

Original Research Article

INTERACTION EFFECT OF CHICKPEA (*Cicer arietinum* L.) CROP TO SULPHUR AND ZINC ELEMENTS

ABSTRACT

A field experiment was convened objective to study the interaction effect of chickpea (*cicer arietinum* L.) crop to sulphur and zinc elements on growth and yield attributes under rainfed condition during the Rabi season 2019-20. On a study sandy loam soil having low status of available nitrogen, low status of available phosphorus and medium status of available potassium. The treatment consisted of four levels of Sulphur (0, 20, 30 and 40 kg S ha⁻¹) and four levels of zinc (0, 10, 15 and 20 kg Zn ha⁻¹) applied from gypsum and zinc sulphate respectively. The findings result that the combination of S₄₀ Zn₁₅ recorded at before harvesting stage highest plant height (59.79 cm) and maximum root length at 45 DAS 14.82 cm & general mean 14.20 cm, maximum number of nodules plant⁻¹ at 60 DAS 14.78 & general mean 11.40, the general mean was 54.3 pods plant⁻¹, general mean value 186.6 g of test weight (1000 seeds), maximum grain yield 1399 kg ha⁻¹, maximum stover yield 2085 kg ha⁻¹. Chickpea variety GNG-469 (Samrat) was grown with the recommended agronomic practices. The synergistic effect of Sulphur and Zinc was reported on plant height, number of pod plant⁻¹, number of seed pod⁻¹ and seed yield.

Key words – Chickpea, Growth, Interaction, Sulphur, Zinc and Yield.

Abbreviations: - kg- Kilogram, ha- hectare, cm- centimeter,

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a legume crop belong to family Fabaceae, subfamily Faboideae the largest produced food legume in South Asia and the third largest production food legume in the world, its different types are variously known as gram or Bengal gram, more than 50 countries are grown to chickpea crop. Maximum chickpea-production countries are: India (65% of annual production), Pakistan (10%), Turkey (7%), Iran (3%), Myanmar (2%), Mexico (1.5%) and Australia (1.5%) (FAO, 2008). Australia (1.5%) (FAO, 2008). In India chickpea grown area 9995.75-thousand-hectare, production 11911.18 thousand tons and productivity 1192 kg/hectare in rabi 2020-21. In Madhya Pradesh chickpea grown area 2160.00-thousand-hectare, production 3214.08 thousand tons and productivity 1488 kg/hectare in rabi 2020-21(Anonymous, 2020-21). Chickpea is an important source of protein for millions of people in the developing countries. In addition to having high protein content (20-22%), chickpea is rich in fiber, minerals (phosphorus, calcium, magnesium, iron and zinc) and B-carotene. Chickpea plays a significant role in improving soil fertility by fixing the atmospheric nitrogen. Chickpea meets 80% of its nitrogen requirement from symbiotic nitrogen fixation and can fix up to 140 kg N ha⁻¹ from air. It leaves substantial amount of residual nitrogen for subsequent crops and adds plenty of organic matter to maintain and improve soil health and

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fertility. Because of its deep tap root system, chickpea can withstand drought conditions by extracting water from deeper layers in the soil profile.

Sulphur (S) is an essential element in forming proteins, enzymes, vitamins, and chlorophyll in plants. It is crucial in nodule development and efficient nitrogen fixation in legumes crops. Protein synthesis requires large amounts of sulphur, especially in the formation of oils within the seed, and is a sulphur is a constituent of several amino acids and vitamins found in both plants and animals. Thus, sulphur is an important factor in determining the nutritional quality of foods. Sulphur is also important in photosynthesis and contributes to crop winter hardiness. An adequate supply of mineral nutrients to legumes enhances nitrogen fixation Ganeshamurthy *et al.*, (2000).

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Zn is involved in auxin metabolism like, tryptophane synthesis, tryptamine metabolism. Zn also plays an important role in protein synthesis and nucleic acid and helps in utilization of N and P by plants. It is associated with water uptake and retention in the plants. Zn is also known to stimulate plant resistance to dry and hot weather and also bacterial and fungal diseases. Zinc also stabilizes ribosomal fraction in the plants.

