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Effect of Sulphur and Zinc Fertilization on Growth, Yield, and Yield Attributes of Greengram (Vigna radiata L.) under Eastern Uttar Pradesh Conditions

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ABSTRACT

The present study was conducted to study the effect of Sulphur and Zinc application on Growth and Yield of Green Gram (Vigna radiata L.) under eastern Uttar Pradesh condition. The treatments considered consisted of four levels sulphur (0, 15, 30, and 34 kg/ha) and four levels zinc (0, 5, 10, and 15 kg/HA) making sixteen treatment combination and was laid out in factorial randomised block design with three replications. The treatment combinations were evaluated for their effect on growth, and yield greengram of different treatment combinations. The results showed that application of 30 kg S/ha along with 5 kg Zn/ha proved to be the most remunerative and economical dose for getting the higher yield of the greengram under the eastern U.P. condition.

Keywords: Green Gram, Sulphur, Zinc, Mini-Nitrogen Plant, Pulses

I. INTRODUCTION

Pulses, "The wizard of the health" owe a strategic position in agricultural economy of India. Symbolic to its nomenclature, pulse (P = People, U = Umbrella, L = Livestock, S = Soil and E = Energy) is indeed a superb energy umbrella for people as dietary proteins, for livestock as green nutritious fodder and feed, for soil as mini-nitrogen plant and green manure **(Ali, 1988).** The pulses are a major source of protein for Indian people. Pulses have remained an integral component of Indian crop husbandry since time immemorial as they keep the soil productivity and alive. The area, production and productivity of pulses in India have been more or less stagnant, fluctuating between 21-23 million hectares 10-13 million tonnes and 475-547 kg/ha, respectively over the last three decades and thus production of pulses has not kept pace with

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increase in per capita availability of pulses. According to a prospective planning, a developing country like India would need around 24.7 million tonnes pulses at present. However, during the year 96-97 the production of pulses was only 14.46 million tonnes, and per capita availability of pulses at 37g per day was also much less than the minimum requirement of 47 g per day as per norms of Indian Council of Medical Research **(Anonymous, 1996-97).** Thus, production of pulses is one of the such forgotten fronts and its vitalness in providing nutritionally balanced meals for Indian masses calls for immediate attention. Green gram is an excellent source of high-quality protein. It is consumed in different ways as dal, halwa, snack and so many other preparations. Ascorbic acid (Vitamin C) is synthesized in sprouted seeds of green gram. The amount of riboflavin and thiamine is also increased. Green gram is a leguminous crop. It has the capacity to fix atmospheric nitrogen through symbiotic nitrogen fixation. It is also used as green manure crop. It also provides an excellent green fodder to the animals. Being a short duration crop, it fits well in various multiple and intercropping systems. After picking of pods green gram plants may be used as green fodder or as green manure. The strategy for augmenting the pulse production in country without diverting land area from the existing crop is to grow a legume as a catch crop in the rice-wheat growing tracts of northern India, where assured irrigation facilities exist. After the harvest of rabi crops, a vast area in northern India is brought under the cultivation only with the onset of monsoon. The yield of legumes during summer season is much higher than that of kharif season as there is less infestation of diseases, insects and pests during summer. This is more true with short duration pulses **(Lai and Yadav, 1981).** Green gram is primarily a short duration pulse crop of rainy season, however, with the development of early maturing varieties, it has proved to be an ideal crop for spring and summer season. It is, therefore, apparent that summer season offers and excellent opportunity for raising green gram. Increased use of high-analysis fertilizer materials free from sulphur and zinc ingredients and continuous multiple cropping with fertilizer responsive varieties of crops have accentuated the depletion of their reserves in the soil often leading to significant responses to their application.

Sulphur is an essential macronutrient that plays a critical role in the growth, yield, and protein quality of pulse crops due to their high protein content and nitrogen-fixing ability (**Lakkineni & Abrol, 1994; Saraf, 1988; Aulakh & Pasricha, 1986).** Research has shown that sulphur deficiency reduces plant height, branching, nodulation, and dry matter production, whereas its application significantly improves these growth parameters **(Dube & Mishra, 1970; Aulakh & Pasricha, 1977; Nad & Goswami, 1983).** Combined application with phosphorus enhances shoot, root, and nodule biomass **(Khandkar et al., 1985),** and gypsum-applied sulphur increases dry matter yield in cowpea and black gram **(Raikhy et al., 1985; Bapat et al., 1986).** Sulphur application also corrects chlorosis and promotes synchronized flowering and uniform maturity **(Chatterjee, 1992; Raju et al., 1994).** Yield attributes and grain yield respond positively to sulphur fertilization, with reports of up to 95% yield increase in green gram **(Mehta & Singh, 1979)** and significant improvements in pods per plant, seeds per pod, and 1000-seed weight up to 30–40 kg S/ha **(Patel et al., 1992; Sharma & Singh, 1993)**. Multi-location trials confirmed 20 kg S/ha as the most beneficial dose for major pulses (**Singh & Ali, 1994**), though excessive application (80 kg/ha) sometimes reduced yields **(Singh et al., 1994).** Sulphur also enhances nutrient uptake, with increases in seed and straw sulphur content by up to 62.5% **(Mehta & Singh, 1979)** and improved total S uptake across several pulses **(Kumar et al., 1994)**. Importantly, S application significantly raises protein content, with reported increases of 3–12% in seeds **(Arora & Luthra, 1972; Aulakh & Chhibba, 1992; Sharma & Singh, 1992),** underscoring its vital role in improving crop nutritional quality.

