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The Function of Sulphur in Plant Nutrition

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Sulphur is a non-metallic chemical element with the letter S as its symbol. Sulphur is the thirteenth most crucial element in the earth's crust and occurs naturally in the environment. Like nitrogen, phosphorus, and potassium, sulphur is an essential plant nutrient. Like Mg and Ca, it is a secondary element, yet it is frequently referred to as "the fourth important nutrient." Some crops can absorb as much S as they can P. For various reasons, sulphur has become an essential limiting nutrient in crop yields in recent years. Higher agricultural yields need more S. Contemporary fertilisers with fewer S impurities, less use of S-containing herbicides, lower industrial S emissions into the atmosphere, and a greater understanding of S demands are among them.

Sulphur's role in plants

Sulphur content in plant dry matter ranges from 0.2 to 0.5 per cent (about the same percentage as phosphorus). Sulphur's most crucial role in crop production is to aid in forming protein molecules and amino acids, which are essential for the production of chlorophyll, lignin, and pectin. It accomplishes this by assisting photosynthesis, which is the process by which plants transform sunlight into chemical energy. Sulphur aids nitrogen metabolism in one component of protein formation. A plant tissue test that finds a sulphur shortage will almost certainly detect a nitrogen deficiency. Sulphur (like nitrogen) is required early in the season since they are both structure-building components. The plant requires sulphur to construct the factory to generate the seeds or fruit. Sulphur insufficiency causes slowed development as well as a light green colour. Anything that slows down development causes maturity to be delayed. Corn with a sulphur deficiency delays tasseling and pollination and matures later. As a result, plants become less efficient and produce less growth every day. A sulphur shortage manifests itself below ground as a slow-growing, more minor, and inefficient root system. The light green coloration, limited development, and delayed maturity resemble nitrogen shortage symptoms. The primary distinction is that nitrogen deficit manifests itself in the plant's bottom leaves, whereas sulphur deficiency manifests itself in its younger development, the top leaves or whorl. Sulphur, unlike nitrogen, is not mobile in the plant; therefore, it cannot be mobilised from older parts and moved to younger ones.

Sulphur uptake

Sulphate is the primary form of sulphur that plants may take up, except for a small quantity of sulphur in rainfall or foliar application of sulphur fertiliser. To satisfy the plant's demands, the huge amounts of sulphur required for crop production must be taken up by the root system. The quantity of sulphur the plant consumes is determined by how much of the nutrient the roots come into touch with as they develop through the soil. Sulphate diffuses, and mass flows toward the roots in the soil. Sulphate diffuses from a more concentrated state

to a less concentrated state, similar to how food colour diffuses in water. More water is drawn out of the soil by transpiration, carrying sulphate.

The sulphur cycle

Sulphur exists in three forms in the soil: sulphide gas, sulphide minerals, and elemental sulphur, all of which must be oxidised into sulphate before plants can utilise it. All of these sources are subjected to oxidation. Sulphur, like nitrogen and phosphorus, goes through a cycle in which it transitions from an organic form that plants can't utilise to an inorganic one that they can use and return to. Sulphur is immobilised by some microorganisms and plants, while it is mineralized (or oxidised) by others. Mineralisation and immobilisation occur simultaneously. Figure 1 depicts the sulphur cycle, which depicts how sulphur reaches the crop, the many forms of sulphur, and what happens to the sulphur, such as plant absorption, leaching, and volatilization. It's important to remember that sulphur, like nitrogen, gets lost from the soil. Sulphur is absorbed as the ion sulphate, and it can also enter plants as the gas sulphur dioxide. The mineralisation of organic materials releases sulphur into the soil solution. Because 95 per cent of the sulphur in the soil is bound up in organic matter, low organic matter soil might be insufficient. Mineralisation can provide 1.4-2.3 kilogramme of sulphur for every 1% of organic waste. Sulphur deficiency is becoming increasingly common in soils, and sulphur fertiliser has grown more significant as crop yields increase and more sulphur is removed. Simultaneously, crops are absorbing less sulphur from the air as a result of reduced usage of high-sulphur coal and removal of sulphur dioxide from stack gases (up to 25-35 kg/hectare of sulphur used to be deposited free in industrialised nations *via*., acid rain).

