Sulphur Nutrition for Quality Crop Production and Soil Health Sustenance

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ABSTRACT

Sulphur is one of the essential elements required for plant growth and development and has also been acknowledged for improving productivity and quality of the crops. Globally, the rising demand for adequate and highly nutritious food for the increasing human population, there is a need to enhance overall food production. Sulphur deficiencies in soils during post-green revolution period have been found to be one of the major constraints for sustainable growth and productivity of several field crops. One of the ways for improving crop production and productivity is through modifying soil nutrient supply. The N, P and K hold the major share of recommended dose of nutrients supplied to the crops and nutrients such as sulphur are supplied in inadequate amount through high analysis fertilisers only and ultimately deteriorating the soil health. Sulphur has received little attention from many years because previously it was thought that fertilizers and atmospheric deposition sufficiently supplied the soil with enough of the nutrient. Such negligence has resulted in soils deficient in sulphur and other essential nutrients and sulphur status of Indian soils is decreasing with each passing year.

INTRODUCTION

Sulphur is considered as quality nutrient as its application not only influences crop yield but also improves crop quality owing to its influence on protein metabolism, oil synthesis and formation of amino acids. It is a constituent

of three amino acids viz. Methionin (21% S), Cysteine (26% S) and Cystine (27% S), which are the building blocks of protein. Therefore, access to an adequate supply of S for plants throughout their development is necessary for optimum crop performance. Sulphur deficiencies in soils during post-green revolution period have been found to be one of the major constraints for sustainable growth and productivity of several field crops. In India, removal of S by crops is about 1.26 million tonne (Mt), whereas its replenishment through fertilizers is only about 0.76 Mt leading to continuous mining and long lasting negative impacts on the soil health (Tiwari and Gupta 2006). Improper and imbalanced use of chemical fertilizers coupled with less addition of organic manures, has resulted in deterioration in physical, chemical and biological properties of soil. The scenario of sulphur deficiency is more pronounced in Alfisols compared to Vertisols due to the low organic matter content. In sulphur deficient condition, the use efficiency of applied NPK fertilizers and the economics of their use may be seriously affected. Complete yield potential of a crop cannot be obtained where soil is suffering with sulphur deficiency, even irrespective of all the other nutrients application and under excellent management practices.

Sulphur forms and transformations in soil

Sulphur is the most abundant and widely distributed element in the nature and found both in free as well as combined states. Sulphur exists in soil mainly as organic sulphur compounds and inorganic sulphide (S^{2-}), elemental sulphur (S^0) and sulphate (SO_4^{2-}). About 98 per cent of the total soil sulphur occurs in form of organic sulphur compounds and comprises a heterogeneous mixture of plant residues, soil microbes and animal manures. The organic form is not directly available to plants until it undergoes mineralisation by micro-organisms to release SO_4^{2-} for plant uptake. The transformation between these forms occurs by the processes of mineralization, immobilization, oxidation, and reduction.

Mineralization

The breakdown / decomposition of large organic sulphur compounds to smaller units and their conversion into inorganic compounds (sulphates) by the microorganisms. The rate of sulphur mineralization is about 1.0 to 10.0 percent / year.

Immobilization

Microbial conversion of inorganic sulphur compounds to organic sulphur compounds.

Reduction-oxidation reactions of sulphur

In the process of microbial decomposition of organic sulphur compounds, sulphides are formed along with other incompletely oxidized substances, such as elemental sulphur, thiosulfates, and polythionates. These reduced forms are then subjected to oxidation.

$$H_2S + 2O_2 \text{--------} H_2SO_4 \text{-------} 2H^+ + SO_4^{2-}$$

$$2S + 3O_2 + 2H_2O \text{------} 2H_2SO_4 \text{------} 4H^+ + SO_4^{2-}$$

Oxidation of sulphur in soil is biochemical in nature, carried out by a number of autotrophic bacteria, and occur at pH values not less than 2 and greater than 9. Sulphate ions tend to be unstable in anaerobic environments. These ions are reduced to sulphide ions by a number of bacteria of two genera, Desulfovibrio and Desulfotomaculum. The organisms use the oxygen present in sulphate to oxidise organic material. The oxidation and reduction reactions of inorganic sulphur

compounds play an important role in determining quantity of sulphur present at any time in the soil.

Effect of sulphur on quality crop production and soil health sustenance

Knowledge of different forms of S is of much relevance in assessing the long-term availability of nutrients and in formulating strong fertilizer recommendations. In a study, Dutta et al. (2013) observed that continuous application of chemical fertilizers and amendments improved all the S fractions in soil except where S was not applied. Soil enzymes play a crucial role in sustaining the soil health by enabling the breakdown of organic matter into nutrients that plants can use for growth and development. Sulphur is essential as microbial-S for the micro-organisms. In an experiment, Ram et al. (2016) reported that application of sulphur through gypsum or phosphogypsum in soil improved the soil microbial properties like Microbial biomass carbon (MBC), Dehydrogenase activity, Fluorescein diacetate (FDA) hydrolysis and Arylsulphatase activity. Improvement in quality parameters of wheat crop viz. crude protein, gluten, ash and carbohydrate as compared to control was reported with application of FYM and lime along with recommended doses of fertilizers was reported by Chauhan et al. (2020). Improvement in quality parameters under the influence of FYM which is the major source of sulphur might be attributed to its important role in providing the secondary and micro nutrients along with primary nutrients and improving the physical chemical and biological properties. They further reported that imbalanced fertilization for the last 45 years has led to decline in quality parameters of wheat.

CONCLUSION

Sulphur deficiency is currently one of the key constraints for the sustainable growth and productivity of a number of field crops. Efficient management of sulphur is the only way to make Indian soils jump out of the deficiency. Ensuring quality crop production is possible only through balanced application of nutrients including Sulphur. Thus, sulphur as a source must be given priority.

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