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Agronomic response of sulphur and zinc levels on growth and yield of maize (*Zea mays* L.)

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Abstract
A field experiment was conducted at Crop Research Farm (CRF), SHUATS, Prayagraj, during the *Zaid* season of 2021 with 10 treatments replicated thrice in randomized block design, to study the Agronomic Response of Sulphur and Zinc Levels on Growth and Yield of Maize (*Zea mays* L.). Report of the study revealed that Treatment T_3 (120 kg N ha^{-1} + 40 kg S ha^{-1} + 15 kg Zn ha^{-1}) was found to be maximum for obtaining maximum plant height (208.53 cm), dry matter accumulation (171.72 g $plant^{-1}$), CGR (13.09 g m^{-2} day^{-1}), RGR (1.96 g/g/day), number of leaves (14.67), test weight (249.29 g), number of rows (13.67), number of grains (30.67). grain yield (9.93 t ha^{-1}) and stover yield (22.50 t ha^{-1}).

Keywords: Maize, sulphur, zinc, growth, yield

Introduction

Maize (*Zea mays* L.) is an important cereal crop which ranks third after wheat and rice in the world. Maize grains are extensively grown worldwide for both human and livestock consumption. Maize grain is the major cereal used for animal feed. In case of human consumption, it is used for food and also as source of raw materials for manufacturing of several products such as corn sugar, corn flakes, corn oil and corn protein. Maize is known as a huge agricultural economic value crop, because of its long-term use in agricultural industry. There is no cereal crop on earth which has so immense potentiality and that is why it is called 'queen of cereals'.

Sulphur is one of the essential plant nutrients and its role in plant nutrition is well documented. Sulphur plays a vital role in the primary metabolism of higher plants and involved in synthesis of secondary metabolic products in certain groups of plants. It ranks along with nitrogen and phosphorus in importance in the formation of proteins. It not only influences yield but also improves crop quality owing to its influence on protein metabolism and oil synthesis. It is being realized that apart from major nutrients, the role of secondary nutrients in general and sulfur in particular in increasing cereal production is well established. Sulfur has specific functions during plant growth, metabolism, and enzymatic reactions (Mengal and Kirkby, 1987). Sulfur improves crop management through its favorable effects on environmental stress, resistance against pest and diseases.

Zinc is an essential element for higher plants, and its importance in agriculture is increasingly being recognized (Genc *et al.*, 2006) [3]. Generally, zinc affects the synthesis of protein in plants hence is considered to be the most critical micronutrient. Zinc is also crucial in taking part in plant development due to its catalytic action in metabolism for all crops especially maize. Zinc is used by the plant in many of its vital processes such as synthesis of protein, structure and functions of membrane, expression of genes and oxidative stress tolerance. Zinc is important in photosynthesis and respiration, and zinc deficiency decreases the photosynthetic rate, chlorophyll content, activity of carbonic anhydrase, and protein biosynthesis (Cakmak, 2008; Kaya and Higgs, 2002; Fu *et al.*, 2016) [2, 6]. Therefore, application of zinc fertilizer may be an important measure for improving the yield and quality of maize. Therefore, an experiment was conducted to study Agronomic response of Sulphur and Zinc levels on growth and yield of Maize (*Zea mays* L.)

Materials and Methods

The experiment was carried out at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.). The area is situated on the south of Prayagraj on the right hand of rivers Yamuna at Rewa Road at a distance of about 7 km of

Prayagraj city. Prayagraj has sub-humid sub-tropical climate with the monsoon commencing from July and withdrawing by the end of September. The rainfall is unevenly distributed and most of it is received between July and September.

Apart from this, a few winter and summer showers are also received. The soil of the experimental field was sandy loam in texture with pH 7.7, low in organic carbon 0.61%, available P 31.6 kg/ha and available K 251.1 kg/ha. This experiment was conducted in year 2020-21 during the Zaid season and maize variety 'SWARAJ' was sown on 06th April, 2021.

The experiment consisted of three Sulphur levels, *viz*. 20,40 and 60 kg/ha and three Zinc levels, *viz*. 15, 30 and 45 kg/ha with 10 treatments replicated thrice in randomized block design.

The RDF i.e half of nitrogen was applied through urea as basal dressing at sowing and rest half of nitrogen was top-dressed at second irrigation. Full dose of Phosphorus and Potassium was applied through diammonium phosphate and muriate of potash respectively, at the time of sowing.

Other agronomic management practices were followed as per the standard recommendation. Crop was harvested in the first week of July. The data on growth parameters, yield attributes and yield were recorded in different treatments. All the data were statistically analysed.

