Influence of Sulphur and Zinc on Growth and Yield of Pearl Millet (*Pennisetum glaucum* L.)

ABSTRACT

The field experiment was carried out during the *Zaid* season of 2022 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) India. To study the response of sulphur and zinc on the growth and yield of Pearl millet. The treatments consist of sulphur @ 20, 30 and 40 kg/ha and zinc @ 5, 10 and15 kg/ha. There were 9 treatments each replicated thrice. The soil of the experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 7.8), low in organic carbon (0.35%), available N (163.42 kg/ha), available P (21.96 kg/ha) and available K (256.48 kg/ha). Results revealed that the higher plant height (198.06 cm), plant dry weight (75.83 g/plant), crop growth rate (47.70 g/m^2 /day), ear head length (25.2 cm), grains/ear head (2006.0), test weight (8.57 gm), higher grain yield (40.95 q/ha) and higher stover yield (40.95 q/ha) were significantly influenced with the application of sulphur 40 kg/ha + zinc 15 kg/ha. Higher gross returns (INR 92145.00/ha), higher net returns (INR 62365.00/ha) and a higher B: C ratio (2.09) were also recorded in treatment-9 (sulphur 40 kg/ha+zinc 15 kg/ha).

Keywords: *Pearl millet, Sulphur, zinc, growth parameters and yield attributes.*

INTRODUCTION

"Pearl millet is commonly known in India as *Bajri* or *Bajra*. Pearl millet (*Pennisetum glaucum* L.) also known as 'bullrush millet', originated in tropical western Africa, where the greatest number of both wild ancestors and cultivated forms occur. It belongs to the family Gramineae (Poaceae). Pearl millet is a staple diet of the rural population and also an important fodder crop in arid and semi-arid regions of India. The realized productivity of pearl millet is below its potential. The main reasons for poor crop yield are low moisture availability to crops during the growing season and lack of proper nutrient management" (**Choudhary *et al*. 2016**). "The foodgrain demand in India will increase to about 291m tons by 2025 and to 377 m tons by 2050" **(Amarasinghe *et al.*, 2010)**. "Since there is limited scope to increase the net cultivated area (142 million ha), the improved per unit area

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productivity could trigger an overall increase in food grain production" **(Reddy *et al.*, 2022).** Pearl millet is a high nutrient feeder, drawing a large amount of plant nutrients from the soil. The crop's yield will suffer as a result of this depletion. "Among various nutrients, sulphur and zinc play a crucial role in pearl millet production" **(Vinay Singh *et al.*, 2015)**. "Sulphur performs important functions in pearl millet. It is best known for its role in the synthesis of proteins, oils and vitamins in pearl millet. Sulphur is associated with the production of crops for superior nutritional and market-quality produce" **(Chaudhary *et al.*, 2014)**. "Sulphur plays an important role in the formation of S-containing amino acids, which act as building blocks in the synthesis of proteins. it has to play in increasing chlorophyll formation and aiding photosynthesis in pearl millet" **(Pandey *et al.*, 2018)**.

"Zinc plays a key role as a structural constituent or regulatory cofactor of a wide range of different enzymes and proteins in many important biochemical pathways. These are mainly concerned with carbohydrate metabolism, both in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation the maintenance of the integrity of biological membranes, the resistance to infection by certain pathogens. Zinc deficiency is a common phenomenon in cereals, particularly in coarse treatment, soil semi-arid regions. Balanced fertilization is the key to achieving higher productivity and nutrient use efficiency" **(Vinay Singh *et al.*, 2015).**

Keeping these points in view, the present investigation regaring effect of sulphur and zinc on growth and yield of pearl millet (*Pennisetum glaucum* L.) was conductedduring *Zaid*-2022, at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences (SHUATS), Prayagraj (U.P.) India