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2. MATERIALS AND METHODS

The experiment was conducted, during the rabi season of 2019 – 20 at the Rajola Farm of the Faculty of Agricultural Sciences, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot – Satna (Madhya Pradesh) located from 24° 31' N latitude and 81° 15' E longitude. Chitrakoot is situated at an altitude of 306 m above mean sea level at the climate of the region is semi-arid and sub-tropical having extreme winter and summer. The studies interaction effect of chickpea (*cicer arietinum* L.) crop to sulphur and zinc elements on growth and yield attributes under rainfed condition. The graded levels of Sulphur and Zinc were applied through gypsum and Zinc Sulphate and mixed in soil after layout before sowing. Healthy seeds of chickpea varieties GNG-469 (Samrat) were sown @ 80 kg ha⁻¹. To achieve the objectives 16 different treatments were tested in randomized block design with three replications. Four levels of sulphur (0, 20, 30 and 40 kg ha⁻¹) and four levels of zinc (0, 10, 15 and 20 kg ZnSO₄ ha⁻¹). The Physico- Chemical properties of the experiment is shown in Table 1.

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Table 1. Physico- Chemical properties of the experimental soil.

S. No	Soil Properties	Values	Methods of determination
1	Soil Texture	Sandy Loam	Hydrometer Method (Bouyoucos, 1962)
	Sand (%)	52%	
	Silt (%)	22%	
	Clay (%)	26%	
2	pH (1:2 Soil: Water)	7.78	Glass Electrode pH meter (Jackson, 1973)
3	EC ₂ (dSm ⁻¹)	0.26	Solubridge conductivity meter method (Jackson, 1973)
4	Organic Carbon (%)	0.33	(Walkley and Black, 1934)

5	Available N (kg ha ⁻¹)	202.36	Alkaline permagnate method (Subbiah and Asija, 1956)
6	Available P (kg ha ⁻¹)	16.12	0.5 M NaHCO ₃ (Olsen <i>et. al.</i> 1954)
7	Available K (kg ha ⁻¹)	246.22	Alkaline permagnate method (Subbiah and Asija, 1956)
8	Available S (kg ha ⁻¹)	15.88	1N NH ₄ OAC (Hanway and Heidel, 1952)

3. RESULTS

3.1 Growth Parameter

3.1.1 Plant height (cm)

Increasing levels of sulphur increased the plant height linearly and significantly and the data are presented in Table No. 2. At the harvest the plant height varied from 44.69 to 59.79 cm and the minimum and maximum values were observed in control S₀ Zn₁₀ and S₄₀ Zn₁₅. Each increase in S levels gave significant increase in plant height. In case of main effects of Zn, Zn₁₀ was significantly superior over control but Zn₁₀ did not differ significantly from Zn₁₅. The interaction S x Zn was also significant.

3.1.2 Number of branches plant⁻¹

Observations on number of branches plant⁻¹ were recorded at 60 DAS and the data are presented in Table No. 2. There was an overall deviation in number of branches from 6.59 to 12.20 and these values were given by control and S₄₀ Zn₁₀. Main effect of S levels was significantly superior over control. S₃₀ was significantly superior over S₂₀ but was at par with S₄₀. Interaction of S x Zn was also significant. S₄₀ Zn₁₅ was the best combination followed by S₃₀ Zn₁₅.

3.1.3 Root length

Observations on root length were recorded at 60 DAS and the data are presented in Table No. 2. It was revealed that no definite trends in the variations of root length were visible due to different treatments and the results were not significant. Wherein it was revealed that root length varied from 9.25 to 14.82 cm with a mean of 14.20 cm. The lowest and the highest values were recorded in control and S₄₀ Zn₂₀. Regarding the main effects of sulphur all the treatments were significantly superior to control. S₃₀ was significantly superior to S₂₀ and was not significantly different from S₄₀. In case of Zn₀, Zn₁₀ and Zn₁₅ were significantly superior over control and Zn₁₅ was also significantly superior to Zn₁₀. S x Zn interactions were also significant.

