

Effect of Boron, Zinc and Sulphur on growth, yield and Mineral Composition of Black gram(*Vigna mungo* (L) Hepper) in alluvial soil

ABSTRACT

A pot experiment was conducted during kharif 2023 at Net House in Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, B.H.U, Varanasi, U.P. to study the effect of Boron, Zinc and Sulphur on growth, yield and quality of black gram (*Vigna mungo* (L) Hepper). The experiment was laid-out in a Completely Randomized design (CRD) with eight treatments, each having three replications. Dry matter accumulation, Number of branches plant⁻¹, test weight, grain yield kg ha⁻¹, straw yield kg ha⁻¹, harvest index significantly affected due to various treatments. T₇ (B +Zn+ S) recorded most pronounced improvements.

Keywords: Blackgram; sulphur; zinc; boron; quality and yield

1. INTRODUCTION

Pulses are integral to Indian cooking due to their affordability, accessibility, and rich protein content. Farmers benefit significantly from cultivating pulse crops, which offer sustainable agricultural advantages such as minimal water needs, deep root systems that prevent soil erosion, extensive ground coverage, and their ability to enhance productivity and resilience in farming through crop rotation and intercropping[1]. Pulse crops hold a crucial role in Indian agriculture for several reasons. Firstly, they have the unique capability of biological nitrogen fixation, which enriches the soil with essential nutrients. Additionally, their deep root systems help in mobilizing insoluble soil nutrients and improving soil structure. These plants also bring about beneficial changes in the physical properties of the soil, earning them the title of 'soil fertility restorers'. Beyond their agronomic benefits, pulses are highly valued as sources of food, fodder, and animal feed. India is the world's largest producer of pulses, accounting for one-third of the global pulse acreage and a quarter of its total production. For a significant segment of the population, especially vegetarians, pulses are the main source of protein.

Black gram (*Phaseolus mungo* L.) is a significant pulse crop and a staple in tropical and subtropical regions. Also known as urad bean, urad dal, or urad, it thrives in light soils that retain moisture, though loamy and clay loam soils are also suitable. Neutral pH loam to clay loam soils are ideal for its cultivation, as it does not tolerate waterlogged conditions well. Black gram is valued for its nutritional richness, boasting high protein content (22.24%), carbohydrates (56.6-59.6%), fats (1.2-

1.4%), minerals (3.2%), and significant amounts of phosphorous (385 mg/100g), calcium, and iron. Unlike other pulses, it stands out for its somewhat mucilaginous texture, which adds density due to its long polysaccharide carbohydrate chains. Because it provides affordable protein, it is often referred to as the "poor man's meat" [2].

Boron is an essential element for healthy plant growth and development. It is essential to the fertilization and blooming processes, which raise crop yield and quality [3]. Since its deficiency has been documented in 132 crops, it is acknowledged as one of the most often deficient micronutrients in soils. More than 80 nations [4]. Zinc is a crucial nutrient for plants that is involved in several metabolic, regulatory, and developmental processes [5]. Additionally, it has been demonstrated to play a role in defense against the harmful effects of reactive oxygen species. [6]. Concern over zinc nutrition in plants is growing as zinc deficiency is common in the world's arid and semi-arid regions [7]. Sulphur (S) is a vital plant nutrient that is necessary for the manufacture of protein, vitamins, enzymes, and amino acids such as cystine, cysteine, and methionine. It also plays a major part in maintaining increased output of pulse crops. It also participates in a number of metabolic and enzymatic processes, such as respiration, photosynthesis, and the nitrogen fixation symbiotic relationship between legumes and rhizobium. [8].

2. MATERIALS AND METHODS

2.1 Experimental site

A pot experiment on wheat was conducted on July 30th, 2023 in the Net House of the Department of Soil Science and Agricultural Chemistry at the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, situated at an altitude of 80.71 meters above mean sea level, lies between 25°18' North latitude and 80°36' East longitude. The region has a humid subtropical climate, with an average annual rainfall of approximately 1100 mm and a potential evapotranspiration of around 1525 mm.