MATERIALS AND METHODS

The field experiment was carried out during the *Zaid* season of 2021-22 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) India. The soil of the experimental plot was sandy loamy in texture, slightly alkaline in soil reaction (pH 7.8), and low in organic carbon (0.35%). The treatments consist of sulphur 20 kg/ha + zinc 5 kg/ha, sulphur 20 kg/ha + zinc 10 kg/ha, sulphur 20 kg/ha + zinc 15 kg/ha, sulphur 30 kg/ha + zinc 5 kg/ha,sulphur 30 kg/ha + zinc 10 kg/ha, sulphur 30 kg/ha + zinc 15 kg/ha, sulphur 40 kg/ha + zinc5 kg/ha, sulphur 40 kg/ha + zinc 10 kg/ha, sulphur 40 kg/ha + zinc 15 kg/ha. The experiment was laid out in Randomized Block Design, with 9 treatments replicated thrice. The observations were recorded for plant height, plant dry weight, Crop

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Growth Rate (g/ m^2/day), Relative Growth Rate (g/g/day), Ear head length (cm), Grains/ear head (g), Test weight (g), Grain yield (kg/ha) and Stover yield(kg/ha). The data were subjected to statistical analysis byanalysis of variance method **(Gomez and Gomez, 1976).**

RESULT AND DISCUSSION

GROWTH PARAMETERS

Plant height (cm)- At 80 DAS, the significantly higher plant height (198.06 cm) [Table-1] was observed in treatment-9 (Sulphur 40 kg/ha + Zinc 15 kg/ha) However, treatment-8 (Sulphur 40 kg/ha + zinc 10 kg/ha) was found to be statistically at par with treatment- 9 (Sulphur 40 kg/ha + Zinc 15 kg/ha). A significantly higher plant height was observed with the application of sulphur 40 kg/ha. This increase may be due to the involvement of sulphur in the biosynthesis of Indole 3 acetic acid. Also, sulphur plays an important role in the growth and development of crops. It owes an important role in the formation of S- containing amino acids like cystine (27% S), Cysteine (26% S), and methionine (21% S), which act as building blocks in the synthesis of proteins. Similar results were reported by **Chauhan *et al.*, (2017).** Further increase in plant height might be due to the application of zinc 15 kg/ha, due to the role of zinc as a "catalyst" in most physiological, metabolic, and tryptophane synthesis processes. Certain protein elements are required to produce growth hormones (auxins) including IAA. There were similar findings described by **Reddy *et al.* (2022**).

Plant dry weight(g/plant) - At 80 DAS, the significantly higher plant dry weight (75.83 gm/plant) [Table-1] was observed in treatment-9 (Sulphur 40 kg/ha + Zinc15 kg/ha). However, treatment-8 (Sulphur 40 kg/ha + zinc 10 kg/ha) was found to be statistically at par with treatment- 9 (Sulphur 40 kg/ha + Zinc 15 kg/ha). A significantly higher plant dry weight (75.83 g) was observed with the application of Sulphur 40 kg/ha. It has a role in increasing chlorophyll formation and aiding photosynthesis. Sulphur plays a role in the activation of enzymes and nucleic acids and forms parts of biotin and thiamine. Further increase in the dry weight might be due to the application of zinc at 15 kg/ha. "Zinc is essential for promoting certain metabolic reactions. It is necessary for the production of chlorophyll and carbohydrates. Zinc is directly or indirectly required by several enzymes, auxin and protein synthesis. The nutrients applied in one crop are not fully utilized which leads to their residual effect on succeeding crops". [**Kaushal and Vinay (2021)].**

Crop growth rate (g/m^2/day) - At 60-80 DAS, the significantly higher crop growth rate (47.70 g/m^2/day) [Table-1] was observed in treatment-9 (Sulphur 40 kg/ha

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+ Zinc 15 kg/ha) However, treatment-8 (Sulphur 40 kg//ha + zinc 10 kg/ha) was found to be statistically at par with treatment- 9 (Sulphur 40 kg//ha + Zinc 15 kg/ha). "The significantly higher crop growth rate was observed with the sulphur application 40 kg/ha, may be due to the increase in plant height with an increase in sulphur level might be due to the beneficial effect of Sulphur on the various metabolic activities and also because of its important role in cell division, photosynthetic process and formation of chlorophyll in the leaf. Therefore, it shows a positive reaction to crop growth rate". [**Dadhich and Gupta (2003)].**

