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Research Paper

Sulphur fertilization for improving yield of oilseeds and pulses –A review

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Abstract
*Sulphur deficiency is wide spread in different parts of the world including India. The reasons for its fast increase to the present level of 30% in Indian soils are discussed. It has become clear that oilseeds require S in high amounts followed by pulses, forages, tuber crops and cereals. Numerous field experiments clearly showed that more than 40 crops have responded to S fertilization with mean yield increase ranging from 14% to 74%. The large body of evidence indicates that S requirements must be an integral part of balanced fertilization for obtaining optimum crop yields of high quality (oil, protein, fatty acids, and reduced nitrate in foliage). S fertilization is a feasible technique to enhance the uptake and fertilizer-use efficiency of N, P, K and Zn, and suppress the plant uptake of undesirable, toxic elements such as Se and Mo because of the sulphur's synergistic relationships with the former and antagonistic with the latter elements. . **(Aulakh and Dev ,2003)***

The key measures needed for optimizing S use for sustainable crop productivity and reducing environmental risks are (i) timely prediction of S deficiency, (ii) timely sowing of crops, (iii) selection of proper method and right time of application of S from suitable sources, (iv) interrelationships of nutrients and balanced fertilization, (v) greater need for S recycling through green manures and crop residues, and (vi) minimizing desorption of SO_4^{2-} *from colloidal surface and leaching by avoiding the excessive use of phosphatic fertilizers. **(Aulakh and Chhibba, 2001).** There is an urgent need to delineate unexplored and potentially S-deficient areas; develop reliable, efficient and quick methods for diagnosing S deficiency in different soils and crops; identify the contribution of atmospheric pollution and irrigation waters towards S nutrition of crops; frame effective policies addressing the availability and distribution of S-containing fertilizers especially in S-deficient area; and to undertake systematic studies to malnourishment emerging as a consequence of wide spread S deficiency in animal and human beings*

Keywords*: Sulphur, Synergistic, FUE and atmospheric Pollution*

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I. Introduction :

Sulphur (S) is a non-metallic, light yellow element having an atomic number 16, atomic weight 32.06 and several oxidation states ranging from the most oxidized (+6) state as in sulphate $(SO_4)^{2-}$ to the most highly reduced state (-2) as in the sulphides ($H-_2S$). It is one of the 17 essential plant nutrients. Essentiality of S for plants was established by Salm-Horstmann in 1851. Sulphur is conventionally classified as secondary nutrient. However, this does not mean that it has a secondary role in plant nutrition. It is recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium. Sulphur requirements of crops are very similar to that of phosphorus needs.

Indian agriculture has entered into an era of multinutrient deficiency and the deficiency of at least 5 essential nutrients, viz. nitrogen, phosphorus, potassium, sulphur and zinc, is quite wide spread. Sulphur deficiency is on increase due to persistent depletion of soil sulphur. Using consolidated database of 135,000 soil-samples analysis, over 42% of samples have been found deficient in available sulphur. The increasing deficiency of sulphur has become major constraint in increasing crop productivity, quality of farm produce and farm income. Sulphur is becoming increasingly important in balanced nutrition of crops to meet complete nutrient requirement, resulting in higher use efficiency, reduction in cost and environmental impact.

Sulphur is ranked the thirteenth most abundant element in the earth's crust. Sulphur occurs as sulphides in igneous and sedimentary rocks. It is also present in organic compounds soil, in industrial wastes, sea-water and as gaseous emissions in atmosphere. The major source of sulphur under natural conditions is organic matter. More than 90% of total sulphur in soil is present in organic matter under temperate conditions, but inorganic sulphates are also important in tropics and sub-tropics. Besides organic matter, the other sources of sulphur are inorganic minerals in soil, atmospheric accretions of S through rainfall; and S addition through irrigation water. Sulphur in soil may be lost due to crop removal, leaching, erosion and volatilization.

