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Vivek Kumar Singh
M.Sc. (Ag) Scholar, Department of Agronomy, FASAI, Rama University, Kanpur, Uttar Pradesh, India

Ravikesh Kumar Pal
Assistant Professor, Department of Agronomy, FASAI, Rama University, Kanpur, Uttar Pradesh, India

Mandeep Kumar
Assistant Professor, Department of Agronomy, FASAI, Rama University, Kanpur, Uttar Pradesh, India

Raghvendra Singh
Assistant Professor, Department of Soil Science, FASAI, Rama University, Kanpur, Uttar Pradesh, India

Durgesh Kumar Maurya
KVK Sant Kabir Nagar, Uttar Pradesh, India

Corresponding Author:
Vivek Kumar Singh
M.Sc. (Ag) Scholar, Department of Agronomy, FASAI, Rama University, Kanpur, Uttar Pradesh, India

Effect of sulphur and zinc on growth and yield of Black gram

Vivek Kumar Singh, Ravikesh Kumar Pal, Mandeep Kumar, Raghvendra Singh and Durgesh Kumar Maurya

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Abstract
A field experiment was conducted during Zaid (summer) season of 2024 at Crop Research Farm Department of Agronomy. The treatments consisted of 3 levels of Sulphur (10, 20 and 30 kg/ha) and 3 levels of zinc (10kg/ha, 0.1% and 0.2% foliar application) along with recommended doses of nitrogen, phosphorus and potash and a control (20-50-40 kg N-P-K/ha). The experiment was laid out in a Randomized Block Design with 10 treatments and replication thrice. Application of Sulphur (30 kg/ha) + Zinc (10kg/ha) (treatment 9) recorded higher Plant height (28.80 cm), maximum number of branches/plant (11.06), higher nodules/plant (16.44), higher plant dry weight (11.56 g), higher number of Pods/Plant (38.67), higher number of seeds/pod (6.93), higher test weight (37.44 g), higher seed yield (1504.55 kg/ha) and higher stover yield (2906.30) The treatment also recorded Maximum gross return (INR 98297.69 /ha), net return (INR 64701.09/ha) and B:C ratio (2.41)

Keywords: Black gram, sulphur, zinc, growth, yield and economics. introduction

Introduction
Black gram (*Phaseolus mungo* L.), also known as urdbean, is one of the most important pulse crops cultivated in tropical and subtropical regions. Pulses are a vital component of the human diet, particularly in developing countries, as they are rich sources of protein, vitamins, and minerals, playing a crucial role in food and nutritional security (Anonymous, 2024; Ghanshyam *et al*., 2010) [3, 6]. Black gram grows well in light soils with good moisture retention, but loamy and clay loam soils with neutral pH are considered most suitable for its cultivation (Bahadur & Tiwari, 2014) [4]. Globally, India dominates black gram cultivation, contributing nearly 70% of total production, with an annual yield of 11.99 million tonnes from 9.85 million hectares (Government of India [GOI], 2021-22) [7]. Uttar Pradesh, Madhya Pradesh, Maharashtra, and Rajasthan are among the leading states, with Uttar Pradesh alone producing about 0.84 million tonnes from 0.61 million hectares (GOI, 2021-22).

Nutrient management plays a critical role in improving the productivity of black gram. Among the secondary nutrients, sulphur (S) is vital for enhancing growth, nodulation, and yield. Sulphur is an essential constituent of amino acids such as cysteine and methionine, and it supports enzymatic activities that are fundamental to plant metabolism (Khan & Joergensen, 2019; Sharma *et al*., 2018) [9, [17]]. It also improves the efficiency of biological nitrogen fixation in legume crops by fostering symbiotic relationships with rhizobia (Ahirwar *et al*., 2016; Kumari *et al*., 2015) [1, 11]. Research has shown that sulphur application significantly enhances plant height, leaf area, dry matter accumulation, and ultimately grain yield in pulses (Mohammad *et al*., 2017) [13]. Furthermore, the integration of sulphur with biofertilizers improves soil fertility status, phosphorus availability, and crop productivity (Gupta *et al*., 2016; Choudhary & Yadav, 2011) [8, 5].

Given the importance of black gram in India's food system and the critical role of sulphur in optimizing its growth and productivity, studies focusing on the interactive effects of sulphur and biofertilizers are of great significance. Such interventions can enhance yield attributes while sustaining soil health, thereby contributing to sustainable agricultural production (Amit *et al*., 2019) [2].

Objectives

To study the effect of Sulphur and Zinc on Growth and Yield of Blackgram

To assess the Economics of different treatment combination.

