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Effect of Sulphur and Zinc on Growth and Yield of Cowpea (*Vigna unguiculata* L.)

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Abstract
A research trial was conducted at Crop Research Farm (CRF) of Department of Agronomy, SHUATS, Prayagraj, (U.P) in *kharif* season with an objective to check the response of sulphur and zinc on growth and yield of cowpea. Data of growth and yield characters of the crop were recorded. Randomized Block Design was implemented for the experiment with 10 treatments replicated thrice. The Treatments consisted of 3 levels of Sulphur (25, 30, 35 kg ha^{-1}) and zinc (5, 10, 15 kg ha^{-1}) with Cowpea var. Kashinidhi. The results reported application of Sulphur 35 kg ha^{-1} + zinc 15 kg ha^{-1} achieved highest plant height (58.6 cm), plant dry weight (34.11 g/plant), nodules/plant (25.9), pods/plant (17.1), seeds/pod (9.8), seed yield (1423.27 kg ha^{-1}), stover yield (3201.9 kg ha^{-1}), maximum gross returns (INR 1,06,745.14 /ha), net returns (INR 73,245.14 /ha) and Benefit Cost ratio (2.19) were attained in (T_9) that is with 35 kg ha^{-1} Sulphur along with 15 kg ha^{-1} Zinc.

Keywords: cowpea, growth parameters, sulphur, yield parameters, zinc.

Introduction
Cowpea (*Vigna unguiculata* (L.) Walp.), commonly known as chowli, holds significant importance as a legume crop. In the Indian diet, cowpea stands out due to its high protein content, which exceeds that of cereals by more than twice. The cultivation of cowpea spans an area of 8.29 lakh hectares, resulting in a periodic yield of 5.22 lakh tonnes and a productivity rate of 576 kg per hectare (as reported by the Department of Agriculture, 2011). Compared to other pulses nutritional values in cowpea grain contains about 24-26% of protein, 59-60% carbohydrates, 1.02-4.10% fibre, 8-11% fat, 15-30% moisture. It also promotes nodulation in legumes. It's a crop that can be used as catch crop, mulch crop, intercrop, mixed crop and green crop. It has capability to fix atmospheric N_2 in the soil @ 56 kg/ ha in association with symbiotic bacteria under favourable conditions (Mandal *et al*., 2009) [9].

Sulphur being fourth major nutrient after nitrogen, phosphorous and potassium is also an essential element for plant growth particularly for legumes, and plays an important part in plant metabolism system. S contains amino acids (cystine, methionine and cysteine) and promotes nodule formation in legumes. It is essential for chlorophyll synthesis and promoting nodule formation. In addition to primary nutrients, the inclusion of secondary nutrients, particularly sulphur, is essential for achieving optimal yields in pulses. Sulphur also plays a crucial role in promoting nodulation in legumes (Tandon, 1991) [15].

Zinc is an important element of enzymes and proteins. It's the only essence element present in all the six enzyme classes, oxidoreductases, transferases, hydrolases, lyases, isomerases and ligases (Auld, 2001) [2]. Zinc plays a major part in numerous physiological processes *viz*., nodule formation, fertilization, chlorophyll formation, cell elongation, pollen formation etc. Hence, Zn nutrition has positive influence on the growth, yield physiological parameters and nodule formation in pulses (Kuniya *et al*. 2018) [4]. Zinc not only increases the yield, but also improves the quality of the yield. It's involved in several enzyme systems, growth hormone (auxins) and the conflation of nucleic acid and plays crucial part in intake and use of water by plants (Thamke 2017) [16].

Materials and Methods

The experiment was conducted in *kharif* (rainy season) 2023 at CRF, DOA, SHUATS, Prayagraj (U.P) which is located at 25.40793'' N latitude, 81.8842394" E longitude and 98 m altitude above the mean sea level (MSL). The texture of the soil of experimental field was sandy loam, nearly neutral in soil reaction (pH 7.5), organic carbon (0.81%), available nitrogen (184.79 kg ha^{-1}), available phosphorous (250 kg ha^{-1}) and available potassium (33.33 kg ha^{-1}). The treatments consist two variables var-1 Sulphur and var-2 zinc each of three treatment levels. The treatment combinations are T_1 Sulphur 25 kg ha^{-1} + zinc 5 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^{-1}).

