Original Research Article

Influence of Sulphur and zinc on growth, yield and economics of cowpea (*Vigna unguiculata* L.*)*

ABSTRACT

A field experiment was conducted during *Zaid* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36 %), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The experiment was laid out in Randomized Block Design with nine treatments each replicated thrice on the basis of one year of experimentation. The treatments which are T_1: 2% Sulphur+0.5% zinc, T_2: 2% Sulphur+ 1% Zinc, T_3: 2% Sulphur + 1.5% Zinc, T_4: 3% Sulphur + 0.5% Zinc, T_5: 3% Sulphur +1% Zinc, T_6: 3% Sulphur +1.5% Zinc, T_7: 4% Sulphur + 0.5% Zinc, T_8: 4% Sulphur+ 1% Zinc, T_9: 4% Sulphur +1.5% Zinc, T_{10} N:P: K 20:40:40 kg/ha. The results showed that application of 4% Sulphur+ 1.5% Zinc was recorded significantly higher plant height (79.17 cm), nodules/ plant (30.93), Plant dry weight (22.83 g/plant), No. of pods/ plant (12.14), Test weight (100.23 g), maximum crop growth rate (8.90g/m^2/day). However, higher Seed yield (1.32 t/ha), Stover Yield (3.48 t/ha) gross returns (INR84971.50/ha), net return (INR60594.40/ha) and benefit cost ratio (1.28) were obtained with application of 4% Sulphur+1.5% Zinc as compared to other treatments.

Key words*:* Sulphur, Zinc, Growth, Yield, Cowpea, Economics.

Introduction:

Cowpea (*Vigna unguiculata* L.) commonly referred to as "Lobia," serves as a versatile plant, functioning as a pulse, fodder, and green manure crop. With its origins tracing back to the Asian and African tropics, cowpea boasts a lengthy history as one of the earliest pulse crops in these regions. Renowned for its protein abundance and diverse nutrient content, it has earned the moniker of "vegetable meat." This plant holds particular significance as a valuable protein source for economically disadvantaged populations, standing as a timeless staple in human diets and likely having been cultivated since the Neolithic era. At its core, cowpea seeds stand out as a primary reservoir of protein and carbohydrates. These seeds assume a critical role in human nutrition and also serve as a nourishing feed for livestock. Notably, the protein within cowpea seeds showcases an impressive concentration of essential amino acids such as lysine and tryptophan, setting it apart from cereal grains. The mature cowpea seed contains 24.8% protein, 63.6% carbohydrate, 1.9% fat, 6.3% fibre, 7.4 ppm thiamine, 4.2 ppm riboflavin and 28.1 ppm niacin (**Ahlawat and Shivkumar 2005**). Cowpea boasts a remarkable versatility, finding utility as a catch crop, mulch crop, intercrop, mixed crop, and green crop. Within the realm of nutritional security, pulses hold a crucial position, and cowpea is no exception. Its cultivation footprint spans across Africa, Asia, North and South America, Australia, as well as the central and southern regions of Europe. Operating as a leguminous plant, cowpea plays a pivotal role by harnessing significant levels of atmospheric nitrogen to fulfill its own needs. In India it is cultivated mainly in UP, MP, Bihar, Punjab, Haryana, Rajasthan, HP, etc. where it is grown for both vegetable and pulse purposes and is a highly remunerative crop (**Upadhayay and Anita Singh, 2016**).

It is asserted that in India, pulses are cultivated on an area of 29.36 mha with a production and productivity of 24.51 mt and 835 kg per hectare (**Anonymous, 2016-17a**). Wide spread deficiency of micronutrient has become major constraint for achieving higher genetic potential yield along with quality of crop. Among the micronutrients, the deficiency of Zinc and sulphur has become wide spread in recent years all over the country. In India nextto nitrogen, phosphorus, potassium and sulphur 5th important yield limiting nutrient is Zincwhich accounts for 48 per cent of Indian soils (**Vinodkumar *et al*., 2020**).

