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Impact of sulphur and zinc fertilization on the growth and yield of Blackgram (*Vigna mungo* L.) under the rainfed condition

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Abstract
The experiment entitled "Impact of Sulphur and Zinc fertilization on the growth and yield of Blackgram (*Vigna mungo* L.) under the rainfed condition" was laid down factorial randomized block design with tree replication and sixteen treatments. The plant spacing was kept 40X10sqcm in T9 variety. In relation to growth parameters the best treatment interaction was 20kg. S plus 15kg Zn/ha which recorded the maximum height i.e., 11.80cm. at 20 days, 29.86 cm at 40 days and 68.73cm at 60 days stage. This treatment interaction was found significantly superior to most of the remaining having S level only up to 10kg/ha with all the Zinc level. However, the second best interaction was 30kg S plus 10kg. Zn/ ha. In contrast to this, the significant lowest plant height was recorded in case of without S and Zn application (absolute control). Among the yield parameters, the best treatment combination appeared to be $S_{20}Zn_{15}$ producing 10.90q/ha grain. This was followed by $S_{20}Zn_{10}$ and $S_{30}Zn_{10}$ interactions producing equal grain (10.48 to 10.35/ha) on the other hand the lowest yield only 7.30q/ha ware recorded in case of absolute control (S_0Zn_0).

Keywords: Sulphur, zinc, fertilization, Blackgram, Rainfed, *Vigna mungo* L.

Introduction
Black gram (*Vigna mungo* L.) or Urid is one of the important pulse crops in India. It is reported that Black gram is originated in India and is the largest producer and consumer in the world. It is a rich protein food which contains about 26 percent protein, almost three times that of cereals. Black gram supplies a major share of protein requirement of vegetarian population of the country.

Black gram is important grain legume crop of rainfed agriculture in the semi-arid tropic. Legumes are rich source of protein common masses especially vegetarian. In complete both grains and stalk of legumes contain good amount of protein and minerals which are essential for the growth and development of human and animal body. India produced 22.09 million tonnes pulse during 2008-09. Important states producing black gram are Maharashtra, Uttar Pradesh, Andhra Pradesh, Orrisa, Tamil Nadu, Rajasthan, Chhattisgarh and Madhya Pradesh. Fluctuation in area, Production and productivity of black gram was observed in the past few years due variation in market rates, rainfall, Poor nutrient management and other factors. Sulphur is one at the sixteen nutrient elements which all plants must have for normal growth and development. Plants deficient in an essential nutrient have poor growth, give low yield and the produce is also inferior quality. The sulphur application in to increasing the yield of crop. (Singh *et al.* 2014) [4].

Pulses production is very low and become challenging problem against the requirement of increasing population of our country. The pulses availability per capita was 69.9g in 1951, by increasing in 1971, it comes to 50g and in 1982 remained only 40g and in 2005, it was 27g. The availability of pulses is very negligible at present as against required 85g day-1 capita-1 for balanced diet. To recover this deficit of production It is high time to cultivate pulses crops scientifically with increasing area. It plays an important role in maintaining and improving the fertility status of the soil, as they have ability to fix atmospheric N symbiotically in soil through root nodules.

Green gram commonly known as 'Moongbean' or 'moong' It contains 24.3 per cent protein fairly rich in carbohydrates and also contains small amount of riboflavin and thiamine, also rich in phosphorus and iron. It generally grown as intercrop, mixed crop and sole crop in kharif as well as in summer season where adequate irrigation facilities are available Among

the various production factors, optimum fertilizer management and application either in the form of organic and inorganic is one of the well-established techniques for increasing crop production. Sulphur containing amino acids like cystine, cysteine and methionine and promotes nodulation in legumes, also helps in increasing protein per cent in legumes and oil per cent in oilseeds and involved in the formation of chlorophyll that permits photosynthesis.

Recently observed lower sulphur emission to the atmosphere decreased the amount of sulphur in soil and caused worse sulphur nutrition of crop plant. It has long been known that in regions where sulphur deficient soil occur, legumes specially pulses are particularly responsive to sulphur containing fertilizers and that elementary sulphur or sulphates increase the percentage nitrogen as well as yield on such deficient soils. Now areas of sulphur deficiency are becoming widespread throughout the world.

Sulphur is one of the limiting plant nutrients threatening the sustainability of crop production in semiarid tropical regions of India cover 73 million ha of vertisols and associated soils. Sulphur as a fertilizer or as a constituent of other fertilizers is generally not applied by farmers. As a result, large areas of S deficiency are reported from this agroecological region.