One of richest sources of proteins is pulses. The major pulses grown in India are chickpea, red gram, green gram, black gram, red kidney bean, lentils, peas (Asif et al., 2022). These crops are mainly grown for human consumption as dal to meet the requirements of body which is of low-cost protein and its end product is used as fodder for animals (Ghosh et al., 1996; Nadathur et al., 2017). Growing pulses can improve the nutrient status in the soil by fixing atmospheric nitrogen to the soil as pulses are leguminous crops and maintain soil fertility and improves soil health (Abobatta et al., 2022; Sahu et al., 2020). Pulses are considered as poor man's meat as it provides energy and imbalances proteins, vitamins and minerals as deficiency of protein is major in India (Sahu et al., 2021). The edible portion of green gram contains calcium-75mg, phosphorous-4.5grams, protein-24.5g and 348k cal energy. In present year 2021, about 45grams of pulses was available per capita daily it shows there is an increase compared to 2020 (Statista Research Department, 2022). Area of cultivating pulse crops was estimated around 29million hectares production of pulses in India was estimated that 25million metric tons in 2021 (Statistics Research Department, 2022)

Sulphur in the Earth Crust

In the earth's crust, S is present in very small amount as compared to iron (5.0 %), calcium (3.6 %), potassium (2.6 %) and magnesium (2.1 %) . Sulphur in the earth crust occurs as elemental sulphur, sulphide and sulphate minerals. The sulphate minerals include anhydrite (CaSO4), gypsum ($CaSO_4$.2H2O), barite ($BaSO^4$), Kieserite ($MgSO^4$- H2O) and epsonite (MgSO42H2O), while the sulfide minerals include pyrites (FeS2), chalcocite (Cu2S), bornite (Cu5FeS4), digenite (Cu9S5), tetrahydrite (Cu12Sb4S13), molybdenite (MoS2), sphalerite (ZnS), galena (PbS) etc. . Elemental S is found near hot springs and volcanic regions in Indonesia, Chile, Japan and Italy .The anaerobic bacteria acting on sulphate minerals, such as, gypsum in salt domes produce S. Such deposits in salt domes occur along the coast of Gulf of Mexico and evaporate in Europe. Fossil based S deposits from salt domes which have been recently the basis of commercial S production in USA, Russia, Turkmenistan and Ukraine . However, today most elemental S is produced as a byproduct of natural gas and petroleum industry

Function of sulphur in plant:-

Sulphur plays an important role and has specific functions to perform in plant metabolism. The keyfunctions of S in plants are:

✓ Helps in production of protein because S is constituent of 3 inter-related sulphur-bearing amino acids (cysteine 26% S, cystine 27% S and methionine 21% S).

✓ Necessary for formation of chlorophyll, the green substance in leaves that is the key compound for photosynthesis to take place in plant.

✓ Constituent of nitrogenase, an enzyme involved in biological nitrogen fixation and nitrate reductase, an enzyme which catalyzes the synthesis of plant proteins from the absorbed inorganic nitrogen. It helps in stabilizing protein structure.

✓ Involved in the metabolic activities of vitamin (biotin and thiamines and coenzyme.

✓ Helps in synthesis of oils there by crucial for oilseed production Promotes nodulation for biological N fixation in legumes .

The major causes of increasing sulphur deficiency in Indian soil -

✓ Increased agriculture production catalyzing the removal of Sulphur.

✓ Increase in net depletion of soil sulphur due to due to complete crop removal(grain +straw).

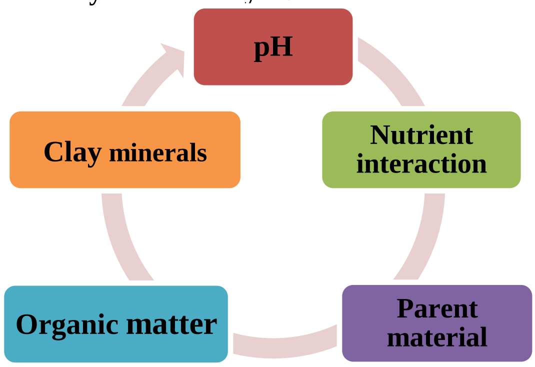
✓ Low level of Sulphur fertilization used even for high sulphur requirement crops like pulses and oilseed.

✓ Intensification of agriculture, i.e., taking more number of crops from the same land

✓ Use of high-yielding varieties and increased crop production.

