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A review on effect of sulphur on growth and yield of mung bean in Punjab region

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Abstract

Mung bean is a low input, short duration and high value cash crop. Therefore, that fits very well in the rice-wheat cropping system of the Punjab and other states. There is a gap of 65 to 70 days for growing a crop after wheat and before the main rice crop plantation. . Less amount of fertilizer use in commonly on oil seed and pulses that have a higher sulphur demand per unit of pulses production than cereals. Generally, farmer using sulphur free fertilizer like DAP, Urea, MOP therefore sulphur deficient in soil. The correction of sulphur deficeinces, application of sulphur fertilizer 40 kg/ha increase height and branches per plant of green gram significantly and also application of sulphur was also reported to increase number and weight of root nodules in green gram use mostly,available in market sulphur as bentonite sulphur 90%, sulphur WP application this is effective sources it also improve soil ph and quality of vegetable and fodder crops.

Keywords: Sulphur, Mung bean, Fertilizer, Yield

Introduction

In Indian agriculture sector lead to day by day bringing prosperity but nowadays some people also suffering to protein deficiency that insufficient of protein in body may cause several health problems such as organ failure , marasmus, , edema, impaired mental health, kwashiorkor shrinkage and wasting of muscle tissues, also weakness of immune system. It noticeable reduction in the atmospheric accumulation of sulphur in nowadays (Irwin *et al.*, 2002). Earth mass makes a near by 3% sulphur (chemicool)

Mungbean, soyabean, checkpea, pulses and legumence crop have good amount of sources of protein. Some of protein made up sulphur.with nearly 100 million tons of waste sulfur produced a year, the 10 percent not used

in sulfuric acid production comes out to a not-insignificant 10 million tons a yearSulfur makes up almost 3 percent of the Earth's mass, according to Chemicool

In Indian soil has S deficient. Available S in Indian soil form of organic Sulphur deficiencies have been reported from 72 countries in the world (Morris, 1998). Over 27000 soil samples from 12 states of India were analyzed, of which 40% were found deficient and another 35% were potentially deficient in available sulphur (Biswas et al., 2004). More than 70% of soil samples taken from U.P., M.P, Maharashtra, Orissa, Jharkhand, West Bengal, Andhra Pradesh and Karnataka were found low to medium in available sulphur. There are 72 country suffering for sulphur Many- several various sulphur present in the plants play a cant role in helping the growth of the human hair as sulphur is the□signi basic chemical for building up of amino acids.

Elemental sulphur is produced all over the world. Major production occurs where sulphur-rich gas and oil is processed and refined United States, Canada, the Former Soviet Union, & Asia.

Sulphur is also used in many other industries including non-ferrous metals, pigments, fibers, hydrofluoric acid, carbon disulphide, pharmaceuticals, agricultural pesticides, personal care products, cosmetics, synthetic rubber vulcanization, water treatment, and steel pickling. sulphuric acid is used by the fertilizer industry to manufacture primarily phosphates, and also nitrogen, potassium, and sulphate fertilizers Sulfur is a vital element for all organisms due to its important role in methionine and cysteine biosynthesis. Cysteine is not only an important constituent of proteins, but is also essential to determine the structural conformation of proteins and metal binding, and contributes to the catalysis of enzymatic reactions (Kertesz et al., 2007). Sulfur is also essential for the synthesis of coenzyme A, which is important for fatty acid biosynthesis and oxidation, amino acid uptake, oxidation of intermediates of the citric acid cycle, and for ferredoxin oxidation, which is vital in photosynthesis and biological N fixation. Furthermore, S is key in vitamin synthesis (Havlin et al., 2005) Mainly sources of sulphure recovered by brimstone, elemental sulphur during the oil and gas production sulphure is a by product during the production of sulphuric acid in that procces,some power plants, also good amount of produced sulphur dioxide so2.

