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Effect of sulphur and zinc fertilization on growth and yield of cowpea [*Vigna unguiculata* (L.) Walp.]

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Abstract
A field experiment was conducted at Research Farm of Suresh Gyan Vihar University, Jaipur (Rajasthan) during *kharif* 2023 on loamy sand soil, which consisted ten treatments *viz.* control (T_0), Sulphur @ 15 kg ha^{-1} (T_1), Sulphur @ 30 kg ha^{-1} (T_2), Sulphur @ 15 kg ha^{-1} (T_3), Sulphur @ 45 kg ha^{-1} (T_4), Sulphur @ 15 kg ha^{-1} + Zn @ 0.1% (T_5), Sulphur @ 30 kg ha^{-1} + Zn @ 0.1% (T_6), Sulphur @ 45 kg ha^{-1} + Zn @ 0.1% (T_7), Sulphur @ 30 kg ha^{-1} + Zn @ 0.5% (T_8) and Sulphur @ 45 kg ha^{-1} + Zn @ 0.5% (T_9) were laid out in randomized block design with three replication. Variety RC-19 was used for experiment.
Results clearly showed that application of sulphur @ 45 kg ha^{-1} + Zn @ 0.5% (T_9) significantly increased plant height, dry matter accumulation, number of branches $plant^{-1}$, number of nodules $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}, seed, straw and biological yield, of cowpea over control. However, treatment sulphur @ 30 kg ha^{-1} + zinc 0.5% (T_8) was remained at par with each other.

Keywords: Cowpea, sulphur, zinc, fertilization

Introduction
Cowpea [*Vigna unguiculata* (L.) Walp], belonging to the family Fabaceae is an important *Kharif* pulse crop grown in India for vegetable pods, grain, forage and for green manure purpose. Cowpea is grown both for its tender pods and also for its dry seeds used as pulse for culinary purpose. Vegetable cowpea is one of the most ancient crops known to man. It is a popular vegetable grown throughout the world. It is a warm season crop, well adapted to many areas of humid tropics and subtropical zones. In India, it is grown widely round the year. Cowpea is also called as vegetable meat due to high amount of protein in grain with better biological value on dry weight basis. Cowpea grain contains 23.4 percent protein, 1.8 percent fat and 60.3 percent carbohydrates on dry weight basis and it is rich source of calcium and iron. Apart from this, cowpea forms excellent forage and it gives a professed vegetative growth and covers the ground so well that it checks the soil erosion. Cowpea pods are good source of protein, fiber, minerals, calcium and vitamins particularly vitamin A and vitamin C. It contains 8 g carbohydrates, 43 g proteins and 0.6 g fat, 2 g fiber per 100 g of edible portion. Tender fruits contain 80 mg calcium, 74 mg phosphorus and 2.5 mg iron per 100 g fresh pod, amino acid profile is particularly high in cowpea which greatly improves the protein quality of pulses (Gopalakrishnan, 2007) [3]. Sulphur are most vital nutrients for quality of pulses crop. Sulphur is considered to be the fourth important essential nutrient after nitrogen, phosphorus and potassium for the plant growth. Sulphur performs many physiological functions like synthesis of cysteine, methionine, chlorophyll and protein content of crops (Patil *et al*., 2022) [11]. Zinc is one of the seventh plant micronutrient, involved in many enzymatic activities of the plant. It functions generally as a metal activator of enzymes. It is reported that, Zinc improves crop productivity almost as much as major nutrients. Besides increasing crop yield, it increases the crude protein content, amino acids, energy value and total lipid in chickpea, soybean, blackgram etc. Sharma *et al*. (2013) [13] and Debnath *et al*. (2018) [1].

