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Impact of Sulphur and Zinc Levels on Growth and Yield of Maize (*Zea mays* L.)

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ABSTRACT: A field experiment was conducted during *Kharif* season 2020 at SHUATS university Allahabad, (U.P.). The soil of experiment plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.2), 0.35% organic carbon, 203.7 kg ha^{-1} nitrogen, 7.2 kg ha^{-1} available phosphorus. The effect of sulphur and zinc levels growth and yield of maize (*Zea mays* L.) nine treatment consisted of three levels of Sulphur (15, 25 and 35 kg ha^{-1}) and Zinc (0.5% foliar application, 25 kgha^{-1} soil application and 20 kg/ha+ 0.5 % foliar application). In the experiments nitrogen was applied in two split doses 50% as basal and 50% as top dressing at 40 DAS and entire dose of phosphorous, potassium and sulphur were applied as basal and where foliar application of zinc were applied at 20 and 35 DAS. There were nine treatments which replicated thrice. The experiment was laid out in Randomized Block Design. The result showed that there was significant increase in growth and yield parameters *viz.*, plant height (170.5 cm), number of leaves plant^{-1} (12.1), Dry weight (97.82 g) yield and yield attributes *viz.*, seed index (270.2 g), cob plant^{-1} (1.80 plant^{-1}), cob length (18.65), row cob^{-1} (14.9), grains row^{-1} (22.1), Number of grains cob^{-1} (330.47), Grain yield (5.8 t ha^{-1}), stover yield (8.8 t ha^{-1}), seed index (270.2 g) and harvest index (39.7%) were recorded higher in which are application of Sulphur 35 kg/ha + Zinc 20 kg/ha (Soil application) + Zinc 0.5 % (Foliar application).

Keywords: Sulphur, Zinc, Yield, Maize.

INTRODUCTION

Maize is one of the important cereal crops in the world's agricultural economy both as food for humans and feed for animals, because of its higher yield potential compared to other cereals it is called as "Queen of Cereals". It is the second most widely grown crop in the world and cultivated in tropics, sub-tropics to temperate climate and has several types like field corn, sweet corn, popcorn and baby corn. Within field corn, it has several other types like quality protein maize (QPM), waxy maize, high-oil maize etc. Maize is an important crop for billions of people as food, feed, and industrial raw material. Currently, nearly 1147.7 million MT of maize is being produced together by over 170 countries from an area of 193.7 million ha with an average productivity of 5.75 t/ha (FAOSTAT, 2020). The global consumption pattern of maize is: feed-61%, food-17% and industry-22%. It has attained a position of industrial crop globally as 83% of its production in the world is used in feed, starch and bio fuel industries. Further, using maize directly or indirectly more than 3000 products are being made providing wide opportunity for value addition. Because of its myriad uses, it is a prime driver of the global agricultural economy (iimr.icar.gov.in).

Among the maize growing countries India rank 4th in area and 7th in production, representing around 4% of world maize area and 2% of total production. During 2018-19 in India, the maize area has reached to 9.2 million ha (DACNET, 2020). During 1950-51 India used to produce 1.73 million MT maize, which has increased to 27.8 million MT by 2018-19, recording close to 16 times increase in production. The average productivity during the period has increased by 5.42 times from 547 kg/ha to 2965 kg/ha, while area increased nearly by three times. Though the productivity in India is almost half of world the average per day productivity of Indian maize is at par with many lead maize producing countries.

In India, maize is principally grown in two seasons, rainy (kharif) and winter (rabi). Kharif maize represents around 83% of maize area in India, while rabi maize correspond to 17% maize area. Over 70% of kharif maize area is grown under rainfed condition with prevalence of many biotic and abiotic stresses. The stress prone ecology contributes towards lower productivity of kharif maize (2706 kg/ha) as compared to rabi maize (4436 kg/ha), which is predominantly grown under assured ecosystem. In recent past spring maize area is also growing quite fast in north western parts of the country, in the states of Punjab, Haryana and Western Uttar Pradesh. Unfortunately the area and production data of spring maize is not well documented. However, informal estimate suggest the area to be around 150 thousand ha. Among cereals maize has highest growth rate in terms of area and productivity increasing @ over 50 kg/ha/year.

