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Response of Sulphur and Zinc on Yield Attributes, Yield and Economics of Cowpea (*Vigna unguiculata* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

During the *Kharif* season of 2023, a field experiment took place at the Crop Research Farm within the Department of Agronomy at SHUATS in Prayagraj, Uttar Pradesh. The objective was to investigate the influence of sulphur and zinc on the yield attributes, yield and economics of cowpea. Growth and yield data were collected for the crop.The experiment followed a Randomized Block Design with 10 treatments, each replicated three times. The treatments included varying levels of sulphur (25, 30, 35 kg/ha) and zinc (5, 10, 15 kg/ha), along with a control treatment of 20-50-20 kg/ha using Cowpea variety '*Kashinidhi'*. The findings indicated that applying 35 kg/ha of sulphur in along with 15 kg/ha of zinc resulted in the following outcomes for cowpea, Maximum Number of pods per plant (17.1), Number of seeds per pod (9.8), Seed yield (1423.27 kg/ha), Stover yield

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(3201.9 kg/ha), Maximum gross returns (1,06,745.14 INR/ha), net returns (73,245.14 INR/ha) and B:C ratio (2.19). These favourable results were observed in Treatment-9, where the specified combination of 35 kg/ha of Sulphur + 15 kg/ha Zinc was applied.

Keywords: Cowpea; economics; sulphur; zinc; yield parameters; yield.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* Walp.) holds significant importance as a versatile leguminous plant cultivated for various purposes, including pulses, vegetables, and fodder [1]. **“**It is poor man’s protein source, considered one of the most ancient human food sources, and has probably been used as a crop plant since Neolithic times” [2]. “In 2017, grain legume production in India reached an impressive 22.95 million metric tons from a cultivated area of 29.46 million hectares, with a productivity of 779 kg/ha. India’s significant contribution to pulse production underscores its position as the largest producer globally” [3]. “Cowpea (*Vigna unguiculata*) is a versatile legume crop widely grown in arid and semi-arid regions” [4,5,6,7]. “It serves primarily as a pulse, but its leaves and green peas are also consumed as vegetables, and it provides fodder for livestock. The age-old practice of mixed cropping of cowpea for vegetable purposes with widely spaced crops such as cotton, pigeon pea, maize, sorghum, pearl millet, sunflower, castor, and plantation crops, or its cultivation in cropping systems, is now being practiced with an improved package of practices in terms of spacing, choice of appropriate varieties, nutrients, water and weed management, and plant protection” [8].

“Sulphur is recognized as a major plant nutrient. Ni It is essential. Most of the plant's requirement for sulphur is absorbed through the roots in the form of sulphate (SO_4^{-2}). Sulphur is an important constituent of sulphur, containing the amino acids cystine, cysteine, and methionine, and plays a vital role in regulating metabolic and enzymatic processes” [9]. “It’s response has been observed for several legume crops, and its application to sulphur-deficient soil has been found to increase crop yield and improve the quality of crop produce” [10].

Zinc serves as a crucial component of enzymes and proteins, playing a significant role in various physiological processes. These include chlorophyll formation, pollen development, fertilization, cell elongation, and nodule formation. Consequently, adequate zinc nutrition positively impacts pulse growth, yield, physiological parameters, and nodule formation, as highlighted by Kuniya et al. [11]. Applying elevated levels of zinc to cowpeas enhances auxin activity in plants, leading to improved growth characteristics and increased biomass accumulation. As a result, the plants exhibit higher dry matter content. These findings are consistent with the research by Kumar et al. [12].

1.1 Objectives

Keeping the above two factors into consideration an attempt has been made to do research upon, the present study titled "Effect of Sulphur and Zinc on Growth and Yield of Cowpea (*Vigna unguiculata* L.)” was conducted during *Kharif* season of 2022-23.

1) To Study the yield of cowpea as influenced by the application of Sulphur and Zinc.
2) To Work out the economics of different treatment combinations.