Materials and Methods

The field experiments were carried out during *kharif* season (2023) to study the "To Study the Effect of Sulphur and Zinc Fertilization on Growth and Yield of Cowpea [*Vigna unguiculata* (L.) Walp.]" In randomized block design with 10 treatments and 3 replication at Research Farm, Suresh Gyan Vihar University- Jaipur, Rajasthan. The experimental farm is geographically located at 75° 51'44" E longitude, 26°48'35'' N latitude and an altitude of 432 m above mean sea level (AMSL). The experimental fields were clay loam and the soil fertility status contained available nitrogen (137.8 kg ha^{-1}) by Subia and Asija 1996, available phosphorus (16.3 kg ha^{-1}) by Olsen *et al*. 1954 and available potassium (250.12 kg ha^{-1}) by Jackson, 1973. The organic carbon content was from 0.34-0.38 percent. The weekly mean maximum and minimum temperatures were of temperature during both summers (40.6 °C) and winters (2.7 °C). The mean relative humidity fluctuated from 63.50 to 91 percent during the crop season. The average rainfall is 557 mm per annum, which is mostly received during July to September. The sporadic showers during winters are also common, which are probably observed during this period. The experiments were laid out in randomized block design with three replications and ten treatments. The following treatments were included in the study, *viz*. control (T_0), Sulphur @ 15 kg ha^{-1} (T_1), Sulphur @ 30 kg ha^{-1} (T_2), Sulphur @ 15 kg ha^{-1} (T_3), Sulphur @ 45 kg ha^{-1} (T_4), Sulphur @ 15 kg ha^{-1} + Zn @ 0.1% (T_5), Sulphur @ 30 kg ha^{-1} + Zn @ 0.1% (T_6), Sulphur @ 45 kg ha^{-1} + Zn @ 0.1% (T_7), Sulphur @ 30 kg ha^{-1} + Zn @ 0.5% (T_8) and Sulphur @ 45 kg ha^{-1} + Zn @ 0.5% (T_9). The observation were recorded at harvest was analysed by Statistical methods (Fisher, R.A. 1950.)

Results and Discussion

It is clear from the result of present study that, application of sulphur and zinc had significantly affected on growth and yield parameters of cowpea at harvest. Application of sulphur @ 45 kg ha^{-1} + Zn @ 0.5% (T_9) recorded the highest growth attributes like plant height (72.04 cm), dry matter accumulation (123.63 g plant^{-1}), number of branches plant^{-1} (9.66) and number of branches plant^{-1} (35.54) at harvest (Table 1). Plant height and dry matter accumulation increased with the application of T_9 due to increased cell division and cell elongation at higher level of sulphur and zinc. The increase in plant height due to adequate availability of zinc and sulphur attributed to better nutritional environment for plant growth at active vegetative stages as result of enhancement in root growth, energy providing, multiplication, cell elongation and cell expansion in the plant body which ultimately increased the height of plant. The results of present investigation are in agreement with the finding of Mavrkar *et al.* (2008) [8] and Kumar *et al.* (2024) [6]. Dry matter production successively increased till maturity due to favorable effect of zinc and sulphur on the growth and development of plants. Increase in number of branches plant^{-1} and plant height is directly responsible for increasing the dry matter accumulation in plants at higher levels of sulphur and zinc. Singh and Yadav *et al.* (2022) [22] and Kiran *et al.* 2018 [5], also reported the similar results. Further yield attributes and yields like number of pods plant^{-1} (9.81), number of seeds pod^{-1} (7.49), seed yield (1079.83 kg ha^{-1}), stover yield (2052.97 kg ha^{-1}) and biological yield (3132.0 kg ha^{-1}) (Table 2) recorded with Sulphur @ 45 kg ha^{-1} + Zn @ 0.5% (T_9). However, test weight and harvest index (Singh and Stoskopt, 1971) was found non-significant by idifferent combination of sulphur and zinc in cowpea. Yield components by enhancing cell division, cell elongation process and photosynthetic activity leading to production and accumulation of more carbohydrates and auxins which favours retention of more flowers ultimately leading to more number of reproductive parts plant^{-1}. Similar results were also reported by Maur *et al.* (2017) [7] and Muindi *et al.* (2019) [9].

