Original Research Article

RESPONSE OF SULPHUR AND ZINC ON YIELD ATTRIBUTES , YIELD AND ECONOMICS OF COWPEA (*Vigna unguiculata* L.)

ABSTRACT:

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A field experiment was conducted during Kharif 2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.). The experiment followed a Randomized Block Design with 10 treatments, each replicated three times. The treatments included varying levels of sulphur (25 kg/ha, 30 kg/ha, 35 kg/ha) and zinc (5 kg/ha, 10 kg/ha, 15 kg/ha), along with a control treatment of 20-50-20 kg/ha using Cowpea variety 'Kashinidhi'. The treatment combinations are mentioned as T_1: sulphur 25 kg/ha + zinc 5 kg/ha; T_2: sulphur 25 kg/ha + zinc 10 kg/ha; T_3: sulphur 25 kg/ha + zinc 15 kg/ha. T_4: sulphur 30 kg/ha + zinc 5 kg/ha, T_5: Sulphur 30 kg/ha + Zinc 10 kg/ha; T_6: Sulphur 30 kg/ha + Zinc 15 kg/ha; T_7: Sulphur 35 kg/ha + Zinc 5 kg/ha; T_8: Sulphur 35 kg/ha + Zinc 10 kg/ha; T_9: Sulphur 35 kg/ha + Zinc 15 kg/ha; T_{10}: Control (RDF-N-P-K-20-50-20 kg/ha). The important findings of the experiment have been summarized and concluded here under the objectives taken. The application of (treatment 9) Sulphur 35 kg/ha + Zinc 15 kg/ha was recorded. Significantly Maximum Number of pods per plant (17.1), Number of seeds per pod (9.8), Seed yield (1423.27 kg/ha), Stover yield (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) obtained in T_9 Sulphur 35 kg/ha + Zinc 15 kg/ha.

Key words: cowpea, economics, sulphur, zinc, yield parameters, yield , ~~zinc~~.

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INTRODUCTION:

Cowpea (*Vigna unguiculata* Walp.) holds significant importance as a versatile leguminous plant cultivated for various purposes, including pulses, vegetables, and fodder(citation). 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 **(Ng and Marechal 1985)**. What looks like the production of cow pea in the world, then go to the indian .India is the largest producer of grain legumes in the entire world. India produces 22.95 million metric tons of pulses from a 29.46-million-hectare area, with a productivity of 779 kg/ha in 2017 **(Tiwari and Shivhare, 2017).** Cowpea is an important multipurpose grain legume extensively cultivated in the arid and semiarid tropics. 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 **(Sudhir Kumar Rajpoot, 2016).**

Generally your citation is very shallow , very long sentences without citation make your citations updated (current).

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 (Prasad and Shivay 2018). 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 **(Kumar *et al.* 2009).**

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.* 2018).** Application of higher levels of zinc to cowpeas leads to an increase in auxin activity in plants, which promotes growth attributes and higher biomass accumulation in plants. This resulted in higher plant dry matter. The outcomes aligned with the findings of **Kumar and Bohra (2014).**

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MATERIALS AND METHODS:

The research was conducted during the 2023 *kharif* season 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: sulphur 25 kg/ha + zinc 5 kg/ha; T_2: sulphur 25 kg/ha + zinc 10 kg/ha; T_3: sulphur 25 kg/ha + zinc 15 kg/ha. T_4: sulphur 30 kg/ha + zinc 5 kg/ha, T_5: Sulphur 30 kg/ha + Zinc 10 kg/ha; T_6: Sulphur 30 kg/ha + Zinc 15 kg/ha; T_7: Sulphur 35 kg/ha + Zinc 5 kg/ha; T_8: Sulphur 35 kg/ha + Zinc 10 kg/ha; T_9: Sulphur 35 kg/ha + Zinc 15 kg/ha; T_{10}: Control (RDF-N-P-K-20-50-20 kg/ha).

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 8th and 7th 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. **This is already put in the data collected part** . ~~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).~~ ~~The collected data underwent statistical analysis using the analysis of variance method~~ ~~**(Gomez *et al.* 1976)**~~

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Number of pods/plants:

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

Number of seeds/pods:

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

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 averageyield for each treatment was calculated.