Experiment Site

The experiment was conducted in Randomized complete Block Design (RBD) consisting of ten treatments combinations replicated thrice. Treatments were randomly arranged in each replication, divided into thirty plots. The Layout Design of experiment Randomize Block Design Number of treatments 10 Number of replications 3 Total number of plots 30 Size of each plot 3 m x 3m ($9m^2$) Width of main irrigation channel 1.0 m Width of sub irrigation channel 0.5 m Width of bunds 0.3 m Length of experimental field 34.6 m Width of experimentalfield11.8 m Gross cultivated area 408.28 m^2 Net cultivated are 270.0 m^2

Table 1: Effect of Sulphur and Zinc on Crop Growth Rate (g/m2 /day) of Black gram

Treatment Combination	Plant Height				Number of branches/plants of Black gram.				Number of nodules/plants				Dry weight (g/Plant)			
	15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS
Sulphur (10kg/ha) + Zinc (0.2%)	7.83	14.72	18.96	23.56	2.53	4.06	5.33	7.43	4.06	22.33	34.06	13.8	0.35	1.47	4.65	6.98
Sulphur (10kg/ha) + Zinc (0.1%)	7.57	14.56	18.24	22.36	2.46	3.8	5.2	7.4	3.86	20.04	33.86	13.13	0.34	1.35	4.38	6.65
Sulphur (10kg/ha) + Zinc (10kg/ha)	8.23	14.73	19.25	23.71	2.43	4.93	5.73	7.66	4	22.53	36.78	14.33	0.33	1.61	4.85	7.87
Sulphur (20kg/ha) +	8.4	15.83	21.39	24.8	2.7	5.33	7.06	9.13	4.26	22.93	33.66	14.53	0.4	1.7	6.55	9.14
Zinc (0.2%)																
Sulphur (20kg/ha) + Zinc (0.1%)	9.3	15.42	20.5	23.94	2.46	5.13	6.13	8.46	3.73	23.66	34.2	14.86	0.37	1.66	5.81	9.1
Sulphur (20kg/ha) + Zinc (10kg/ha)	9.58	15.85	22.12	25.86	2.56	5.53	7.13	9.46	3.93	22.86	34.13	15.4	0.39	2.05	6.8	9.68
Sulphur (30kg/ha) + Zinc (0.2%)	10.52	17.35	23.18	27.86	2.83	6.15	7.68	10.43	4.06	22.7	36.29	15.4	0.41	2.62	7.62	10.14
Sulphur (30kg/ha) + Zinc (0.1%)	9.89	17.1	22.7	26.45	2.46	6	7.66	10.33	3.73	21.73	34.6	16.42	0.38	2.19	7.45	9.9
Sulphur (30kg/ha) + Zinc (10kg/ha)	10	17.72	24.98	28.8	2.86	6.46	8.13	11.06	4.33	24.2	37.66	16.44	0.43	2.74	8.71	11.56
Control (N:P: K 20:50:20 kg/ha)	7.17	13.35	17.93	21.43	2.4	3.79	4.13	6.13	4	21.7	33.6	13	0.32	1.34	4.15	6.46
test	NS	S	S	S	NS	S	S	S	NS	S	S	S	NS	S	S	S
S.Em(±)	0.81	0.52	0.62	0.75	0.19	0.28	0.39	0.45	0.38	0.68	0.47	0.62	0.03	0.11	0.43	0.41
CD (p=0.05)	-	1.55	1.84	2.24	-	0.85	1.17	1.34	-	2.03	1.41	1.84	-	0.33	1.27	1.68

Table 2: Effect of Sulphur and Zinc on yield and yield attributes of Black gram.

Treatment Combination	Number of pods/Plants	Number of seed/ pods	Test weight (g)	Seed Yield (kg/ha)	Stover Yield (kg/ha)	Harvest Index (%)
Sulphur (10kg/ha) + Zinc (0.2%)	28.5	4.43	32.77	909.51	1965.51	32.16
Sulphur (10kg/ha) + Zinc (0.1%)	26.58	4.23	31.75	904.31	1924.27	32.66
Sulphur (10kg/ha) + Zinc (10kg/ha)	31.08	5.17	33.01	947.41	1967.18	32.5
Sulphur (20kg/ha) + Zinc (0.2%)	32.67	5.7	34.01	1000.81	2268.71	30.85
Sulphur (20kg/ha) + Zinc (0.1%)	31.25	5.5	33.06	988.81	2034.47	32.7
Sulphur (20kg/ha) + Zinc (10kg/ha)	34.67	6.17	35.44	1054.69	2370.06	30.76
Sulphur (30kg/ha) + Zinc (0.2%)	37.18	6.42	36.89	1249.64	2890.78	30.24
Sulphur (30kg/ha) + Zinc (0.1%)	36.17	6.27	36.39	1229.45	2728.07	31.04
Sulphur (30kg/ha) + Zinc (10kg/ha)	38.67	6.93	37.44	1504.55	2900.3	34.12
Control (N:P: K 20:50:20 kg/ha)	26.09	4.06	31.41	889.51	1803.44	33.19
F test	S	S	S	S	S	NS
Sem (±)	1.04	0.11	1.02	62.47	165.29	2.18
CD (p=0.05)	3.09	0.32	3.02	281.3	491.04	-

Table 3: Effect of Sulphur and Zinc economics of Black gram.