Among Indian states Madhya Pradesh and Karnataka has highest area under maize (15% each) followed by Maharashtra (10%), Rajasthan (9%), Uttar Pradesh

(8%) and others. After Karnataka and Madhya Pradesh Bihar is the highest maize producer. Andhra Pradesh is having highest state productivity. Some districts like Krishna, West Godavari etc. records as high as 12 t/ha productivity. Bulk of the maize production in India, approximately 47%, is used as poultry feed. Of the rest of the produce, 13% is used as livestock feed and food purpose each, 12% for industrial purposes, 14% in starch industry, 7% as processed food and 6% for export and other purposes.

Sulphur is one of the 16 elements essential for crop production (Marshner, 1995). Sulphur is a component of the amino acids cysteine, cystine and methionine (Gangadhara *et al.,* 1990) making it essential for protein synthesis in plants. Plants also contain a large variety of other organic sulphur compounds such as glutathione. Sulphur is also a constituent of vitamins (thiamine and biotin), glycosides and co-enzyme A (Tisdale *et al.,* 1985). (ijcmas.com)

Zinc (Zn) is an essential micronutrient for plant growth, Zn input has received much less attention than nitrogen (N), phosphorus (P), or irrigation during the Green Revolution. However, nearly half of the cereal growing areas worldwide have soils with low plant-available Zn. Therefore the application of Zn fertilizers is necessary in such soils to ensure cereal yield and grain Zn concentration (Cakmak, 2008). Many studies have demonstrated that the maize grain yield increases significantly with the application of Zn fertilizer to Zn-deficient soils. A better understanding of the physiological role of Zn fertilizer application in increasing the yield of maize is needed (www.frontiersin.org). Therefore, this study aimed to study the effect of Sulphur and Zinc levels on growth and yield of maize and to work out the economics of different treatment combinations.

MATERIALS AND METHODS

A field trial was conducted to study the sulphur and zinc levels growth and yield of maize (*Zea mays* L.) at the Crop Research Farm, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during *Kharif* season of 2020. The experimental soil contained 0.35% organic carbon, 203.7 kg ha^{-1} nitrogen, 7.2 kg ha^{-1} available phosphorus with pH 7.2.

The treatment consisted of levels of Sulphur (15, 25 and 35 kg ha^{-1}) and Zinc (0.5% foliar application, 25 kg ha^{-1} soil application and 20 kg/ha+0.5 % foliar application). Foliar application of 0.5% Zn at knee height stage and one week later after previous spray. There were nine treatments which replicated thrice. The field trial was laid out in Randomized Block Design. In the field trial nitrogen applied in two split doses 50% as basal and 50% as top dressing and dose of phosphorous, potassium and sulphur were applied as basal. Plant samples were collected from plot to record plant height, dry matter production, and number of leaves. To determine grain yield, cobs from net plot were collected, sundried till moisture attained and weighed. To determine stover yield was harvested to ground level and sundried.

Table 1: Treatment combination.

Sr. No.	Treatment No.	Treatment Combination
1.	T_1	15 kg/ha (S) + 0.5 % (Zn Foliar application)
2.	T_2	15 kg/ha (S) + 25 kg/ha (Zn Soil application)
3.	T_3	15 kg/ha (S) +20 kg/ha(Zn Soil application)+ 0.5 % (Zn Foliar application)
4.	T_4	25 kg/ha (S) +0.5 % (Zn Foliar application)
5.	T_5	25 kg/ha (S) +25 kg/ha (Zn Soil application)
6.	T_6	25 kg/ha (S) +20 kg/ha(Zn Soil application)+ 0.5 % (Zn Foliar application)
7.	T_7	35 kg/ha (S) +0.5 % (Zn Foliar application)
8.	T_8	35 kg/ha (S) +25 kg/ha (Zn Soil application)
9.	T_9	35 kg/ha (S) +20 kg/ha (Zn Soil application)+ 0.5 % (Zn Foliar application)

RESULT AND DISCUSSION

A. Growth Parameters

The results of the experimental field trial show on the topic of impact of sulphur and zinc levels on growth parameters of Maize (*Zea mays* L.) during *kharif* season at Prayagraj. Growth parameters of maize, *viz.* plant height (cm), number of leaves/plant and dry matter at harvest stage. The T_9 sulphur 35 kg/ha+Zinc 20 kg/ha(Soil application)+Zinc 0.5 % (Foliar application) shows the best result in among the treatment as compared to other resulted in higher plant height (170.5 cm) in plant height T_8 and T_6 is at par to T_9, number of leaves/plant (12.8) in number of leaves T8 is at par to T_9, dry matter (97.80 g).

