispersion of aggregates. Amelioration of soil physical and chemical properties by gypsum alleviates salt stress by providing high Ca content and increasing ionic strength. This is because of the high solubility of gypsum, increases electrolyte concentration in soil solution, increasing soil permeability resulting in more water infiltration through soil profile. This is reflected by reducing dispersion of soil colloids and flocculation of soil particles.

Nutrient Source for Crops: In the recent years, use of S free agricultural chemicals, lower use of single super phosphate, less atmospheric S deposition etc. has reduced the quantity of available S in soils. Oilseed crops have high S requirement and removes 10 to 25 kg ha^{-1} S. Gypsum, being a good source of Ca and S, can be a good alternative for oilseed farmers. Gypsum is commonly applied in peanut for better peg formation and to keep it disease free. Sufficient amount of Ca is the prime requirement to keep peanuts disease free. Also, Ca is essential for crop root growth, especially in subsoils with suboptimal pH. Gypsum is 200 times more soluble than limestone when applied to neutral soil pH and allows movement of Ca and S within soil profile. Increased Ca uptake with gypsum by plant roots can reduce soil pH of rhizosphere, thus have an effect on the availability of iron and zinc to crops. The quantity of gypsum required to increase Ca in soil solution is less compared to quantity of lime required in chemical equivalent terms. Application of gypsum also prevents blossom end rot in tomatoes and bitter pit in apples.

Reduce Soil Erosion: In the arable soils of semi -arid regions, surface sealing and soil crusting common phenomena that cause soil erosion. To enhance infiltration, decrease surface sealing/crusting, reduce runoff and soil loss gypsum has been used in many regions of the world. In general, application of gypsum at higher rates (1.1 to 10 t ha^{-1}) is recommended for soil and water conservation, depending upon the soil type, slope and weather conditions. According to Chen and Dick (2011) gypsum rate can vary between 100 kg ha^{-1} to several mega grams per hectare, when used as soil conditioner. It improves soil and water characteristics by influencing soil physical properties which directly impact runoff, sediment and nutrient losses. Norton, (2008) reported decrease in soil erosion and runoff in gypsum amended no-till and reduce till fields. Gypsum increase surface roughness and the tortuosity of the flow paths to reduce overland flow and sediment losses. Rashmi et al. (2021) reported gypsum alone and combined with organic amendments reduced runoff and soil loss by 26 and 29 percent respectively under soybean-mustard cropping system of western India.

Ameliorant for Subsoil Acidity: Sub-soil acidity, a common phenomenon observed in Ultisol or Oxisol, where aluminium (Al) toxicity, rather than Ca deficiency hampers root growth. In such soils, reclamation cannot be fully achieved by lime application. Gypsum also known to alleviate subsoil acidity by displacing Al with Ca, followed by reaction of Al with sulphate to reduce Al toxicity (Shainberg et al., 1989). Potential of gypsum to reduce surface crusting and ameliorate sub soil acidity by improving water penetration, thus, increases crop yield. This decrease in subsoil acidity will enhance root proliferation that in turn improves water and nutrient use efficiency. On acid soils gypsum increases crop yields through improving subsoil fertility.

Improve Soil Properties: In soils, addition of gypsum improves its physical and chemical properties. Gypsum improves soil structure, by providing Ca which improves flocculation, favourable for root growth, air and water movement. Improvement in hydraulic conductivity and exchangeable Ca and Ca/Mg ratio was found with higher level of gypsum. Soils with high clay content that may open deep cracks in soil profile can be amended with gypsum which keeps the soils from drying out and developing cracks. In gypsum amended soils, positive effect of increased exchangeable Ca:Mg ratio improves soil structure, infiltration capacity, thus increases water storage and water penetration into soil profile.

Gypsum treated soil become more friable, prevents crusting making seedling emergence more uniform. Also, these soils are safe to till with reduced chance of compaction and deflocculation. Soil pH might increase or decrease with gypsum addition depending upon soil

mineralogy and cation exchange capacity. The magnitude of change in soil pH is small varying between 0.2-0.3 units which either increase or decrease soil reaction. Gypsum addition increases stability of soil organic matter by forming soil-Ca-organic matter complex giving stability to soil aggregates.

Besides improving chemical and physical properties, gypsum enhances the values of organic amendments. Bioaugmented gypsum application increases microbial diversity, respiration and biomass. Remarkable effect of organic amendments with gypsum on soil properties reduces salinity effect more efficiently as compared to their sole application.