2. MATERIALS AND METHODS

The study was carried out during the *kharif* season of 2023 at the Crop Research Farm within the Department of Agronomy at SHUATS in Prayagraj, Uttar Pradesh. The experimental site is situated at a latitude of approximately 25.40793° N, a longitude of approximately 81.8842394° E, and an altitude of 98 meters above mean sea level (MSL). The soil texture in the experimental field was sandy loam, with a nearly neutral soil reaction (pH 7.5). The soil composition included 0.81% organic carbon, 184.79 kg/ha of available nitrogen (N), 250 kg/ha of available phosphorus (P), and 33.33 kg/ha of available potassium (K). The treatment consists of T_1: 25 sulphur kg ha^{-1} + 5 zinc kg ha^{-1}; T_2: sulphur 25 kg ha^{-1} + zinc 10 kg ha^{-1}; T_3: sulphur 25 kg ha^{-1} + zinc 15 kg ha^{-1}. T_4: sulphur 30 kg ha^{-1} + zinc 5 kg ha^{-1}, T_5: Sulphur 30 kg ha^{-1} + Zinc 10 kg ha^{-1}; T_6: Sulphur 30 kg ha^{-1} + Zinc 15 kg ha^{-1}; T_7: Sulphur 35 kg ha^{-1} + Zinc 5 kg ha^{-1}; T_8: Sulphur 35 kg ha^{-1} + Zinc 10 kg ha^{-1}; T_9:

Sulphur 35 kg ha^{-1} + Zinc 15 kg ha^{-1}; T_{10}: Control (RDF-N-P-K-20-50-20 kg/ha).

2.1 Field Management

On August 10, 2023, the cowpea variety known as *Kashinidhi* was planted in rows with a spacing of 30 cm between rows and 15 cm between individual plants. The recommended seed rate for this planting was 20–25 kg/ha. To maintain the ideal plant population, thinning and gap filling were performed on the 8^{th} and 7^{th} days after sowing. Additionally, weeding was carried out twice: first at 20 days after sowing (DAS) and then again at 45 DAS. For observation purposes, five healthy plants were randomly selected and tagged**.** At the time of harvest, various yield-contributing factors were meticulously recorded. These included the maximum number of pods per plant, the number of seeds per pod, seed yield (kg/ha), stover yield (kg/ha), and economic parameters such as gross returns, net returns, and the benefit-cost ratio (B:C ratio).

2.2 Number of Pods/Plants

From the five tagged plants of each plot the number of pods/plants was taken and the average no. of pods/plant was recorded.

2.3 Number of Seeds/Pods

To calculate the average number of seeds/pods, four or ten randomly selected mature siliquae from the harvest and then their seeds were counted.

2.4 Seed Yield (kg/ha)

The total seed yield obtained from the harvest area ($1m^2$) per plot was multiplied by the conversion factor for obtaining the total yield in tons per hectare and the average yield for each treatment was calculated.

2.5 Stover Yield (kg/ha)

The total stover yield obtained from the harvest area ($1m^2$) per plot was multiplied by the conversion factor for obtaining the total yield in tons per hectare and the average yield for each treatment was calculated.

2.6 Data Analysis

The collected data underwent statistical analysis using the analysis of variance method [13]. The data recorded during the course of investigation was subjected to statistical analysis by Analysis of variance technique. The significant and non-significant treatment effects were judged with the help of F‘ (variance ratio) table. The significant differences between the means were tested against the critical difference at 5% probability level by using ANOVA table.

3. RESULTS AND DISCUSSION

Significantly Maximum Number of Pods/plant (17.1) was recorded with (T9) the application of Sulphur 35 kg/ha along with Zinc 15 kg/ha. However, the treatment (T8) Sulphur 35 kg/ha + Zinc 10 kg/ha (16.5) was found to be statistically at par with T9. The enhanced crop growth, nodulation, and yield associated with sulfur application can be attributed to its crucial role in regulating metabolic and enzymatic processes, including photosynthesis, respiration, and symbiotic nitrogen fixation with legume-Rhizobium. These findings align with previous research by Rao et al. [14].

Maximum Number of seeds/pod (9.8) was recorded with (T9) the application of Sulphur 35 kg/ha along with Zinc 15 kg/ha. However, the treatment (T8) Sulphur 35 kg/ha + Zinc 10 kg/ha (9.0) was found to be statistically at par with T9. The application of sulfur and zinc to cowpea crops generally enhances fruit growth by promoting the synthesis of tryptophan and auxin. This enhancement effect on seeds per pod and pods per plant can be attributed to the favorable influence of zinc application on nutrient metabolism, biological activity, and growth parameters. As a result, the applied zinc leads to increased plant height and higher enzyme activity, ultimately encouraging greater seed production per pod and more pods per plant. Similar findings have been previously reported by Hamouda et al. [15] and Nishant Srivastava et al. [16].