The Cowpea seeds were sown on 10-08-2023 at a spacing of 30 cm x 15 cm at a depth of 3-5 cm with a seed rate of 20 - 25 kg ha^{-1}. Thinning and gap filling was carried out at 8^{th} and 7^{th} days after sowing to maintain optimum plant population. First and second hand weeding were done at 20 and 45 DAS. Five representative healthy plants were selected and tagged randomly to take observations. The growth contributing characteristics such as plant height, dry weight of plant and nodules/plant. Yield contributing characters such as pods/plant, seeds/pod, seed yield (kg ha^{-1}) and stover yield (kg ha^{-1}) were noted at the time of harvest. Analysis of variance method was used to analyze the collected data. (Gomez *et al.*, 1976)

Results and Discussion growth parameters

The results depict that there was a significant difference in height of the plant. Greater height (58.6 cm) was observed with (T_9) Sulphur 35 kg ha^{-1} along with Zinc 15 kg ha^{-1}. However, treatment (T_8) Sulphur 35 kg ha^{-1} + zinc 10 kg ha^{-1} (54.2 cm) was statistically at par with highest. Application of sulphur increased photosynthesis rate influenced by protein synthesis enhancement and high chlorophyll content maintenance. Thus, ultimately increasing the plant growth parameter (Prajapati *et al.*, 2013) [11].

The results depict that highest plant dry weight (34.11 g) was observed with (T_9) application of Sulphur 35 kg ha^{-1} along with Zinc 15 kg ha^{-1}. However, treatment (T_8) Sulphur 35 kg ha^{-1} + zinc 10 kg ha^{-1} (32.12 g) was statistically at par with highest. Fresh and dry weight of garden pea increased due to sulphur and boron and could be attributed to low availability of S and B. The stimulating effect of applied sulphur helped in the synthesis of chloroplast, resulting in enhanced photosynthesis which might have led to an increased fresh and dry weight of pea. Similar results have also been reported by other workers in legume crops (Khanna and Gupta 2005) [6].

The same trend was followed by attaining maximum no. of nodules/plant (25.9) was observed with (T_9) Sulphur application at 35 kg ha^{-1} along with Zinc 15 kg ha^{-1}. However, treatment (T_8) was statistically at par with highest. More number of nodules/plant was found with use of Zn and B. Zn plays an important role in synthesis of leg hemoglobin and also reported that number of nodules, size, leghemoglobin content and nodules dry weight depend on the Zn availability. This result might be because nutrients availability during the crop growth period was improved by the action of zinc and boron. Similar findings were also reported for Soil application of 15 kg Zn/ha recorded higher number of nodules, effective nodules and nodule fresh weight per plant in cowpea (Upadhyay and Singh, 2016) [17].

Yield Parameters

Significantly higher no. of Pods/plant (17.1) was recorded with T_9 Sulphur 35 kg ha^{-1} + Zinc 15 kg ha^{-1}. However, the treatment (T_8) Sulphur 35 kg ha^{-1} along with Zinc 10 kg ha^{-1} (16.5) was statistically at par with T_9. Improvement in crop growth, nodulation and yield with application of sulphur could be due to its pivotal role in regulation of the metabolic and enzymatic processes *viz.*, photosynthesis, respiration and symbiotic nitrogen fixation which reflected in increased yield. Similar findings were also observed by (Rao *et al.* 2001) [13].

In Respect to no. of pods/plant it was observed that maximum no. of seeds/pod (9.8) were also recorded in the treatment (T_9) with application of Sulphur 35 kg ha^{-1} + Zinc 15 kg ha^{-1}. However, the treatment Sulphur 35 kg ha^{-1} + Zinc10 kg ha^{-1} (9.0) was statistically at par with T_9.