Zinc (Zn) is a vital micronutrient required for enzymatic activities, chlorophyll synthesis, and nodulation, making it crucial for the growth and productivity of green gram and other pulses. Zinc deficiency leads to stunted growth, reduced branching, and poor nodulation, while its application markedly improves plant height, dry matter accumulation, and nodule number **(Sharma et al., 1981; Yadav et al., 1996).** Studies have reported significant yield responses to Zn application, with optimal doses ranging from 4–25 kg Zn/ha depending on soil conditions **(Singh & Bhandari, 1985; Yadav et al., 1997).** Foliar and soil-applied zinc have been shown to enhance chlorophyll content, photosynthetic activity, and biomass production, especially in zinc-deficient soils **(Khinchi et al., 2007).**

Zinc fertilization also improves yield attributes such as number of pods per plant, seeds per pod, 1000-seed weight, and overall grain and straw yield **(Bansal et al., 1990; Meena et al., 2006).** Uptake of zinc and other nutrients is significantly increased, leading to better nutrient balance in plants **(Shukla & Warsi, 2000).** Furthermore, zinc plays a vital role in protein synthesis, with several studies reporting an increase in seed protein content and quality following Zn application **(Khinchi et al., 2007; Patel et al., 2010**). Excessive zinc, however, may have no additional benefit or even depress yield, indicating the importance of applying zinc at recommended rates for maximum benefit. Overall, zinc management is essential for improving growth, nutrient uptake, yield, and quality of green gram.

II. MATERIAL AND METHODS

Sultanpur is found under a sub-tropical climate and situated in eastern U.P. India. The precipitation is normally spread over three and four months i.e. from the last week of June to the second week of October. The period from November to February is generally cool and dry. The summer season from the third week of March to May.

The field experiment was conducted during the *Zaid* season of 2024 on the research plot of the Department of Agriculture Chemistry and Soil Science, Kamla Nehru Institute of Physical & Sciences, Sultanpur (U.P.). Sultanpur's soils, formed on alluvial deposits deposited by the river Gomati, are dominated by illite, quartz, and feldspars. Illite minerals are partly inherited from micas, which are predominant in the sand and silt fractions.

There were four levels each of sulphur and zinc included in the experiment. The detail of treatments of year with their symbol is given below in Table 1.

Table 1. Treatments and their Symbols

Details of Treatments		Symbol
A.	**Level of Sulphur**	
1.	Control	S0
2.	15.0 Kg / ha	S15
3.	30.0 Kg / ha	S30
4.	45.0 Kg / ha	S45
B.	**Level of Zn**	
1.	Control	Zn0
2.	5.0 Kg / ha	Zn5
3.	10.0 Kg / ha	Zn10
4.	15.0 Kg / ha	Zn15

To see the effect of different treatments on crop, a number of observations on growth, yield attributes and yield of crop were recorded at different stages of crop growth. Since it is very difficult to study all the individuals of plant population. 5 plants sample from each plot were selected randomly and tagged for further study. The observations on growth of tire crop were taken starting from 15 days after sowing to harvest of the crop at the interval of 15 days. Plant population per running meter was recorded at 15 days after sowing. All the observation taken are categorized mainly in two groups, viz. pre- and post-harvest studies.

III.RESULT AND DISCUSSION

All the data of growth and yield revealed that study showed significant variation when treated with different sources Sulphur and Zinc which applied were applied individually.

3.1 Pre-harvest studies

3.1.1 Plant population & Plant height

Plant population, recorded at 15 DAS, showed no significant differences due to varying levels of sulphur and zinc in either year. Plant height, measured at 30, 45, 60 DAS and at harvest, exhibited slow growth until 30 DAS, followed by a rapid increase between 30 and 45 DAS, reaching maximum height at harvest, with minimal increments after 60 DAS (Fig 1). Sulphur application significantly influenced plant height at all stages, with 30 kg S/ha (S30) generally showing optimal response; 45 kg S/ha (S45) was statistically at par with S30, both significantly taller than control (S0) and 15 kg S/ha (S15), while S15 also improved height over control. The percent increase in plant height due to S30 over control was 33, 18, 15, and 16 at 30, 45, 60 DAS and harvest, respectively, in 2024. Zinc application also significantly affected plant height at all growth stages, with 5 kg Zn/ha (Zn5) producing the tallest plants, significantly superior to control (Zn0), 10 kg Zn/ha (Zn10) and 15 kg Zn/ha (Zn15). Zn10 and Zn15 were statistically similar, showing reduced height compared to Zn5, though Zn15 still exceeded control without reaching significance. The increase in plant height due to Zn5 over control was 31, 18, 15, and 16% at 30, 45, 60 DAS and harvest, respectively.