Stover yield (kg/ha):

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

Data analysis

The collected data underwent statistical analysis using the analysis of variance method **(Gomez *et al.* 1976)**. **What type of data analysis methed used for your mean separation. Make clear the method**

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RESULTS AND DISSCUSSION:

YIELD PARAMETERS:

Number of Pods/plant:

Significantly Maximum Number of Pods/plant (17.1) was recorded with (T_9) the application of Sulphur 35 kg/ha along with Zinc 15 kg/ha and minimum was recorded in control (11.7). However, the treatment (T_8) Sulphur 35 kg/ha + Zinc 10 kg/ha (16.5) was found to be statistically at par with T_9.

Number of Seeds/pod:

Maximum Number of seeds/pod (9.8) was recorded with (T_9) the application of Sulphur 35 kg/ha along with Zinc 15 kg/ha. Minimum was recorded in control (6.7). However, the treatment (T_8) Sulphur 35 kg/ha + Zinc 10 kg/ha (9.0) was found to be statistically at par with T_9.

Seed Yield (kg/ha):

Same trend followed with seed yield with application of Sulphur 35 kg/ha + Zinc 15 kg/ha resulted maximum yield (1423.7 kg/ha). Minimum was in control (1196.41 kg/ha). However, the treatment (T_8) Sulphur 35 kg/ha + Zinc 10 kg/ha (1392.99 kg/ha) which was found to be statistically at par with T_9.

Stover Yield (kg/ha):

Significantly Maximum stover yield (3201.9 kg/ha) was recorded with the (T_9) application of Sulphur 35 kg/ha + Zinc 15 kg/ha. Minimum was recorded in control (3000.1 kg/ha).However, the treatment (T_8) Sulphur 35 kg/ha + Zinc 10 kg/ha (3169.4 kg/ha) was found to be statistically at par with T_9.

ECONOMICS:

Gross returns (INR/ha):

Gross Returns (1,06,745.14.20 INR/ha) was found to be highest in the treatment T_9 Sulphur 35 kg/ha + Zinc 51 kg/ha, and minimum Gross Returns (89,731.12 INR/ha) was found to be in Control as compared to other treatments.

Net returns (INR/ha):

Net Returns (73,245.14 INR/ha) was found to be highest in the treatment T_9 Sulphur 35 kg/ha +Zinc 15 kg/ha, and minimum Net returns (58,031.12 INR/ha) was found to be in Control as compared to other treatments.

Benefit cost Ratio:

Benefit Cost Ratio (2.19) was found to be highest in the treatment T_9 Sulphur 35 kg/ha +Zinc 15 kg/ha, and minimum Benefit Cost Ratio (1.83) was found to be in Control as compared to other treatments.

DISCUSSIONS:

The improvement in crop growth, nodulation and yield attributes with sulphur application could be ascribed to its pivotal role in regulation of the metabolic and enzymatic processes including photosynthesis, respiration and legume- Rhizobium symbiotic nitrogen fixation reflected in increased yield. Similar results were also reported by **(Rao *et al.* 2001).** Application of Sulphur and Zinc to cowpea crop generally improves fruit growth by synthesizing tryptophan and auxin. The enhancement effect on seeds/pod and pods/plant attributed to the favorable influence of the Zn application to crops on nutrient metabolism, biological activity and growth parameters and hence, applied Zinc application led to increased plant height and enhanced enzyme activity**,** which, in turn, promoted greater seed production per pod and more pods per plant. These findings align with previous studies by **Hamouda *et al.* (2018) and Nishant Srivastava *et al.* (2017)**. The application of sulphur positively impacted seed yield, resulting in a 13.6% increase**,** along with enhanced protein content. Notably, the highest bean seed yield, protein levels, and nitrogen content were observed when molybdenum and sulphur were used together. Specifically, foliar applications of molybdenum and sulphur led to significant increases in sulphur content compared to the control treatment **(Aleksandra *et al.* 2018).**

Sulphur fertilization is particularly effective in soils with a deficiency of this element (**Barczak *et al.* 2013**). Moreover, it positively influences the binding of atmospheric nitrogen by root nodules in plants from the Fabacea family, leading to improved utilization of mineral nitrogen and ultimately resulting in higher protein production and increased plant biomass. Higher seed yield and stover yield positively correlates with economics. The increased gross returns, net returns and benefit: cost ratio was due to increased seed and stover yield under foliar application of Sulphur 4% with zinc at 1.5%. The findings are in close conformity with those of **(Durugude *et al.* 2014)**.