Crop	Application
wheat	After applying nitrogen at a dose of 80 kg/ha and sulphur at a dose of 50 kg/ha the maximum grain yield (5.43 t/ha) was obtained.(Hanna klikocha et al; 2018)
potato	application of 45 kg h a -1 sulphur, the highest tuber yield, broad and medium tuber yield, dry matter quality, basic gravity, sugar content and starch content were identified.(D K Sharma et al;2011)
mungbean	NPK with S was found to be significantly superior to other treatments and the maximum grain yield was reported (1524 Kg ha1). (Deeksha et al ., 2019)
cumin	Sulphur 40% WP @ 1.4 KG (Kishore Chand et al., (2000)
Isabgol (Plantago ovato)	0.2 % wettabla sulphur at 2 weeks interval 2 or 3 times. (R s jat et al., 2015)
Pomegranate	Sulphur 80% WP 2.5 gm/l at rest period (National Research centre on Pomogranate 2017)
mustard	Sulphur was computed 49.6 kg ha-1 (Kumar Vinod .,2015)
castor	Application of 30 kg sulphur/ ha through gypsum at the time of last ploughing for higher castor yield (S. K. Srivastava et al.,2015)

Symptoms of S deficiency in plants are characterized by reduced plant growth and occurrence of uniform chlorosis on younger leaves (Havlin et al., 2005).If the soil contain 10mg/S kg that is considered as a deficient soil

Why sulphure ?

Sulphure free fertiliser use in the neglect of S replenishment in crop production, intensive farming has led to widespread sulphur deficiencies in world wide. sulphur present in the plants play a cant role in helping the growth of the human hair as sulphur is the□signi basic chemical for building up of amino acids.(savitha et al 2019)

The suggestion of sulphur to control diseases was first reported by (FORSYTH 1802) mixture of quicklime, sulphur, elderberry bud, and tobacco was his recommendation for controlling powdery mildew on fruit trees. (ROBERTSON 1824) N:S for proper growth and development ,a ratio of about 20:1 is good for the plant Alfalfa is the most commonly deficient field/forage crop in S. Deficiency of S can also result in N deficiency in alfalfa because S is required for health and functioning of N fixing nodules. When fed to livestock, S deficient forages can reduce animal performance.(Cram,1990)Sulphur-oxidizing bacteria can show to be great choices for bioformal preparations and can be used to reclaim alkaline soil, improve soil fertility and increase oil seed crop production (Naveen Joshi et al .,2020)

Aerial pollution control, less use of manure, and the introduction of insecticides and fungicides which replace sulfur based dusts, are factors which aggravate the sulfur deficiency problem

Sulphur plays an important role in the synthesis of amino acid-containing sulphur such as cysteine and methionine Biswas and Tewatia (1991) reported that the use of sulphur improved the quality of green gramme grains. Protein synthesis requires a large amount of sulphur, especially when oils are produced within the seed, and sulphur is a component of many amino acids and vitamins contained in plants and animals (Liuch et al 1983). Sulphur applications increase the root and shoot length.Garlic, onion, oilseeds, and require Sulphur for the formation of aromatic flavour compounds. For these crops in particular, fertilisation with sulphur frequently results in enormous increases in yield and quality

sulphur require in oilseed crop little bit more than other secondary nutrient,in crop wise pulses >forages >tuber > cereals crop.Inhibition of photosynthetic activity in higher SUE (Saturnin) cultivars The degradation of Rubisco proteins induced by drought stress was much lower, including

.

The present study clearly shows that the higher SUE genotype is more tolerant of PEG-induced drought stress. Decreased fertilisation of sulphur Fat content and improved seed protein content (Wielebski)

In 2011). None impacts of sulphur fertilisation on the fat content of oilseed rape seeds have been identified (Krauze, Bowszys 2001). This was confirmed in studies as well. who did not see any major improvements in After spring fertilisation with nitrogen and sulphur, the content of fat and protein in crops.Wielebski and Wójtowicz (2004)

Importance of sulphur for plant

Sulphur (S) have beneficial and bad effect on plant cells. plant uptake of sulphure is sulphate or thiosulphate form. The nutrition of plant sulphur is based mainly on inorganic sulphate uptake.

S plant root uptake occurs preferentially in the form of sulphate (SO42-), and S can also be absorbed as thiosulfate (S2O32-).leaves can also consume small quantities of SO2 in adiition (Havlin et al., 2005).also recorded foliar assimilation of S in soybeans that resulted inincreased Nitrogenand S l evels in the leaves, regardless of the dose and quality of the source, relative to S delivered to the soil (Vitti et al. (2007).