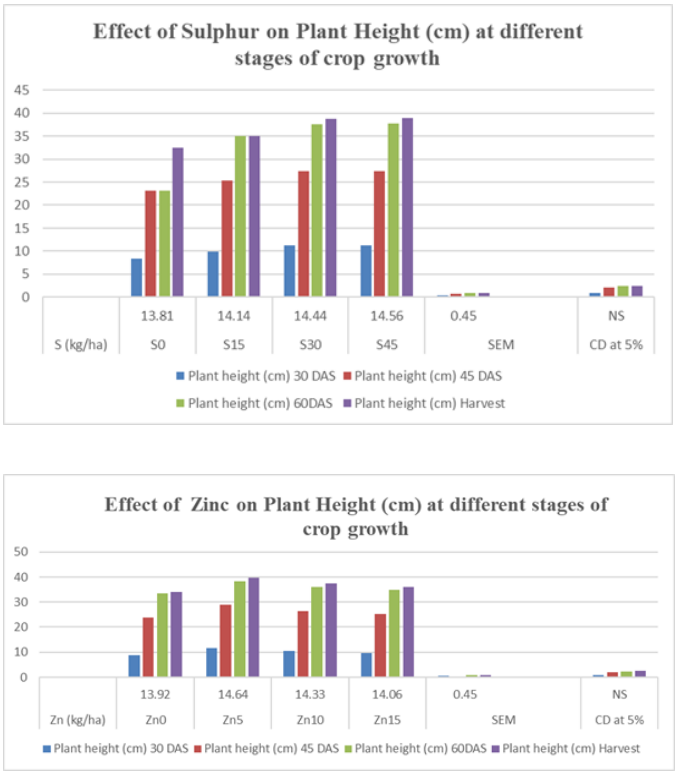
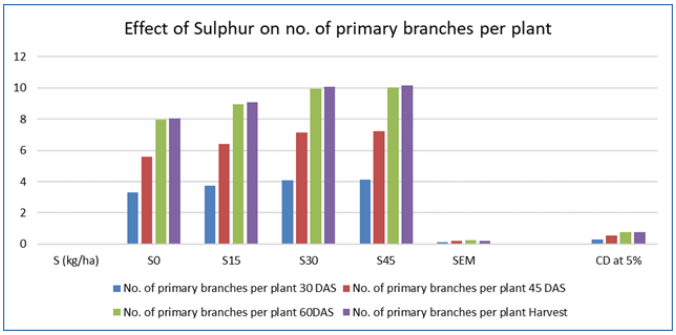


Fig. 1 Effect of Sulphur and Zinc on Plant Height (cm) at different stages of crop growth

3.1.2 Number of primary branches per plant

It is evident from data given in Fig. 3 that number of primary branches per plant increased significantly with the increasing levels of sulphur up to 30 kg/ha at all the stage of crop growth. S45 was at par with S30. Zinc application @ 5 kg/ha recorded significant increase over control, Zn_{10} and Zn_{15} but Zn_{10} and $Z\ n_{15}$ showed significant reduction in number of primary branches per plant at all the stages of crop growth. However, Zn_{10} being at par with $Z\ n_{15}$ recorded significant increase over control but $Z\ n_{15}$ did not reach the level of significance.



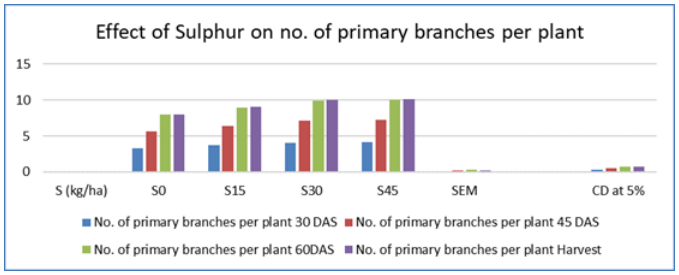
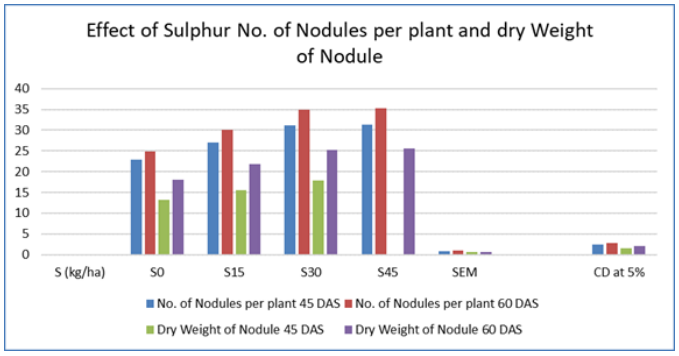


Fig 2. Effect of Sulphur and Zinc on no. of primary branches per plant

3.1.3. Number and dry weight of nodules per plant

The number and dry weight of nodules per plant at 45 and 60 DAS were significantly influenced by both sulphur and zinc application (Table 10). Sulphur application increased nodule number and dry weight up to 30 kg S/ha (S30), with 45 kg S/ha (S45) showing no significant advantage over S30. The response to S30 over control was 36–40% for nodule number and 35–40% for nodule dry weight during 2024. Zinc application also enhanced nodulation, with 5 kg Zn/ha (Zn5) producing the highest number and dry weight of nodules, significantly superior to higher zinc levels. Zn10 and Zn15 improved nodulation over control, but doses beyond 5 kg/ha showed reduced effectiveness or even adverse effects. The increase due to Zn5 over control was 33–37% for nodule number and 32–37% for nodule dry weight at 45 and 60 DAS, respectively, highlighting the importance of optimal sulphur and zinc levels for effective nodulation in green gram.