Table 1: Effect of sulphur and zinc on growth attributes of cowpea

Treatments	Plant height (cm)	Plant dry matter (g m^{-2})	Number of branches plant^{-1}	Number of nodules plant^{-1}
T_0: Control	61.42	98.48	5.36	29.15
T_1: Sulphur @ 15 kg ha ha^{-1}	62.77	102.21	5.90	30.44
T_2: Sulphur @ 30 kg ha ha^{-1}	63.85	103.37	6.51	31.09
T_3: Sulphur @ 45 kg ha ha^{-1}	64.47	104.55	6.62	31.34
T_4: Sulphur @ 15 kg ha^{-1} + zinc 0.1%	65.62	108.56	7.27	32.01
T_5: Sulphur @ 30 kg ha^{-1} + zinc 0.1%	66.77	112.24	7.89	32.91
T_6: Sulphur @ 45 kg ha^{-1} + zinc 0.1%	67.34	113.7	7.98	33.11
T_7: Sulphur @ 15 kg ha^{-1} + zinc 0.5%	68.48	117.41	8.68	33.81
T_8: Sulphur @ 30 kg ha^{-1} + zinc 0.5%	70.71	121.04	9.37	34.62
T_9: Sulphur @ 45 kg ha^{-1} + zinc 0.5%	72.04	123.63	9.66	35.54
SEm±	0.34	1.01	0.19	0.21
CD at (p= 0.05)	1.02	3.03	0.58	0.61
CV (%)	10.35	8.61	9.27	8.20

Table 2: Effect of sulphur and zinc on yield parameters of cowpea

Treatments	Number of pods plant^{-1}	Number of seeds pod^{-1}	Test weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_0: Control	6.65	5.06	85.37	604.6	1302.61	1907.18	31.70
T_1: Sulphur @ 15 kg ha ha^{-1}	7.02	5.39	85.43	664.34	1374.44	2038.70	32.59
T_2: Sulphur @ 30 kg ha ha^{-1}	7.39	5.74	85.53	701.9	1535.62	2237.49	31.37
T_3: Sulphur @ 45 kg ha ha^{-1}	7.45	5.87	86.69	715.08	1539.57	2254.57	31.72
T_4: Sulphur @ 15 kg ha^{-1} + zinc 0.1%	7.97	5.92	85.71	756.69	1611.71	2368.35	31.95
T_5: Sulphur @ 30 kg ha^{-1} + zinc 0.1%	8.38	6.28	86.84	876.29	1718.58	2594.78	33.77
T_6: Sulphur @ 45 kg ha^{-1} + zinc 0.1%	8.45	6.33	87.02	899.48	1778.23	2677.72	33.59
T_7: Sulphur @ 15 kg ha^{-1} + zinc 0.5%	8.96	6.67	88.07	944.78	1890.47	2835.16	33.32
T_8: Sulphur @ 30 kg ha^{-1} + zinc 0.5%	9.41	7.06	89.41	1031.09	1972.32	3003.34	34.33
T_9: Sulphur @ 45 kg ha^{-1} + zinc 0.5%	9.81	7.49	88.78	1079.83	2052.97	3132.65	34.47
SEm±	0.12	0.09	0.72	11.01	22.52	33.69	1.45
CD at (p= 0.05)	0.35	0.29	NS	32.07	68.34	101.07	NS
CV (%)	9.24	8.09	10.20	9.26	9.78	9.01	8.87

Conclusion

In light of the results obtained from the present investigation, it may be concluded that the of sulphur @ 45 kg ha^{-1} + Zn @ 0.5% (T_9) effective in increasing plant height, plant dry matter, number of branches $plant^{-1}$, number of pods $plant^{-1}$, seed, straw and biological yield of cowpea.

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