Understanding the role of sulphur in pulses growth is important from the point of view that the deficiency of the sulphur containing amino acids cysteine, cystine and methionine may limit the nutritional value of food and feed. Studies with medicagoativa indicate that with suboptimum sulphur supply, the mole percent of both amino acids significantly decreased, resulting in lower protein concentration, while non-protein N is accumulated. Also in Pisum sativum, sulphur deficiency resulted in a decreased synthesis of sulphur- containing storage protein albumin and legumin. The protein quality of glycine max can be enhanced by increasing the concentration of sulphur-containing amino acids.

Material and Methods

The present investigation entitled "Impact of Sulphur and Zinc fertilization on the growth and yield of Blackgram (*Vigna mungo* L) under the rainfed condition." Was carried out at Rajola Agriculture farm, of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.) during kharif season of 2016-17. The experiment was carried out at Rajola Agriculture farm, Mahatma Gandhi Chitrakoot Satna (M.P.) which lies in the semi- arid and sub-tropical region of Madhya Pradesh between 25010' to 250 15' North latitude and 800 80' to 800 85' east longitude. The altitude of Research field is about 190-210 meter above mean sea level and the location enjoys extremes of winter and summer temperatures with an average maximum and minimum temperature of 46.9 ^{0}C and 4.8 ^{0}C. The major precipitation of field between July to Oct. The average rainfall of Chitrakoot area was good but since lasts year's rainfall is very scantly less than 300mm/year. The soil texture of the experiment field, sandy loam with 51% sand, 21.6% silt and 27 clay were observed during investigation. The experiment was laid down factorial randomized block design with tree replication and sixteen treatments. The plant spacing was kept 40X10 sqcm in T9 variety.

Table 1: Treatment combination and details

A. Sulphur levels					
T_0	S_0Zn_0	T_8	S_2Zn_0	S_0	Control
T_1	S_0Zn_1	T_9	S_2Zn_1	S_1	10 kg S / ha.
T_2	S_0Zn_2	T_{10}	S_2Zn_2	S_2	20 kg S / ha.
T_3	S_0Zn_3	T_{11}	S_2Zn_3	S_3	30 kg S / ha.
B. Zinc levels					
T_4	S_1Zn_0	T_{12}	S_3Zn_O	Zn_0	Control
T_5	S_1Zn_1	T_{13}	S_3Zn_1	Zn_1	5 kg Zn / ha.
T_6	S_1Zn_2	T_{14}	S_3Zn_2	Zn_2	10 kg Zn / ha.
T_7	S_1Zn_3	T_{15}	S_3Zn_3	Zn_3	15 kg Zn / ha.

Result and Discussion

It is evident from the results in Table: 2 that the plant height increased steadily with the increase of fertilizers up to 60 days of observation. The plant height at 20 days stage ranged from 9.28 to 11.48 cm in different treatments, where at 60 days stage, it increased from 58.64 to 63.36cm.

Table 2: Plant height of Black gram at different growth intervals as influenced by sulphur and zinc levels.

Levels	**PLANT HEIGHT (cm)**		
S (kg/ha)	**20DAYS**	**40DAYS**	**60DAYS**
0	9.28	22.41	58.64
10	10.17	24.56	60.08
20	11.04	27.02	61.84
30	11.48	27.09	63.36
SE±	0.44	0.55	0.62
CD(P=0.05)	0.91	1.13	1.27
Zn (kg/ha)			
0	10.07	23.93	56.22
5	10.53	25.01	59.04
10	10.56	25.71	62.56
15	10.81	26.44	66.09
SE±	0.44	0.55	0.62
CD(P=0.05)	0.91	1.13	1.27
Interaction	Sig.	Sig.	Sig.