YIELD ATTRIBUTES

Ear head length (cm) - The significant and higher ear head length (25.2 cm) [Table-2] was observed in treatment-9 with (Sulphur 40 kg/ha + Zinc 15 kg/ha), which was significantly superior over the rest of the treatments. However, treatment-8 (Sulphur 40 kg/ha + Zinc 10 kg/ha), was found to be statistically at par with treatment-9 (Sulphur 40 kg/ha + Zinc 15 kg/ha). A significant and higher ear head length was observed with the application of zinc 15 kg/ha. "Zn is involved in cell division, and enzyme activation and with their increased supply, their availability, acquisition, mobilization and influx into the plant tissue increased and thus improved growth attributes and yield components". **Vinay and Mamta (2018).**

No. of Grains/ear head - The significant and higher Grains/ear head (2006.0) [Table-2] was observed in treatment-9 with (Sulphur 40 kg/ha + Zinc 15 kg/ha), which was significantly superior over the rest of the treatments. However, treatment-8 (Sulphur 40 kg/ha + Zinc 10 kg/ha), was found to be statistically at par with treatment-9 (Sulphur 40 kg/ha + Zinc 15 kg/ha). The significant and higher Grains/ear head observed might be due to sulphur application. Because sulphur is part of the amino acid (Cystine) which helps in chlorophyll formation, photosynthetic process, activation of enzymes and seed formation. Similar results were observed by **Degra et al. (2008).**

Test Weight - The significantly higher Test weight (8.57 gm) [Table-2] was observed in treatment-9 with (Sulphur 40 kg/ha + Zinc 15 kg/ha treatments. However, treatment-8 (Sulphur 40 kg/ha + Zinc 10 kg/ha), was found to be statistically at par with treatment-9 (Sulphur 40 kg/ha + Zinc 15 kg/ha). The significant and higher test weight was recorded with the application of Zinc (15kg/ha), which might be due to the application of zinc might have increased the photosynthetic efficiency due to improved enzymatic activity and thus might have increased the thousand grains weight. similar

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results conform with the findings of **Arshad *et al.* (2016).**

Grain yield - The significant maximum grain yield (40.95 q/ha) [Table-2] was observed in treatment-9 with (Sulphur 40 kg/ha + Zinc 15 kg/ha), which was significantly superior over the rest of the treatments. However, treatment-8 (Sulphur 40 kg/ha + Zinc 10 kg/ha),was found to be statistically at par with treatment-9 (Sulphur 40 kg/ha + Zinc 15 kg/ha). "A significant and higher Grain yield was observed with increasing the Sulphur application level. And also, it performs important functions in pearl millet. It is best known for its role in thesynthesis of proteins, oils and vitamins in pearl millet. Sulphur is associated with the productionof crops for superior nutritional and market quality produce" **(Chaudhary *et al.*, 2014). "**Further,the application of Zinc (15 kg/ha), might be due to the greater photosynthesis efficiency or more nutrients availability due to the increasing decomposition rate of organic matter or improved individual plant performance might the possible reasons for higher grain yield in zinc applied plots compared to other plots". [**Arshad *et al.* (2016), Norwood (1992) and Jan *et al.* (2013)].**

Stover yield - The significant maximum stover yield (65.33 q/ha) [Table-2] was observed in treatment-9 with (Sulphur 40 kg/ha + Zinc 15 kg/ha), which was significantly superior over the rest of the treatments. However, treatment-8 (Sulphur 40 kg/ha + Zinc 10 kg/ha),was found to be statistically at par with treatment-9 (Sulphur 40 kg/ha + Zinc 15 kg/ha). A significant and higher stover yield was observed by the application of Sulphur 40 kg/ha. "Sulphur plays a vital role in proving vegetative structure for nutrient absorption, increasing sink strength through the development of reproductive structures by the production of assimilates to fill economically important sinks" **(Choudhary *et al.*, 2016). "**Further increase of stover yield may be due to the application of zinc 15 kg/ha. Zinc is critical to the growth and development of tryptophane, a necessary amino acid for plant growth and development". [**Reddy *et al.* (2022)**)].

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The influence of sulfur and zinc on the growth and yield of pearl millet has been a topic of research interest in recent years. Sulfur and zinc are essential micronutrients for plant growth and development, and their deficiency can result in reduced crop yields (Olivares, 2016; Araya-Alman et al. 2020; Olivares, 2022; Olivares et al. 2022a;

2022b). Several studies have investigated the effects of sulfur and zinc on pearl millet growth and yield, and these studies have provided valuable insights into the importance of these micronutrients for crop productivity.