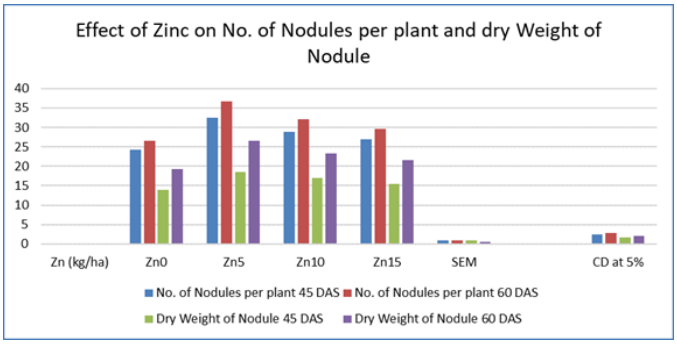


Fig. 3 Effect of Sulphur and Zinc on No. of Nodules per plant and dry Weight of Nodule

3.2 Post-harvest studies

The number of pods per plant in green gram increased significantly with sulphur application up to 30 kg/ha (S30), with S45 showing no significant advantage; the increment due to S30 over control was 10–23% during 2024. Zinc application also enhanced pod number, with 5 kg Zn/ha (Zn5) being significantly superior to Zn10, Zn15, and control, while higher zinc levels showed reduced effectiveness; the response to Zn5 was 9–22%. Pod length and number of grains per pod were not significantly affected by sulphur or zinc, although maximum pod length and grain number were observed with S45 and Zn5, respectively. Grain weight per plant increased markedly with S application up to 30 kg/ha, with S45 at par with S30, showing 17–45% enhancement over control. Similarly, Zn5 significantly improved grain weight per plant over other zinc levels, with Zn10 and Zn15 also showing increases over control but lower than Zn5, indicating that moderate sulphur and zinc doses optimize yield components in green gram.

Table 2 Effect of Sulphur and Zinc on Number of pods per plant, Length of pod, Number of grains per pod, Grain weight per plant

Treatment	Number of pods per plant	Length of pod (cm)	No. of grains per pod	Grain weight per plant (g)
S (kg/ha)				
S_0	8.78	6.14	7.99	2.61

Treatment	Number of pods per plant	Length of pod (cm)	No. of grains per pod	Grain weight per plant (g)
S_{15}	9.84	6.40	8.31	3.24
S_{30}	10.84	6.69	8.61	3.80
S_{45}	10.93	6.72	8.64	3.86
SEM±	0.20	0.20	0.19	0.13
CD at 5%	0.58	NS	NS	0.36
Zn (kg/ha)				
Zn_0	9.14	6.20	8.10	2.82
Zn_5	11.20	6.84	8.72	4.01
Zn_{10}	10.28	6.53	8.44	3.49
Zn_{15}	9.77	6.38	8.29	3.18
SEM±	0.20	0.20	0.19	0.13
CD at 5%	0.58	NS	NS	0.36

Sulphur application up to 30 kg/ha significantly improved 1000-grain weight, grain yield, biological yield, and harvest index in green gram, with S30 increasing test weight by 2–5% over control and S15, and raising grain yield by 39% compared to control during 2024. Higher sulphur levels (S45) were generally at par with S30. Zinc application at 5 kg/ha (Zn5) was most effective in enhancing these parameters, increasing 1000-grain weight by 2–5%, grain yield by 73%, biological yield, and harvest index (26.36%) compared to control, while higher zinc doses (Zn10 and Zn15) were less effective or even reduced performance. Overall, moderate doses of sulphur and zinc optimized yield, biomass accumulation, and harvest efficiency in green gram.

