J. Sher-e-Bangla Agric. Univ., 14(1&2): 59-68, January & July 2023 ISSN 1997-6038

EFFECT OF SULPHUR AND ZINC FERTILIZERS ON THE GROWTH AND YIELD OF CHILI (BARI Morich 4)

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ABSTRACT

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka, during the Rabi season from November 2021 to April 2022 to study the effect of sulphur (S) and zinc (Zn) fertilizer on green chili production (cv. BARI Morich 4). The experiment consisted of two factors, viz., Factor A: 3 levels of Sulphur (S_0: 0 kg ha^{-1}, S_1: 20 kg ha^{-1}, S_2: 30 kg ha^{-1}) and Factor B: three levels of zinc (Zn_0: 0 kg ha^{-1}, Zn_1: 2 kg ha^{-1} and Zn_2: 4 kg ha^{-1}). Two-factor experiments with Randomized Complete Block Design (RCBD) were followed with 9 treatment combinations and replicated three times. Vegetative growth, yield contributing characters, and yield were measured during the experiment. The growth and yield of BARI Morich 4 were significantly affected by different levels of S. The highest plant height (66.12 cm), number of leaves plant^{-1} (96.13), number of branches plant^{-1} (15.50) and the highest number of fruits plant^{-1} (104.57), flowers plant^{-1} (111.18), fruit length (7.10 cm), fruit diameter (0.56 cm), individual fruit weight (1.73 g), average fruit weight plant^{-1} (177.27 g), fruit yield ha^{-1} (28.21 t) were obtained from S_1 treatment. Similarly, the growth and yield were significantly affected by different rates of Zn fertilizer application. The highest plant height (66.06 cm), number of leaves plant^{-1} (92.61), number of branches plant^{-1} (14.76) and the highest number of flowers plant^{-1} (109.24), fruits plant^{-1} (98.81), fruit length (6.93 cm), fruit diameter (0.58 cm), individual fruit weight (1.69 g), average fruit weight plant^{-1} (169.05 g), fruit yield ha^{-1} (27.35 t) were recorded from Zn_2 treatment. Considering the combined effect of S and Zn, growth contributing parameters and yield were affected and the tallest plant (74.83 cm), maximum number of leaves plant^{-1} (101.32), maximum number of branches plant^{-1} (16.74), highest number of flowers plant^{-1} (121.26), maximum number of fruits plant^{-1} (114.09), highest fruit length (7.79 cm), highest fruit diameter (0.63 cm), highest individual fruit weight (1.78 g), average fruit weight plant^{-1} (203.49 g) and fruit yield ha^{-1} (33.52 t) were recorded from S_1Zn_2. Meanwhile, the lowest values of the parameters were found in the control application of sulphur and zinc. Therefore, it can be concluded that 20 kg ha^{-1} of sulphur and 4 kg ha^{-1} of zinc were found beneficial for the growth and yield of green chili in the soils of Madhupur Tract.

Keywords: Green chili, growth, sulphur, yield, zinc

INTRODUCTION

Chili (*Capsicum annum* L.) is a vital spice crop in the Solanaceae family, ranked 3rd after tomato and potato in significance. It's widely grown in Bangladesh, covering a large area and serving as a cash crop. Among the 20 species in the Capsicum genus, only 5 are cultivated, with *Capsicum frutescence* and *Capsicum annum* being the most common worldwide (Khan, 2014). *Capsicum frutescence*, known as hot peppers, contains an extra amount of alkaloid capsaicin ($C_{18}H_{27}O_3$) responsible for spiciness (Udoh *et al.*, 2005). Chili is a globally recognized spice, cultivated extensively in temperate, tropical, and subtropical regions. Its ground powder and oleoresin are used in pharmaceutical preparations (Warrier, 1989). Bangladesh produces around 79,747 metric tons of Rabi chili annually from 426,157 acres of land, with prominent cultivation in districts like Bogura, Rangpur, Kurigram, Natore, Jamalpur, and Jashore (BBS, 2019). In Bangladesh, farmers typically choose local chili cultivars that yield poorly due to factors like outdated techniques and inadequate fertilization. Achieving higher yields requires adopting modern practices and maintaining nutrient balance through proper fertilizer application. It is realized that the productivity of crops is being adversely affected in different areas due to deficiencies of micronutrients (Bose and Tripathi, 1996). The application of micronutrients can enhance growth attributes by boosting photosynthesis and metabolic activity. This can elevate plant metabolites responsible for cell division and elongation, as suggested by (Hatwar *et al.,* 2003). Sulphur is a plant nutrient with a crop requirement similar to that of phosphorus. Sulphur is known as the fourth

