Original Research Article

EffectofSulphurandMicronutrientonGrowthandYieldofLentil(*Lens culinaris*Medik)

ABSTRACT

A field experiment was conducted during *Rabi*, 2022 at Crop Research Farm, Departmentof Agronomy, SHUATS, Prayagraj (U.P). The treatment consisted of three level of Sulphur (25,35,45 kg/ha) and three level of Micro-nutrient Boron (1 kg/ha), Zinc (4 kg/ha), Molybdenum (0.4 kg/ha) and control. The experiment was laid out in Randomized Block Design with ten treatments each replica~~n~~ted thrice. The soil in the experimental area was sandy loam with pH (8.0), EC (0.56 dS/m), Organic Carbon (0.62%), Available N (225 kg/ha), Available P (38.2 kg/ha), and Available K (240.7 kg/ha). higher plant height (36.93 cm), number of nodules (16.44) higher dry weight (6.67 g/plant), maximum number of pods/plant (160.33), maximum number of seeds/pod (1.89), higher seed yield (2028.04 kg/ha) and higher stover yield (3540.60 kg/ha). However, the maximum gross return (129245.56 INR/ha), maximum net return (91679.57 INR/ha) and maximum benefit cost ratio (2.44) was obtained with same treatment-9 [Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha)].

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Keyword: Lentil, Rhizobium, Sulphur, Zinc, Boron, Molybdenum Growth, Yield and Economic

INTRODUCTION

India is largest pulse-growing country which accounts for nearly one-third of the total world area under pulses and one-fourth of the total world production. Lentil (Lens culinarisMedikus) is an important Rabi season legume crop in India, lentils are drought tolerant crop. It belongs to the sub-family Papilionaceae under the family Fabaceae (Leguminosae). Lentil (Lens culinaris M.) Medik a name given by the German botanist medikus in 1778. Lentils are known for their nutritional benefits. They are a rich source of plant-based protein, containing about 25-30% protein by weight. They are a good source of essential minerals like iron, potassium, and folate, as well as vitamins, including vitamin B6 and vitamin **Rozan et al. (2001),**

Utter Pradesh is one of the key lentil-producing states in India. The state's favorable agroclimatic conditions and fertile soils make it suitable for lentil cultivation. Lentils are primarily grown in the districts of Sitapur, Lucknow, Barabanki, Faizabad, Allahabad, and Gorakhpur, among others. Farmers in Uttar Pradesh predominantly cultivate desi lentils, which are smallsized lentils with a rich flavor. The most commonly cultivated varieties include Pusa Masoor-21, Pant Lentil-8, and Pant Masoor-22, among others. These varieties have been developed by agricultural research institutes to enhance yield potential and disease resistance. In recent years, efforts have been made to promote lentil cultivation in Uttar Pradesh through the dissemination of improved production technologies, availability of quality seeds, and agronomic practices.

In India Madhya Pradesh ranks first in acreage i.e., 37.02% followed with the aid of U.P. 31.46 % and West Bengal 12.23% and in terms of production Madhya Pradesh ranks first at 41.05% accompanied with the aid of Uttar Pradesh (31.27%) and West Bengal (11.02%) in terms of production. The absolute best yield was recorded by the state of Rajasthan (1162 kg/ha) followed by Madhya Pradesh (1145 kg/ha) and Uttar Pradesh (1026 kg/ha). The National yield average was (1032 kg/ha). The lowest yield was observed in the state of Assam (712 kg/ha), Jharkhand (882 kg/ha) **(GOI, 2021-22).**

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Sulphur is a vital macronutrient that contributes to various metabolic processes in plants. It is an essential component of amino acids, proteins, and enzymes. Lentil plants require sulphur for chlorophyll synthesis, nitrogen metabolism, and overall plant growth. Adequate sulphur availability promotes vigorous vegetative growth, enhances root development, and improves nitrogen utilization efficiency. Sulphur deficiency can lead to stunted growth, reduced seed yield, and decreased protein content in lentils **Bhattacharjee et al. (2013).**

Zinc is a micronutrient that acts as a catalyst for several enzymatic reactions in plants. It is crucial for lentils as it facilitates protein synthesis, carbohydrate metabolism, and hormone regulation. Zinc deficiency can result in reduced growth, delayed maturity, and smaller seeds in lentil plants. Supplementing zinc can enhance root development, improve flowering, and increase the number of pods per plant, ultimately leading to higher seed yield Sharma et al. (2017), **Alloway et al. (2008).**

Boron is another micronutrient required by lentil plants in small amounts. It plays a vital role in cell wall synthesis, pollen tube elongation, and carbohydrate metabolism. Boron deficiency can lead to abnormal flower development, poor pollen viability, and reduced seed set in lentils. Adequate boron supply improves lentil plant fertility, enhances seed development, and ultimately increases yield **Moghaddam et al. (2015).**