Table 1. Treatment details of the experiment

Treatments	Abbreviations
Control	T ₀
Boron (@ 1.5 kg ha ⁻¹)	T ₁
Zinc (@ 5 kg ha ⁻¹)	T ₂

Sulphur (@ 20 kg ha ⁻¹)	T ₃
Boron + Zinc	T ₄
Boron + Sulphur	T ₅
Zinc + Sulphur	T ₆
Boron + Zinc + Sulphur	T ₇

(Recommended dose of N, P and K, seed treatment with Rhizobium + PSB was given for each treatment, Recommended dose of N: P₂O₅: K₂O, 20: 40: 20 kg ha⁻¹)

2.2 Experimental Setup

Initially, the soil had a sandy clay loam texture. It was slightly alkaline (pH 7.41), had normal salt content (EC 0.17 dS m⁻¹), low organic carbon content (0.48%), low available nitrogen (155.36 kg ha⁻¹), high available phosphorus (23.46 kg ha⁻¹), and medium available potassium (190 kg ha⁻¹) and Available Sulphur (17.80 kg ha⁻¹). The soil also had DTPA-extractable micronutrients with concentrations of Zn at 1.20 mg kg⁻¹ and Available boron 0.51 mg kg⁻¹. During August-September 2023, a pot experiment was conducted using Black gram (variety T-9) as the test crop. The soil for the experiment was collected from the Agro farm at BHU, air-dried, ground, sieved through a 2-mm mesh, and placed in polythene-lined pots. The experiment was laid-out in a Completely Randomized design (CRD) with eight treatments, each having three replications. Uniform basal application was made with 20 kg N ha⁻¹, 40 kg P₂O₅ ha⁻¹, 20 kg K₂O ha⁻¹ through urea, DAP (Diammonium phosphate) and MOP (Murate of Potash), respectively. Sulphur, Zn and B were applied @ 20, 5 and 1.5 kg ha⁻¹ from Bentonite-S, Zinc sulphate and Di-sodium tetra-borate pentahydrate, respectively. The pots were kept at field capacity throughout the study period.

2.3 Growth and Yield Attributes

Growth attributing characters of wheat mainly plant height at 20, 40 and 60 days after sowing (DAS), number of branches per plant, dry matter accumulation were recorded. At maturity grain yield, straw yield, test weight (g) was recorded and harvest index were calculated.

$$\text{Harvest index} = \frac{\text{Economical yield}}{\text{Total biological yield}} \times 100$$

2.4 Statistical Analysis

The entire experiment's raw data were subjected to statistical analysis using the Complete Randomized Design (CRD) in order to identify any meaningful differences between the treatments.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The analysis of variance for the data on plant height shows non-significant difference was found on growth stages. T₇ (Boron + Zinc + Sulphur) exhibited the highest plant height (17.31,39,45.69 cm) which was statistically at par with T₅ (Boron + Sulphur) that is (17.05,39.11,44.18 cm). This was followed by treatment T₆ (Zinc + Sulphur), T₄ (Boron + Zinc), and T₃ (Sulphur @20 kg ha⁻¹), with harvest plant heights of 43.8 cm, 43.34 cm, and 42.58 cm, respectively. In contrast, the control group recorded the lowest harvest plant height of 40.75 cm. T₇ was statistically at par with T₅ and T₆. More availability of B, Zn and S might have encouraged growth promoting hormones and protein synthesis means more chlorophyll content leading to higher photosynthesis. These resulted into rapid cell elongation and enlargement and ultimately plant height [9] [10] [11]. Number of branches count plant⁻¹ was statistically significant due to various treatments (Table 2).

The analyzed data relating to the dry matter accumulation at harvest of blackgram in Tab.1. T₇, which involved the application of Boron, zinc and Sulphur, resulted in the highest dry matter accumulation at 4.95 grams per plant. This was followed closely by treatment T₅, which involved the application of Boron and Sulphur with 4.78 grams per plant. Treatments T₆ (Zinc and Sulphur) and T₄ (Boron + Zinc) recorded 4.56 grams per plant and 4.50 grams per plant, respectively. In contrast, the lowest dry matter accumulation of 3.98 grams per plant was observed in treatment T₂, which involved Zinc application at 5 kg ha⁻¹. T₇ was statistically at par with all the treatments except control. It was revealed from the data that there was significant difference among various treatments. These findings align with previous research by [12] who found that sulphur rate significantly affects soybean dry matter.

