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

ABSTRACT

A field experiment was convenedobjective to study the interaction effect of chickpea (*cicerarietinum*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 Sha^{-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 S_{40} Zn_{15} 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. INTRODUCATION

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). 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 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, 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).

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.

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 ChitrakootGramodayaVishwavidyalaya, 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 (*cicerarietinum* L.) crop to sulphur and zinc elements on growth and yield attributes under rainfed condition.The grated 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 $ZnSO_4$ ha^{-1}). ThePhysico- Chemical properties of the experiment is shown in Table 1.

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	EC2 (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 *et. al.* 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_4OAC (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 S_0 Zn_{10} and S_{40} Zn_{15}. Each increase in S levels gave significant increase in plant height. In case of main effects of Zn, Zn_{10} was significantly superior over control but Zn_{10} did not differ significantly from Zn_{15}. 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 DASand 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 S_{40} Zn_{10}. Main effect of S levels was significantly superior over control. S_{30} was significantly superior over S_{20} but was at par with S_{40}. Interaction of S x Zn was also significant. S_{40} Zn_{15} was the best combination followed by S_{30} Zn_{15}.

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 S_{40} Zn_{20}. Regarding the main effects of sulphur all the treatments were significantly superior to control. S_{30} was significantly superior to S_{20} and was not significantly different from S_{40}. In case of Zn_0, Zn_{10} and Zn_{15} were significantly superior over control and Zn_{15} was also significantly superior to Zn_{10}. 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 (S_{40} Zn_{15}). Thus, S_{40} Zn_{15} 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 S_{40}. Similar trend was observed in the main effects of Zn and the maximum number was recorded at Zn_{15}. 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		

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 $S_{40}Zn_{20}$. S_{40} was significantly superior to S_{30} and S_{30} was significantly higher than control but the difference between S_{30} and S_{40} were not significant. Increasing levels of zinc gave a linear and significant increase in pod number and Zn_{20} 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 $S_{30}Zn_{20}$ 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 S_{20} and S_{30} which gave the mean values of 184.4 and 196.5 respectively, but there was no significant difference between S_{30} and S_{40}, rather the value was marginally decreased at 50 as compared to S_{40}. Regarding the main effect of zinc, Zn_{10} was significantly superior to control but it was not significantly different from Zn_{15}. Thus, the combined dose of S_{30} and Zn_{20} 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 (g) (1000 seeds)				
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} Zn_{20}. But this value was not statistically significant from those of S_{30} Zn_{15} and S_{40} Zn_{20} (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 Zn_{10} and Zn_{15} were significantly superior over control. Zn_{10} was significantly better than control but Zn_{10} and Zn_{15} did not differ significantly, although Zn_{20} gave numerically higher yield (1399 kg ha^{-1}) than Zn_{15} (1378 kg ha^{-1}). Thus, it was clear that Zn_{20} was a better dose than Zn_{15}. Magnitude of per cent increase due to Zn_{15} was 7.9% and that of Zn_{20} 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} Zn_{20} level to a non-significant extent as compared to that of S_{30} and Zn_{15} level. It was, therefore, evident that maximum grain yield was obtained by S_{30} Zn_{20} 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 S_{30} Zn_{20}. But this value was not statistically significant from those of S_{30} Zn_{15} and S_{40} Zn_{20} (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 S_{20} and S_{40} was 24.2% and 36.60% respectively over control.However, at S_{40} the magnitude of increase was 38.66% 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 Zn_{10} and Zn_{15} were significantly superior over control. Zn_{10} was significantly better than control but Zn_{10} and Zn_{15} did not differ significantly, although Zn_{20} gave numerically higher yield (1829 kg ha^{-1}) than Zn_{15} (2050 kg ha^{-1}). Thus, it was clear that Zn_{20} was a better dose than Zn_{15}. Magnitude of per cent increase due to Zn_{15} was 7.9% and that of Zn_{20} 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 S_{40} Zn_{20} level to a non-significant extent as compared to that of S_{30} and Zn_{15} level. It was, therefore, evident that maximum grain yield was obtained by S_{30} Zn_{20} 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 kgha^{-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 S_{30} and Zn_{15} respectively over control. Interaction caused 28% increase over control. $S_{30}Zn_{20}$ come out to be the best treatment combination.

The grain yield tended to decrease to a non-significant extent at S_{40} and Zn_{20}. This might be ascribed to the antagonistic effect of S and Zn which was expressed at the highest levels of these nutrients (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). This might be reason for improvement in seed yield.

The results of this study are corroborated by those of several investigators (Mako*et.al.* (2020), Kumar *et.al. (*2020), Khan *et.al. (*2003), 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 dose of S_{30} Zn_{20} (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 S_{30} and Zn_{15}, 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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