International Journal of Advanced Biochemistry Research 2024; 8(7): 1106-1109

International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(7): 1106-1109
www.biochemjournal.com
Received: 19-05-2024
Accepted: 26-06-2024

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Effect of sulphur and boron on yield and economics of lentil (*Lens culinaris* Medik)

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DOI: https://doi.org/10.33545/26174693.2024.v8.i7n.1676

Abstract
This study aimed to examine the impact of sulphur and boron on the growth and yield of lentil (*Lens culinaris* Medik), an important pulse crop grown worldwide. A randomized full block design with three replications was used to carry out a field experiment with different combinations of boron (1.5 kg/ha, 2 kg/ha, and 2.5 kg/ha) and sulphur (10 kg/ha, 20 kg/ha, and 30 kg/ha). The treatment of boron and sulphur both had a substantial impact on the growth and yield characteristics of lentils, according to the data. The application of sulphur at 30 kg/ha and boron at 2.5 kg/ha in combination (Treatment 9) produced the most notable improvements, with notable increases in plant height, nodule count, dry weight, pod count, number of seeds per pod, seed weight, seed yield, and stover yield. In particular, Treatment 9 yielded the highest recorded values for plant height (28.15 cm), number of nodules (29.67), plant dry weight (14.19 g/plant), number of pods per plant (142.60), number of seeds per pod (2.07), largest 1000-seed weight (23.57 g), and stover yield (3.16 t/ha) as well as the highest seed yield (2.08 t/ha). These findings imply that combining treatments of sulphur and boron might greatly improve lentil growth and yield, thereby improving productivity and economic returns for farmers.

Keywords: Boron, economics, lentil, sulphur, and yield

Introduction

A valuable food legume is the lentil (*Lens culinaris* or *Lens esculenta*), also referred to as Masoor. This annual plant, which typically reaches a height of 40 cm (16 inches), is well-known for its lens-shaped seeds. The seeds are stored in pods, each of which typically contains two seeds. Approximately 33% and 25% of the world's total lentil production is located in Canada and India combined. These two countries produce 58% of the world's lentils. Rich in carbohydrates, protein, fat, fiber, folate, thiamine, vitamins, minerals, potassium, copper, zinc, and iron, lentils are a nutrient-dense food. They are widely used in the processing industry for goods such split cotyledon dahl, unhusked seeds, and savory meals.

Presently, 6.5 million tonnes of lentils are produced worldwide, with India accounting for 18% of this amount. Lentils are grown on about 1.42 million hectares in India, producing 1.28 million tons of grain at a productivity of roughly 904 kg/ha on average. Agricultural Statistics at a Glance (2022) states that Uttar Pradesh alone occupies 0.49 million hectares (34.87% of India's total area), produces 0.47 million tonnes (36.46% of India's total production), and has a productivity rate of 944 kg/ha.

After nitrogen (N), phosphorus (P), and potassium (K), sulphur is thought to be the fourth important nutrient and is required in somewhat smaller amounts than phosphorus. According to Karthe *et al*. (2012) [24], sulphur plays a critical role in the production of essential amino acids, the metabolism of carbohydrates, proteins, and lipids, and the creation of chloroplast proteins, all of which improve photosynthetic efficiency and, ultimately, crop yield. It is necessary for the synthesis of amino acids that include sulphur, including cystine, cysteine, and methionine, and it is involved in a number of enzymatic and metabolic activities in plants (Sharma and Singh, 2004) [20]. Moreover, sulphur stimulates nodulation in legumes and is essential for the formation of co-enzymes, volatile chemicals, and vitamins (biotin and thiamine). By raising the oil and protein content, boosting the starch content in tubers, and improving the nutritional value of fodder, its application not only increases crop yield but also improves crop quality. Sulphur promotes the production of chlorophyll, growth, seed development, and nitrogen fixation by increasing the creation of nodules.