The highest no. of branches plant⁻¹ was observed with application of B + Zn + S, which was statistically superior from all the treatments except T₅ (B + S). The lowest number of branches plant⁻¹ was observed with control T₀ [13] [14].

3.2 Yield Component

The data of grain yield were analyzed and summarized in Table 3. Different treatments exhibited significant variation in grain yield of urad bean. Treatment T₇, involving the application of boron, zinc, and Sulphur, resulted in the highest seed output at 1.95 t ha⁻¹ followed by T₅ (1.68 t ha⁻¹) and T₆ (1.62 t ha⁻¹). In contrast, the control treatment (T₀) exhibited the lowest grain production at 0.66 t ha⁻¹. T₇ demonstrated the highest haulm yield of 3.71 t ha⁻¹, surpassing the control (2.61 t ha⁻¹) and treatments T₅ (3.63 t ha⁻¹), and T₆ (3.5 t ha⁻¹). T₇ was statistically at par with T₄, T₅, T₆. However, three other treatments with application of B + S, Zn + S and B + Zn were also found effective to enhance yield over control as well as those treatments where applied alone nutrients i.e. B, Zn and S. The lowest grain and straw yield were found in control. The Harvest Index of black gram demonstrates significant variation ranging from 20.21% to 34.40%. T₇, exhibited the highest Harvest Index at 34.45 %, while the control treatment (T₀) showed the lowest Harvest Index at 20.21% [15] [

16]. Treatments exerted significant impacts on variations in test weight (1000-seed weight). T₇ (Boron + Zinc + Sulphur) emerged as the most effective, producing the highest test weight of 40.20 grams followed by T₅ and T₆. Conversely, the control group (T₀) exhibited the lowest test weight at 33.20 grams. Noteworthy improvements in test weight were observed with alternative treatments.

3.3 Nutrient content

Table 4 shows Nitrogen content ranged from 1.80% to 3.80% in seeds and 1.40% to 2.80% in haulm across the treatments. Analysis of the data revealed that nitrogen content increased in both seed and haulm compared to the control when treated with boron, Zinc and Sulphur. T₀ had the lowest content of phosphorus (0.51 and 0.21), in seed and haulm while the T₇ with combine application of Boron, Zinc and Sulphur had the highest content of Phosphorus (1.17 and 0.45), followed by the T₅, T₆ and T₄. The T₀ produced the lowest value (0.20 % and 0.41%) in seed and haulm, respectively, whereas the combine application of Boron, Zinc and Sulphur (T₇) had the highest potassium content in both seed and haulm (1.04% and 0.89%).

3.4 Available nutrients in post-harvest soil of blackgram

Table 5 shows the lowest amount of nitrogen, at 160 kilograms per hectare, was observed in the control (T₀), while the soil in T₇ exhibited the significantly highest nitrogen content at 296.00 kg per hectare. T₇ resulted in the largest amount of accessible phosphorus (50.90 kg ha⁻¹). The available phosphorus value was lowest (23.06 kg ha⁻¹) in the control, or T₀. The data in Table 5 shows information on available potassium in soil post the harvest of Black gram and it varied from 201.15 to 312.20 kg ha⁻¹ indicating that soil was categorized under medium to high in available potassium.

Table 2: Effect of different treatments on Plant height, dry matter accumulation and number of branches per plant at harvest of black gram.

Treatments	Plant height (cm)			Dry matter accumulation (g plant ⁻¹)	Number of branches per plant at harvest
	at 20 DAS	at 40DAS	at 40DAS		
Control	13.51	34.01	40.75	3.98	6.23
T ₀	16.10	36.35	42.06	4.35	7.16

T ₁	15.76	36.06	41.85	4.20	6.67
T ₂	16.03	36.65	42.58	4.38	7.42
T ₃	16.10	37.02	43.34	4.50	7.48
T ₄	17.05	39.11	44.18	4.78	7.82
T ₅	16.83	38.78	43.80	4.56	7.64
T ₆	17.31	39.00	45.69	4.95	8.23
T ₇	0.67	1.211	1.89	0.15	0.21
CD (5%)	1.33	1.94	1.80	0.54	0.41

Table 3: Effect of different treatments on seed yield, haulm yield, harvest index and test weight of black gram.