Plants require essential nutrients for better growth and yield. Sulphur is a major nutrient for healthy crop growth. It is the fourth major nutrient after NPK (**Najar *et al.*, 2011**). Sulphur is the constituent of the cysteine, amino acids, methionine and chlorophyll (**Wani *et al.*, 2001**). Oilseed crops require higher amounts of S for their growth and oil yield because it is critical.

in the oil synthesis and formation of bold grains for oil production in the oil seeds crops (**Brady and Weil, 2002**).

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. Zn deficiency can also adversely affect the quality of harvested products, plants susceptibility to injury by high light or temperature intensity and infection by fungal diseases can also increase. Zinc seems to affect the capacity for water uptake and transport in plants and also reduce the adverse effects of short periods of heat and salt stress.(**Chalak *et al*., 2018**). The accumulation of Zinc in edible parts of plant serves as Zinc sourcefor primary consumers. Unfortunately, about 50% of Indian soils are deficient in Zinc and sulphur expected to further increase up to 63% by 2025 which imparting Zinc malnutrition in population especially in children (**Singh, 2006; Shukla *et al*., 2014**). One third of the world population is reported at the risk of Zinc malnutrition due to inadequate dietary intake of Zincresulting from wide spread hidden hunger of Zinc in seeds and feeds (**Singh, 2010**). Zinc being essential nutrient plays a significant role in stomatal regulation and reducing the tensions of less water by creating ionic balance in plants system and is involved in various physiological processes such as synthesis of protein and carbohydrates. Similarly, **S** application improves growth, and enhances stress tolerance in plants and improves grain production. Sulphur and Zinc are the essential plant micronutrients and their importance for crop productivity is similar to that of major nutrients. Both play an important role in the basic plant functions like photosynthesis, protein and chlorophyll synthesis. Keeping all these factsin view, the present investigation entitled, "Effect of sulphur and zinc on growth and yield ofcowpea (*Vigna unguiculata* L.*)*".

MATERIALS AND METHODS:

The field experiment was conducted during *Zaid* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.). The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 8), low level organic carbon (0.62%), medium available N (225 Kg/ha), high in available P (38.2 kg/ha) and low available K (240.7 kg/ha).).The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations are T_1: 2% Sulphur+0.5% zinc, T_2: 2% Sulphur+ 1% Zinc, T_3: 2% Sulphur + 1.5% Zinc, T_4: 3% Sulphur + 0.5% Zinc, T_5: 3% Sulphur +1% Zinc, T_6: 3% Sulphur +1.5% Zinc, T_7: 4% Sulphur + 0.5% Zinc, T_8: 4% Sulphur+ 1% Zinc, T_9: 4% Sulphur +1.5% Zinc T_{10}: N:P: K 20:40:40 kg/ha.

The growth parameters and yield, production was recorded at harvest from randomly selected plants in each plot. The data was computed and analyzed by following statistical method of Gomez and Gomez (1984).

RESULT AND DISSCUSSION:

Growth parameters

Plant height (cm):

The Data revealed that that the 75 DAS, plant height (79.17 cm) was maximum T_9 4% Sulphur + $ZnSO_4$ 1.5%. While T_8 4% Sulphur + $ZnSO_4$ 1% (75.77 cm) and T_7 4% Sulphur + $ZnSO_4$ 0.5% (74.17 cm) was found to be statistically at par with T_9. Increase in plant height might be the involvement of micronutrients in different physiological processes like enzyme activation, electron transport, chlorophyll formation, stomatal regulation, etc. Wythe plant height gradually increased, which might be attributable to greater photosynthetic activity and chlorophyll synthesis due to Sulphur and zinc fertilization resulting into better vegetative growth. Similar results were reported by Barbara M Humtsoe et al. (2018); Lal Babu Singhet al. (2015).