✓ Losses of sulphur from soil through soil erosion, volatilization and leaching.

Factor Affecting Availability of Secondary Nutrient-



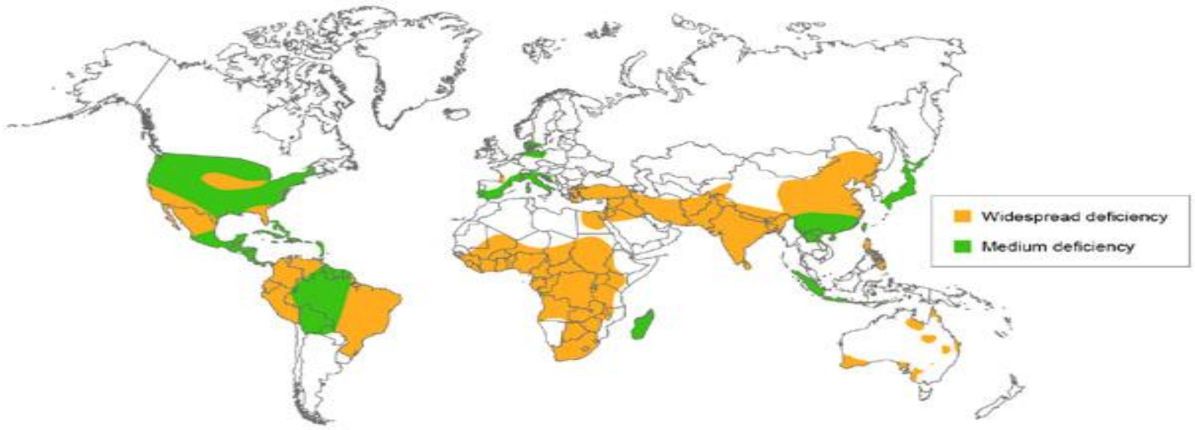
1. **Ph :-** In case of S, Sulphate ions can be loosely held by positive charges developed on soil colloids under low concentration Unlike nitrate and chloride ions, sulphate is less amenable to leaching losses.

2. **Clay minerals :-** Adsorption of sulphur in soils containing high amounts of hydrous-oxides of Fe and Al is common, especially in Ultisols, Oxisols, and Alfisols. Adsorbed sulphate-sulphur can account for up to one-third of the total sulphur in subsoils, while the same fraction represents less than 10% of the total sulphur in the surface soils. Sulphate-sulphur adsorption by soils is beneficial since it protects sulphur from getting leached out of the root zone in high rainfall areas.

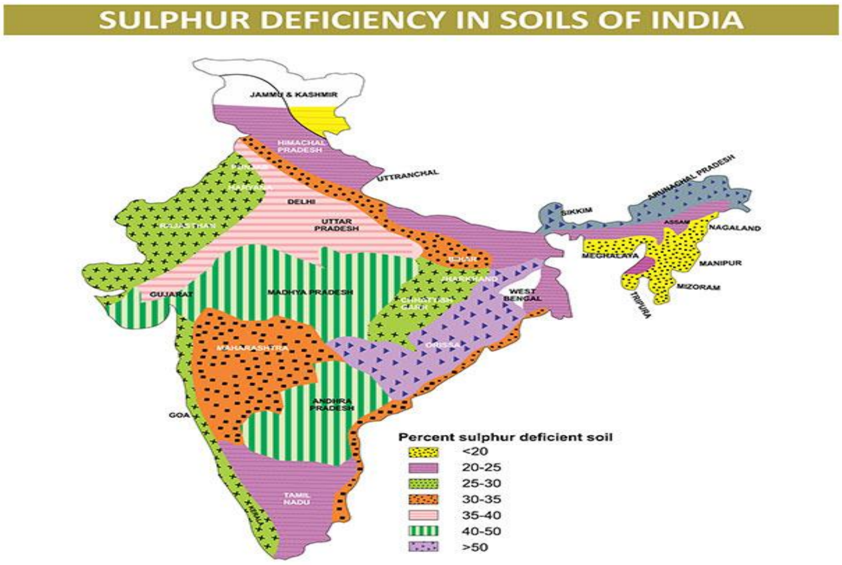
3. **Nutrient interaction:-**Nitrogen-sulphur interactions are positive or synergistic as both are the key constituents of proteins. The N.S ratio of 16:1 is often used for separating S-deficient plants from the non-deficient ones. Depending on the rates of application, phosphorus sulphur, magnesium-sulphur and boron-sulphurinteractions could be synergistic or antagonistic. For example, Aulakh et al. (1990) reported that the interaction in soybean was positive at 80 kg P.O, ha', but became negative at 120 kg PO, ha' in light textured soils of Punjab (Table 20.3). Presence of excess amounts of anions like phosphates, nitrates and chlorides can also induce sulphur deficiencies.