In plant height T_8 and T_6 is at par to T_9, in number of leaves T_8 is at par to T_9, in dry matter T_8 is at par to T_9 while the lowest data was record in T_1 sulphur15 kg/ha + 0.5 % Zinc (Foliar application) as shown in Table 2.

Increase in plant height, number of leaves and dry weight per lant with to increase in nitrogen and sulphur application is ascribed to its positive effect on plants. The reason for attaining maximum values & parameters with nitrogen as sulphur application. This finding is in accordance by Souza *et al.,* (2017); Pavithra *et al.,* (2018). Higher photosynthetic activity and chlorophyll synthesis due to nitrogen and sulphur fertilizers seemed to give a favourable effect on plant height, number of leaves and dry weight.

Table 2: Effect of Sulphur and Zinc levels on growth attributes of Maize *(Zea mays* L.)

Treatment	At harvest		
	Plant height (cm)	Number of leaves/plant	Dry matter (g plant^{-1})
1. 15 kg/ha (S) + 0.5 % (Zn Foliar application)	156.4	10.6	82.90
2. 15 kg/ha (S) + 25 kg/ha (Zn Soil application)	163	11.2	87.60
3. 15 kg/ha (S) +20 kg/ha(Zn Soil application)+ 0.5 % (Zn Foliar application)	164.1	11.2	90.20
4. 25 kg/ha (S) +0.5 % (Zn Foliar application)	159.3	10.8	85.20
5. 25 Kg/ha (S) +25 Kg/ha (Zn Soil application)	166.5	11.3	91.80
6. 25 kg/ha (S) +20 kg/ha(Zn Soil application)+ 0.5 % (Zn Foliar application)	168.8	11.4	92.30
7.35 kg/ha (S) +0.5 % (Zn Foliar application)	160.2	10.9	86.20
8. 35 kg/ha (S) +25 kg/ha (Zn Soil application)	169.3	11.5	94.60
9. 35 kg/ha (S) +20 kg/ha(Zn Soil application)+ 0.5 % (Zn Foliar application)	170.5	12.1	97.80
SEm(±)	1.01	0.19	1.7
CD (P=0.05)	3.04	0.56	5.3

B. Yield attributes

Yield attributes of Maize *viz*. cobs plant^{-1}, cob length (cm), number of rows cob^{-1}, number of grains row^{-1}, kernels cob^{-1} were significant among different treatments. The T_9 Sulphur 35 kg/ha + Zinc 20 kg/ha (Soil application) + Zinc 0.5 % (Foliar application) shows significantly higher in among the treatment as compared to others treatment. The T_9 shows highest result in cobs plant^{-1} (1.80), cob length (18.65cm), number of rows cob^{-1} (14.9), number of grains row^{-1} (22.1), number of kernels cob^{-1} (330.47). In cobs plant^{-1} T_8, T_6, T_5 is at par with T_9, in cob length T_8 and T_6 is at par to T_9, in number of rows cob^{-1} T_8 and T_6 is at par to T_9, in number of grains row^{-1} T_8 is at par to T_9, in number of kernels cob^{-1} T_8 is at par to T_9. While the lowest data was record in T_1 sulphur 15 kg/ha + Zinc 0.5 % (Foliar application) as shown in Table 3.

In maize, yield of crop is the manifestation of yield attributes characters. Higher grain yield could be attributed to higher yield attributing character like number of cob/plant and stover yield (8.8), number of grain/cob, significantly maximum grain yield (5.8 t/ha) was recorded with treatment T_9 Sulphur 35 kg/ha + Zinc 20 kg/ha (Soil application) + Zinc 0.5% (Foliar application) whereas, T_8, T_6, T_5 and T_3 was found to be at par with maximum yield producing treatment T_9 (Sulphur 35 kg/ha + Zinc 20 kg/ha (Soil application) + Zinc 0.5 % (Foliar application)).

Moreover, nitrogen and sulphur nutrients have synergistic effect on growth and yield attributes resulting in greater trans location of photosynthesis from source to sink help to maximize maize yield. These finding is accordance Amjed *et al.*, (2013).

C. Number of cobs per plant

Yield attributing character like number of cobs per plant, the results revealed that there was significant difference between the treatments and maximum number of cob/plant (1.80/plant) was observed by the application of T_9 (Sulphur 35 kg/ha + Zinc 20 kg/ha (Soil application) + Zinc 0.5 % (Foliar application)).