Significantly more seed yield (1423.7 kg ha^{-1}) was achieved with T_9 Sulphur 35 kg ha^{-1} + Zinc 15 kg ha^{-1}. However, the treatment Sulphur 35 kg ha^{-1} + Zinc 10 kg ha^{-1} (1392.99 kg ha^{-1}) was statistically at par with T_9. The utilization of sulphur demonstrated a beneficial effect on seed yield, with a notable increase of 13.6%, along with enhanced protein content. Employing molybdenum in conjunction with sulphur, and the method by which sulphur was applied, led to the highest yield of bean seeds, as well as increased protein and nitrogen content in the seeds. The elevated sulphur levels, compared to the control treatment, were attributed to the application of molybdenum and the foliar application of sulphur.

Highest stover yield (3201.9 kg ha^{-1}) was recorded with T_9 Sulphur 35 kg ha^{-1} + Zinc 15 kg ha^{-1}. However, the treatment Sulphur 35 kg ha^{-1} + Zinc 10 kg ha^{-1} (3169.4 kg ha^{-1}) was statistically at par with T_9. High yield due to sulphur fertilization can be achieved on soils having low sulphur (Barczak *et al.* 2013) [3]. The utilization of sulphur contributes positively to the binding of atmospheric nitrogen by root nodules in plants from the *Fabaceae* family, enhancing the utilization of mineral nitrogen. Consequently, this leads to increased production of protein and plant biomass.

Table 1: Influence of Sulphur and Zinc on Growth Attributes of Cowpea.

S. No.	Treatment combination	Plant height (cm)	Plant Dry Weight (g)	Nodules/Plant (No.)
1	25 kg/ha Sulphur + 5 kg/ha zinc	50.0	29.25	19.1
2	25 kg/ha Sulphur + 10 kg/ha zinc	50.3	30.35	20.6
3	25 kg/ha Sulphur + 15 kg/ha zinc	51.2	30.56	20.4
4	30 kg/ha Sulphur + 5 kg/ha zinc	51.4	30.96	21.1
5	30 kg/ha Sulphur + 10 kg/ha zinc	52.1	31.11	21.4
6	30 kg/ha Sulphur + 15 kg/ha zinc	52.6	31.43	22.0
7	35 kg/ha Sulphur + 5 kg/ha zinc	53.2	31.84	22.3
8	35 kg/ha Sulphur + 10 kg/ha zinc	54.2	32.12	24.0
9	35 kg/ha Sulphur + 15 kg/ha zinc	58.6	34.11	25.9
10	Control: (20-50-20 N-P-K kg/ha)	47.9	28.98	18.6
	S.Em(±)	1.56	1.00	0.67
	CD (p=0.05)	4.63	2.98	1.99

Table 2: Influence of Sulphur and Zinc on yield characters and yield of Cowpea.

S. No	Treatment combination	Pods/plant (No.)	Seeds/pod (No.)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
1	25 kg/ha Sulphur + 5 kg/ha zinc	12.2	6.9	1248.63	3013.1
2	25 kg/ha Sulphur + 10 kg/ha zinc	13.0	7.0	1272.88	3031.0
3	25 kg/ha Sulphur + 15 kg/ha zinc	12.7	7.9	1290.64	3050.4
4	30 kg/ha Sulphur + 5 kg/ha zinc	13.6	7.7	1311.90	3074.6
5	30 kg/ha Sulphur + 10 kg/ha zinc	15.0	9.0	1320.56	3080.7
6	30 kg/ha Sulphur + 15 kg/ha zinc	15.3	7.4	1340.57	3109.2
7	35 kg/ha Sulphur + 5 kg/ha zinc	16.2	8.7	1357.42	3127.5
8	35 kg/ha Sulphur + 10 kg/ha zinc	16.5	9.0	1392.99	3169.4
9	35 kg/ha Sulphur + 15 kg/ha zinc	17.1	9.8	1423.27	3201.9
10	Control: (20-50-20 N-P-K kg/ha)	11.7	6.7	1196.41	3000.1
	S.Em (±)	0.62	0.43	29.28	37.83
	CD (p=0.05)	1.86	1.28	87.01	112.4

Conclusion

It is concluded that implementation of Sulphur 35 kg ha^{-1} + Zinc 15 kg ha^{-1} has given better results both in growth and yield attributes.

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Competing interests

It is declared that authors have no existing competing interests.

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