Same trend followed with seed yield with application of Sulphur 35 kg/ha + Zinc 15 kg/ha resulted maximum yield (1423.7 kg/ha). However, the treatment (T8) Sulphur 35 kg/ha + Zinc 10 kg/ha (1392.99 kg/ha) which was found to be statistically at par with T9. “Sulphur application had a positive effect on seed yield (13.6% increase) and protein content. The highest yield of bean seeds, protein, and nitrogen content in seeds was found after the use of molybdenum and sulphur, and the way sulphur was brought had significant effect. The greatest increases in sulphur content, as compared to the control treatment, were identified as a result of the application of molybdenum and sulphur used in the foliar applications" [17].

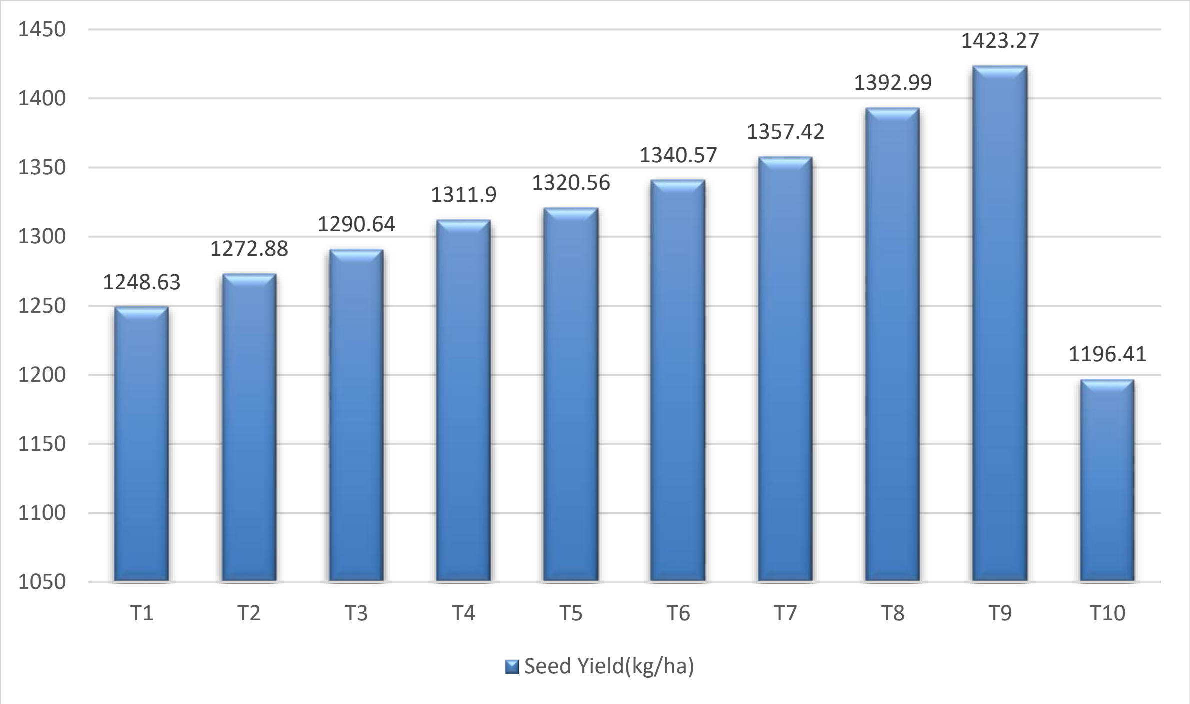

Fig. 1. Graphical representation of Seed yield kg/ha as influenced by Application of Sulphur 35 kg/ha along with Zinc 15 kg/ha