Treatment Combination	Cost of Cultivation (INR/ha)	Gross Returns (INR/ha)	Net Returns (INR/ha)	B:C Ratio
Sulphur (10kg/ha) + Zinc (0.2%)	29240	64398.15	35158.15	1.2
Sulphur (10kg/ha) + Zinc (0.1%)	29115	63879.95	34764.95	1.19
Sulphur (10kg/ha) + Zinc (10kg/ha)	29990	66680.5	36690.5	1.22
Sulphur (20kg/ha) + Zinc (0.2%)	29615	71392.15	41777.15	1.41
Sulphur (20kg/ha) + Zinc (0.1%)	29490	69500.95	40010.95	1.36
Sulphur (20kg/ha) + Zinc (10kg/ha)	30365	75131.7	44766.7	1.47
Sulphur (30kg/ha) + Zinc (0.2%)	29990	89432.3	59442.3	1.98
Sulphur (30kg/ha) + Zinc (0.1%)	29865	87407.35	57542.35	1.93
Sulphur (30kg/ha) + Zinc (10kg/ha)	30740	104774.5	74034.5	2.41
Control (N:P:K 20:50:20 kg/ha)	28615	62387.8	33772.8	1.18

Plant height (cm)

The growth of the plant's height clearly happens at the 15, 30, 45, and 60-day marks. DAS. Although there was no discernible difference across the treatments, treatment 9 had the tallest plant at 15 DAS (10.00 cm). Treatment 9 had a noticeably greater plant height (17.72 cm) at 30 DAS. Nonetheless, it was discovered that treatments 7 (17.35 cm) and 8 (17.10 cm) were statistically equivalent to treatment 9 (17.72 cm). Treatment 9 showed a noticeably greater plant height (28.80 cm) at 60 DAS. Nonetheless, it was discovered that treatment 7 (27.86 cm) and treatment 9 (28.80 cm) were statistically equivalent.

Number of Branches per plant

Observation regarding the effect of different levels of potassium and zinc on number of branches per plant of Black gram. The data on number of branches was recorded at 15, 30, 45 and 60 DAS. The statistically analysis of data was found to be significant at growth stages. At 15 DAS, maximum number of branches/plant (2.86) was recorded with treatment 9. However, was found to be non- statistically. At 30 DAS, significantly and higher number of branches/plant (6.46) was recorded in treatment 9. However, treatment 7 (6.16) and treatment 8 (6.00), were found to be statistically at par with treatment 9 (6.46). At 45 DAS, significantly and higher number of branches/plant (8.13) was recorded in treatment 9. However, treatment 6 (7.13), treatment 7 (7.68) and treatment 8 (7.66), were found to be statistically at par with treatment 9 (8.13). At 60 DAS, higher number of branches appear.

Number of nodules/ plants

Observation regarding the effect of different levels of Sulphur and Zinc on number of nodules per plant of Black gram. The data on number of branches was recorded at 15, 30, 45, 60 DAS. The statistically analysis of data was found to be significant at growth stages.

Plant dry weight (g/plant)

Observation regarding the effect of different levels of Sulphur and Zinc on Plant dry weight of Black gram. The data on plant dry weight was recorded at 15, 30, 45, 60 DAS. The statistically analysis of data was found to be significant at growth stages. At 15 DAS, highest dry weight (0.43 g) was recorded in treatment 9, though there was no significant difference among the treatments. At 30 DAS, maximum plant dry weight (2.74 g) was recorded in treatment 9. treatment 7 (2.62 g) were found to be statistically at par with treatment 9 (2.74 g). At 45 DAS, maximum plant dry weight (8.71 g) was recorded in treatment 9. treatment 7 (7.62 g) and treatment 8 (7.45 g), were found to be statistically at par with treatment 9 (8.71 g). At 60 DAS, maximum plant dry weight (11.56 g) was recorded in treatment 9, treatment 7 (10.14 g) and treatment 8 (9.90 g) was found to be statistically at par with treatment 9.