Sulphur is crucial for crops as a secondary nutrient and is necessary for metabolism and development. In oil seeds, the sulphur concentration is highest, intermediate in pulses and lowest in cereals (Singh 2001). In the seed formation of oil seed crops, sulphur plays a significant role (Shrivastava et al. 2000). Many researchers have highlighted a clear linkage between sulphur and nitrogen in terms of dry matter and seeds, as well as oil yield in crops (Fazli et al. 2005)

Different enzymatic and metabolic processes are needed , including nitrogen fixation, respiration, photosynthesis and large-grain output (Srinivasarao et al. 2004). In comparison with cereals and other crops, oil seed crops demand large concentrations of sulphur. Soybean is a major crop of oil seeds that is produced and consumed globally). Soybeans belong to the family of legumes which require sufficient quantities of sulphur. (Wilcox 2004) For the improvement of aromatic flavour compounds, many crops, such as oilseeds, legumes, onions, leek, and garlic, need S. In particular, fertilisation with sulphur also results in tremendous yield and quality increases for these crops.(olli 2010)

Sulphur is important for chloroplast and chlorophyll synthesis owing to its role in protein synthesis and important enzymes and redox reactions. Sulphur is also associated with flowering, nodulation and the quality of oilseeds and especially of groundnut crop

Sulphure plays an important role in the synthesis of sulphure containing amino acids like cysteine and methionine (kokani et al 2014). Biswas and Tewatia (1991) recorded that the application of sulphureimproved the quality of green gram grains. Sulphureapplications increase the root and shoot length (Liuch et al 1983). Sulphure has a great role in increase nodule growth in their fresh and dry weight (Azevedo et al 2002, Handouit 2003).Sulphure can be associated with leghaemoglobin pigment formation in nodules and also active nodulation and N- fixation in legumes (Patel et al; 1998; Zhau et al; 1999 and Ahmad 2000) Sulphure application promotes the reproductive, meristematic activity and promotes floral primordial, therefore improve growth, quality,and yield (Patel et al., 1998, Ayub et al., 1999, Budhar and Tamilselvan 2001, Moniruzzaman et al., 2008 and (Kumar and Singh, 1992).The requirement of sulphureis more in mung bean-like pulses and oilseed crop compare to cereal crops. (Caines and Pathak,1982) reported that the application of sulphure

increasesthe N:S ratio. (Kamat et al 1981) showed that application @ 30 kg/ha increase the quality of green gram.S deficiency and soil acidity causes the sesame productivity, it fulfill with applications of 30 kg S/ha and 250 kg lime/ha in U.P. state.The results showed that the S application significantly increased the plant height, stem diameter, total wo ody stem and biomass yield of leucaena, while the leaf yield was not affected by S addition. (Songyos et al; 2015).McGrath and Zhao (1996) noted a rise in rates of 42-267 percent with the application of the Brassica napus seed yield 40 kg of S ha-1 and 180 and 230 kg of N ha-1. The seed yield was dependent on When N was applied at the 180-230 scale, it was found to decrease, Without S, kg ha-1. 5.6 ppm ppm in field trials for soil testing S available, 2.5 percent rise in the yield of mustard oil due to S and N.The synergistic impact of the application could be attributed to S. The adoption was discovered by Fazli et al. (2008),

Under S deficiency, N was substantially reduced in E. Uh, Sataiva.

The positive and significant Aulakh et al. (1977, 1980) acknowledged the positive and significant Interaction of the applied S and N in brown plant tissues, Sarson. The Brown mustard concentration of S and N was the concentrations of S and N With a combined application of 75 kg N ha-1 and 60 kg S, the highest Ha-1-10

It was the crop that did If N was optimally deficient, do not respond to the S application, S and S added increased straw with excess N but not grain yield.The yield increased linearly in the S and N of wheat crops.A analysis of interaction (Reneau et al., 1986) with increased N Requesting. Furthermore, it was proposed that the S concentration of 0.2 percent in the flag leaf and a N/S ratio of 18 is adequate for Application of sulphur at a rate of 400 kg S / Fed. In the first season, all the measured parametsof vegetative gr owth were substantially improved, except for the bulb diameter(Rizk et al; 2012)