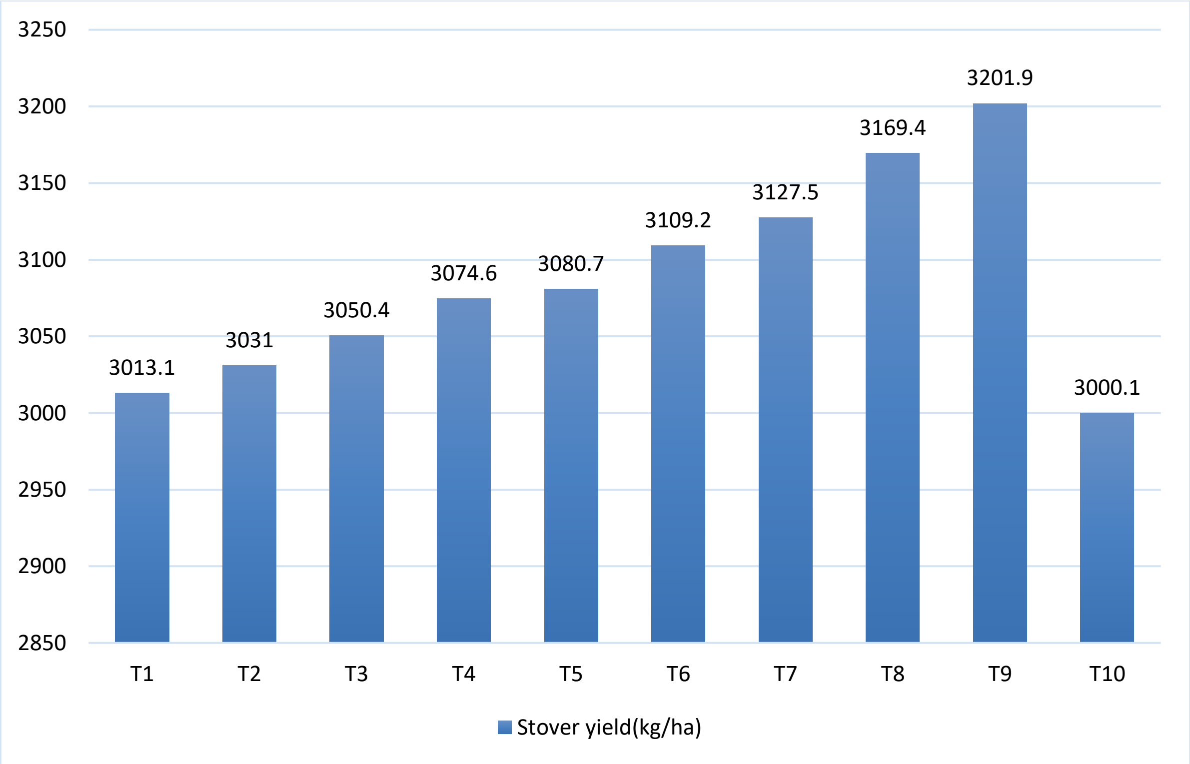

Fig. 2. Graphical representation of Stover yield kg/ha as influenced by Application of Sulphur 35 kg/ha along with Zinc 15 kg/ha

Table 1. Influence of Sulphur and Zinc on Yield Attributes and Yield of Cowpea

Treatment combination	Number of pods/plant	Number of seeds/pod	Seed yield (kg/ha)	Stover yield (kg/ha)
Sulphur 25 kg/ha + Zinc 5 kg/ha	12.2	6.9	1248.63	3013.1
Sulphur 25 kg/ha + Zinc 10 kg/ha	13.0	7.0	1272.88	3031.0
Sulphur 25 kg/ha + Zinc 15 kg/ha	12.7	7.9	1290.64	3050.4
Sulphur 30 kg/ha + Zinc 5 kg/ha	13.6	7.7	1311.90	3074.6
Sulphur 30 kg/ha + Zinc 10 kg/ha	15.0	9.0	1320.56	3080.7
Sulphur 30 kg/ha + Zinc 15 kg/ha	15.3	7.4	1340.57	3109.2
Sulphur 35 kg/ha + Zinc 5 kg/ha	16.2	8.7	1357.42	3127.5
Sulphur 35 kg/ha + Zinc 10 kg/ha	16.5	9.0	1392.99	3169.4
Sulphur 35 kg/ha + Zinc 15 kg/ha	17.1	9.8	1423.27	3201.9
Control (RDF 20-50-20 N-P-K kg/ha)	11.7	6.7	1196.41	3000.1
SEm(±)	0.62	0.43	29.28	37.83
CD (p=0.05)	1.86	1.28	87.01	112.4

Table 2. Influence of Sulphur and Zinc on Economics of Cowpea

Treatment combination	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C Ratio
Sulphur 25 kg/ha + Zinc 5 kg/ha	33,000.00	93,647.50	60,647.50	1.84
Sulphur 25 kg/ha + Zinc 10 kg/ha	33,100.00	95,466.18	62,366.18	1.88
Sulphur 25 kg/ha + Zinc 15 kg/ha	33,200.00	96,797.85	63,597.85	1.92
Sulphur 30 kg/ha + Zinc 5 kg/ha	33,200.00	98,392.50	65,192.50	1.96
Sulphur 30 kg/ha + Zinc 10 kg/ha	33,300.00	99,042.35	65,742.35	1.97
Sulphur 30 kg/ha + Zinc 15 kg/ha	33,400.00	1,00,542.52	67,142.52	2.01
Sulphur 35 kg/ha + Zinc 5 kg/ha	33,300.00	1,01,806.40	68,506.40	2.06
Sulphur 35 kg/ha + Zinc 10 kg/ha	33,400.00	1,04,474.30	71,074.30	2.13
Sulphur 35 kg/ha + Zinc 15 kg/ha	33,500.00	1,06,745.14	73,245.14	2.19
Control (RDF 20-50-20 N-P-K kg/ha)	31,700.00	89,731.12	58,031.12	1.83