The data regarding the number of cobs per plant are presented in Table 3, which indicated that application of nitrogen and Sulphur partly affected the number of cobs per plant. It seems that number of cobs per plant is basically a genetic character and not too much influenced by crop nutrition. These results are in line with the finding of Amjed *et al.*, (2013).

Table 3: Effect of Sulphur and Zinc levels on yield attributes of Maize (*Zea mays* L.)

Treatment	At harvest				
	Cobs/plant	Cob length(cm)	Number Rows/cob	Number Grains/row	Kernels/cob
1. 15 kg/ha (S) + 0.5 % (Zn Foliar application)	1.20	14.07	12.1	18.1	219.8
2. 15 kg/ha (S) + 25 kg/ha (Zn Soil application)	1.47	14.56	13.2	19.4	256
3. 15 kg/ha (S) +20 kg/ha (Zn Soil application)+ 0.5 % (Zn Foliar application)	1.53	17.24	13.6	20.1	272.9
4. 25 kg/ha (S) +0.5 % (Zn Foliar application)	1.27	15.29	12.6	18.3	230.2
5. 25 kg/ha (S) +25 kg/ha (Zn Soil application)	1.67	15.35	13.9	20.2	280
6. 25 kg/ha (S) +20 kg/ha(Zn Soil application)+ 0.5 % (Zn Foliar application)	1.60	17.44	14.6	21.2	309.5
7. 35 kg/ha (S) +0.5 % (Zn Foliar application)	1.33	15.17	12.8	19.2	246
8. 35 kg/ha (S) +25 kg/ha (Zn Soil application)	1.73	14.18	14.8	21.8	322.8
9. 35 kg/ha (S) +20 kg/ha(Zn Soil application)+ 0.5 % (Zn Foliar application)	1.80	18.65	14.9	22.1	330.47
SEm(±)	0.07	0.97	0.22	0.14	4.7
CD (P=0.05)	0.23	2.93	0.68	0.43	14.3

D. Cob length

This result was in accordance with the data recorded by Pavithra *et al.*, (2018). That the significant increase in yield parameters was due to application of higher doses of N and S fertilizers which enhanced nutrients uptake by the crop, by better translocation of photo synthates from source to sink. Grain and stover yield is also higher due to higher growth and yield parameters like cob length etc.

Yield: Yield of Maize viz. grain yield (tha^{-1}), stover yield (tha^{-1}), seed index (g), harvest index (%) were significant among the different treatment. The T9 Sulphur 35 kg/ha + Zinc 20 kg/ha (Soil application) + Zinc 0.5% (Foliar application) shows significantly higher in among the treatment. It shows significantly higher in grain yield (5.8 tha^{-1}), stover yield (8.8 tha^{-1}), seed index (270.2g) and harvest index (39.7%). In grain yield T_8, T_6, T_5 and T_3 is at par to T_9, in stover yield T_8, T_6, T_5, T_4 is at par to T_9, in seed index T_8, T_7, T_6 is at par to T_9 in harvest index T_8, T_7, T_6, T_5, T_3, T_2 is at par to T_9. While the lowest data was record in T_1 Sulphur 15 kg/ha + 0.5 % Zinc (Foliar application) as shown in Table 4.

Table 4: Effect of Sulphur and Zinc levels on yield of Maize (*Zea mays* L.)

Treatment	At harvest			
	Grain yield (t/ha)	Stover yield (t/ha)	Seed index (g)	Harvest index
1. 15 kg/ha (S) + 0.5 % (Zn Foliar application)	4.2	7.6	267.1	35.6
2. 15 kg/ha (S) + 25 kg/ha (Zn Soil application)	5.1	7.7	267.5	39.5
3. 15 kg/ha (S) +20 kg/ha (Zn Soil application)+ 0.5 % (Zn Foliar application)	5.2	7.9	268.1	39.6
4. 25 kg/ha (S) +0.5 % (Zn Foliar application)	4.7	8.5	268.6	36.1
5. 25 kg/ha (S) +25 kg/ha (Zn Soil application)	5.4	8.3	269.1	39.4
6. 25 kg/ha (S) +20 kg/ha(Zn Soil application)+ 0.5 % (Zn Foliar application)	5.5	8.4	269.5	39.6
7. 35 kg/ha (S) +0.5 % (Zn Foliar application)	4.9	8.1	269.9	37.7
8. 35 kg/ha (S) +25 kg/ha (Zn Soil application)	5.6	8.6	270.1	39.4
9. 35 kg/ha (S) +20 kg/ha(Zn Soil application)+ 0.5 % (Zn Foliar application)	5.8	8.8	270.2	39.7
SEm(±)	0.13	0.18	0.35	0.75
CD (P=0.05)	0.41	0.55	1.06	2.2

Zn application increased maize yield due to increased kernel numbers and kernel weight in inferior grains. An adequate Zn supply in maize plants maintained high pollen viability and a sufficient carbohydrate source. The critical shoot Zn concentrations for high pollen viability and high kernel numbers of inferior grains were respectively. These finding is accordance Cakmak (2008).