Sulphur increased more than Arsenicum album values of fresh and dried biomass. The two drugs and their resp ective dynamizations increased plant height. Although Sulphur, with the exception of 6CH dynamization, inhib ited the development of dry biomass, it greatlyincreased the essential oil content of mint plants**.** (Carlos et al ; 2009). Sulphur is important for chloroplast and chlorophyll synthesis owing to its role in protein synthesis and important enzymes and redox reactions. Sulphur is also associated with flowering, nodulation and the quality of oilseeds and especially of groundnut (Rao et al ;2013) Fe-S protein, referred to as ferrodoxin (Vidyalakshmi et al. 2009). Sulphur raises grain yields and oil quality in oil seed crops (Singh et al. 2000). Sulphur's most fascinating fact is that it enhances the absorption of other nutrients, i.e. Nitrogen, phosphorus, potassium, etc (Singh et al ; 2001).Sulphur along with nitrogen shows improved growth characteristics, soybean cultivar seed and oil yield Similar results have been observed in rapeseed-mustard with combined sulphur and nitrogen application. In rapeseed-mustard with combined sulphur and nitrogen treatment, similar findings were observed (Sharma et al;2014) Improves in productivity, nutrient content at the harvest point, nutrient absorption and plant nutrient content(jamal et al.2005) Changes in the content of total sulphur and sulphate in

plants are caused by sulphur fertilisation. Probably, the net sulphur, or-ganic sulphur and sulphate content increases. (Koter, Grzesiuk 1966, Babuchowski 1971,Uziak, Szymańska 1979, Benedycka 1983, Uziak, Szymańska 1987, Krauze,Bowszys 2000, Podleśna 2004, Barczak, Nowak 2015).Curiously, fodder plants cultivated under severe conditions generated by

No adverse (toxic) amounts of sulphur landfill sites were found nearby.

In terms of both plant physiology and suitability for animal feeding, sulphur. (Bowszys et al; (2001).

sulphure in soil

When measuring less than 10 mg S / kg of extractable soil with 0.15 percent CaCl22 percent, a soil is deemed deficient in S the Sulfur Institute predicted a deficit of 11.1 million t of S

input to soils in the year 2010 ,world wide (Messick and Escobar, 1994)

Up to 98 percent of the total soil sulphur may be present as organic S compounds, according to Bloem (1998), and is associated with a heterogeneous mixture of plant residues, animals and soil microorganisms (Freney, 1986). The organic S concentration profile typically follows the organic matter concentration pattern in soils with depth (Probert, 1980).

Inorganic S is a readily available fraction for root uptake, but represents on average less than 5 % of the total S in the soil. The majority of S (> 95 %) in soil is bound to organic molecules and is only indirectly available to plants (Kertesz & Mirleau, 2004). Traditional chemical methods allow for the fractionation of soil S in three large fractions of organic S: (a) organic S not directly bound to carbon (C), which is reduced to H_2S by hydriodic acid (HI); (b) organic S directly bound to C (C-S), which is reduced to H_2S by Raney nickel, and (c) residual C bonded S. Organic S not directly bound to C is composed primarily of sulfate esters (C-O-S), such as phenol sulfate, sulfated lipids and sulfated polysaccharides, among others. The fraction of organic S directly bound to C consists of the S-containing amino acids, thiols, disulfides, sulfones, and sulfonic acids. The third fraction of organic S is probably composed of sulfonates, sulfoxides, and heterocyclic S (Freney, 1967; Tabatabai, 1984; Kertesz et al., 2007; Eriksen, 2008)

Intensive farming with the use of improved cultivars and seedlings

High analytical fertilisation offers nutrient conditions

Exhaustion, which results in soil nutrient imbalance. Fazili et al.,(2008) indicated that the absence of S limits the efficiency of added N,Therefore the addition of S is required to achieve the maximum.The efficiency of the nitrogen fertiliser used. Kowalenko and Kowalenko and

Lowe (1975) observed that a high ratio of N:S (produced by he addition of N) resulted in a reduction of S mineralization in S

Bettany and Janzen (1984) The optimum ratio of N available to S available was indicated to be

7:1. The The decreased seed yields were determined by ratios below 7. Under field conditions, rapeseed and mustard crops recovered 27-31 percent of the added S without N, but 37-38 percent with 60 kg of N ha-11 (Sachdev and Deb, 1990).

The overall soil S content depends upon the type of fertiliser used (mineral or organic manure), and soil changes have been found to be relative to the quantity of organic residues applied (Larson et al., 1972). Total S ranged from 1392 kg ha-1 in the control without application of fertiliser to 1808 kg ha-1 in the treatment of farmyard manure in a long-term field experiment. With rises in added sulphur and phosphorus to the soil, soybean plants' absorption of total and nutrient sulphur increased significantly.(kumar et al;1980)

Reclamination of Acid soil is required P and S to improve the soil and also increase legume growth, increase of root growth and N_2 fixation (Kisinyo et al., 2005)