3.1.4 Number of nodules plant⁻¹

Observations on root length were recorded at 60 DAS and the data are presented in Table No. 2. It was clear that both S and Zn were effective in improving the nodulation in chickpea. At 60 DAS nodule number ranged from 8.21 (control) to 14.78 (S₄₀ Zn₁₅). Thus, S₄₀ Zn₁₅ was the best treatment combination in this respect. The mean number was 11.40. Regarding the main effects each successive increase in S level resulted in significant increase in nodule number being maximum of S₄₀. Similar trend was observed in the main effects of Zn and the maximum number was recorded at Zn₁₅. The interaction of S x Zn was also significant.

Table 2: Interaction of sulphur and zinc levels on Growth attributing characteristic

Level of S (kg ha ⁻¹)	Levels of Zn (kg ha ⁻¹)				Mean
	0	10	15	20	
	Plant height (cm) At Harvest				
0	46.22	44.69	44.79	45.46	45.29
20	46.8	50.3	49.54	50.28	49.23
30	48.63	55.76	54.46	55.28	53.53
40	54.1	58.21	58.91	59.79	57.75
Mean	48.94	52.24	51.92	52.7	51.45
	S	Zn	SxZn		
S.E. (m)+	2.05	1.54	3.59		
CD(p=0.05)	4.15	3.11	7.25		
	No. of Branches/Plant 60 DAS				
0	6.59	6.86	7.3	7.19	6.98
20	7.44	9.21	9.76	9.61	9.01
30	9.25	11.61	11.51	11.33	10.93
40	10.16	12.2	12.04	11.86	11.57
Mean	8.36	9.97	10.15	10	9.62
	S	Zn	SxZn		
S.E. (m)+	0.32	0.24	0.42		
CD(p=0.05)	0.6	0.49	0.84		
	Root length (cm) 60 DAS				
0	9.25	10.63	10.79	10.9	10.39
20	10.34	12.76	12.95	13.08	12.28
30	13.08	14.31	14.52	14.67	14.14
40	12.87	14.45	14.67	14.82	14.2
Mean	11.38	13.04	13.23	13.37	12.76
	S	Zn	SxZn		
S.E. (m)+	0.45	0.34	0.87		
CD(p=0.05)	0.91	0.69	1.75		
	No. of Nodules/Plant 60 DAS				
0	8.21	8.47	8.87	8.78	8.58
20	8.94	10.07	10.59	10.48	10.02
30	10.72	14.22	14.68	14.53	13.54
40	10.62	13.77	14.78	14.63	13.45
Mean	9.62	11.63	12.23	12.1	11.4
	S	Zn	SxZn		
S.E. (m)+	0.34	0.27	0.64		
CD(p=0.05)	0.68	0.53	0.64		

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3.2 Yield Attributes

3.2.1 Number of Pods Plant⁻¹

At the time of harvesting the data were recorded on number of pods plant⁻¹ and the results are given in Table 3. Large variations were observed in pod number under the influence of different treatment. The number ranged from 41 to 70, and these values were given by control and S₄₀Zn₂₀. S₄₀ was significantly superior to S₃₀ and S₃₀ was significantly higher than control but the difference between S₃₀ and S₄₀ were not significant. Increasing levels of zinc gave a linear and significant increase in pod number and Zn₂₀ gave the highest number. The general mean was 54.3 pods plant⁻¹.