4. **Organic matter:-** Most of soil sulphur resides in the organic fraction and hence soil organic matter content has direct bearing on S availability in the soil.

Status of Sulphur in world:-
In the world , wide- spread deficiency of sulphur is found in Indian sub-continent , Africa and some parts of America. Medium deficiency of sulphur is occurs in North America and in some patches in Europe.



Status of sulphur deficiency in India:-
In the early 1990s, sulphur deficiencies in Indian soils were estimated to occur in about 130 districts. More recently, soil fertility surveys by the ICAR system (analysis of 60,000 soil samples) have shown sulphur deficiencies to be a widespread problem. A soil is considered deficient in S if it tests less than 10 mg S/kg soil extractable with 0.15% $CaCl_2$.



A = 45% districts having more than 40% soil samples deficient in S
B = 40% districts having 20-40% soil samples deficient in S
C = 15% districts having less than 20% soil samples deficient in S

Forms of Sulphur in soil:-

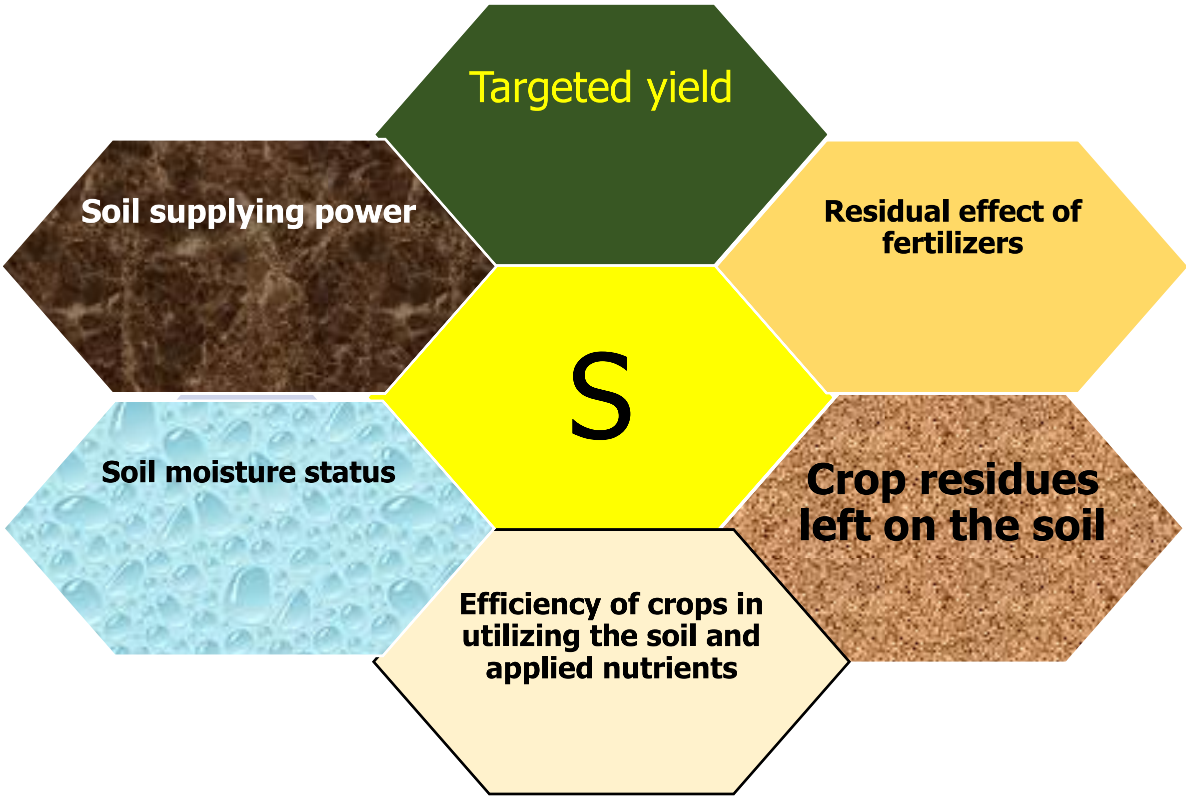
Sulphur in soils can be broadly grouped in 4 forms, namely total S, organic S. non sulphate S and available S. Total S is the sum of different fractions of S such as organic sulphur, non-sulphatesulphur and plant-available sulphur. Total sulphur in upper layer of the cultivated soils may vary from 50 to 300 ppm (mg/kg soil). It may be more than 1,000 ppm in saline and acid sulphate soils. Total S in soil is mainly present in organic combination. Organic sulphur is part of sulphur-containing compounds (protein) which in turn are part of soil organic matter. Soils rich in organic matter have higher levels of S. Organic S can constitute less than 10% to more than 90% (generally 30-70%) of total sulphur. Non-sulphatesulphur consists primarily of occluded/ precipitated S as gypsum and can vary from less than 5 to 50% of total sulphur. Its distribution pattern is generally reverse of organic sulphur.