Enhance Availability of Other Nutrients: S in gypsum, have synergistic effect on nitrogen availability and improve its use efficiency. Both N and S have regulatory effect on each other, as both are involved in protein synthesis. Some studies reported significant improvement in crop yield when low rates of both N and S are applied. However, few studies reported no effect of high rate of gypsum application on N use efficiency. Phosphorus availability also increases with gypsum application by balancing concentration of electrolytes in soil solution. Moreover, change in soil pH as influenced by gypsum can significantly affect P availability in soils. Similarly, acidifying effect of gypsum increases solubility of micronutrients such as zinc, iron, and copper, and improves its availability in soil solution. Various studies highlighted the different interaction of gypsum with nutrients showing inconsistent patterns, illustrates that it is highly depends on site-specific soil characteristics and management practices.

Impact on Crop Yield: Yield responses associated with gypsum application highly depend upon crop type, soil properties, time lapse and rate of gypsum application, rainfall patterns etc. Generally, amendment of soil with gypsum improves crop yield in most cases, and it is related with supply of Ca and S nutrients to crops, and improving soil environment. Ca plays an important role in biochemical mechanism of plant metabolism which helps in the assimilation of other nutrients by plant roots. Oilseed crops such as mustard, groundnut, soybean etc are highly responsive to S. Gypsum improves efficiency of acidic soil amendments (lime, silicate etc), because of its higher solubility and mobility of Ca through the soil profile. This movement of Ca influences growth of roots to deeper soil layers thereby reducing water stress during drought period. In oilseed crops, S requirement is very high and addition of gypsum improves oil quality of oilseed and protein content of pulse crops.

In moderate sodic soil, positive yield response with gypsum was reported due to improved infiltration capacity and better crop population/stand. The cumulative infiltration increase almost 50-100% with gypsum usage, enhancing water availability to crops showing positive crop yield responses. In most of gypsum-based experiments, adequate S availability and improved S uptake by crops shows positive effect on yield. Besides S, gypsum increases Ca nutrient in soil solution better than lime, and this contributes to better root growth, reducing Al toxicity in acidic soils. Typically, in calcareous sodic soils, gypsum can improve physical and chemical properties, but addition of organic amendments mobilizes inherent Ca and precipitates as $CaCO_3$. Thus, use of organic manures with gypsum increases soil organic carbon stock which is directly associated with improved crop yield/biomass.

Environmental Benefits: Soils subject to intensive fertilizer applications, organic manure loadings on N basis are often susceptible to erosion, nutrient losses, heavy metal accumulation, transport of pathogens etc to water bodies. Gypsum amendments immobilize heavy metals and pathogenic micro-organism (*E.coli*) present in organic manures or biosolids.

Gypsum is successfully tested as P sorbing material especially in fields with higher application of poultry litter or manures, thus prevents chances of algal bloom or eutrophication in water bodies. This is because Ca precipitates with P, reducing soluble reactive P content in water and thus could improve water quality. However, use of other sources such as phosphogypsum, flue gas desulfurization gypsum sources can sometime be potential environmental concerns as they contain trace metals, radioactive compounds or other pollutants. As final consideration, such gypsum sources can be use for agronomic purpose should be monitored regularly to know loading and mobility of contaminants in soils.

CONCLUSION

Gypsum is easily available, economic and commonly used soil amendment highly preferred for agronomic and soil reclamation purposes. However, in order to take the multi-benefits of gypsum amendments, and its worthwhile responses on soil properties and crop yields, gypsum requirement of the soil to be determined. Moreover, in sodic soils, addition of gypsum ameliorates salt stress, improves soil tilth, water infiltration showing positive impact on crop yields. Gypsum is usually broadcasted in soil and thoroughly incorporated in plough surface before crop sowing. Irrigation or rain is required to leach down soluble salts in profile, away from rooting zone. Gypsum combined with organic amendments are found to more effective in reducing deleterious Na effect, enhance cost effectiveness, more eco-friendly and improves overall soil health for longer duration. Gypsum thus has multitude impacts on soil physic-chemical properties, ultimately influencing crop production and environmental quality.

REFERENCES

Chen L. and Dick W. A. 2011. Gypsum as an agricultural amendment: General use guidelines. *Ohio State University Extension.* http://ohioline.osu.edu/b945/b945.pdf

Norton L. D. 2008. Gypsum soil amendment as a management practice in conservation tillage to improve water quality. *Journal of Soil and Water Conservation*, *63*(2), 46A-48A.

Rashmi I., Ali S.,Mina B.L., Kumar K.,Kumar A, and Singh R.K. 2021. Short-term effect of resource conservation practices on soil loss, productivity and energy budgeting of soybean–mustard system in table lands of Chambal ravine. *Agricultural Research*.10: 223–233.

Shainberg L., Sumner M.E., Miller W.P., Farina M.P.W., Pavan M.A. and Fey, M.V. 1989. Use of gypsum on soils: a review. Advances in Soil Science 9: 1–111.

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