Number of leaves:

Observed that the 75 DAS, plant leaf (28.67) was maximum T_9 4% Sulphur + $ZnSO_4$1.5%. While T_8 4% Sulphur + $ZnSO_4$ 1% (27.60), T_7 4% Sulphur + $ZnSO_4$ 0.5% (26.40) T_6 Sulphur 3% + Zinc 1.5% (24.93) and T_5 Sulphur 3% + Zinc 1% (23.47) was found to be statistically at par with T_9. The best obtained results were found with effect of Sulphur and zinc might be attributed to the favorable influence of them on plant metabolism and biological process activity and their stimulating effect on photosynthetic pigments and enzyme activity which in turn encourage vegetative growth. The reported positive effect of application of Zn on an enhanced branching impulses mainly attributed to promotion of bud and branch development by the auxins whereas Zn application ultimately increased the availability of other nutrients and accelerated the translocation of photo assimilates. Similar results were reported by **Ravichandra *et al.* (2015) and Hamouda *et al.* (2018).**

Number of Branches:

Observed that the 75 DAS, plant branch (9.74) was maximum T_9 4% Sulphur + $ZnSO_4$ 1.5%. While T_8 4% Sulphur + $ZnSO_4$ 1% (9.59), T_7 4% Sulphur + $ZnSO_4$ 0.5% (9.28), T_6 Sulphur 3% +Zinc 1.5% (9.02), T_5 Sulphur 3%+Zinc 1% (8.65), T_4 Sulphur3%+Zinc 0.5% (8.55) and T_3 Sulphur 2% +Zinc1.5% (8.28) was found tobe statistically at par with T_9. The best obtained results were found with effect of Sulphur or zinc might be attributed to the favorable influence of them on plant metabolism and biological process activity and their stimulating effect on photosynthetic pigments and enzyme activity which in turn encourage vegetative growth. The reported positive effect of application of Zn on an enhanced branching in pulses mainly attributed to promotion of bud and branch development by the auxins whereas Zn application ultimately increased the availability of other nutrients and accelerated the translocation of photo assimilates. Similar results were reported by **Ravichandra *et al.* (2015).**

Number of Nodules:

Observed that the 75 DAS, plant nodule (30.93) was maximum T_9 4% Sulphur + $ZnSO_4$ 1.5%. While T_8 4% Sulphur + $ZnSO_4$ 1% (29.87) and T_7 4% Sulphur + $ZnSO_4$ 0.5% (28.67), T_6 Sulphur 3% + ZnSO4 1.5% (27.20) and T_5 Sulphur 3% + $ZnSO_4$ 1% (25.73) was found to be statistically at par with T_9. The best obtained results were found with effect of zinc or Sulphur might be attributed to the favorable influence of them on plant metabolism and biological process activity and their stimulating effect on photosynthetic pigments and enzyme activity which in turn encourage vegetative growth. The reported positive effect of application of Zn on an enhanced branching impulses mainly attributed to promotion of bud and branch development by the auxins whereas Zn application ultimately increased the availability of other nutrients and accelerated the translocation of photo assimilates. Similar results were reported by **Ravichandra *et al.* (2015) and Hamouda *et al.* (2018)**

Plant dry weight:

Observed that the 75 DAS, plant dry weight (22.83) was maximum T_9 4% Sulphur + $ZnSO_4$ 1.5%. While T_8 4% Sulphur + $ZnSO_4$ 1% (22.03 g), T_7 4% Sulphur + $ZnSO_4$ 0.5% (21.02 g), T_6 Sulphur 3% + ZnSO4 1.5% (20.84 g), T_5 Sulphur 3% + ZnSO4 1 % (20.27 g), T_4 Sulphur 3%+$ZnSO_4$0.5 % (19.45g) was found to be statistically at par with T_9. Dry weight was increased significantly with increasing as spray of sulphur 4% and Zinc 1.5%. As Zinc generally influences cell division and nitrogen absorption from the soil might enhanced plant growth which reflects in terms of plant dry weight. These findings are in harmony with those obtained by **Barbara M Humtsoe *et al.* (2018) and El-Afifi *et al.* (2016).**

Yield parameters:

Number of pods/plants

Maximum (12.14) number of pods/plants was obtained with application of T_9 (4% Sulphur +$ZnSO_4$ 1.5%). Whereas, T_8 (4% Sulphur + $ZnSO_4$ 1%) (11.53) were statistically at par T_9. Application of Sulphur along with Zinc increased the number of pods per plant might be due to the enhanced early vegetative growth in terms of higher leaf area, dry matter accumulation and vigorous root system resulted in more branches which consequently increased the number of pods bearing branches significantly. Similar findings were observed by **Singh *et al*. 2020.**