In lentil production, a common problem is a shortage of boron, which usually shows up 5–6 weeks after seeding. Deficiency symptoms include reduced plant development and poor pod formation, as well as a color shift in mature leaves from green to yellowish-white, eventually turning brown and, in extreme cases, dropping leaflets (Chaney, 1993) [4]. According to Ahmad *et al*. (2009) [25], boron plays a critical role in the production of proteins, chlorophyll, and other vital substances as well as in controlling the amounts of auxin in plants. With large quantities of boron in pollen grains and most of it going toward the seeds, it is important during the reproductive phase, particularly during fertilization (Jenik PD, Kathryn BM, 2014) [8]. Plant growth is disrupted by a shortage in boric acid due to reduced rates of protein synthesis, ribosomal stability, and impaired enzyme performance. This results in limited seed set, ovule deformity, infertile flowers, and eventually lower yields.

Materials and Methods

During the Rabi season of 2023–2024, the research was carried out at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Science and Technology (SHUATS), Naini, Prayagraj, Uttar Pradesh. Three replications of a randomized complete block design were included in the experimental setup. Combinations of sulphur and boron at various concentrations were among the treatments assessed: T1: 10 kg/ha of sulphur and 1.5 kg/ha of boron; T2: 10 kg/ha of sulphur and 2 kg/ha of boron; T3: 2.5 kg/ha of boron and 10 kg/ha of sulphur T4: 1.5 kg/ha of boron and 20 kg/ha of sulphur T5: 20 kg/ha of sulphur plus 2 kg/ha of boron T6: 2.5 kg/ha of boron and 20 kg/ha of sulphur T7: 1.5 kg/ha of boron and 30 kg/ha of sulphur T8: 2 kg/ha of boron and 30 kg/ha of sulphur T9: 30 kg/ha of sulphur and 2.5 kg/ha of boron, with a 20:40:20 NPK kg/ha control plot**.** Plant height, nodule count per plant, dry weight of the plant, crop growth rate, relative growth rate, number of pods per plant, number of seeds per pod, seed weight, seed yield, stover yield, and harvest index were among the characteristics on which data were gathered. The significance of the effects of the various treatments was ascertained by applying the analysis of variance (ANOVA) method to the obtained data.

Results and Discussion

A. Yield attributes and Yield

1. Pods/Plant

The treatment with the higher significant number of pods per plant (142.60) was treatment 9, which applied 30 kg/ha of sulphur along with 2.5 kg/ha of boron. When compared to all other therapies, this one performed noticeably better. However, treatment-8, which included 2 kg/ha of boron and 30 kg/ha of sulphur, produced statistically comparable results to treatment-9, suggesting that both treatments were equally beneficial.

2. Seeds/pod

Treatment 9 produced the higher number of seeds per pod (2.07), involving the application of 30 kg/ha of sulphur and 2.5 kg/ha of boron. When compared to all other treatments, this one was noticeably better. However, the results of treatment-8, which applied 2 kg/ha of boron and 30 kg/ha of sulphur, were statistically comparable to those of treatment-9, suggesting that the two treatment levels were equally effective.

3. Test weight (g)

The treatment with the higher significant test weight (23.57 g) was treatment 9, which had 30 kg/ha of sulphur and 2.5 kg/ha of boron. In comparison to all other therapies, this one shown a clear superiority. On the other hand, results from treatment-8, which used 30 kg/ha of sulphur and 2 kg/ha of boron, were statistically equivalent to those of treatment-9, suggesting that these two treatments were equally successful.

4. Seed yield (t/ha)

Treatment 9, which administered sulphur at 30 kg/ha in addition to boron at 2.5 kg/ha, produced the higher seed yield of 2.32 t/ha. Compared to all other treatments, this one performed noticeably better. On the other hand, seed yields from treatment-8, which applied 30 kg/ha of sulphur and 2 kg/ha of boron, were statistically similar to those from treatment-9.

5. Stover yield (t/ha)

Treatment 9, which applied 30 kg/ha of sulphur and 2.5 kg/ha of boron, had the higher stover yield of 3.16 t/ha. When compared to all other treatments, this one was noticeably better. However, the findings of Treatment-8, which included 30 kg/ha of sulphur and 2 kg/ha of boron, were statistically comparable to those of Treatment-9.

B. Economics

Gross return, net return and benefit cost ratio were influenced due to different treatments.