Available sulphur refers to the soluble, exchangeable and easily extractable sulphur which can be utilized by plants. Available S can constitute 1-15% of total soil S. It is not a single discreet form of sulphur rather a pool of sulphatesulphur from mineral and organic sources which can be extracted by a suitable extractant (0.15% CaCl, solution or 500 ppm solution of $KH\text{-}PO_2$). The amount of available sulphur is significantly correlated with plant growth and provides an estimate of sulphur status of soil. In general, soil testing less than 10 ppm available S (10 mg Skg soil) or 20 kg S/ha are considered to be low/ deficient in sulphur.

Availability classes of Sulphur in soil:-

Classes	Sulphur range
1. Very low	< 5 ppm
2. Low	5-10 ppm
3. Marginally low	10-15 ppm
4. Adequate	15-20 ppm
5. Moderately High	20-40 ppm
6. High	> 40 ppm

How much quantity of sulphur to apply :-
The quantity of sulphur requires for fertilization depends upon the various factor like targeted yield, residual effect of fertilizers, crop residues left on the soil, soil moisture status , soil supplying power and efficiency of crop in utilizing the soil and applied nutrients.



Role of sulphur in pulses

Role of sulphur in enhancing yield-

Sulphur is important element for the pulse crop (Vidyalakshmiet al., 2009). The amount of sulphur present in pulses is 0.24 –0.32%.it is responsible for protein synthesis, chlorophyll formation, growth and metabolism (Parashar and Tripathi, 2020). Soils containing less amount of sulphur in pulse crops growing region show stunted growth and causes decline in photosystem 1 and photosystem 2 which results in decrease in chlorophyll which leads to less photosynthetic rates (Giordano et al., 2000) which finally cause decrease in the chlorophyll a/b binding protein and Rubisco (Jamal, 2006). In sulphur deprived plants Rubisco content and the number of monosaccharides were significantly decreased and there will be increase in amount of starch substance. while there are no changes in the metabolite levels were observed in the calvin cycle or TCA (Lundeet al., 2009). Sulphur content show positive effect on yield and its effect is clearly seen, when sulphur substance is near to the ground in soil (Eriksen,2009).Due to the less amount of sulphur in soil, biological nitrogen fixation, nodulation and yield of peanut crops are decreased (Jamal et al., 2010) form of sulphur there is increase in whole plant dry mass ,nodule biomass ,and root length, expressed on root length basis due to the application of sulphate form of s because to inadequate nodule development, as well as low nitrogenase and leghaemoglobin synthesis, nitrogen fixation was severely effected in sulphur scarce plants that the application of sulphur cause nodule formation.