Molybdenum is a micronutrient that is essential for nitrogen metabolism in legumes, including lentils. It is a component of the enzyme nitrogenase, which converts atmospheric nitrogen into a usable form for plants. Molybdenum deficiency can result in reduced nitrogen fixation, leading to poor plant growth and lower yield in lentils. Supplying sufficient molybdenum promotes efficient nitrogen fixation, improves plant vigor, and increases seed yield **Ahlawat et al. (2007), Togay et al. (2008)**

MATERIALS AND METHODS

This experiment was laid out during the *Rabi* season of 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The crop research farm is situated at 25^0 39” 42” N latitude, 81^0 67” 56” E longitude and at an altitude of 98 m above mean sea level. The experiment was laid out in Randomized Block Design Which consisting of ten treatments T1 Sulphur (25 kg/ha) + Boron (1 kg/ha) T2 Sulphur (25 kg/ha) + Zinc (4 kg/ha) T3 Sulphur (25 kg/ha) + Molybdenum (0.4 kg/ha) T4 Sulphur (35 kg/ha) + Boron (1 kg/ha) T5 Sulphur (35 kg/ha) + Zinc (4 kg/ha) T6 Sulphur (35 kg/ha) + Molybdenum (0.4 kg/ha) T7 Sulphur (45 kg/ha) + Boron (1 kg/ha) T8 Sulphur (45 kg/ha) + Zinc (4 kg/ha) T9 Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha) T10-Control (40-20-40 NPK kg/ha)Seeds are sown at a spacing of 30x10 cm to a seed rate of 45 kg/ha. The recommended dose of Nitrogen (20 kg/ha), Phosphorus (40 kg/ha) and Potassium (20 kg/ha). Sulphur and Micronutrient (Boron, Molybdenum, and Zinc) were applied as per the treatments. Nitrogen, Phosphorus and Potash was applied as basal at the time of sowing. One hand weeding was done manually with *Khurpi* at 30 DAS followed by second manual weeding was done at 60 DAS. This was done to control grass as well as broad leaf weeds.Two irrigation was applied to field.Data recorded on different aspects of crop, *viz.*, growth, yield attributes were subjected to statistically analysis by analysis of variance method.**(Gomez and Gomez, 1984)**

RESULT AND DISCUSSION:

Growth parameters

Plant height (cm)

At 80 DAS, significantly and higher plant height (36.93 cm) was recorded in treatment 9 [Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha)].The significant and higher plant height was with application of Sulphur (45 kg/ha) and micronutrients might be due to involvement of due to retardant properties of plant growth regulators results a significant reduction in plant height during the entire growing season even with the higher dose of nitrogen. Similar findings were recorded by **Arunraj et al. (2018); Singh et al. (2014).**

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Number of Nodules

At 60 DAS, significant and maximum number of nodules (37.66 g) was recorded in treatment 9 [Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha)].M~~m~~aximum number of nodules/plant was with application of sulphur might be due to the increasing leg hemoglobin pigment formation in nodules. M~~m~~aximum number of nodules/plant might be due to the application of boron root and shoot growth, flower fertility and essential nutrient for nodule forming bacteria. Similar results were reported by **Movalia et al. (2017). Parry et al. (2018).**

Plant dry weight

The data revealed, Significant and maximum plant dry weight t (6.67 g) was recorded in treatment 9 [Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha)]. The significant and higher plant dry weight was with the application of sulphur might be due to the continuous and slow release of nutrients. Further application of Molybdenum increased the availability of nutrients like N and P. Increased physiological processes such cell division, elongation and meristematic tissue creation resulted from the availability of more nutrients, which enhanced growth characteristics and dry matter production. Reported by **Arunraj et al. (2017). Chaudhary et al. (2005).**

Number of pods/plant

M~~m~~aximum number of pods per plant recorded a significant difference among treatment combinations. However, number of pods (160.33/plant) recorded significantly higher in Treatment 9 [Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha)] Improved availability of sulphur and favourable nutritional environment might have helped the plants at the peak growth period and flowering stages which ultimately increased the number of pods per plant.