Seeds/pod (No.):

Maximum (11.03) number of seeds/pods was obtained with application of T_9 (4% Sulphur + ZnSO4 1.5%) Whereas, T_8 (4% Sulphur + $ZnSO_4$ 1%) (10.55) and T_7 (4% Sulphur

+ $ZnSO_4$ 0.5%) (9.88) were statistically at par T_9. Application of Sulphur and Zinc to cowpea crop generally improves fruit growthby 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 resulted in taller and higherenzyme activity which in turn encourage more seeds/pod and pods/plant. Similar findings havebeen reported earlier by **Hamouda *et al.* (2018) and Nishant Srivastava *et al*. (2017).**

Test weight (g)

Maximum (100.23 g) test weight (g) was obtained with application of T_9 (4% Sulphur + $ZnSO_4$1.5%) which was superior over rest of the treatments. Whereas, T_8 (4% Sulphur + $ZnSO_4$ 1%) (96.09 g) and T_7 (4% Sulphur + $ZnSO_4$ 0.5%) (94.50 g) were statistically at par T_9. Zinc plays a very important role in the metabolism of the plant process by influencing the activity of growth enzymes as well as it is involved in carbohydrate metabolism, maintenanceof the integrity of cellular membranes, protein synthesis, and regulation of auxin synthesis andpollen formation. The positive effect of Sulphur may be due to key role in plant metabolism and in the synthesis of nucleic acid. Similar findings were under the conformity of **Ravichandra *et al.* (2015)**.

Seed yield (t/ha):

Highest (1.32 t/ha) seed yield (t/ha) was obtained with application of T_9 (4% Sulphur + $ZnSO_4$ 1.5%) Whereas, T_8 (4% Sulphur + $ZnSO_4$ 1%) (1.27t/ha) and T_7 (4% Sulphur + $ZnSO_4$ 0.5%) (1.22t/ha) were statistically at par T_9. Zinc plays a vital role in increasing seed yield because zinc takes place in many physiological processes of plant such as chlorophyll formation, stomatal regulation, starch utilization which enhance seed yield. Zinc also converts ammonia to nitrate in crops which contribute to yield. These results are in confirmatory with the work of **Abid Khan *et al.*(2019).**

Stover yield:

Stover yield (t/ha) was maximum (3.48 t/ha) in the application T_9 (4% Sulphur + $ZnSO_4$1.5%). Whereas, T_8 (4% Sulphur + $ZnSO_4$1%) (3.39 t/ha) and T_7 (4% Sulphur + $ZnSO_4$ 0.5%) (3.31 t/ha) T_6 Sulphur 3% + $ZnSO_4$ 1.5% (3.28t/ha) and T_5 Sulphur 3% + $ZnSO_4$ 1% (3.25t/ha) were statistically at par T_9. This indicates that higher uptake of Zn resulted maximum yield under the same treatments. The present findings are well in agreement with that of **Debnath *et al.* (2018).**

Harvest index:

Maximum harvest index (%) was obtained with application of T_9 (4% Sulphur + $ZnSO_4$ 1.5%) (29.48%). While T_8 4% Sulphur + $ZnSO_4$ 1% (27.66%), T_7 4% Sulphur + $ZnSO_4$ 0.5% (27.58%), T_6 Sulphur 3% + $ZnSO_4$ 1.5% (27.32%) harvest index (%) was found to be statistically at par with T_9. This was mainly because of increase in seed yield with optimum stover yield which in turn resulted in higher harvest index. These results were in conformity with findings of **Nishant Srivastava *et al*. (2017).**

Economics:

The result showed that maximum gross returns (Rs.84971.50/ha), net return (Rs.60594.40/ha) and benefit cost ratio (1.28) was recorded in treatment 9 Sulphur 4% and $ZnSO_4$ 1.5%. 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).**

CONCLUSION:

It can be concluded that in Cowpea with the application of Sulphur 4% and $ZnSO_4$ 1.5% treatment 9 recorded higher Seed yield, higher gross returns, net returns and benefit cost ratio.