Role of sulphur in oilseeds Sulphur in enhancing growth and yield of oilseeds-

Sulphur nutrition is an important component of oilseed crop quality (Walker and Booth, 2003). The amount of sulphur present in oilseeds crop is (1.1-1.7) less application of sulphur in oilseed crops, cause formation of poor quality seed (Haneklauset al, 2016). Sulphur is necessary to enhance the quantity of glucosides, glucosinolate, and protein in rapeseed and mustard (Chandelet al., 2003). According to the results of the experiment sulphur application at a level of 60kg/ha had a substancial impact on the content of glucosinolate and oil percent increased by 44.6 %. At the stage of grain filling, oilseed crops were more responsive to specific nutrient and irrigation management to mitigate derivatives of oil components. Application of sulphur to ensure the flavour imparting components in oil is vital for oil quality (Nepali and Bhandari, 2019). The concentration of allylisothiocyanate in mustard seeds increased when sulphur fertilizer levels increased from 0 to 60 kg s/ha (Chandelet al., 2003).

Quantity of S recommended for soybean and mustard crops

- Soybean crop respond up to 40 kg S/ha, applied through gypsum (Aulakh*et al*., 1990), at Pantnagar.
- Soybean crop respond up to 60 kg S/ha, applied through SSP (Nambiar, 1988), at Ludhiana.
- Soybean crop respond up to 80 kg S/ha, applied through pyrites(Sharma and Gupta, 1992).
- To correct the S deficiency in rapeseed and mustard in different soils, 30-40 kg S/ha, most field conditions (Rana*et al.,* 2001).

Quantity of S recommended for groundnut, sunflower, castor and sesame crops

- In field trial on clay soils, application of 25 kg S/ha, significantly increased yield of groundnut (Ramdevputra*et al*., 2010).
- Response of S application in sunflower, significantly increased up to 45 kg S/ha (Tondon, 1986).
- Response of S application in sesame, significantly observed (Deshmukh*et al*., 2010; Nagavni*et al.,* 2001).
- Improved in yield and oil quality in castor due to S application (Mathukia and Khanpara, 2008).

Quantity of S recommended for pulse crops :-

- As research findings from multi-locational trials, optimum dose of S for lentil was 20 kg S/ha (Ali *et al.,* 1993).
- Response of S application in gram was optimum with 20-60 kg S/ha (Aulakh and Pasricha, 1986).
- Response of S application in pigeonpeawas significant observed up to 20 kg S/ ha (Palsaniya and Ahlawat, 2007).
- Application of S increased the yield of most of pulses by 20-28% (Tondon, 1991).

Time of sulphur application:-

- Once the deficiency of sulphur established by soil testing, application of S should be done at the sowing time.
- Inadequate sulphur in plant, not showing any visual deficiency symptoms known as hidden hunger.
- Application of S as basal dressing is the best strategy to correct S deficiency.
- To correct the S deficiency in standing crop, ammonium sulphate is best fertilizer.
- Elemental sulphur should be applied a few weeks before planting in aerated and moist soils.
- When elemental S applied just before planting, this should be supplemented with readily available S fertilizer.

Sources for S fertilization as per needs:-

- **Ammonium sulphate**:-Integrated N+S application, particular suitable for top dressing to correct S deficiency.
- **Single super phosphate**:-Integrated P+S application for basal dose. Provide P + S + Ca for groundnut where Ca is needed for pod formation
- **Potassium sulphate**:-Integrated K + S application where crops are sensitive to Cl^- and quality considerations.
- **Ammonium phosphate sulphate**:-Integrated N + P + S application as basal for most crops.
- **Elemental S products**-Particularly suitable for fine textured alkaline calcareous soils. Application 3-4 weeks before planting in moist and aerated soils.
- **S- Fortified ammonium phosphate**:- Suitable for basal dressing as a source of readily plus slowly available source of S. Application suggested on surface 2 – 3 weeks before planting in moist and aerated soils.
- **Gypsum**:-Suitable as source of sulphur for most situation, need where Ca is needed for pod formation.