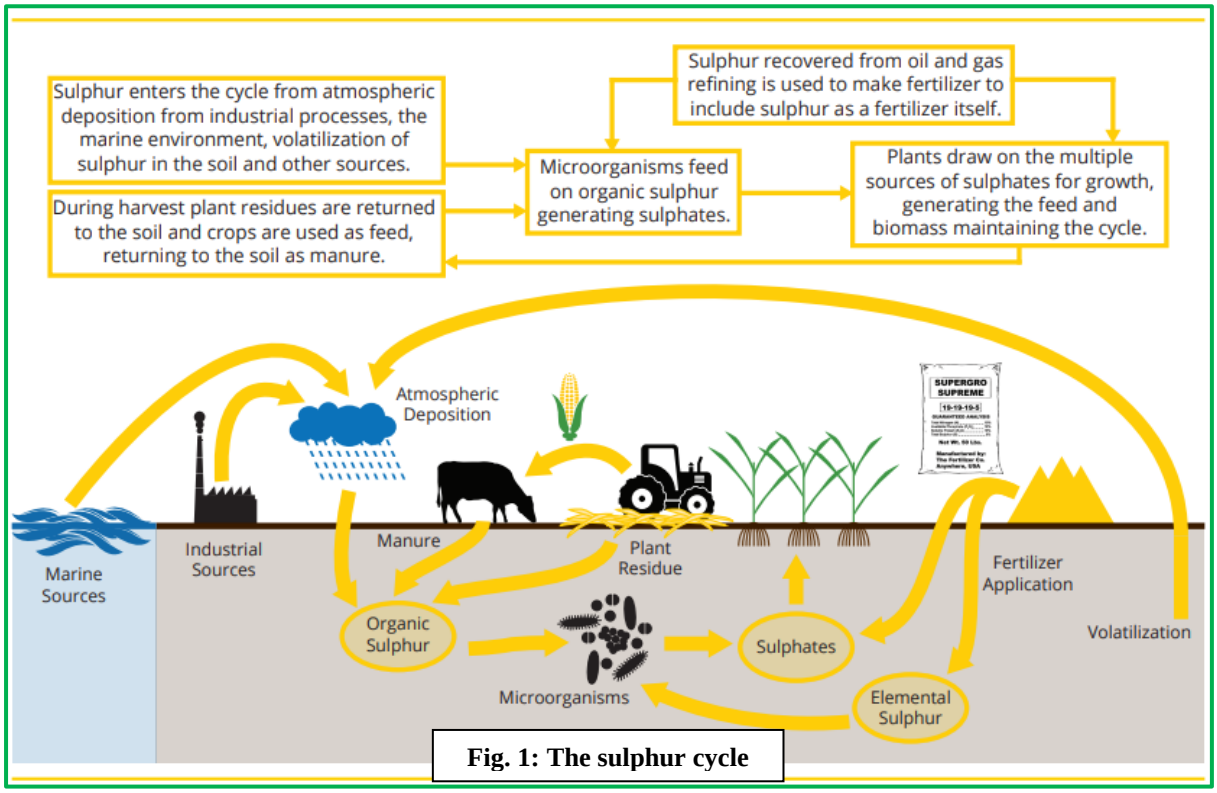

Fig. 1: The sulphur cycle

Sulphur in Indian Agriculture

Sulphur fertilisers can be divided into various categories. The Fertiliser Control Order (FCO) has incorporated a number of them, and their sulphur content is now part of the fertiliser requirements. Sulphur fertiliser pricing and use are inextricably tied to fertiliser policy, which have a direct impact on the sulphur fertiliser business.