Grain yield: Maximum grain yield (5.8t/ha) was recorded due to application of T_9 Sulphur 35 kg/ha + Zinc 20 kg/ha (Soil application) + Zinc 0.5 % (Foliar application) at 80 DAS which was proved significantly superior over the all application.

This result was in accordance with the data recorded by Pavithra *et al.,* (2018). Higher rate of nitrogen and sulphur had beneficial effect on physiological processes, plant metabolism, dry matter production, growth etc there by leading to higher grain yield.

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Stover yield: The results revealed that there was significant difference between the treatments and maximum stover yield (8.8t/ha) was observed by the application of T_9 Sulphur 35 kg/ha + Zinc 20 kg/ha (Soil application) + Zinc 0.5 % (Foliar application), and T_8 35 kg/ha (S) + 25 kg/ha (Zn Soil application), T_6 25 kg/ha (S) + 20 kg/ha(Zn Soil application) + 0.5 % (Zn Foliar application), T_5 25 kg/ha (S) +25 kg/ha (Zn Soil application) and T_4 25 kg/ha (S) + 0.5 % (Zn Foliar application) were found to be statistically at par T_9. Maximum stover yield (8.8 t/ha) was recorded due to application of Sulphur 35 kg/ha + Zinc 20 kg/ha (Soil application) + Zinc 0.5 % (Foliar application) at 80 DAS which was proved significantly superior over all the application.

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Seed index: Maximum seed index (270.2 gm) was recorded due to application of T_9 Sulphur 35 kg/ha + Zinc 20 kg/ha (Soil application) + Zinc 0.5 % (Foliar application) at 80 DAS which was proved significantly superior over the all application.

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CONCLUSION

At above research, it may concluded that in Maize crop the application of Sulphur 35 kg/ha + Zinc 20 kg/ha (Soil application) + Zinc 0.5 % (Foliar application) is the best combination for obtaining better growth attributes like plant height, number of leaves/plant, dry weight and higher yield attributes of hybrid maize like number of cob/plant, cob length (cm), number of grain/cob, seed index (g), grain yield (t/ha), stover yield (t/ha), and can be recommended to the farmers of Allahabad region for sustaining productivity and profitability of maize.

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Conflict of Interest. Nil.

REFERENCES

Amjed, A., Zafar Iqbal, Syed Waseem Hassan, Muhammad Y., Tasneem Khaliq & Ahmad, S. (2013). Effect of nitrogen and sulphur on phenology, growth and yield parameters of maize crop, *25*(2): 363-366.

Cakmak, I. (2008). Enrichment of cereal grains with zinc: Agronomic or genetic biofortification. *Journal of Plant Soil*, *30*(2): 1-17.

DACNET, (2020).

FAOSTAT (2020).

Gangadhara, G. A., Manjunathaiah, H. M., & Satyanarayana, T. (1990). Effect of sulphur on yield, oil content of sunflower and uptake of micronutrients by plants. *Journal of Indian Society of Soil Science*, 38(4): 692-694.

iimr.icar.gov.in

Marshner, H. (1995). *Mineral Nutrition of Higher Plants* (2nd Ed.). Academic Press, London.

Pavithra, M., Reddy, G. P., Chandrika, V., & Umamahesh, V. (2018). Nitrogen and sulphur nutrition for enhancing the growth and yield of quality protein maize (QPM). *Journal of Pharmacognosy and Phytochemistry*, *7*(6): 142-144.

Souza, R. S., Helena, L., & Chaves, G. (2017). Initial growth of chia (*Salvia hispanica* L.) Submitted to nitrogen, phosphorus and potassium fertilization. *Australian Journal of Crop Science*, *11*(05): 610-615.

Tisdale, S. L., Nelson, W. L., & Beaton, J. D. (1985). *Soil Fertility and Fertilizers*; Macmillan Publishing Company: New York, 75-79.

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