- **Sulphate of micronutrients**:-Need dictated by micronutrients but S added through them is to be taken into account. These can deliver S both through soil and foliar application

Soil application of S to oilseeds and pulses:-

- **Broadcasting:** Suitable where adequate rainfall and irrigation facility are available .
- **Band placement:**Where soils are coarse in texture and leaching problem is severe.
- **Side-banding:**Most effective way to apply sulphate-S fertilizers to produce maximum seed yield and to prevent any damage to seedlings.

Foliar spray of S to oilseeds and pulses:-

- ❑ Sources: nitrosulf (Bose *et al*., 2009) and thiourea (Singh and Sharma, 2009).
- ❑ Supplement with micronutrient: $FeSO_4$ (Basu, 2011); $ZnSO_4$ (Pal and Gangwar, 2004).
- ❑ Thiourea@500 ppm.
- ❑ Nitrosulf can be spray three times at 20 days of crop growth, vegetative growth stage (35 DAS) and pre-flowering stage (50 DAS) in mustard crop @0.2 %.
- ❑ 3-5 sprays of 0.5% soluble sulfate salts like ammonium sulfate, potassium sulfate and zinc sulfate can be use, standing crop (Rathore *et al.*, 2015).

S fertigation to oilseeds and pulses:-

- ❑ Fertilizer solubility is one of the most important parameters, as it affects the both fertigation- system efficiency and fertilizer use efficiency.
- ❑ The solubility is greatly affected by the temperature variation.
- ❑ Ammonium thiosulphate, ammonium polysulphide, ammonium sulphate and urea-sulfuric acid ((Havlin*et al*., 2005).

Applications of S oxidizing bacteria:-

- ❑ The microorganisms present in soil improve the plant growth by providing nutrients and defending them against stress and pathogens.
- ❑ Anandham et al., (2007) demonstrated the use of *Rhizobium* co-inoculation with the sulphur (S)-oxidizing bacterial strains.
- ❑ Clay-based pellets of *Thiobacillus,* formulated (2.5 x10^7 CFU/g pellet) and their efficacy to enhance plant growth was tested in groundnut under pot house and field conditions with sulphur-deficit soil.

Integrated use of S with organic manure:-

- ❑ Organic bound S is the potential source of plant available S in many soils.
- ❑ Therefore, use of organic manure improves the availability of S in soils and leaves residual effect for longer time.
- ❑ Application of 20 (kg S/ha) + 5 t FYM to a crop carries significant residual effect for the succeeding crop and it also increases utilization efficiency of native S.
- ❑ Integrated effect of pyrite in combination with 10 t/ha of FYM or pressmud results in significant increase in yield than their alone application.

II. Research finding

Effect of nitrosulf and elemental sulphur on yield attributes of rapeseed :-

The analysis of table revealed that the 0.2% S as nitrousulf is best over all the concentration of nitrosulf and elemental sulphur dose of 30kg ha^{-1} and 60 kg ha^{-1}.The analysis of data revealed that the plant height (cm) , No of siliqua $plant^{-1}$ and 1000 seed weight (g) contribute highest in the treatment no 5.