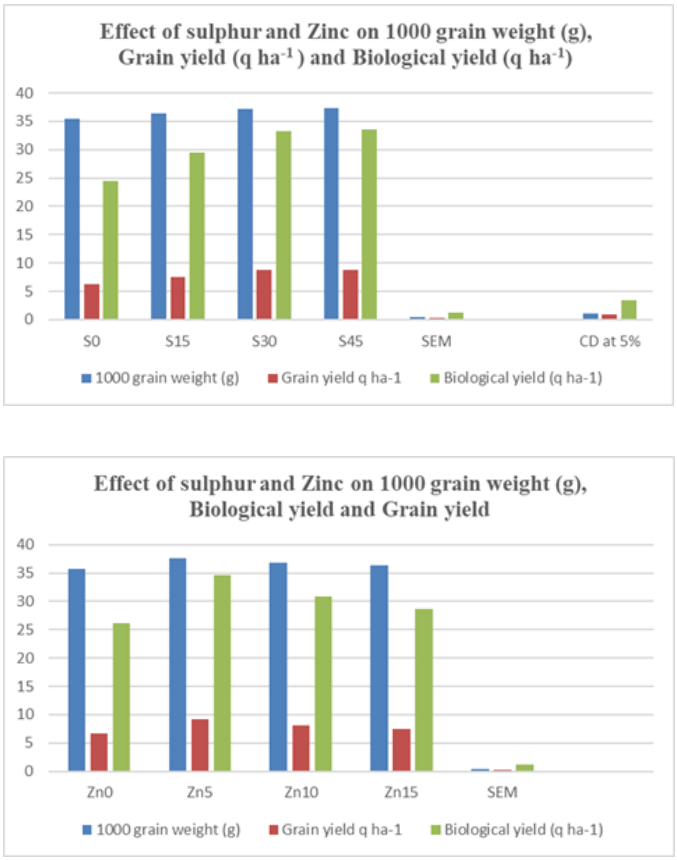


Fig. 6. Effect of sulphur and Zinc on 1000 grain weight (g), Biological yield and Grain yield

IV. CONCLUSION

Sulphur plays a vital role in plant growth and metabolism, being essential for the synthesis of S-containing amino acids (cystine, cysteine, methionine), proteins, enzymes, coenzymes, vitamins, chlorophyll, ferredoxins, and alkaloids, and indirectly supporting nitrogen fixation **(Tisdale et al., 1993).** In green gram, sulphur application up to 30 kg/ha significantly enhanced vegetative growth, including plant height, primary branches, functional leaves, dry matter accumulation, and nodulation, though it did not markedly affect flowering or maturity. Improved vegetative growth translated into superior yield attributes such as number of pods per plant, grain weight, and 1000-grain weight, ultimately increasing grain, straw, and biological yields as well as harvest index. Sulphur uptake, along with zinc uptake, increased significantly with higher sulphur levels due to enhanced biomass and nutrient concentration. Seed

protein content and yield also improved with sulphur application, reflecting its direct role in protein synthesis and enhanced seed production (**Aulakh and Pasricha, 1977; Rathee and Chahal, 1977; Khandkar et al., 1985; Joseph and Varma, 1994; Kamat et al., 1981).** Zinc is a crucial micronutrient involved in the synthesis of tryptophan, a precursor of auxins like indole acetic acid, and is essential for chlorophyll, starch, protein synthesis, and several enzymatic activities **(Tisdale et al., 1993; Marschner, 1988).** In green gram, zinc application significantly enhanced vegetative growth, including plant height, primary branches, functional leaves, and dry matter accumulation, with the optimum response observed at 5 kg Zn/ha, while higher doses caused reductions. Nodulation and nodule dry weight also increased due to zinc's role in auxin production, supporting nitrogen fixation (Skoog, 1940). Zinc influenced flowering and maturity, reducing days to 75% flowering and maturity at higher doses, and improved yield attributes such as number of pods per plant, grain weight, and 1000-grain weight, though pod length and grains per pod were not significantly affected. Consequently, grain, straw, and biological yields increased markedly at 5 kg Zn/ha, with harvest index also improving due to better translocation of photosynthates. Zinc application enhanced both sulphur and zinc uptake and increased seed protein content, reflecting its role in protein synthesis and overall growth, consistent with findings in mungbean, urdbean, lentil, soybean, and pigeonpea (**Ahmed et al., 1986; Shukla et al., 1983; Puste and Jana, 1995).**

REFERENCES

[1]. Ahmed, I.U., Rahman, S., Begum, N. and Isiam, M.S. (1986). Effect of phosphorus and zinc application on growth, yield and P, Zn and protein content of mungbean. J. Indian Soc. Soil Sci., 34 (2): 305 -308.

[2]. Ali, M. (1988). Response of pulses to phosphorus in N. Indian. Proc.FAI (NR) Seminar, New Delhi.

[3]. Anonymous (1975-1977). Annual Report on Coordinated. Micronutrient Sheme. Haryana Agricultural University, Hissar, India.

[4]. Anonymous (1993-1994). Economic Survey. Govt, of India, Ministry of Finance, Economics Division, p. 71.

[5]. Anonymous (1995). Director's Report. Indian Institute of Pulses Research, Kanpur.

[6]. A.O.A.C. (1970). Association of official Agricultural Chemists official methods of analysis, P.O. Box 540, Benjamin Franklin Station, Washington-4, D.C.

[7]. Arora, S.K. and Luthra, Y. P.(1972). Improvement in the quality of Phaseolus aureus Linn, by the application of sulphur, phosphorus and nitrogen. Indian J. Agric. Chem. 5 (2):77-83.

[8]. Amnachalm, 1., Purushothaman, S,, Palaniappan, S.P. and Devasahyam, M.M. (1995). Response of pigeonpea to P and S nutrition. Madras Agric. J., 82 (4): 266-267.

[9]. Aulakh, M.S. and Chhibba, I.M. (1992). Sulphur in soils and response on crops to its application in Punjab. Fert. News, 37 (9): 33-45.