Treatments	Seed yield (t ha⁻¹)	Haulm Yield (t ha⁻¹)	Harvest index (%)	Test weight (gm)
T ₀	0.66	2.61	20.2	33.20
T ₁	1.03	3.06	25.06	34.20
T ₂	0.82	2.8	22.73	32.80
T ₃	1.35	3.17	29.9	34.70
T ₄	1.56	3.41	31.32	37.20
T ₅	1.68	3.63	32.72	38.75
T ₆	1.62	3.55	31.65	38.21
T ₇	1.95	3.71	34.45	40.20
SEm _±	0.03	0.139	0.763	0.78
CD (0.05)	0.1	0.42	4.48	2.24

Table 4.Effect of different treatments on nutrient content in seed and haulm of black gram

Treatments	N Content (%)		P Content (%)		K Content (%)	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
T ₀	1.80	1.40	0.51	0.21	0.20	0.41
T ₁	2.68	1.91	0.81	0.24	0.39	0.57
T ₂	2.15	1.60	0.69	0.23	0.37	0.53
T ₃	2.98	1.94	0.98	0.34	0.42	0.64
T ₄	3.12	1.98	1.05	0.37	0.51	0.69
T ₅	3.80	2.60	1.11	0.41	0.80	0.84
T ₆	3.64	2.27	1.08	0.38	0.74	0.77
T ₇	3.90	2.80	1.17	0.45	1.04	0.89
SEm±	0.059	0.021	0.073	0.005	0.012	0.371
CD (0.05)	0.19	0.05	0.053	0.014	0.042	1.14

T₀=Control, T₁=RDF+B @ 1.5kg ha⁻¹, T₂=RDF+Zn @ 5kg ha⁻¹, T₃=RDF+S @ 20 kg ha⁻¹, T₄=RDF+B+Zn, T₅=RDF+B+S, T₆=RDF+Zn+S, T₇=RDF+B+Zn+S RDF=Recommended dose of fertilizer

Table 5. Effect of different treatments on available N, P, K, S (kg ha⁻¹) and B (mg kg⁻¹) in post-harvest soil of Black gram

Treatments	Available Nitrogen (kg ha ⁻¹)	Available Phosphorus (Kg ha ⁻¹)	Available potassium (Kg ha ⁻¹)	Available Sulphur (kg ha ⁻¹)
T ₀	167.00	23.06	201.15	21.45
T ₁	225.20	27.89	235.48	23.45
T ₂	215.34	25.64	224.45	25.65
T ₃	260.50	31.15	250.54	30.86
T ₄	277.28	32.46	262.34	29.45
T ₅	283.20	42.67	290.89	31.45
T ₆	281.06	36.78	276.60	32.86
T ₇	296.00	50.90	312.20	35.68
SEM±	2.17	1.04	2.74	0.79
CD 5%	6.54	3.20	8.28	2.45

T₀=Control, T₁=RDF+B @ 1.5kg ha⁻¹, T₂=RDF+Zn @ 5kg ha⁻¹, T₃= RDF+S@ 20 kg ha⁻¹, T₄=RDF+B+Zn, T₅=RDF+B+S, T₆=RDF+Zn+S, T₇=RDF+B+Zn+SRDF=Recommended dose of fertilizer

DISCLAIMER

Author(s) hereby declare that no generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

Conclusion

Increased plant height, accumulation of dry matter, and more branches were observed upon application of (B@ 1.5 kg ha⁻¹, Zn (@ 5 kg ha⁻¹, S 20 kg ha⁻¹). When T₇ (B+Zn+ S) was applied in combination, the maximum grain yield, straw yield, harvest index, and test weight were also recorded which was significantly superior over T₀ (control), T₁ (B), T₃ (S), T₄ (B + Zn), and T₂ (Zn) and at par with T₅ (B + S) and T₆ (Zn + S). Though all treatments showed positive effect in increasing growth parameter and yield. This suggests that the application of these nutrients enhances the nutritional quality of the seeds, making them more valuable in terms of human and animal nutrition. Additionally, the study highlights improvements in soil properties resulting from the application of boron, zinc and sulphur. The treatment leads to enhancements in soil fertility, indicated by higher levels of organic carbon and nitrogen content in the soil. This suggests that the combination of these nutrients not only benefits the crop but also contributes to long-term soil health and sustainability.

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