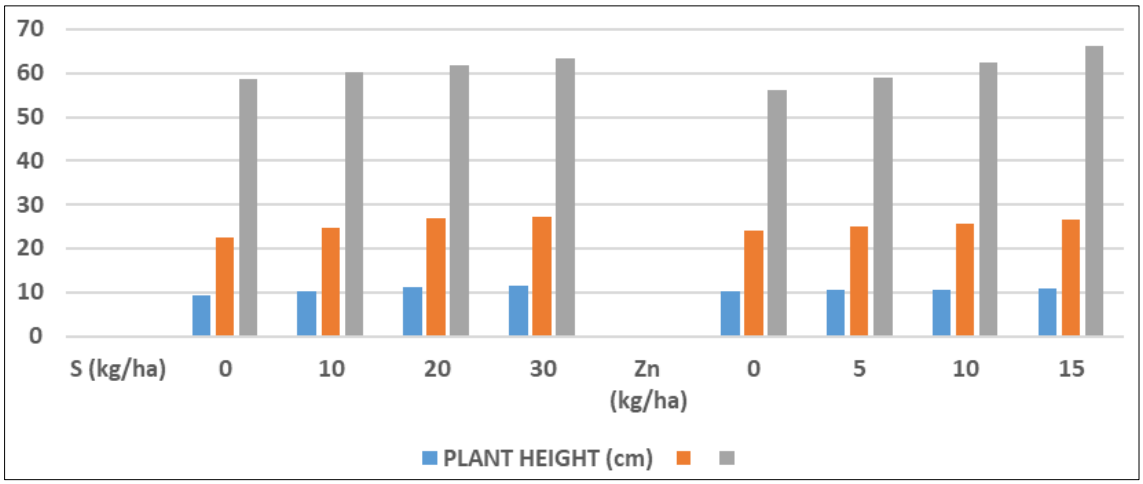

Fig 1: Plant height of Black gram at different growth intervals as influenced by sulphur and zinc levels.

The applied sulphur and zinc levels exerted significant influence upon this parameter at each stage of observation except at 60 days in case of S levels. The treatment interactions were found to be significant at every stage.

At 20 and 60 days stages, applied zinc up to 15kg/ha raised the plant height significantly over zero level. Thus the maximum height was up to 10.81 and 66.09cm, respectively rather increase in zinc level up to 15kg/ha decreased the plant height significantly. Thus, 10 and 20kg S/ha were found statistically at par in their influence.

The increasing levels of sulphur only up to 30kg/ha increased the plant height significantly at every stage of observation. Thus the maximum height at 20, 40 and 60 days was 11.04, 27.02 and 61.84 cm, respectively. Further increase in S level up to 30kg/ha tended to decrease the plant height almost significantly. It might be due to the treatments variation and the closely findings are Saviour and Stalin (2013) and Singh *et al* (2004), Singh, *et al* (2006) [6] and Shamsuddoha *et al.* (2011) [3].

Table 3: Plant height of Black gram at different growth intervals as influenced by sulphur and zinc levels and their interaction

Level of S (kg/ha)	Levels of Zinc (kg/ha)				Mean
	0	5	10	15	
	20 Days				
0	8.46	9.53	9.53	9.60	9.28
10	9.86	10.06	10.13	10.66	10.17
20	10.73	10.80	10.86	11.80	11.04
30	11.26	11.73	11.73	11.20	11.48
Mean	10.07	10.53	10.56	10.81	
40 Days					
0	20.26	22.80	23.26	23.33	22.41
10	23.60	23.80	24.86	26.00	24.56
20	25.33	25.86	27.06	29.86	27.02
30	26.53	27.60	27.66	26.60	27.09
Mean	23.93	25.01	25.71	26.44	
60 Days					
0	55.06	56.73	60.46	62.33	58.64
10	55.06	58.26	61.00	66.00	60.08
20	58.13	58.40	62.13	68.73	61.84
30	56.66	62.80	66.66	67.33	63.36
Mean	56.22	59.04	62.56	66.09	
		S	Zn	SxZn	
20DAYS	S.E±	0.44	0.44	0.88	
	CD(p=0.05)	0.91	0.91	1.82	
40DAYS	S.E±	0.55	0.55	1.10	
	CD(p=0.05)	1.13	1.13	2.26	
60DAYS	S.E±	0.62	0.62	1.24	
	CD(p=0.05)	1.27	1.27	2.54	