[10]. Aulakh, M.S. and Pasricha, N.S. (1977). Interaction effect of sulphur and phosphorus on growth and nutrient content of moong (.Phaseolus aureus L.). Plant and Soil, 47 (2): 341-350

[11]. Aulakh, M.S. and Pasricha, N.S (1986). Proceedings ofTSI-FAJ Symposium on Sulphur in Indian Agriculture, SII/3/1-14, New Delhi.

[12]. Backer, N.R., Femyhough, P. and Meek, T.T. (1982). Light dependent inhibitors of photosynthetic electron transport by zinc. Plant Physiol., 56:217-222

[13]. Bahl, G.S., Baddesha, H.S., Pasricha, N.S. and Aulakh, M.S. (1986) Sulphur and zinc nutrition

of groundnut grown on Tolewal loamy- sand soil. Indian. J . Agric. Sci., 56 (6): 429-433.

[14]. Bansal, K.N. (1991). Effect of levels of sulphur on the yield and composition soybean, greengram, blackgram and cowpea, Madras Agric. J . 78 (5-8): 188-190.

[15]. Bapat, P.N. Sinha, S.B.and Shinde, D.A. (1986) . Effect of sulphur and phosphorus on yield and nutrient content of blackgram. J. Indian Soc. Soil Sci., 34 (1): 82-86.

[16]. Bouyocous (1936). Direction for making mechanical analysis of soil by hydrometer method. Soil Sci., 42:225-228.

[17]. Brady, N.C. (1990). The Nature and Properties of Soils. Prentice-Hall of India Pvt. Ltd., New Delhi.

[18]. Chatterjee, C., Shukla, S. Khurana, N. (1992). Effect of sulphur deficiency on metabolism of greengram {Phaseolus radiatus). Indian j. Agric. Sci., 62(7): 445-449.

[19]. Chaudhary, L.S. and Singh, L. (1994). Effect of nitrogen, phosphorus and zinc on growth, yield attributes and yield of rainfed horsegram (Macrotyloma uniflorum) in Rajasthan. Indian J. Agric.SCL, 64(4):257-258.

[20]. Chesnin, L. and Yield C.H. (1950). Turbidimetric determination of available sulphur. Soil Sci. Soc. Am. Proc., 15149-151.

[21]. Cochran, W.G. and Cox, G.M. (1970) . Experimental Designs. Asia Publishing House, New Delhi..

[22]. Devarajan, R., Sheriff, M.M., Ramanathan, G. and Selvakumari, G.(1980). Effect of phosphorus and zinc fertilization on yield, content and its uptake by pulse crops. Indian J. Agric. Res., 14 (1): 47-52.

[23]. Dhankar, J.S. Kumar, V. and Karwasra, S.P.S. (1991). Effect of S application on diy matter yield, concentration and uptake of N.P.K in different pulse crops. Agrochimica, XXXV : 314-326.

[24]. Duxit, M.L. and Shukla, U.C. (1984) Effect of boron, sulphur and zinc at different phosphorus and moisture levels on yield of mustard (Brassica jnncea L.). J. Indian Soc. Soil. Sci, 32: 168-188.

[25]. Dube, S.D. and Misra, P.H. (1970). Effect of sulphur deficiency on growth, yield and quality of some of the important leguminous crops. J. Indian Soc. Soil Sci., 18(4): 375- 378.

[26]. Dwivedi, G.K., Singh, V.P.and Dwivedi, M. (1988). Effect of phosphorus and sulphur on yield potential and nutritional quality of blackgram (Vigna immgo L . Hepper). Ann. Agril. Res., 9(1): 6-12.

[27]. Gangwar, K.S. and Singh, N.P. (1991). Growth and development behaviour of lentil in relation to zinc fertilization. Indian J. Agric. Sci., 25(1): 38-42.

[28]. Gangwar, K.S. and Singh, N.P.(1991), Influence of zinc application on concentration and uptake of zinc in lentil. Indian J. Pulses Res., 4 (1): 57-59.

[29]. Gupta, J.K. and Gupta Y.P. (1972). Indian J. Agron., 17 : 245.

[30]. Gupta, V.K. (1983). Studies of the comparative responses of some kharif crops to zinc application. Agric. Sci. Digest, 3(2): 79-80

[31]. Islam, M.S., Hossain, K.M. Sarkar, N.I., Altamash, S.and Sarkar. J.U. (1986). Experimental methodology and responses of principal crops to sulphur fertilization in Bangladesh. (In) Proceedings Intentional Symposium, held on April 20-22, 1986, at Dhaka, Bangladesh, pp. 184-211.

[32]. Jackson, M.L. (1958). Soil Chemical Analysis. Prentice- Hall Inc., Englewood cliffs, New Jersey.

[33]. Jat, R.l. and Rathore, P.S. (1994) Effect of sulphur, molybdenum and Rhizobium inoculation on greengram (Phaseolus radiatus). Indian J. Agron ., 39(4):651-654.