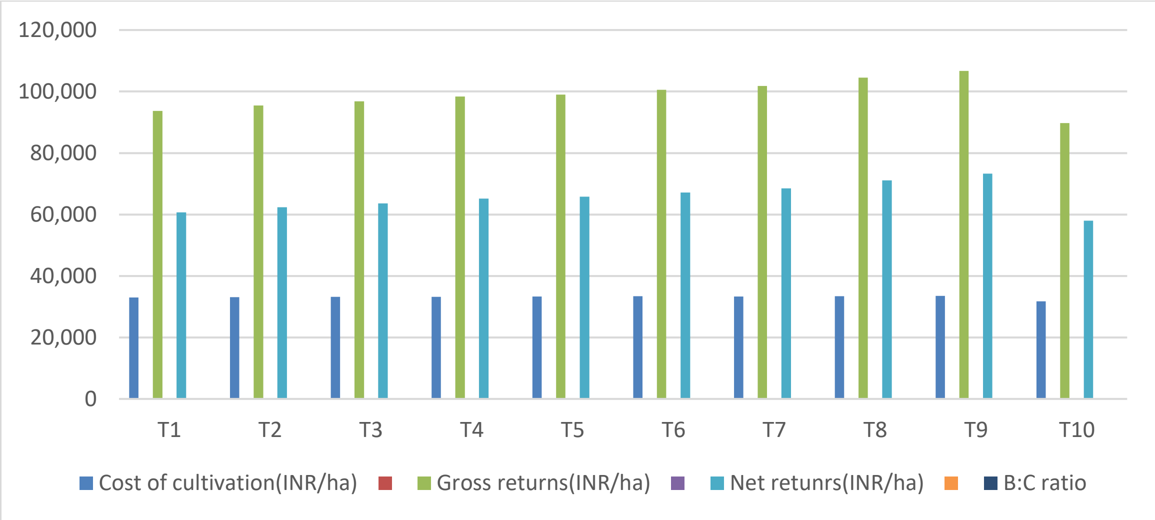

Fig. 3. Graphical representation of Economics of Different treatment combinations as influenced by Application of 35 kg/ha Sulphur along with 15 kg/ha of Zinc

Significantly Maximum stover yield (3201.9 kg/ha) was recorded with the (T9) application of Sulphur 35 kg/ha + Zinc 15 kg/ha. However, the treatment (T8) Sulphur 35 kg/ha + Zinc 10 kg/ha (3169.4 kg/ha) was found to be statistically at par with T9. “High yield effectiveness of sulphur fertilization can be achieved on soils characterized by a deficit of this element” [18]. Sulphur fertilization has a positive effect on the binding of atmospheric nitrogen by root nodules of plants from the Fabaceae family and better utilization of mineral nitrogen, and thus higher production of protein and plant biomass.

3.1 Economics

Economics of different treatment combinations was calculated and it was observed that in treatment (T9) with application of Sulphur 35 kg/ha along with Zinc 15 kg/ha has gained more Benefit-cost ratio (2.19) and maximum gross returns (1,06,745.14 INR/ha), net returns (73,245.14 INR/ha) was recorded in (T9) Sulphur 35 kg/ha + Zinc 15 kg/ha. The positive correlation between higher seed yield and stover yield has implications for economics. The observed increase in gross returns, net returns, and benefit-to-cost ratio can be attributed to the enhanced seed and stover yield resulting from foliar application of 4% sulfur combined with 1.5% zinc. These findings align closely with the research conducted by Durugude et al. [19].

4. CONCLUSION

Based on the results, it is evident that applying 35 kg/ha of sulphur along with 15 kg/ha of zinc (treatment 9) led to significantly better yield components and economic performance in cowpea cultivation. Treatment 9 exhibited superior outcomes in terms of Maximum number of pods per plant, Number of seeds per pod, Seed yield, Stover yield, Gross returns, Net returns, Benefit-Cost Ratio. Therefore, adopting this specific combination of sulphur and zinc is recommended for achieving improved quality and higher yields in cowpea crops.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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