Results and Discussion

Growth attributes

Growth attributes of Maize *viz*, Plant height (cm), dry weight (g/plant), Crop Growth Rate (g/m^2/day), Relative Growth Rate (g/g/day) and Number of leaves per plant varied due to different treatments and are presented in Table 1. Treatment T_3 (120 kg N ha^{-1} + 40 kg S ha^{-1} + 15 kg Zn ha^{-1}) recorded significant and highest plant height (208.53 cm), dry weight (171.72 g $plant^{-1}$), CGR (13.09 g m^{-2} day^{-1}), and RGR (1.96 g/g/day). Whereas, treatment T_9 was found to be statistically at par with treatment T_3 in case of plant height and treatment T_6 was found to be statistically at par with treatment T_3 in case of CGR and RGR. Maximum number of leaves (14.67) was recorded in treatment T_3 (120 kg N ha^{-1} + 40 kg S ha^{-1} + 15 kg Zn ha^{-1}).

The probable reason for attaining maximum values of aforesaid parameters with Sulphur is because Sulphur plays multiple roles in protein and carbohydrate metabolism of plants by activating much number of enzymes that play an essential role in dark reaction of photosynthesis. Sulphur application promotes the production of plant growth hormones for improving better growth of plants. Adequate sulphur is required for carbohydrate formation; thus, it has role in photosynthesis by influencing the formation of chlorophyll Sutar *et al.*, (2018) [16].

Application of zinc result in high rate of photosynthesis, chlorophyll content and more leaf expansion. These finding are in relevance with Maqsood *et al.*, (1999) [10]. The favourable effect of applied zinc on plant height and other growth attributes may be ascribed to its stimulatory effect on most of the physiological and metabolic processes of plant (Panneerselvam and Stalin 2014) [14].

Yield attributes

Test weight

A perusal of table 2 reveals that there was significant effect of treatments on test weight. Treatment T_3 (120 kg N ha^{-1} + 40 kg S ha^{-1} + 15 kg Zn ha^{-1}) recorded significant increase in test weight (249.29 g). However, treatment T_2 (120 kg N ha^{-1} + 20 kg S ha^{-1} + 15 kg Zn ha^{-1}) was statistically at par with the treatment T_3. Increase in size of cobs might have accommodated number of grains providing sufficient space for development of individual grain, leading to higher test weight with sulphur application resulting in higher grain weight cob^{-1}. These results are similar with the findings of Thirupathi *et al.*, (2013) [18]. Further, zinc plays a vital role in reproductive phase of crop growth. These results are in line with the findings of Kumar *et al.*, (2014).

Number of rows per cob

The observation showed that there was non-significant effect in number of rows cob^{-1} with respect to different levels of sulphur and zinc. Treatment T_7 (120 kg N ha^{-1} + 60 kg S ha^{-1} + 30 kg Zn ha^{-1}) recorded highest number of rows (13.67). Sulphur application facilitates a greater number of bigger cobs that might have resulted in increased number of grain row per cob. These observations are similar with the findings of Baktash *et al.*, (2000) [1]. Further, the involvement of zinc in various enzymatic processes helps in catalysing reaction for growth leading to development of more yield attributing character. The results were in close conformity with Jakhar *et al.*, (2006) [5].

Number of grains per row

An appraisal of table 2 reveals that there was significant effect of treatments on no. of grains per row. Treatment T_{10} (120 kg N ha^{-1} + 60 kg S ha^{-1} + 45 kg Zn ha^{-1}) recorded significant increase in number of grains (30.67). However, treatment T_3 (120 kg N ha^{-1} + 40 kg S ha^{-1} + 15 kg Zn ha^{-1}) was statistically at par with the treatment T_{10}. The increase in number of grains per row in case of increasing sulphur and zinc level was mainly due to more cob length. These findings are similar with the results of Khaliq *et al.*, (2008) [7]. Further, increase in number of grains might be due to larger cob size, proper pollination, translocation of sugars and starch by zinc fertilizer application. These finding are similar with the findings of Raskar *et al.*, (2009-10) [15].

Grain yield

A critical review of the table 2 clearly depicts that there was significant influence of sulphur and zinc on grain yield of maize under study. Treatment T_3 (120 kg N ha^{-1} + 40 kg S ha^{-1} + 15 kg Zn ha^{-1}) resulted significant increase in grain yield (9.93 t ha^{-1}). However, treatment T_4 (120 kg N ha^{-1} + 60 kg S ha^{-1} + 15 kg Zn ha^{-1}) was statistically at par with the treatment T_3. Increased grain yield of maize with higher sulphur application could be owing to higher availability of nutrients and development of strong source-sink relationship manifested in realization of higher productivity of maize in terms of seed yield (Tandon, 1999) [18]. Similar findings were also reported by Jaggi and Raina (2008) [4]. Further, the increase in grain yield might be due to better growth and yield attributing character with zinc fertilization. Similar results have been reported by Meena *et al.*, (2013) [11].