~~increasing~~Increasing yield qualities be the reason of moderate plant nutrients availability due to which the plant produces more pods/plant as compare to other treatments and also phosphorus strongly increases the reproduction of the plants i.e., flowering and fruiting. These results were similar with that of **Khan et al., (2014). Mazed et al. (2015).**

Number of seeds/pod

S~~s~~how that maximum number of seeds per pod recorded at harvest stage was found significant effect among treatments Treatment 9 [Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha)] was recorded significant and maximum number of seeds/pod (1.99) which was superior over all other treatments. ~~a~~Application of sulphur, might be due to sulphur in stimulation of cell division, photosynthetic process as well as formation of chlorophyll ultimately helped in realization of higher grain yield increase in number of seeds/pod probably may be due to balanced nutrition and proper vegetative growth which later converted into reproductive phase and resulted might in more number of seeds. The results were similar to **Venkatesh et al. (2020)**

Seed Yield (kg/ha)

Data show that there was a significant effect on treatment combinations of application of sulphur and Molybdenum in relation to seed yield. Significantly higher seed yield was noticed in Treatment 9 [Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha)] was recorded maximum Seed yield (2028.05 kg/ha) which was superior over all other treatments. H~~h~~igher haulm yield was observed with the application of Sulphur (45 kg/ha) might be due to sulphur enhances the plant metabolism and photosynthetic activity. S~~s~~eeds yield probably may be due to balanced nutrition and proper vegetative growth which later converted into reproductive phase and resulted might in more number of seeds. ~~r~~Results were similar to **Venkatesh et al., (2020)** in lentil.

S~~s~~tover yield (kg/ha)

S~~s~~tover yield was significantly higher in Treatment 9 [Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha)] was recorded significantly maximum Stover yield (3540.60 kg/ha) which was superior over all other treatments. Stover yield was obtained with the application of sulphur (45/ha) might be due to the part of amino acid, which helps in chlorophyll formation, photosynthetic process, activation of enzymes and grain formation **Arunraj et al. (2018).**

Harvest index (%):

M~~m~~aximum harvest index (36.39 %) was recorded in Treatment 9 [Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha)] though there was no significant difference among the treatments.

CONCLUSION:

Based on the findings of experimentation in one season in a year, it is concluded that application of sulphur at 45 kg/ha as well as Molybdenum (0.4 kg/ha)was found more helpful for attaining better yields in lentil under north east plane zone(U.P.) climatic condition.

Table: 1 Influence of Sulphur and Micro nutrient on growth of Lentil.

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S.No.	Treatment combinations	Plant height (cm)	No. of Nodules/plant 60 DAS	Dry weight (g/plant) 80 DAS
1.	Sulphur (25 kg/ha) + Boron (1 kg/ha)	30.94	33.86	4.79
2.	Sulphur (25 kg/ha) + Zinc (4 kg/ha)	31.65	34.06	4.91
3.	Sulphur (25 kg/ha) + Molybdenum (0.4 kg/ha)	32.91	36.78	4.97
4.	Sulphur (35 kg/ha) + Boron (1 kg/ha)	32.00	33.66	5.20
5.	Sulphur (35 kg/ha) + Zinc (4 kg/ha)	33.59	34.20	5.28
6.	Sulphur (35 kg/ha) + Molybdenum (0.4 kg/ha)	34.33	34.13	5.29
7.	Sulphur (45 kg/ha) + Boron (1 kg/ha)	34.36	34.10	5.31
8.	Sulphur (45 kg/ha) + Zinc (4 kg/ha)	35.89	34.60	6.13
9.	Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha)	36.93	37.66	6.67
10.	Control (20-40-20 NPK kg/ha)	30.09	33.60	4.54
	F-test	S	S	S
	SEm(±)	1.04	0.76	0.35
	CD (p=0.05)	3.08	2.25	1.05

Table: 2Influence of Sulphur and Micro nutrient on growth of Lentil.

S.No.	Treatment combinations	Number of pods/plant	Number of seeds/pod	Seed Yield (kg/ha)	stover yield (kg/ha)	Harvest index (%)
1.	Sulphur (25 kg/ha) + Boron (1 kg/ha)	130.33	1.43	1160.57	2515.80	31.44
2.	Sulphur (25 kg/ha) + Zinc (4 kg/ha)	131.67	1.59	1314.34	2550.20	33.97
3.	Sulphur (25 kg/ha) + Molybdenum (0.4 kg/ha)	134.33	1.76	1449.03	2584.60	36.01
4.	Sulphur (35 kg/ha) + Boron (1 kg/ha)	138.00	1.63	1468.15	2741.00	34.80
5.	Sulphur (35 kg/ha) + Zinc (4 kg/ha)	136.00	1.73	1508.95	2823.40	34.91
6.	Sulphur (35 kg/ha) + Molybdenum (0.4 kg/ha)	137.67	1.80	1659.16	3056.00	35.09
7.	Sulphur (45 kg/ha) + Boron (1 kg/ha)	148.33	1.78	1728.97	3093.40	35.74
8.	Sulphur (45 kg/ha) + Zinc (4 kg/ha)	150.67	1.86	1806.60	3374.40	34.86
9.	Sulphur (45 kg/ha) + Molybdenum (0.4 kg/ha)	160.33	1.99	2028.05	3540.60	36.39
10.	Control (20-40-20 NPK kg/ha)	131.33	1.46	1142.17	2166.40	34.45
	F-test	S	S	S	S	NS
	SEm(±)	6.15	0.08	103.30	123.28	1.95
	CD (p=0.05)	18.28	0.24	306.88	366.23	-