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Table 1. Effect of sulphur and zinc on growth attributes of Cowpea

S No	Treatments	plant height (cm)	Number of nodules/plant	Plant dry weight (g/plant)
1.	Sulphur 2% + $ZnSO_4$ 0.5%	61.91	21.40	17.36
2.	Sulphur 2% + $ZnSO_4$ 1%	68.40	24.13	18.07
3.	Sulphur 2% + $ZnSO_4$ 1.5%	69.37	24.33	18.76
4.	Sulphur 3% + $ZnSO_4$ 0.5%	70.17	24.93	19.45
5.	Sulphur 3% + $ZnSO_4$ 1%	71.17	25.73	20.27
6.	Sulphur 3% + $ZnSO_4$ 1.5%	72.60	27.20	20.84
7.	Sulphur 4% + $ZnSO_4$ 0.5%	74.17	28.67	21.02
8.	Sulphur 4% + $ZnSO_4$ 1%	75.77	29.87	22.03
9.	Sulphur 4% + $ZnSO_4$ 1.5%	79.17	30.93	22.83
10.	(Control) N: P: K 20:40:40kg/ha	59.78	19.67	16.25
	F-test	S	S	S
	SEm(±)	2.16	1.89	1.30
	CD at 5%	6.42	5.65	3.88

Table 2. **Effect of Sulphur and zinc on Yield of cowpea**

S. No.	Treatments	No. of pods/plant	No. of seed/pod	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	Sulphur 2% + $ZnSO_4$ 0.5%	7.11	7.03	86.87	0.86	2.96	21.90
2.	Sulphur 2% + $ZnSO_4$ 1%	7.75	7.38	87.85	0.90	2.97	22.56
3.	Sulphur 2% + $ZnSO_4$ 1.5%	8.19	7.88	88.54	0.95	3.07	23.81
4.	Sulphur 3% + $ZnSO_4$ 0.5%	8.81	8.61	89.55	1.00	3.10	25.40
5.	Sulphur 3% + $ZnSO_4$ 1%	9.59	9.03	89.67	1.05	3.25	26.14
6.	Sulphur 3% + $ZnSO_4$ 1.5%	10.48	9.43	90.98	1.12	3.28	27.32
7.	Sulphur 4% + $ZnSO_4$ 0.5%	10.95	9.88	94.50	1.22	3.31	27.58
8.	Sulphur 4% + $ZnSO_4$ 1%	11.53	10.55	96.09	1.27	3.39	27.66
9.	Sulphur 4% + $ZnSO_4$ 1.5%	12.14	11.03	100.23	1.32	3.48	29.48
10.	(Control) N: P: K 20:40:40 kg/ha	6.44	6.50	87.36	0.80	2.77	24.71
	F-test	S	S	S	S	S	S
	SEm(±)	0.354	0.531	2.748	0.53	1.21	0.12
	CD at 5%	1.05	1.57	8.16	0.15	0.36	3.62

Table 3. Economics of sulphur and zinc of cowpea.

Sr. No.	Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C
1.	Sulphur 2% + ZnSO4 0.5%	23983.10	56069.50	32086.40	1.34
2.	Sulphur 2% + ZnSO4 1%	24133.10	58665.00	34531.90	1.43
3.	Sulphur 2% + ZnSO4 1.5%	24283.10	61711.50	37428.40	1.54
4.	Sulphur 3% + ZnSO4 0.5%	24030.10	64737.00	40706.90	1.69
5.	Sulphur 3% + ZnSO4 1%	24180.10	68393.00	44212.90	1.83
6.	Sulphur 3% + ZnSO4 1.5%	24330.10	72184.00	47853.90	1.97
7.	Sulphur 4% + ZnSO4 0.5%	24077.10	78231.00	54153.90	2.25
8.	Sulphur 4% + ZnSO4 1%	24227.10	81695.00	57467.90	2.37
9.	Sulphur 4% + ZnSO4 1.5%	24377.10	84971.50	60594.40	2.49
10.	(Control) N: P: K 20:40:40 kg/ha	23139.10	52662.60	29523.50	1.28