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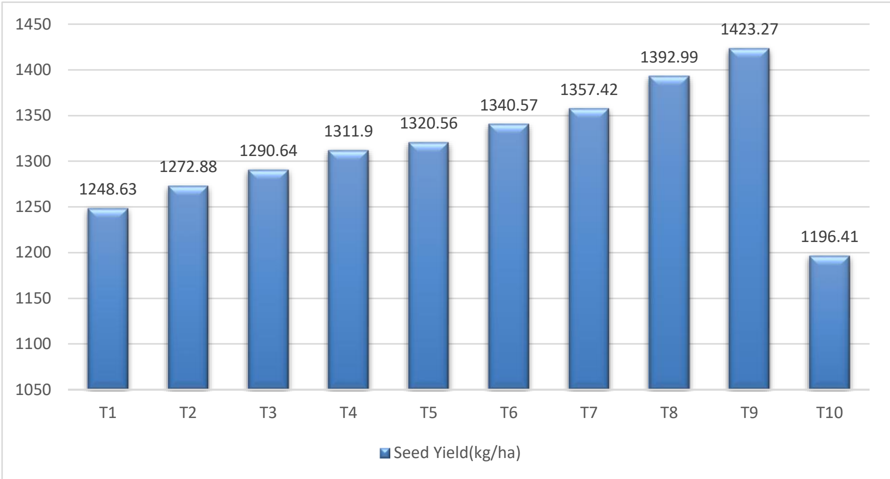

Fig 1 : Graphical representation of Seed yield kg/ha as influenced by Application of Sulphur 35 kg/ha along with Zinc 15 kg/ha

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

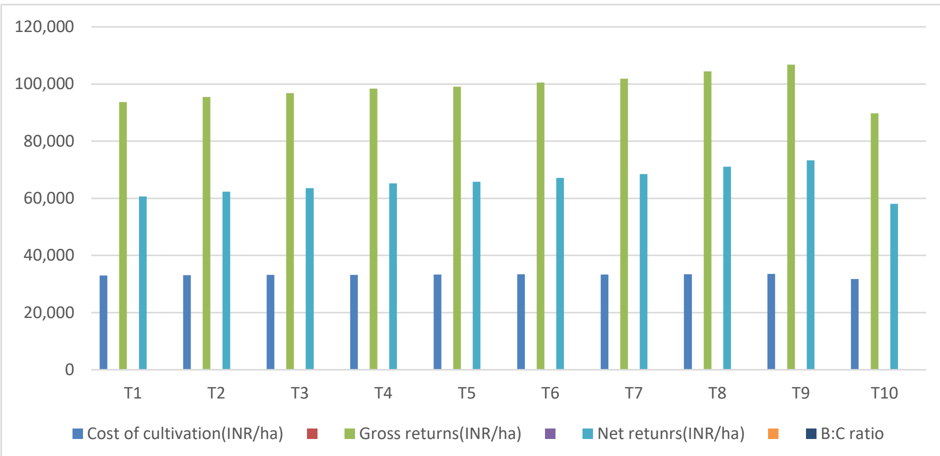

Fig 3 : Graphical representation of Economics of Different treatment combinations as influenced by Application of Sulphur 35 kg/ha along with Zinc 15 kg/ha

The application of Sulphur 35 kg/ha + Zinc 15 kg/ha (treatment 9) resulted in significantly higher yield components for Cowpea, including maximum number of pods per plant, number of seeds per pod, seed yield, stover yield, gross returns, net returns, and benefit-cost ratio. Therefore, for achieving better quality and higher yields, this specific combination of sulphur and zinc is recommended for Cowpea cultivation.

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