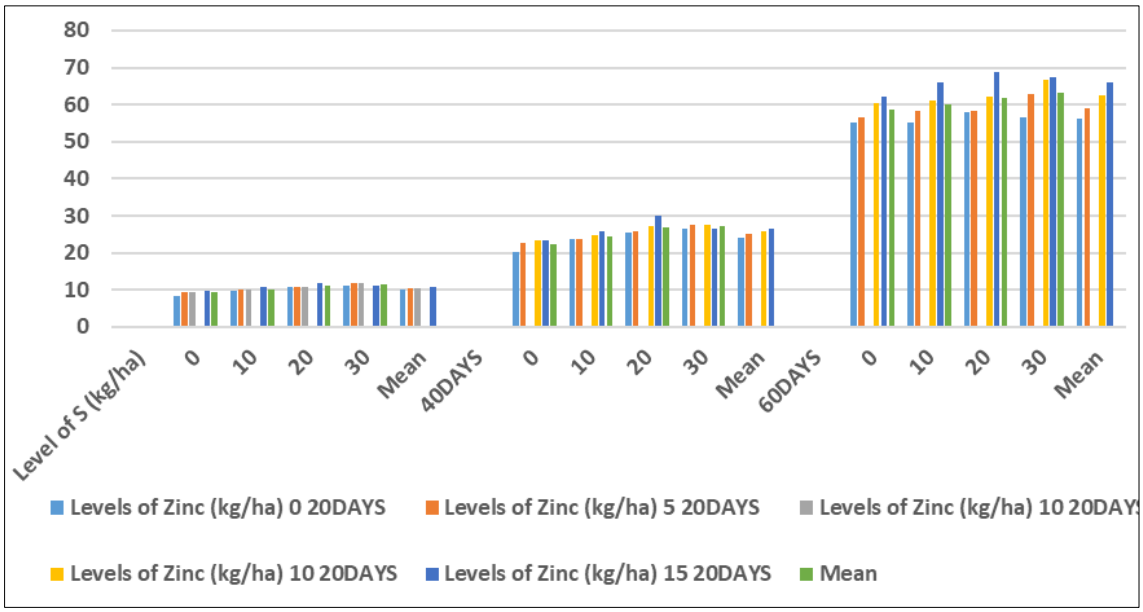

Fig 2: Plant height of Black gram at different growth intervals as influenced by sulphur and zinc levels and their interaction

The results in Table 4 reveal that the best treatment interaction was 20kg. S plus 15kg Zn/ha which recorded the maximum height i.e., 11.80cm. at 20 days, 29.86 cm at 40 days and 68.73cm at 60 days stage. This treatment interaction was found significantly superior to most of the remaining having S level only up to 10kg/ha with all the Zinc level. However, the second best interaction was 30kg S plus 10kg. Zn/ ha. In contrast to this, the significant lowest plant height was recorded in case of without S and Zn application (absolute control).

Yield parameters

Number of pod/plant

The number of pod/plant were counted from the randomly sample plants in each plot and the mean data so obtained were statistically analysed as depicted in appendix-V. The mean data are highlighted in Table 5 and diagrammatically illustrated in fig. 2.

Sulphur and zinc levels as well as their interactions were found to exact significant impact upon the formation of pod/plant. Accordingly, the numbers of pod/plant were enhanced significantly up to 15.99 pod due to 20kg S/ha over no sulphur (9.33 pod). Further increase in S level up to 30kg/ha bring about any significant change (16.71 pod/plant).

Table 4: Number of pod /plant of black gram as influenced by zinc and sulphur levels.

Level of S(kg/ha)	Levels of Zn (kg/ha)				Mean
	0	5	10	15	
0	8.73	9.20	9.66	9.73	9.33
10	12.40	12.53	12.60	13.00	12.63
20	13.00	15.46	16.53	19.00	15.99
30	14.46	17.20	17.60	17.60	16.71
Mean	12.14	13.59	14.09	14.83	
	S	Zn	SxZn		
S.E±	0.32	0.32	0.64		
CD(p=0.05)	0.65	0.65	1.30		