Crop Growth Rate

The crop growth rate was recorded at different intervals i.e., 15, 30, 45 and 60 differe DAS influenced by Sulphur and Zinc of Black gram. At 0-15 DAS, highest crop growth rate (0.637 g/m²/day) was recorded in treatment 9, though there was no significant difference among the treatments. At 15 – 30 DAS, significant and maximum crop growth rate (3.42 g/m2/day) was recorded with treatment 9. However, treatment 7 (3.27 g/m²/day) were found to be statistically at par with treatment 9. At 30–45 DAS, significant and maximum crop growth rate (8.84 g/m2/day) was recorded with treatment 9. However, treatment 7 (7.79 g/m²/day) and treatment 8 (7.40 g/m²/day), were found to be statistically at par with treatment 9. At 45-60 DAS, highest crop growth rate (4.87 g/m²/day) was recorded in treatment 5, though there was no difference between the treatments.

Post-harvest observation

Number of pods/plants

The data pertaining to number of pods/plants affected by different, Sulphur and Zinc are provided in table 4.7. Treatment 9 (38.67) maximum number of pods/ plants which was superior over all other treatments. However, the treatment 7 (37.18) and treatment 8 (36.17) was found to be statistically at par with the treatment 9 (38.67). The significant and higher number of pods/plant was with the application of sulphur (30kg/ha) might be due to the tissue differentiation from somatic to reproductive meristematic activity and development of floral primordial might have increased with increasing in more flowers and pods kumar *et al.* (2018) [10]. Further Significant and higher number of pods/plants was with the application of might be because zinc (10kg/ha) might be due increase levels of Zn application to crops on nutrient metabolism, biological activity and growth parameters and hence which applied zinc results in taller and higher enzyme activity in pods/ plant. Similar results were reported by kumar *et al. (*2024) [10]

Number of seed/pods

There is a higher seed yield with the application of sulphur 45/ha. Due to this photosynthesis process increases.

Economics

The data pertaining to economics of growing as influence Sulphur and Zinc on Black gram has been exhibited. The common and variable cost of production has been given in table 4.8.

Cost of Production (INR/ha)
Cost of production (30740) was found to be highest in treatment 9 [Sulphur (30kg/ha) + Zinc (10kg/ha)] as compared to other treatment.

Gross return (INR/ha)
Gross return (104774.50) was found to be highest in treatment 9 [Sulphur (30kg/ha) + Zinc (10kg/ha)] as compared to other treatment.

Net return (INR/ha)
Net return be (74034.50) was found to be highest in treatment 9 [Sulphur (30kg/ha) + Zinc (10kg/ha)] as compared to other treatment.

B:C ratio(B:C)
Benefit cost ratio (2.41) was found to be highest in treatment 9 [Sulphur (30kg/ha) + Zinc (10kg/ha)] and min benefit cost ratio (1.18) was found to be in treatment 10 (Control) as compared to other treatments. Higher gross returns, net returns, benefit cost ratio was recorded with application of zinc (20kg/ha) might be due to maximum recovery from application of zinc with less expenditure and higher seed yield and strow yield obtained from this treatment. These results are in conformity with those observed by Sunil *et al.* (2017) [16]

Test weight(g)
Treatment 9(237.44g) recorded in higher test weight, however the treatment 7 and 8 was foun DAS per the treatment 9

Seed yield
T9 (1504.55kg/ha) was recorded maximum Seed yield which was superior over all other treatments., the T7 (1249.64kg/ha) and T-8 (1229.45kg/ha) was found to be statistically at par with the T 9 (1504.55 kg/ha).

Straw yield (kg/ha)
T9 (2906.30) kg/ha was max yield better than other treatments and the T7 2890.78 kg/ha and T8 2728.07 kg/ha was as per T92900.3 kg/ha.

Harvest index (%)
At harvest, highest test weight (34.12%) was recorded in T9 [Sulphur (30kg/ha) + Zinc (10kg/ha)], though
there was no difference among the treatments.

Conclusion
The field experiment titled "Effect of Sulphur and Zinc on growth and yield of Black gram" was conducted at Crop Research Farm, Department of Agronomy. The important findings of the experiment have been summarized and concluded below, Based on the objective undertaken significantly higher Plant height (28.80 cm), maximum number of branches/plant (11.06), higher nodules/plant (16.44), higher plant dry weight (11.56 g), higher number of Pods/Plant (38.67), higher number of seeds/pod (6.93), higher test weight (37.44 g), higher seed yield (1504.55 kg/ha) and higher stover yield (2906.30) was recorded with treatment 9[Sulphur (30kg/ha) + Zinc (10kg/ha)] Higher gross returns (104774.50 INR/ha), net return (74034.50 INR/ha) and benefit cost ratio (2.41) was also recorded with treatment 9 [Sulphur (30kg/ha) + Zinc (10kg/ha)]. It is concluded that in Black gram (treatment 9) with application of Sulphur (30kg/ha) and zinc (10kg/ha) recorded highest yield and benefit cost ratio.

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