[34]. Joseph, B. and Varma, S.C. (1994). Response of rained chickpea (Cicer arietinum) to Jalshakli incorporation and sulphurfertilization. Indian,!. Agron., 39(2): 321-314

[35]. Kamat, V.N., Kantute, V.G.Puranik, R.B., Kahadhar, N.S. and Joshi, R.P. (1981). Effect of S and Mo application on yield, protein and S-amino acid contents of greengram. J. Indian. Soc. Soil. Sci., 29(2):225-227.

[36]. Kapur, O.C., Gang war, M.S, Sharma, S.K. and Masand, S.S. (1977). Influence of zinc application on yield and protein content of soybean. Fd. Mg. Agric., 8(10): 36-38.

[37]. Kasthuri, R., Jayapragasam, M. and Sri Rangaswamy, S.R.(1992). Effect of sulphur nutrition on seed protein and yield in blackgram (Vigna mango). Legume Res., 15(1): 15-18.

[38]. Khandkar, U.R., Shinde, D.A.Khandakar, V.S., Jamely,N.R. and Jain, N.K.(1985).Growth, nodulation and yield of rainfed blackgram (Vigna mango L. Hepper) as influenced by phosphate and sulphate fertilization in Vertisol. Indian J.Plant Physiol., 28 (4):318-322.

[39]. Kumar, V. and Singh, M.(1979). Sulphur and zinc relationship on uptake and utilization of zinc in soybean Soil Sci., 128(6): 343-347.

[40]. Kumar, V and Singh, M.(1980). Sulphur and zinc interaction in relation to yield, uptake and utilization of sulphur in soybean. Soil xS'c/.,130(1): 19-25

[41]. Kumar, V., Karwasra, S.P.A., Singh, M. and Dhankar, J.S. (1994). An evaluation of the sulphur status and crop responses in the major soils of Haryana, India. Sulphur in Agriculture, 18: 23-26

[42]. Kushwaha, B. L. (1993) Response of urdbean to phosphorus and zinc application. Indian J. Pulses Res., 6(2): 152-154.

[43]. Lakkineni, K.C. and Abrol, y.p (1994) Sulphur requirement of crop plants: physiological analysis. Fert. News, 39(3): 11-18.

[44]. Lai, R.B.and Jaiswal, P.C.(1981). Influence of sulphur fertilization on grain yield and economics of Urd cultivation. Indian J. Agron., 26 (3): 329-330.

[45]. Lai, S. and Yadav, D.S.(1981). Raise short duration pulses during summer. Indian Farming, XXXI.

[46]. Lindsay, S.L. and Norvell, W.A.(1978). Development of DTPA soil test for Zn, Fe ,Cu and Mn. Soil Sci. Soc. Am. J., 42:421-428.

[47]. Lyon, T.L., Buckiman, H.O. and Brady, N.C.(1952).77?e Nature and Properties of Soils. The Mcmillan company, New York, p.55.

[48]. Malewar, G.U., Budhewar, L.M. and Jadhav, N.S. (1980). Response of greengram to zinc application. Indian J. Agron ., 25(1): 164-165.

[49]. Mali, C.V. and Saikh, A.R. (1994). Influence of different sources of zinc with and without FYM on yield and nutrient content in Rice-Gram cropping sequence. Mysore J. of Agriculture Sci., 24 : 243-251.

[50]. Marschner, H. (1988). Mineral Nutrition of Higher Plants. Academic Press Harcourt Brace Javanovich Publishers, London, pp. 218-225.

[51]. Mehta, U.R. and Singh, H.B. (1979). Response of greengram to sulphur on calcareous soils. Indian J. Agric. Sc/'.,49(9): 703-706.

[52]. Nad, B.K. and Goswami N.N. (1983). Response of legume and oilseed crops to different sources of sulphur and magnesium in some alluvial soils, J. Indian Soc. Soil. Sci., 31(1): 60-64.

[53]. Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorus by extraction with sodium carbonate. USDA circ. 939

[54]. Patel, L.R., Salvi, N.M. and Patel, R.H,(1992). Response of greengram (Phaseolus radiatus) varieties to sulphur fertilization under different levels of nitrogen and phosphorus. Indian J. Agron., 37 (4): 831-833.

[55]. Prasad, J. and Ram, H. (1988). Effect of zinc and copper and Rhizobium on nodulation and yield

of greengram (Vigna radio fa). Indian J. Agric. Sci., 58 (3): 230-232.

[56]. Puste, A.M. and Jana, P.K. (1995). Effect of P and Zn on the yield and yield attributes of pigeonpea varieties grown during winter season. Madras Agric82(5): 348- 357

[57]. Raikhy, N.P., Agrawal, R.K. and Raina, (1985). Performance of pyrite and gypsum as sulphur source in and acid sandy soil. J. Indian Soc. Soil Sci., (2): 447-449.

[58]. Raju, R.A., Reddy, k.k. and Reddy M.N. (1994). Response of rice (Oiyza sativa) to sulphur and zinc on coastal alluvials of Andhra Pradesh. Indian J. Agron., 39(4): 637-638.