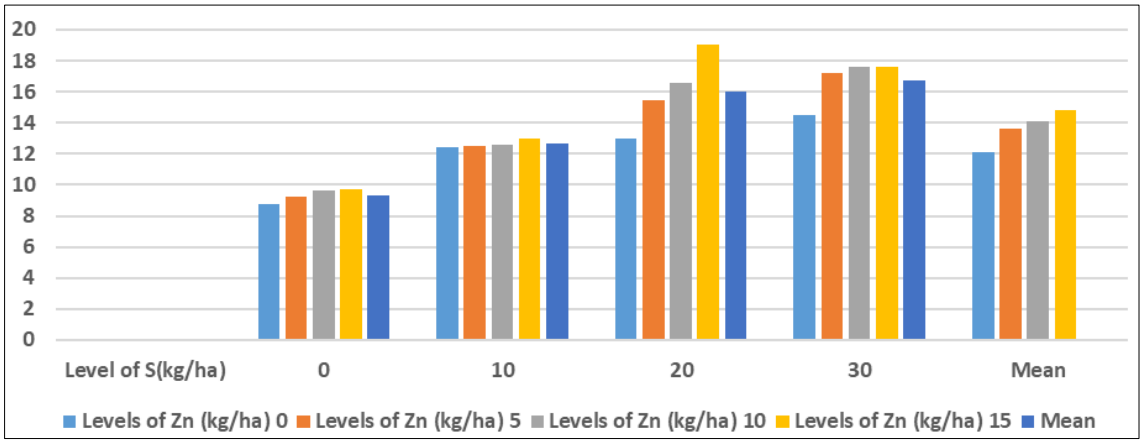

Fig 3: Number of pod /plant of black gram as influenced by zinc and sulphur levels.

As regards with the zinc levels, the pod was increased significantly with each increased in the Zn levels only up to 15 kg/ha 14.83 pod/plant. Thus the maximum 14.83 pod/plant were counted in case of 15kg Zn/ha. As against 12.14 pod /plant in case of no sulphur.

The interactions exerted significant changes in this yield-attributing parameter. The best treatment interaction was 20 kg S plus 15kg Zn/ha which recorded significantly higher

number of pod (19.00 pod/plant) over all the remaining SxZn interactions except $S_{30}Zn_{10}$ and $S_{30}Zn_{15}$ (17.60 to 17.60 pod/plant). In contrast to this, the significantly lowest pod (8.73 pod/plant) was counted in case of absolute control (S_0Zn_0).

Number of seeds/pod

The number of seeds/pod was counted form the randomly selected five plants in each treatment and the mean valued so obtained were subjected to statistical computation as revealed from appendix-VI. The mean data are being presented in Table 5 and diagrammatically illustrated in Fig. 3.

The different treatments as well as treatment interactions were found to deviate this parameter significantly. Accordingly, 30kg S/ha produced maximum 6.72 seeds/pod and seeds/pod proved significantly superior to no sulphur (4.53seed/pod).

The increasing levels of zinc only up to 10kg/ha enhanced the seed number significantly (5.93 seeds/pod). However further increase in Zn level this parameter. Higher dose of zinc proved advantageous (6.58 seeds/pod). The significantly lowest seeds (5.43/.pod) were obtained in case of no zinc

Table 5: Number of seed/pod of black gram as influenced by sulphur and zinc levels.

Level of S(kg/ha)	Levels of Zn (kg/ha)				Mean
	0	5	10	15	
0	4.33	4.60	4.60	4.60	4.53
10	5.73	5.93	5.93	6.06	5.91
20	5.73	5.93	5.93	8.40	6.49
30	5.93	6.46	7.26	7.26	6.72
Mean	5.43	5.73	5.93	6.58	
	S	Zn	SxZn		
S.E±	0.15	0.15	0.30		
CD(p=0.05)	0.30	0.30	0.60		

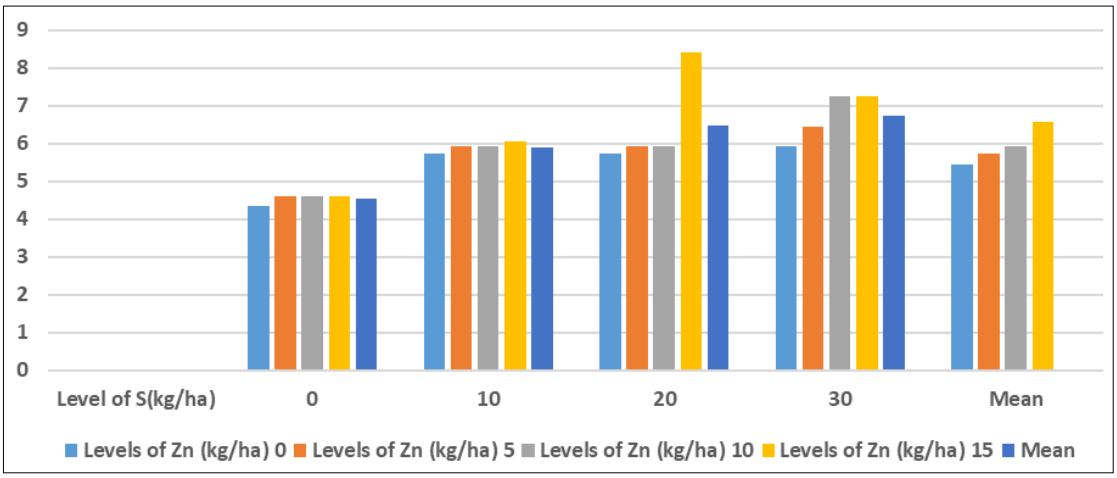

Fig 4: Number of seed/pods of black gram as influenced by sulphur and zinc levels.