Many crops, such as oilseeds, legumes, onions, leek, and garlic, require S for the production of aromatic flavour compounds. For these crops in particular, fertilisation with sulphur frequently results in enormous increases in yield and quality

Sulfate in the soil solution is present in small concentrations (a few lg mL–1), which vary continuously and at any time depending on the balance between plant uptake, S-fertilizer input, mineralization, and immobilization (McLaren and Cameron, 2004). The higher SO2 4 concentration in the top soil layer is mainly caused by the application of S-containing fertilizers (Eriksen, 1996) and by mineralization of S from soil organic matter (McLaren and Cameron, 2004). Normally, the SO2 4 concentration in soil solution is lowest during winter and spring due to leaching and low mineralization rates (Castellano and Dick, 1990; Ghani et al., 1990).

Deficiency

The sulphur deficiency was observed majorly in areas cultivating high S-demanding oil seed crops and pulses. In India, deficiency of sulphur is increasing continuously, 41% soil samples are deficient in sulphur. The S° deficiency is developing fast in the areas where exhaustive cropping system is adopted and in areas where cultivation of high-yielding varieties is done with the use of high scanning chemical fertilizers, specifically sulphur-free fertilizers such as urea and ammonium phosphate (Chaudhary et al. 2019). A project report of TSI-FAI-IFA (1997–2006) by ICAR system reported that forty-nine thousand soil samples across 18 states of India showed 46% sulphur deficiency and 30% showed medium availability of sulphur

The soil is deficient in S and there is no correction of the deficiency, then complete There can be no realisation of the potential of a crop variety, regardless of the top Practices for husbandry (Eppendorfer, 1971) (Eppendorfer, 1971).

The soil is deficient in S and there is no correction of the deficiency, then complete There can be no realisation of the potential of a crop variety, regardless of the top Practices for husbandry (Eppendorfer, 1971) (Eppendorfer, 1971). A marginal change in sulphur deficiency of soil was observed in 2018 and 2019 which was found to be 43%, 40.5%, respectively (Shukla and Behera 2019; Bansal 2019). This increase in sulphur deficiency of soil is a matter of concern and needs urgent attention.Phosphorus and nutrient deficiencies limit plant growth directly and suppress the symbiotic N_2 fixation of leucaena (Shelton and Brewbaker, 1998, Radrizzani et al., 2010).

Only recently have crop deficiencies appeared prevalent, Previously, when N and P fertilisers, such as ammonium sulphate and single superphosphate, were added, adequate S was obtained from regular incidental additions of S to soils to meet crop requirements. Industrial emissions as a result of coal combustion often contributed significant amounts of S to aerial deposition for plant needs. However, in the last two decades, there has been a fundamental improvement in the S (Scherer, 2001)

Conclusion

it may be concluded that - application of Sulphur @ 25 kg Kg per hacter and 6 kg Sulphurper hacter and Gypsum 33.34 kg per hacter Murate of potash 50 kg per hacter may be the best combination for higher growth and yield of mungbean and also to maintain soil fertility and productivity than their individual application. in addition, 30kg/ha sulphur enhanced growth parameters leaf area, number of branches per plant, number of effective root nodules and total biomass of plant which ultimately influenced the yield.

REFERENCES

References

Ali, M., & Gupta, S. (2012). Carrying capacity of Indian agriculture: pulse crops. *Current Science*, 874-881.

Irwin JG, Campbell G, Vincent K.2002 Trends in sulphate and nitrate wet deposition over the United Kingdom, 1986–1999. *Atmospheric Environment* 36,2867–2879.

SongyosChotchutima[a] SayanTudsri [a]KunnKangvansaichol [b]PrapaSripichitt[a](2015)

Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand PTT Research and Technology Institute, PTT Public Company Limited, Ayutthaya, Thailand

Rizk, F., Shaheen, A.M., El-Samad, E.H., & Sawan, O. (2012). Effect of different nitrogen plus phosphorus and sulphur fertilizer levels on growth, yield and quality of onion (AIlium cepa L.). *The Journal of Applied Sciences Research*, 3353-3361.

Sachan, H. K., Krishna, D., & Chaudhary, N. K. (2020). Sulphur Fertilization Effects on Yield and Nutrient Uptake of Mung bean [Vigna radiata (L.) Wilczek]. *Indian Journal of Agricultural Research*, *54*(5).

Rao, K. T., Rao, A. U., & Sekhar, D. (2013). Effect of sources and levels of sulphur on groundnut. *Journal of Academia and Industrial Research*, *2*(5), 268-270.