[59]. Rathee, O.P. and Chahal, R.S. (1977). Effect of phosphorus and sulphur application on yield and chemical composition of groundnut. Haryana Agric. Univ../. Res., 7(4): 173-177

[60]. Rattan, R.K., Saharan, N. and Balloli, S.S. (1995). Soil sulphur status and crop responses to sulphur in western Uttar Pradesh. Perl. Mews, 40 (4):31-40.

[61]. Reddy, T.Y. and Reddy G,H.S.(1992). Principles of Agronomy. Kalyani Publishers, New Delhi.

[62]. Sakai, R., Singh A.P. and Sinha, R.B. (1993). Twenty-five years of Research on micro and secondary nutrients in soils and crops of Bihar. Research Bulletin, Department of Soil Science, RAU, Pusa, Samastipur.

[63]. Saraf, C.S. ((1988). Sulphur fertilization of pulses for yield and quality. Proc. TSI-FAI Symp. on Sulphur in Indian Agriculture, New Delhi, SII/2/1-7.

[64]. Saxena, A. K. and Rewari K.B.(1990). Influence of zinc on nodulation and ion uptake by chickpea under saline conditions. J.Indian Soc. Soil Sci., 38 : 363-364.

[65]. Sharma, M.P. and Singh, R.(1993) Effect of phosphorus and sulphur application on yield and quality of greengram (Phaseohts radiants). Indian J. Agric . Sci., 63 (8): 507-508.

[66]. Sharma, U.C., Gangwar, M.S. and Srivastava, P.C (1990). Effect of Zn and S on nutrient uptake and yield of mustard. J. Indian Sac. Soil Sci., 38(4): 696- 701.

[67]. Shukla, M.P., Shanker , H. and Pathak, R.K.(1983).Sulphur, zinc and boron nutrition of Rai (Brassica juncea). J. Indian Soc. Soil Sci., 31: 517-520.

[68]. Shukla, U.C. and Prasad, , K.G.(1976) Sulphur and zinc interaction in groundnut. Paper presented at 41st annual convention of Indian Society of Soil Science, Hyderabad, India.

[69]. Shukla, U.C. and Prasad K.G. (1979). Sulphur-zinc interaction in groundnut. ,/. Indian Soc. Soil. Sci 39(9): 43-45.

[70]. Singh, B P., Singh A.P. and Sakai, R. (1983). Differential response of crops to zinc application in calcareous soil. J. Indian Soc. Soil Sci.., 31 (4):534- 538.

[71]. Singh, D. and Singh, V. (1995) Effect of potassium, zinc and sulphur on growth characters, yield attributes and yield of soybean (Glycine max). Indian J.Agron, 40 (2): 232-227.

[72]. Singh, D.P. and Singh B.B. (1994). A new variety of mungbean-narendar mung- 1 Indian Farming, 43 (11): 3-5

[73]. Singh, H.G. and Chauhan, Y.S. (1979).Factors limiting rapeseed mustard production in North-Eastern part of India . (In) Research and Development Strategies for Oilseed Production in India. ICAR,New Delhi, 1984.pp. 77-84.

[74]. Singh, S.K., Singh R. and Sing, S. (1994) Yield and yield attributes of greengram (Phaseolus radiatus) in response to sulphur level. Indian J. Agric. SCI., 64(6): 390-392.

[75]. Singh, T., Tewari, K.N.J. and Pathak, A.N. (1988). Yield zinc uptake and content of nutrients as influenced by zinc application in pigeonpea. Indian Agriculturist, 32 (1): 55-61

[76]. Sinha, A.C., Mandal, B.B., and Jana, P.K. (1994). Yield and water use efficiency of rainfed lentil

as influenced by boron, zinc and molybdenum, Indian J. Agric. Set, 64 (12): 863-866.

[77]. Skoog, F. (1940). Relationship between zinc and auxin in the growth of higher plants. Am. J. Bat., 27: 939.

[78]. Takkar, P.N. et al. (1989). Twenty years of Coordinated Research on Micronutrients in Soils and Plants (1967-1987). Bulletin 1, I.I.S.S., Bhopal, p. 314.

[79]. Tandon, H.L.S. (1991). Secondary and Micronutrients in Agriculture- Guidebook-cum-Directory. FDCO, New Delhi.

[80]. Tandon, H.L.S. 1991. Sulphur Research and Agricultural Production in India, edn 3, 140 pp. The Sulphur Institute, Washington DC.

[81]. Tisdale, S.L., Nelson, W.L., Beaton, J.D. and Havlin, J.L. (1993). Soil Fertility and Fetilizers. Prentice-Hall of India Pvt. Ltd., New Delhi.

[82]. Tsui, Chen (1948). The role of zinc in auxin synthesis in tomato plants. Am. J. Bot., 35 : 172

[83]. Walkley, A. and Black, C.A. (1934). An examination of Degtjareff methods for determining soils organic matter and proposed modifications of the chromic acid titration method. Soil Sci., 37 : 29-38.

[84]. Yadav, D.S. (1992). Pulse Crops (Production Technology), Kalyani Publishers, New Delhi.

[85]. Yawalker, K.S., Agarwal, J.P. and Bokde S. (1992). Manures and Fertilizers. Agri-Hort Pub. House, Nagpur, India