The treatment interactions were found to be significant in accordingly this parameter. Thus the best interaction was 20kg S plus 15kg Zn/ha which recorded significantly higher seed count (8.40plant/pod).In contrast to this the significantly lowest seed count only 4.33 seeds/pod were noted in case of absolute control (S_0Zn_0).

Grain yield

The different levels of sulphur and zinc brought about significant influence upon the grain yield of black gram however the treatment interactions were found to be significant.

Application of sulphur up to 20kg/ha the grain yield significantly up to 9.74q/ha. The rather increase in S level up to 30kg/ha. As compared to no sulphur (4.49q/ha).

The increasing zinc level only up to 15kg/ha the grain yield significantly up to 9.87q/ha as compared to no zinc (7.85q/ha).

Although the treatment interactions were found to be significant, the best treatment combination appeared to be $S_{20}Zn_{15}$ producing 10.90q/ha grain. This was followed by $S_{20}Zn_{10}$ and $S_{30}Zn_{10}$ interactions producing equal grain (10.48 to 10.35/ha) on the other hand the lowest yield only 7.30q/ha ware recorded in case of absolute control (S_0Zn_0)

Table 6: Grain yield (q/ha) from of black gram as influenced by sulphur and zinc levels.

Level of S(kg/ha)	Levels of Zn (kg/ha)				Mean
	0	5	10	15	
0	7.30	8.35	9.05	9.28	8.49
10	7.50	8.40	9.20	9.28	8.59
20	7.95	9.65	10.48	10.90	9.74
30	8.65	9.69	10.35	10.05	9.75
Mean	7.85	9.09	9.77	9.87	
	S	Zn	SxZn		
S.E±	0.13	0.13	0.26		
CD(p=0.05)	0.26	0.26	0.52		

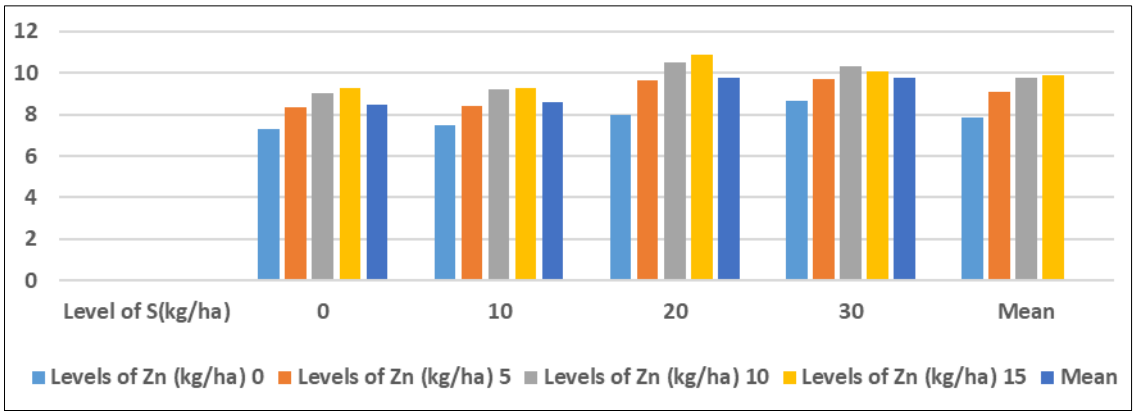

Fig 5: Grain yield (q/ha) from of black gram as influenced by sulphur and zinc levels.

The higher number of pod/plants, seeds/pod and yield due to the fact that applied Zn enhanced the metabolic activities promoting chlorophyll formation and photosynthesis at one hand and root development completed with accelerated microbial activities on the other supported by Singh and Singh (2013) [5], Ganie *et al*. (2014) [2] and Choudhary *et al.* (2014) [1].

Conclusion

It is concluded that the application of 20kg S with 15kg Zn/ha proved the most optimum and the beneficial fertility management for the "T-9" Variety Black gram for the Chitrakoot region of Madhya Pradesh. This fertility management ($S_{20}Zn_{15}$) resulted in maximum growth and yield.

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