3.2.2 Grain Test Weight

Sufficient variation under the influence of fertilizers were observed in test weight (weight of 1000 grain in gram) as shown in Table 3. It was evident that test weight varied from 166.6 to 203.9 g 1000 grain⁻¹. These values were given by control and S₃₀Zn₂₀ respectively and this treatment the best. Considering the main effects of S and Zn it was revealed that all the levels were significantly better than control. There existed a significant difference between S₂₀ and S₃₀ which gave the mean values of 184.4 and 196.5 respectively, but there was no significant difference between S₃₀ and S₄₀, rather the value was marginally decreased at 50 as compared to S₄₀. Regarding the main effect of zinc, Zn₁₀ was significantly superior to control but it was not significantly different from Zn₁₅. Thus, the combined dose of S₃₀ and Zn₂₀ was the best dose in this respect. The positive interaction S x Zn was also significant. The mean value was 186.6 g 1000 grain⁻¹.

Table 3: Interaction of sulphur and zinc levels on Yield attributing characteristic

Level of S (kg ha ⁻¹)	Levels of Zn (kg ha ⁻¹)				Mean
	0	10	15	20	
	No. of Pod Plant ⁻¹				
0	41	42.9	45.8	47	44.2
20	46.8	54.6	58.5	60	55
30	48.8	63.4	67.3	69	62.1
40	21.5	64.4	68.3	70	56
Mean	39.5	56.3	60	61.5	54.3
	S	Zn	SxZn		
S.E. (m)+	3.11	2.02	5.84		
CD(p=0.05)	6.24	4.27	11.81		
	Test weight (1000 seeds) g				
0	166.6	171.5	173.5	177.8	172.3
20	177.4	183.3	186.2	190.9	184.4
30	183.3	199.9	198.9	203.9	196.5
40	183.3	193.1	196.0	200.9	193.3
Mean	177.6	186.9	188.7	193.4	186.6

	S	Zn	SxZn		
S.E. (m)+	3.5	2.6	5.9		
CD(p=0.05)	7.0	5.3	11.9		
	Grain yield kg/ha				
0	957.8	1034.8	1054.3	1070.6	1029.3
20	1143.6	1255.6	1264.7	1283.5	1236.8
30	1303.7	1378.4	1383.5	1391.1	1364.2
40	1274.5	1386.4	1390	1399.6	1362.6
Mean	1169.9	1263.8	1272.1	1286.2	
	S	Zn	SxZn		
S.E. (m)+	0.28	0.28	0.56		
CD(p=0.05)	0.82	0.82	1.64		
	Straw yield kg/ha				
0	1457	1535	1454	1568	1829
20	1543	1455	1564	1483	1936
30	1304	1585	1574	1599	1867
40	1577	1564	1564	1597	2050
Mean	1869	1961	1966	2085	
	S	Zn	SxZn		
S.E. (m)+	35	26	47		
CD(p=0.05)	55	43	96		

3.3 Yield of Chickpea

3.3.1 Grain Yield

The grain yield (kg ha^{-1}) of chickpea is given in Table 3. A perusal of data shows that the yield varied significantly due to fertilizer treatments. It ranged from 957 to 1399 kg ha^{-1} and the highest in $S_{30} Z_{n20}$. But this value was not statistically significant from those of $S_{30} Z_{n15}$ and $S_{40} Z_{n20}$ (1390 kg ha^{-1}). The main effects of S showed that there was a linear and significant increase in grain yield over control. The magnitude of increase due to S_{20} and S_{40} was 20.2% and 33.60% respectively over control.

However, at S_{40} the magnitude of increase was 31.66% showing a marginal and non-significant decrease in yield. Thus, S_{30} gave the highest grain yield. The main effect of zinc showed that both Z_{n10} and Z_{n15} were significantly superior over control. Z_{n10} was significantly better than control but Z_{n10} and Z_{n15} did not differ significantly, although Z_{n20} gave numerically higher yield (1399 kg ha^{-1}) than Z_{n15} (1378 kg ha^{-1}). Thus, it was clear that Z_{n20} was a better dose than Z_{n15} . Magnitude of per cent increase due to Z_{n15} was 7.9% and that of Z_{n20} was 8.81% over control. The general mean of grain yield was 1245 kg ha^{-1} which was about 28% higher than control.