Olle, M., Bender, I., & Koppe, R. (2010). The content of oils in umbelliferous crops and its formation. *Agronomy Research*, *8*(3), 687-696.

.

Krauze A., Bowszys T. 2000. Effect of applying different technologies of sulfur fertilizer applicationon yield and quality of winter and spring rape. Fol. Univ. Stetin., Agric., 204(81): 133-142.(in Polish)

Krauze A., Bowszys T. 2001. Effect of time of sulphur fertilization of spring oilseed rape cv. Staron seed yield, sulphur content and crude oil. Rośl. Oleiste - Oilseed Crops, 22(1): 285-290.
(in Polish)

Kulczycki G. 2003. The influence of elemental sulphur fertilization on yield chemical composi-
tion of plants and chemical soil properties. Fertilizers and Fertilization, 4(17): 151-159.
(in Polish)

Stewart BA, Whitefield CJ (1965) Effect of crop residuces, soil temp and sulfur on growth of winter wheat. Soil Sci Soc Am Proc. 29: 752-755 Takkar PN (1987).

Economics of S fertilization use in India. Proceedings of Symposium on Fertilizer-S Requirements and Sources in Developing Countries of Asia and Pacific, FADINAP/FAO/ The Sulphur Institute and KIAR, Bangkok, p.123-137

Singh A, Sing V, Mehta VS (1980) Effect of nitrogen and sulphur on yield and nutrient uptake by rapeseed. J Ind Soc Soil Sci 36: 182-184 Singh MV (2001)

Elkins DM, Ensminger LE (1971) Effect of soil pH on the availability of adsorbed sulfate. Soil Sci Soc Am Proc 35: 931-943

Eppendorfer WH (1971) Effects of sulfur, nitrogen and phosphorous on amino acid composition of field beans (Vicia faba) and responses of the biological value of the seed protein and sulfur-amino acid content. J Sci Food Agric 22: 501-505

Fazili IS, Masoodi M, Ahmad S, Jamal A, Khan JS, Abdin MZ (2010a). Oil Biosynthesis and its Related Variables in Developing Seeds of Mustard (Brassica juncea L.) as Influenced by Sulphur Fertilization. J Crop Sci Biotech 13: 39-46

Jamal A, Fazli IS, Ahmad S, Abdin MZ, Yun SJ (2005) Effect of sulphur and nitrogen application on growth characteristics, seed and oil yield of soybean cultivars. Korean J Crop Sci 50(5): 340-345

Jamal A, Fazli IS, Ahmad S, Abdin MZ (2006a) Interactive effect of nitrogen and sulphur on yield and quality of groundnut (Arachis hypogea L.). Korean J Crop Sci 51(6): 519-522.

Ahmad S, Fazli IS, Jamal A, Iqbal M, Abdin MZ (2007) Interactive effect of sulphur and nitrogen on nitrate reductase and ATP-Sulphurylase activities in relationto seed yield from Psoralea corylifolia L. J Plant Biol 50: 351-357

Aulakh MS, Pasricha NS, Sahota NS (1977) Nitrogen-sulfur relationship in brown sarson and Indian mustard. Ind J Agric Sci. 47: 249-253

Dev G, Saggar (1974) Effect of S fertilization on the N:S ratio in soybean varieties. Agron J. 66: 454-456

Shinde DA, Thomas PT, Soni BK (1980) Utilization of applied 35 sulfur by wheat and "A" Values of soil sulfur as affected by nitrogen application. J Nuclear Agric Biol 9: 94-97.

Singh A, Sing V, Mehta VS (1980) Effect of nitrogen and sulphur on yield and nutrient uptake by rapeseed. J Ind Soc Soil Sci 36: 182-184

Singh MV (2001) Importance of sulfur in balanced fertilizer use in India. Fert News 46: 55-58

PJ, Spencer K, Freney JR (1981) Sulfur and nitrogen fertilizer on wheat I. Concentration of sulfur and nitrogen and the nitrogen to sulfur ratio in grain, in relation to the yield response. Aust J Agric Res 32: 203-212.