Comment [Dr5]: Table not cited in the manuscript

References

AhlawatI.P.S.,Gangaiah,B.andAshraf,Z.M.(2007).Nutrientmanagementinchickpea.Chickpeabreedingandmanagement.213.11.

Alloway, B.J (2008). Zinc in soils and crop nutrition. Second edition, Published by InternationalZinc Association and International Fertilizer Industry Association, Brussels, Belgium andParis,France.ISBN978-90-8133-310-8, 134

Arunraj, M., Vasanthi, D., Mansingh, M. D. I. (2018). Effect of sulphur on growth and yield ofgreengram [*Vigna radiata*]. *International Journal of Science, Environment and Technology*.7(*5*):1861– 1867.

~~Arunraj, M., Vasanthi, D., Mansingh, M. D. I. (2018). Effect of sulphur on growth and yield ofgreengram [*Vigna radiata*]. *International Journal of Science, Environment and Technology*.7(*5*):1861– 1867.~~

Comment [Dr6]: Repetitive

Bhattacharjee, S., Singh, A. K., Kumar, M. and Sharma, S. K., (2013). Phosphorus, sulfur andcobalt fertilization effect on yield and quality of soyabean (*Glycine max L. Merrill*) in acidicsoilof NortheastIndia. *IndianJournal pfHill Farming.* **26**(*2*):63-66

Chaudhary, V. K. and Goswami, V. K. (2005). Effect of phosphorus and sulphur fertilization onchickpea(Cicerarietinum L.)cultivar. *AnnualAgricultureResearch.***26**(*2*):322-323.

Gomez KA, Gomez AA. Statics Producers for Agriculture Research 1994.

Khan, N.,Tariq, M.,Ullah,K.,Muhammad,D.,Khan,I.,Rahatullah,K.,Ahmad,N.,andAhmed,S. (2014). The effect of molybdenum and iron on nodulation, nitrogen fixation and yield ofchickpea genotypes (*Cicer arietinum L.*). *IOSR International Journal of Agricultural SciencesandVeterinary Medicine*.**7**:63-79. 23.

Mazed, K., Ferdous, J., Nazmul, I. P., and Rahman, H., (2015). Growth and yield of mungbean asinfluencedbypotassiumandsulphur. *AnnalsofBiologicalResearch.***6**(*1*):6-10.14.

Moghaddam, M., Miran, S. N. K., Pirbalouti, A. G., Mehdizadeh, L., &Ghaderi, Y. (2015).Variation in essential oil composition and antioxidant activity of cumin (*CuminumcyminumL.*)fruitsduringstagesof maturity.*IndustrialCropsandProducts*.***70***,163-169.

Movalia, Donga, S. and Parmar, K. B. (2017). Effect of boron and molybdenum on summer green gram (Vigna radiata L.) (GM-4) under medium black calcareous soils. Proceedings of the National Conference on Innovations in Biological Sciences (NCIBS); Januray 10

Parry, S. A., Jaiswal, P. C., Parry, F. A., Ganie, S. A., & Masood, A. (2018). Effect of differentlevels of nitrogen and sulphur on growth, nodulation and yield of green gram (*Vignaradiate*L.).*LegumeResearch-AnInternational Journal*.**41**(*5*),767-770.

Rozan*etal*.(2001),P.,Kuo,Y.H.andLambein,F.(2001).Nonproteinaminoacidsinediblelentilandgarden peaseedlings.*AminoAcids*, **20**, 319-324.

Singh, A. K., Khan, M. A., Srivastava, A. (2014). Effect of boron and molybdenum application on seed yield of mungbean. Asia. Journal Biology Science. 9(2):169-172.

Togay Y, Togay N, Dogan Y. (2008). Research on the effect of phosphorus and molybdenumapplications on theyield andyield parametersin lentil(*Lens culinaris Medic*.). *AfricanJournalof Biotechnology,**7***(*9*):1256–60.

Venkatesh, M. S., Hazra, K. K., Ghosh, P. K., Singh, S. S., Chaturvedi, S. K. and Singh, N. P.,(2020). Response of chickpea (*Cicer arietinum*) to molybdenum in moderately-alkaline soil.*IndianJournal ofAgricultural Sciences.***90**(1):58–63.