Table 1: List of S fertilizers

A. Sulphate Containing Fertilizers	B. Fertilizers Containing Elemental Sulphur
Ammonium Sulphate	Elemental Sulphur
Single Super Phosphate	Sulphur Bentonite
Ammonium Phosphate Sulphate	Elemental Sulphur Fortified N/P Fertilizers
Potassium Magnesium Sulphate	Elemental Sulphur Fortified N Fertilizers
Potassium Sulphate	Sulphur Coated Fertilizers
Magnesium Sulphate	**C. Liquid Sulphur Fertilizers**
Sulphates of Micronutrients	Ammonium Thiosulphate
Gypsum	Potassium Thiosulphate

Table 2: Sulphur Containg Fertilizers

Sulphur Containing Fertilizers	Nutrient Content in %			
	S	N	P_2O_5	K_2O
Ammonium Sulphate	24	21	-	-
Single Super Phosphate	12	-	16	-
Potassium Sulphate	18	-	-	50
Ammonium Phosphate Sulphate	15	16-20	20	-
Elemental Sulphur	85-100	-	-	-
Zinc Sulphate	10-15	-	-	-
S-fortified Ammonium Phosphate	15	13	33	-

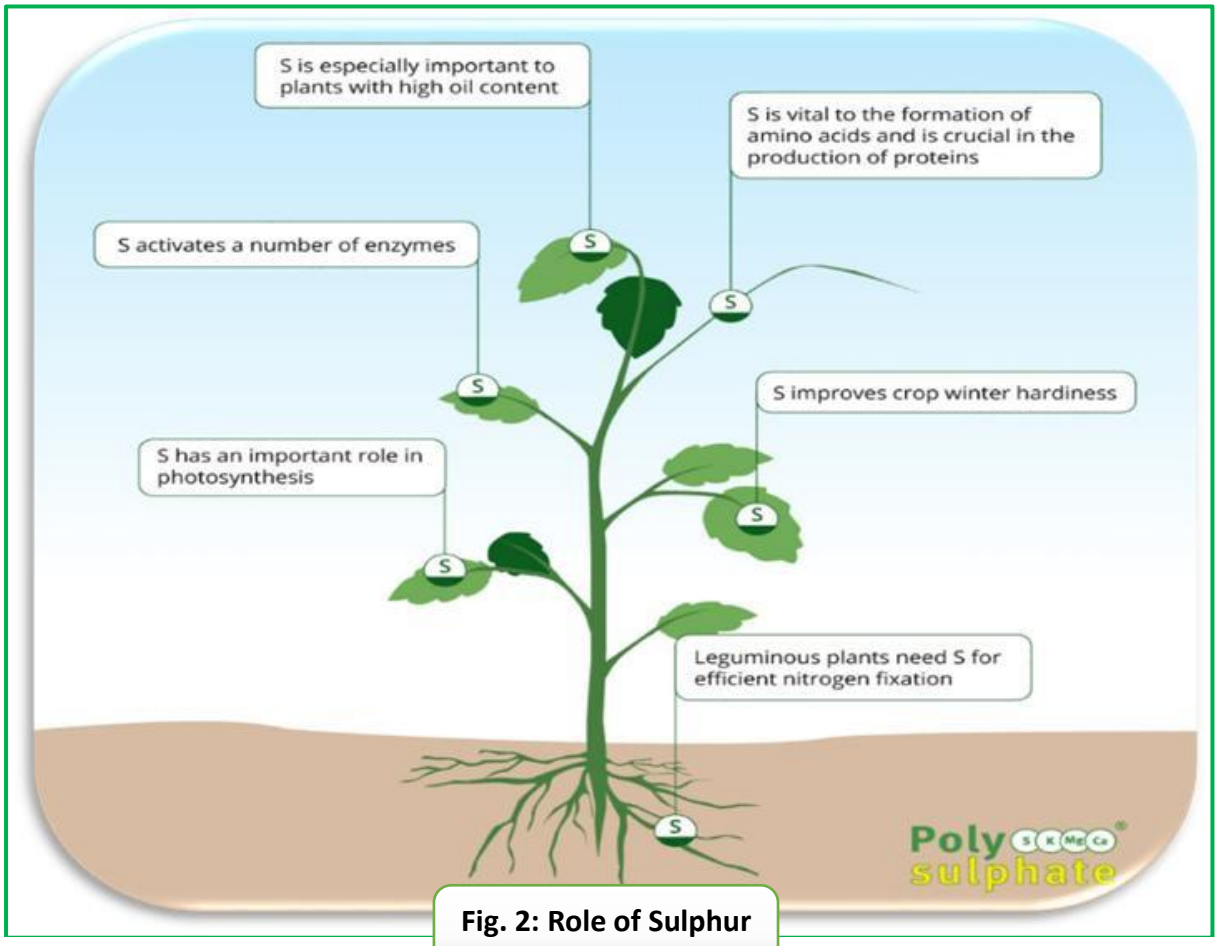

Fig. 2: Role of Sulphur in Plants

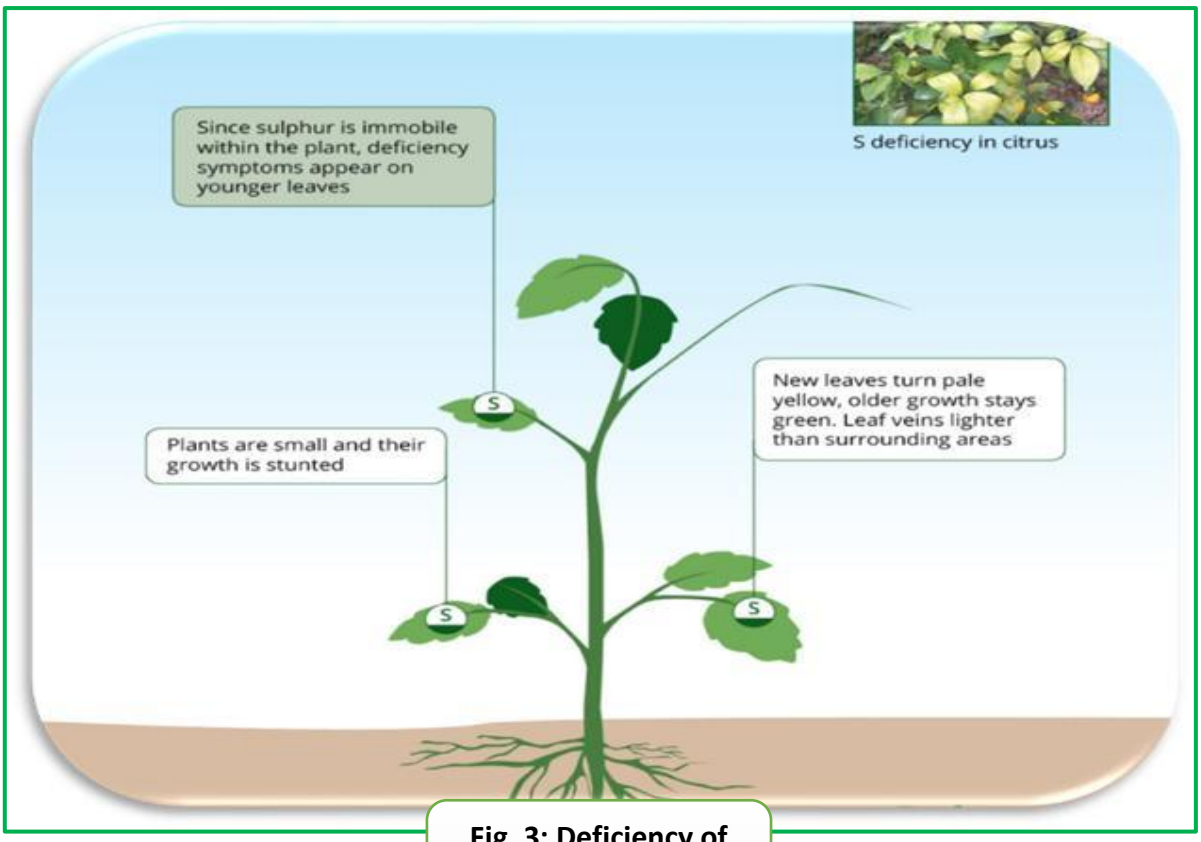

Fig. 3: Deficiency of Sulphur in Plants

Conclusion

Agricultural fertiliser production accounts for over 54% of all recovered sulphur generated globally, which is utilised to feed a hungry world. Sulphur science has remained unchanged. Sulphur will continue to be an important plant nutrient as the Internet of Things, digitalization of agriculture, machine learning, artificial intelligence, and big data bring about changes.

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