Stover yield

An appraisal of table 2 reveals that there was significant effect of treatments on stover yield. Treatment T_3 (120 kg N ha^{-1} + 40 kg S ha^{-1} + 15 kg Zn ha^{-1}) resulted significant increase in stover yield (22.50 t ha^{-1}) while at par value was recorded in treatment T_5 (120 kg N ha^{-1} + 20 kg S ha^{-1} + 30 kg Zn ha^{-1}). The higher stover yield was associated with higher dose of sulphur due to better vegetative growth as indicated by more dry matter production in maize (Mehta *et al.*, 2005) [12]. Further, this might be due to the enhanced translocation of photosynthates with applied zinc, which resulted in higher production of green fodder in the respective levels of nutrient. Kumar *et al.*, 2014.

Table 1: Effect of sulphur and zinc levels on growth of maize

	Treatments	Plant height (cm)	Dry weight (g/plant)	CGR (60-80 DAS) (g/m^2/day)	RGR (60-80 DAS) (g/g/day)	No. of leaves/plant
T1	120:60:60 kg NPK ha^{-1} (Control)	151.63	147.33	10.84	1.63	14.33
T2	120 kg N ha^{-1} + 20 kg S ha^{-1} + 15 kg Zn ha^{-1}	180.53	161.27	12.07	1.81	14.33
T3	120 kg N ha^{-1} + 40 kg S ha^{-1} + 15 kg Zn ha^{-1}	208.53	171.72	13.09	1.96	14.67
T4	120 kg N ha^{-1} + 60 kg S ha^{-1} + 15 kg Zn ha^{-1}	184.94	153.37	11.21	1.68	14.44
T5	120 kg N ha^{-1} + 20 kg S ha^{-1} + 30 kg Zn ha^{-1}	175.16	156.70	11.73	1.71	14.44
T6	120 kg N ha^{-1} + 40 kg S ha^{-1} + 30 kg Zn ha^{-1}	202.33	170.00	12.89	1.94	14.56
T7	120 kg N ha^{-1} + 60 kg S ha^{-1} + 30 kg Zn ha^{-1}	190.26	159.21	11.88	1.80	14.44
T8	120 kg N ha^{-1} + 20 kg S ha^{-1} + 45 kg Zn ha^{-1}	170.90	148.47	10.96	1.65	14.33
T9	120 kg N ha^{-1} + 40 kg S ha^{-1} + 45 kg Zn ha^{-1}	204.23	167.57	12.62	1.89	14.56
T10	120 kg N ha^{-1} + 60 kg S ha^{-1} + 45 kg Zn ha^{-1}	200.84	155.00	11.47	1.72	14.33
	F test	S	S	S	S	NS
	SEd (±)	3.65	0.43	0.10	0.02	0.11
	CD (P=0.05)	7.67	0.91	0.20	0.04	-

Table 2: Effect of sulphur and zinc levels on yield attributes and yield of maize

	Treatments	Test weight (g)	No. of rows cob^{-1}	No. of grains row^{-1}	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
T1	120:60:60 kg NPK ha^{-1} (Control)	237.33	12.00	25.67	6.10	13.70
T2	120 kg N ha^{-1} + 20 kg S ha^{-1} + 15 kg Zn ha^{-1}	249.67	12.00	26.67	8.90	19.40
T3	120 kg N ha^{-1} + 40 kg S ha^{-1} + 15 kg Zn ha^{-1}	256.33	13.00	30.00	9.93	22.50
T4	120 kg N ha^{-1} + 60 kg S ha^{-1} + 15 kg Zn ha^{-1}	243.33	12.67	29.67	9.23	19.23
T5	120 kg N ha^{-1} + 20 kg S ha^{-1} + 30 kg Zn ha^{-1}	244.33	12.00	27.33	8.73	21.30
T6	120 kg N ha^{-1} + 40 kg S ha^{-1} + 30 kg Zn ha^{-1}	249.67	12.67	29.67	9.67	19.17
T7	120 kg N ha^{-1} + 60 kg S ha^{-1} + 30 kg Zn ha^{-1}	243.33	13.67	29.33	8.57	18.83
T8	120 kg N ha^{-1} + 20 kg S ha^{-1} + 45 kg Zn ha^{-1}	241.67	12.00	26.00	8.43	18.97
T9	120 kg N ha^{-1} + 40 kg S ha^{-1} + 45 kg Zn ha^{-1}	252.00	13.00	30.00	8.90	19.70
T10	120 kg N ha^{-1} + 60 kg S ha^{-1} + 45 kg Zn ha^{-1}	249.67	13.00	30.67	8.83	19.00
	F test	S	NS	S	S	S
	SEd (±)	3.35	0.74	1.37	0.42	0.64
	CD (P=0.05)	7.04	-	2.52	0.88	1.34

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