Treatments	Plant height (cm)			Number of siliqua $plant^{-1}$			Number of seeds $siliqua^{-1}$			1000-seed weight (g)		
	2005–06	2006–07	Pooled	2005–06	2006–07	Pooled	2005–06	2006–07	Pooled	2005–06	2006–07	Pooled
T_1: Control (No S)	$101.93^{e\dagger}$	101.13^{d}	101.53^{d}	142^{e}	140^{e}	141.00^{d}	21.70^{e}	20.70^{f}	21.20^{e}	3.91^{e}	3.73^{d}	3.82^{e}
T_2: 0.05% S as nitrosulf	105.49^{d}	110.21^{c}	107.85^{c}	154^{d}	164^{d}	159.00^{c}	23.19^{de}	27.28^{e}	25.24^{d}	4.05^{de}	4.12^{c}	4.09^{d}
T_3: 0.1% S as nitrosulf	110.37^{c}	115.84^{bc}	113.11^{b}	163^{cd}	179^{bc}	171.00^{b}	24.95^{cd}	28.54^{cd}	26.75^{c}	4.19^{bcd}	4.22^{bc}	4.21^{cd}
T_4: 0.15% S as nitrosulf	117.42^{b}	121.33^{ab}	119.38^{a}	177^{ab}	190^{a}	183.50^{a}	27.48^{ab}	30.12^{b}	28.80^{b}	4.30^{ab}	4.46^{ab}	4.38^{b}
T_5: 0.2% S as nitrosulf	120.83^{a}	122.72^{a}	121.78^{a}	185^{a}	195^{a}	190.00^{a}	29.35^{a}	31.23^{a}	30.29^{a}	4.41^{a}	4.66^{a}	4.54^{a}
T_6: Elemental S 30 kg ha^{-1}	103.82^{de}	117.43^{ab}	110.63^{bc}	169^{bc}	172^{c}	170.50^{b}	24.21^{d}	28.37^{d}	26.29^{c}	4.12^{cd}	4.25^{bc}	4.19^{cd}
T_7: Elemental S 60 kg ha^{-1}	106.63^{d}	118.25^{ab}	112.44^{b}	170^{bc}	181^{b}	175.50^{b}	26.53^{bc}	29.53^{bc}	28.03^{b}	4.26^{abc}	4.34^{bc}	4.30^{bc}

†Within a column, means followed by the same letter are not significantly different at the 0.05 level of probability by DMRT.

(Bose *et al.*, 2009)

Effect of nitrosulf and elemental sulphur on yield (q/ha) of rapeseed:- The given table represented the effect of nitrosulf and elemental sulphur on yield (q/ha) of rapeseed. The analysis of data revealed that the seed yield and stover yield recorded highest in the 0.2% S as nitrousulf over all the treatment.

Treatments	Seed yield			Stover yield		
	2005–06	2006–07	Pooled	2005–06	2006–07	Pooled
T_1: Control (No S)	8.26^{d†}	8.11^{c}	8.19^{d}	13.89^{d}	13.72^{c}	13.81^{e}
T_2: 0.05% S as nitrosulf	10.20^{c}	10.79^{b}	10.50^{c}	19.45^{c}	19.98^{b}	19.72^{d}
T_3: 0.1% S as nitrosulf	11.55^{bc}	12.20^{ab}	11.88^{b}	20.55^{bc}	21.87^{ab}	21.21^{bcd}
T_4: 0.15% S as nitrosulf	12.80^{ab}	13.85^{a}	13.33^{a}	21.74^{ab}	23.10^{a}	22.42^{ab}
T_5: 0.2% S as nitrosulf	13.40^{a}	13.78^{a}	13.59^{a}	23.40^{a}	23.97^{a}	23.69^{a}
T_6: Elemental S 30 kg ha^{-1}	11.25^{bc}	11.87^{b}	11.56^{bc}	19.92^{bc}	20.15^{b}	20.04^{cd}
T_7: Elemental S 60 kg ha^{-1}	12.36^{ab}	12.54^{ab}	12.45^{ab}	20.91^{bc}	22.05^{ab}	21.48^{bc}

†Within a column, means followed by the same letter are not significantly different at the 0.05 level of probability by DMRT.

(Bose *et al.*, 2009)

III. Conclusions

In India, the productivity of oilseeds and pulses remains low due to the low consumption of S fertilizers etc. Strategies need to be developed to encourage more use of S through right time, right method, right place, judicious mix of fertilizer S, byproduct S, and organic manure attaining sustainable high pulses and oilseeds productivity.

The sulphur requirements of oilseeds and pulses can be met by a number of S-containing materials, such as gypsum, phosphogypsum, elemental S, pyrite, thiourea, nitrosulf, ammonium sulphate and iron sulfate etc. New fertilizers material like customized fertilizers, fortified fertilizers, liquid and sulphur biofertilizers are alternate options for conventional fertilizers.

Application of S not only helps in sustaining high yields but also improves quality of the produce of oilseeds and pulses. This is important in Indian context as the country is short of vegetable oils and is importing a sizable amount of foreign exchange every year.

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