Scherer HW (2001) Sulphur in crop production - invited paper. Eur J Agron. 14: 81-111 Scherer HW (2009) Sulfur in soils. J Plant Nutr Soil Sci 172: 326-335

Reneau RB Jr, Bran DE, Donohue SJ (1986) Effect of Sulfur on winter wheat grown in the coastal plain of Virginia. Comm Soil Sci Plant Analy 17: 149-158

Sachdev MS, Deb DL (1990) Nitrogen and S uptake and efficiency in the mustard-moong-maize cropping systems. Fertilizer News 35: 49-55

Saito K (2000) Regulation of sulfate transport and synthesis of sulfur-containing amino acids. Curr Opin Plant Biol 3: 188- 195

Lopez-Jurado G, Hannway DB (1985) Sulphur nutrition effects on dinitrogen fixation of seedling alfalfa. J Plant Nutr. 8: 1103-1121

Probert ME. (1980) Sulphur in Australia, In: Freney JR, Nicholson AJ (eds), Australian Academy of Science, Canberra, p. 158-169.

Rabufetti A, Kamprath EJ (1977) Yield, N and S content of corn as affected by N and S fertilization on coastal plain soils. Agron J. 69: 785-788

Mahler RJ, Maples RL (1987) Sulfur fertilization of wheat grown in Arkansas. Bulletin of Arkansas Agricultural Experiment Station No.906, pp.23.

Elkins DM, Ensminger LE (1971) Effect of soil pH on the availability of adsorbed sulfate. Soil Sci Soc Am Proc 35: 931-943

Eppendorfer WH (1971) Effects of sulfur, nitrogen and phosphorous on amino acid composition of field beans (Vicia faba) and responses of the biological value of the seed protein and sulfur-amino acid content. J Sci Food Agric 22: 501-505

Budhar, M. N., &Tamilselvan, N. (2001).Effect of sulphur on yield attributes and yield of rainfed green gram (Vignaradiatus L.). *Madras Agricultural Journal*, *88*(7/9), 504-504.

Dhanushkodi, V., Kannathasan, M., Jamespitchai, G. and Indirani, R, (2009). Influence of sulphur on growth, yield and quality attributes of irrigated blackgram (Vignamungo), Madr. Agric. J. 96: 116-120.

Dhanushkodi, V., Kannathasan, M., Jamespitchai, G., &Indirani, R. (2009). Influence of sulfur on growth, yield and quality attributes of irrigated blackgram (Vignamungo) in Alfisols of Thoothukudi district in Tamilnadu. *Madras Agric J*, *96*, 116-120.

Groswami, N. N. (1988). Sulphur in Indian agriculture. In *TSI-FAI Symposium, New Delhi (India), 9-11 Mar 1988*. Sulphur Institute

Drozdovskaya, M. N., van Dishoeck, E. F., Jørgensen, J. K., Calmonte, U., van der Wiel, M. H., Coutens, A., ... & Wampfler, S. F. (2018). The ALMA-PILS survey: the sulphur connection between protostars and comets: IRAS 16293–2422 B and 67P/Churyumov–Gerasimenko. *Monthly Notices of the Royal Astronomical Society*, *476*(4), 4949-4964.

Singh, Y., Sharma, D. K., Sharma, N. L., & Kumar, V. (2017). Effect of different levels of NPK with combined use of FYM and sulphur on yield, quality and nutrients uptake in Indian mustard (Brassica juncea L.). *International Journal of Chemical Studies*, *5*(2), 300-304.

Lakhan, M. N., Chen, R., Shar, A. H., Chand, K., Shah, A. H., Ahmed, M., ... & Wang, J. (2020). Eco-friendly green synthesis of clove buds extract functionalized silver nanoparticles and evaluation of antibacterial and antidiatom activity. *Journal of microbiological methods*, *173*, 105934.

Bepari, A., Naruka, I. S., Kiran, M. R., & Kumar, K. (2020). Interaction effect of sulphur and zinc on yield attributes and B: C ratio of coriander (Coriandrum sativum L.) cv. RCr-436. *Journal of Pharmacognosy and Phytochemistry*, *9*(4), 242-244.

Shukla, A. K., Sinha, N. K., Tiwari, P. K., Prakash, C., Behera, S. K., Lenka, N. K., ... & Srivastava, P. C. (2017). Spatial distribution and management zones for sulphur and micronutrients in Shiwalik Himalayan Region of India. *Land Degradation & Development*, *28*(3), 959-969.

Srivastava, S. K., & Kumar, J. (2015). Response of castor (Ricinus communis L.) to sulphur under irrigated conditions of Uttar Pradesh, India. *Plant Archives*, *15*(2), 879-881.