It was further indicated that yield tended to decrease at $S_{40} Z_{n20}$ level to a non-significant extent as compared to that of S_{30} and Z_{n15} level. It was, therefore, evident that maximum

grain yield was obtained by S₃₀ Zn₂₀ combination. The effect of interaction of S x Zn was also significant.

3.3.2 Straw Yield

The grain yield (kg ha⁻¹) of chickpea is given in Table 3. A perusal of data shows that the yield varied significantly due to fertilizer treatments. It ranged from 1829 to 2085 kg ha⁻¹ and the highest in S₃₀ Zn₂₀. But this value was not statistically significant from those of S₃₀ Zn₁₅ and S₄₀ Zn₂₀ (2085 kg ha⁻¹). The main effects of S showed that there was a linear and significant increase in grain yield over control. The magnitude of increase due to S₂₀ and S₄₀ was 24.2% and 36.60% respectively over control. However, at S₄₀ the magnitude of increase was 38.66% showing a marginal and non-significant decrease in yield.

Thus, S₃₀ gave the highest grain yield. The main effect of zinc showed that both Zn₁₀ and Zn₁₅ were significantly superior over control. Zn₁₀ was significantly better than control but Zn₁₀ and Zn₁₅ did not differ significantly, although Zn₂₀ gave numerically higher yield (1829 kg ha⁻¹) than Zn₁₅ (2050 kg ha⁻¹). Thus, it was clear that Zn₂₀ was a better dose than Zn₁₅. Magnitude of per cent increase due to Zn₁₅ was 7.9% and that of Zn₂₀ was 8.81% over control. The general mean of grain yield was 2085 kg ha⁻¹ which was about 36% higher than control.

It was further indicated that yield tended to decrease at S₄₀ Zn₂₀ level to a non-significant extent as compared to that of S₃₀ and Zn₁₅ level. It was, therefore, evident that maximum grain yield was obtained by S₃₀ Zn₂₀ combination. The effect of interaction of S x Zn was also significant.

4. DISCUSSION

In the present study the yield varied from 957 to 1399 kg ha⁻¹, under rainfed conditions and under rainfed conditions it may be considered satisfactory since the native status of soil in respect of S and Zn was low. Moreover, the crop was further stained of moisture. High responses of applied nutrients on grain yield of chickpea recorded in this study are as expected. The highest magnitude of percent increase was 33.6% and 7.9% due to S₃₀ and Zn₁₅ respectively over control. Interaction caused 28% increase over control. S₃₀Zn₂₀ come out to be the best treatment combination.

The grain yield tended to decrease to a non-significant extent at S₄₀ and Zn₂₀. This might be ascribed to the antagonistic effect of S and Zn which was expressed at the highest levels of these nutrients (Ajay Kumar *et.al.*2020)

Increased in yield due to S and Zn nutrition might be ascribed to their fundamental metabolic role in plant, particularly, in nodulation and biological nitrogen fixation and carbohydrate metabolism Blevin, 1999, Jyung *et al.* 1975). Consequently, the yield contributory characters were increased (as discussed earlier). This might be reason for improvement in seed yield.

The results of this study are corroborated by those of several investigators (Fayaz Hussain Makol *et.al.* (2020), Ajay Kumar *et.al.* (2020), H. R. Khan *et.al.* (2003, M.S. JAKASANIYA *et.al.* (2012),).

5. CONCLUSION

The results indicated that all these parameters were significantly increased due to S and Zn application. Their interaction was also significant. It was evident that a combination

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dose of S₃₀ Zn₂₀ (30 kg ha⁻¹, sulphur and 20 kg ha⁻¹ zinc sulphate) was found to be best giving the maximum values. The average yield of 1245 kg ha⁻¹. The highest volume of increase 33.6% and 7.9% due to S₃₀ and Zn₁₅, respectively over control. Interaction caused 28% increase in yield over control. The main effects of S and Zn and their interaction were significant.

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