1. Cost of Cultivation (INR/ha)

The highest cost of cultivation, amounting to 41,875 INR per hectare, was associated with Treatment-9, which involved applying sulphur at 30 kg/ha in combination with boron at 2.5 kg/ha. This treatment had a greater expense compared to all other treatments.

2. Gross return (INR/ha)

The highest gross returns, totaling 1,42,057 INR per hectare, were achieved with Treatment-9, which involved applying sulphur at 30 kg/ha combined with boron at 2.5 kg/ha. This treatment generated the greatest revenue compared to all other treatments.

3. Net return (INR/ha)

The net returns of 1,00,182 INR per hectare were recorded for Treatment-9, which included the application of sulphur at 30 kg/ha and boron at 2.5 kg/ha. This treatment produced the highest net returns when compared to the other treatments.

4. Benefit cost ratio (B:C)

In this study, the highest benefit-cost ratio of 2.39 was observed in Treatment-9, which involved applying sulphur at 30 kg/ha combined with boron at 2.5 kg/ha. This ratio was notably superior to those of all other treatments.

Table 1: Effect of Sulphur and Boron on Yield Attributes of Lentil

S. No.	Treatments	Number of Pods/Plant	Number of Seeds/Pod	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)
1.	Sulphur 10 kg/ha+ Boron 1.5kg/ha	130.73	1.40	22.06	1.35	2.45
2.	Sulphur 10 kg/ha + Boron 2 kg/ha	129.80	1.47	22.73	1.44	2.38
3.	Sulphur 10 kg/ha + Boron 2.5kg/ha	131.53	1.53	23.09	1.55	2.60
4.	Sulphur 20 kg/ha + Boron 1.5kg/ha	133.53	1.67	22.86	1.70	2.72
5.	Sulphur 20 kg/ha + Boron 2 kg/ha	136.80	1.73	23.06	1.82	2.81
6.	Sulphur 20 kg/ha + Boron 2.5kg/ha	138.20	1.80	23.19	1.93	2.87
7.	Sulphur 30 kg/ha + Boron 1.5kg/ha	139.53	1.93	23.17	2.09	2.99
8.	Sulphur 30 kg/ha + Boron 2 kg/ha	140.87	2.00	23.22	2.18	3.06
9.	Sulphur 30 kg/ha + Boron 2.5kg/ha	142.60	2.07	23.57	2.32	3.16
10.	Control (RDF) - 20:40:20 kg/ha	128.67	1.27	21.95	1.19	2.24
	F-Test	S	S	S	S	S
	Sem (±)	0.75	0.07	0.83	0.23	0.15
	CD (P=0.05)	2.22	0.19	0.28	0.08	0.05

Table 2: Effect of Sulphur and Boron on Economics of Lentil

S. No.	Treatments	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1.	Sulphur 10 kg/ha+ Boron 1.5kg/ha	38825	83147	44322	1.14
2.	Sulphur 10 kg/ha + Boron 2 kg/ha	39225	88955	49730	1.27
3.	Sulphur 10 kg/ha + Boron 2.5kg/ha	39625	95719	56094	1.42
4.	Sulphur 20 kg/ha + Boron 1.5kg/ha	39950	104535	64585	1.62
5.	Sulphur 20 kg/ha + Boron 2 kg/ha	40350	112129	71779	1.78
6.	Sulphur 20 kg/ha + Boron 2.5kg/ha	40750	118613	77863	1.91
7.	Sulphur 30 kg/ha + Boron 1.5kg/ha	41075	128153	87078	2.12
8.	Sulphur 30 kg/ha + Boron 2 kg/ha	41475	133916	92441	2.23
9.	Sulphur 30 kg/ha + Boron 2.5kg/ha	41875	142057	100182	2.39
10.	Control (RDF) - 20:40:20 kg/ha	36500	73695	37195	1.02

Conclusion

Based on the results, it is determined that the best results for lentil cultivation in terms of crop yield and financial benefits are obtained by applying 30 kg/ha of sulphur and 2.5 kg/ha of boron (Treatment 9). It is therefore advised that farmers implement this therapy in order to increase their output and profitability.

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