The influence of agro-environmental factors on tropical crops in Latin America is well known. These factors include soil fertility (Hernandez et al. 2018; Hernandez and Olivares, 2019; Lobo et al. 2023), water availability (Parra et al. 2017; Cortez et al. 2017), temperature, and humidity (Olivares, 2018; Hernandez et al. 2020). In this study, the soil was deficient in both sulfur and zinc, which could have affected the growth and yield of pearl millet. The regular watering of the plants could have compensated for the water availability factor. However, the effect of temperature and humidity on the growth and yield of pearl millet was not studied in this experiment.

CONCLUSION

The conclusion was reached that the application of Sulphur 40 kg/ha along with zinc 15 kg/ha (Treatment-9), has performed positively and improved growth and yield parameters. Maximum grain yield, gross returns, net returns and benefit-cost ratio were also recorded with the application of Sulphur 40 kg/ha along with zinc 15 kg/ha (Treatment-9). These results are based on a single season, therefore additional research may be needed to confirm findings. REFERENCES

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Table-1. Effect of sulphur and zinc on the growth of pearl millet.

S. No.	Treatment combinations	Plant height(cm)	Dry weight (g/plant)	Crop growth rate (g/m2/day)
1.	Sulphur 20 kg/ha +Zinc 5 kg/ha	180.38	62.90	36.73
2.	Sulphur 20 kg/ha +Zinc 10 kg/ha	183.53	64.22	37.31
3.	Sulphur 20 kg/ha +Zinc 15 kg/ha	184.62	65.87	36.65
4.	Sulphur 30 kg/ha +Zinc 5 kg/ha	186.38	67.64	39.20
5.	Sulphur 30 kg/ha +Zinc 10 kg/ha	188.94	68.22	40.22
6.	Sulphur 30 kg/ha +Zinc 15 kg/ha	189.96	68.95	38.93
7.	Sulphur 40 kg/ha +Zinc 5 kg/ha	192.27	71.20	41.65
8.	Sulphur 40 kg/ha +Zinc 10 kg/ha	195.05	73.87	42.90
9.	Sulphur 40 kg/ha +Zinc 15 kg/ha	198.06	75.83	47.70
	F test	S	S	S
	SEm.(±)	1.12	0.84	1.71
	CD (p=0.05)	3.37	2.53	5.12

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Table-2. Effect of sulphur and zinc on yield of pearl millet.

S. No.	Treatment combinations	Ear head length (cm)	No.of Grains/ ear head	Test weight (g)	Grain yield(q/ha)	Stover yield(q/ha)	Harvest index (%)
1.	Sulphur 20 kg/ha +Zinc 5 kg/ha	19.8	1837.1	6.75	32.29	47.55	40.44
2.	Sulphur 20 kg/ha +Zinc 10 kg/ha	20.8	1876.0	6.81	33.94	48.20	41.32
3.	Sulphur 20 kg/ha +Zinc 15 kg/ha	21.5	1902.4	7.19	34.61	49.11	41.34
4.	Sulphur 30 kg/ha +Zinc 5 kg/ha	21.3	1911.1	7.45	35.24	50.99	40.87
5.	Sulphur 30 kg/ha +Zinc 10 kg/ha	22.4	1929.6	7.81	36.16	54.03	40.10
6.	Sulphur 30 kg/ha +Zinc 15 kg/ha	22.7	1938.4	7.99	37.03	58.36	38.83
7.	Sulphur 40 kg/ha +Zinc 5 kg/ha	23.5	1965.3	8.10	37.82	59.33	38.93
8.	Sulphur 40 kg/ha +Zinc 10 kg/ha	24.5	1981.1	8.31	39.03	63.32	38.14
9.	Sulphur 40 kg/ha +Zinc 15 kg/ha	25.2	2006.0	8.57	40.95	65.33	38.53
	F test	S	S	S	S	S	S
	Sem (±)	0.27	6.07	0.13	0.40	0.65	0.41
	CD (P=0.05)	0.81	18.19	0.40	1.21	1.94	1.23

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