INTRODUCTION

Agriculture, whose share in India's GDP is around 26%, supports more than 70% of the country's population. Even though agriculture's share has been steadily declining over time, it is still a major indicator of the state of economy of India. Oilseeds stand next only to food grains in the acreage, production and value. They are cultivated over an area of 26 million hectares with a production of about 25 million tonnes. These crops, next to food crops hold a sizeable share of the country's gross cropped area (13%) and contributes 5% of its GDP and 10% of the value of all agricultural products. Among the oilseed crops, Brassica crops play an important role in the international market of vegetable oil, meal and seed. Oil extracted from the seeds has a long history of consumption by man. It is an important source of essential fatty acids, namely those of the n-6 and n-3 families of polyunsaturated fatty acids. These fatty acids are important constituents of cell membranes and serve as precursors of a variety of biologically active components known collectively as eicosanoids (e.g., prostaglandins, thromboxanes, and leukotrienes). Besides the oil, seed meal obtained after extraction of the oil constitutes a good quality protein for livestock and poultry. It contains 40-50% protein in the dry matter with a well-balanced amino-acid composition.

Rapeseed-mustard is the third most important among oilseed crops of the world, after soybean and palm. Over 13% of the world's edible oil requirement is now met by these crops. India has the largest acreage under these crops and is the second important producer in the world. In India, rapeseed-mustard (known as 'sarson' in local parlance) ranks second after groundnut in area and production. The crop occupies an area of approximately 6 million hectares with a production of about 6 million tonnes of seeds. It accounts for 23% of total oilseeds production in country. In Indian scenario, the gap between demand and supply of oil is very wide as the land under oilseed cultivation is limited and the population is increasing. Moreover, due to the increasing incidence of cardiac diseases the demand of vegetable oil is increasing. At present, the demand-supply gap is around 1.5 million tonnes, whereas the import of edible oil during 1998-99 is estimated to be at the level of 3.3 million tonnes. Such a situation cannot be allowed to continue for long and a long-term strategy may have to be evolved to boost the domestic production of oilseeds. Consequently, to fill this gap between demand and supply, the agricultural scientists have laid emphasis on improving oilseed production through
proper nutrition of the oilseed crops, by evolving high yielding varieties and adopting improved agronomic practices as well as plant protection measures. These efforts have led to increase in the oilseed production from 12.65 to 25.30 million tonnes during the past ten years (1998 to 1999), while the rapeseed-mustard production has remained stagnant since 1995 (Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India). This could be due to the shortage of plant nutrient, sulphur (S) in the Indian soils as it is evident from the report of joint survey conducted by FAO and ICAR (Abdin et al., 2003; Aulakh and Bahl, 2001; Singh, 1991). The reason for this includes intensive agriculture coupled with the use of high yielding cultivars and high analysis fertilizers as well as pesticides.

Sulphur (S) is increasingly being recognized as the fourth major plant nutrient after nitrogen, phosphorous and potassium. It is the tenth, most abundant element in the universe. Despite its essentiality, it has been described as the neglected plant nutrient. In the past, the requirement of S has been met by the incidental presence of sulphur in NPK fertilizers like ammonium sulphate, ammonium sulphate nitrate, single super phosphate, and sulphate of Potash; thus S-deficiency was rare. The recent trend in fertilizer production is of high analysis type like urea, triple super phosphate, diammonium phosphate and very little sulphur is added to the soil through the use of these fertilizers. Current estimates are that the annual crop uptake of S in India is around 1.0 million tonnes, whereas addition through fertilizers is around 0.34 million tonnes. Without change in recent fertilizer consumption trends, India will have an annual sulphur deficit of 1.6 million tonnes by 2010, which will be nearly a 100 percent increase from 1991 (Tandon, 1995). So, the gap between sulphur addition and its removal is high which is likely to increase with the higher requirement of production. This will further aggravate the current situation of S-deficiency in Indian soils, unless corrective measures such as S-application in the form of fertilizers will not be taken.

Being the constituent of amino acid, namely methionine, that initiates protein synthesis, S-deficiency affects various metabolic processes including photosynthesis due to the impaired protein synthesis. A strong metabolic coupling exists between sulphur and nitrogen assimilation. Sulphur interacts with nitrogen in such a way that the inadequacy of one reduces the uptake and assimilation of the other. Clarkson et al. (1989) observed a marked depression in the ability of cereal plants to take up nitrate and ammonium when plants were starved of sulphur, which was accompanied with the
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The augmented capacity of sulphur uptake. S uptake and assimilation has been shown to be dependent upon a constant supply of the precursor of cysteine, O-acetylserine, whose synthesis, in turn is dependent upon adequate N availability. Cysteine may be involved in the repression of the synthesis of other amino acids, ultimately repressing N-uptake and assimilation. Moreover, as nitrogen occupies a very important place among all the essential nutrients in soil and crop productivity is largely determined by it, hence, soil fertility and soil nitrogen have become almost synonymous to each other. Consequently, S-deficiency may not only result in reduced crop productivity, but also loss of nitrogen, the costly agricultural input. The adequate supply of nitrogen and sulphur is, therefore, essential to achieve optimum N-utilization efficiency, and higher yield and better quality of crops.

When a soil is deficient in S and the deficiency is not rectified, then the full potential of a crop variety cannot be realised regardless of the top husbandary practices (Aulakh et al., 1980; Singh and Bairathi, 1980; Janzen and Bettany, 1984; Sachdev and Deb, 1992; Zhao et al., 1993; Ceccoti, 1996; Ahmad et al., 1998, 1999a). Rapeseed-mustard crop not only respond to applied S, but their requirement for S is also the highest among the crop plants (Aulakh and Pasricha, 1988; McGrath and Zhao, 1996; McGrath et al., 1996), thus indicating a role of the nutrient in oil biosynthesis. The information regarding its role in the physiological and biochemical events that occur in the developing seeds during oil biosynthesis, however, is very meager. Five fatty acids, namely palmitic acid (16:0), oleic acid (18:1), linoleic acid (18:2), linolenic acid (18:3) and erucic acid (22:1) comprise 90% of the total lipid in developing seeds of mustard. Oleic acid is the major fatty acid at the initial stages of seed development and its level declines at the subsequent stages of seed development. Erucic acid content, however, begins to increase right from the beginning, and increase gradually until the seeds mature. S treatment along with nitrogen significantly decreases its content in the oil of mature seeds (Ahmad and Abdin, 2000; 2000b). Ahmad and Abdin (2000; 2000b) reported that major changes occur in the oleic acid and erucic acid content during seed development. The pattern of changes in the content of these fatty acids may be consistent with the chain elongation of oleic acid to yield erucic acid. Supply of S and N in adequate amounts during seed development reduces the conversion of oleic acid (18:1) to erucic acid (22:1), leading to the reduced 22:1/18:1 ratio, and, thus improving the quality of oil. A strong interaction between nitrogen and sulphur for seed production in