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major plant nutrient (Jamal *et al.*, 2010). Sulfur (S) is one of the essential macro elements of plants and is regarded as the fourth key element after N, P, and K (Lewandowska and Sirko, 2008). Sulfur is essential for synthesizing crucial amino acids, increasing specific alkaloids like allyl propyl disulphide (43% S) and capsaicin – the main pungency compound in onion and sweet pepper. Additionally, sulfur aids plant defense against stress, and pests, and enhances chlorophyll and vitamin synthesis (Hasseneen, 1992). It has been observed when Sulphur is present in a critical amount of soil (less than 10 ppm), the plant growth, quality, and total production of the crop are adversely affected (Jones *et al.*, 1984). Zinc is crucial for successful green chili growth, impacting nitrogen metabolism, photosynthesis, protein quality, and resistance to environmental and biological challenges in plants (Potarzycki and Grzebisz, 2009). Zinc plays a crucial role in the activation of enzymes involved in sulphur metabolism, such as adenosine-5'-phosphosulfate reductase (APR). This enzyme catalyzes the reduction of adenosine-5'-phosphosulfate (APS) to sulfite, which is a key step in sulphur assimilation. Zinc deficiency can limit the activity of APR, impairing the plant's ability to utilize sulphur effectively. This can result in reduced synthesis of essential sulphur-containing compounds like cysteine and methionine. Sulphur availability in the soil can affect the solubility and bioavailability of zinc. Adequate sulphur levels can enhance zinc availability by maintaining an optimal soil pH and promoting the formation of soluble zinc-sulphur complexes. The research was conducted to find out the suitable doses of Sulphur and Zinc for the growth and yield of chili.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, during the period From November 2021 to April 2022. The soil of the experimented field belongs to the Tejgaon series under the Agro-Ecological Zone, AEZ-28 (Madhupur Tract). In this series general soil type is shallow deep red-brown terrace soil. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, ground, and passed through a 2 mm sieve and analyzed for some important physical and chemical parameters. Soil pH was determined by the glass-electrode pH meter method (Jackson, 1958) and the wet oxidation method was used for determining soil organic carbon (Walkley and Black, 1934). The available P and S were determined by sodium bicarbonate extraction (Olsen *et al.,* 1954) and Calcium chloride extraction method (Houba *et al.,* 2000). The morphological characteristics of the experimental field and initial physical and chemical characteristics of the soil are presented in Tables 1, and 2, respectively. Chili (cv. BARI Morich 4) was used as an experimental crop. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were 27 unit plots altogether in the experiment. The size of each plot was 3.0 m × 1.75 m. The experiment consisted of three levels of S (S_0 = 0 kg ha^{-1}, S_1 = 20 kg ha^{-1}, S_2 = 30 kg ha^{-1}) and three levels of Zn (Zn_0 = 0 kg ha^{-1}, Zn_1 = 2 kg ha^{-1}, Zn_2 = 4 kg ha^{-1}). Gypsum and Zinc sulphate monohydrate ($ZnSO_4.H_2O$) were used as the source of sulphur and zinc respectively. There were nine treatment combinations such as S_0Zn_0, S_0Zn_1, S_0Zn_2, S_1Zn_0, S_1Zn_1, S_1Zn_2, S_2Zn_0, S_2Zn_1, S_2Zn_2. The N, P, K, and B nutrients were applied through Urea, Triple superphosphate (TSP), Muriate of Potash (MoP), and Boric acid respectively. The N, P, K, and B were applied according to Fertilizer Recommendation Guide, 2018. One-third of the whole amount of Urea, and the full amount of Cowdung as manure, TSP, MoP, and Boric acid were applied at the time of final land preparation. The remaining Urea was top dressed in two equal installments - at 20 days after transplanting (DAT) and 50 DAT respectively. In November 2021, a seedbed of 3 m × 1 m was prepared for green chili seedlings. The soil was well ploughed, cleared of weeds and debris, and enriched with cow dung at 10 t/ha. To prevent ant and cutworm attacks, Sevin 50WP was applied at 5 kg/ha. For seed-borne disease protection, seeds were treated with Vitavex-200 at 5 g per 1 kg of seeds. No chemical fertilizers were applied for the raising of seedlings. Healthy and 30 days old seedlings were transplanted into the experimental field on December 2021. Seedlings were transplanted in the plot and the distance maintained between row to row and plant to plant were 50 cm and 60 cm, respectively and a total of 15 plants were accommodated in each plot. After raising seedlings, various intercultural operations, such as gap filling, weeding, earthing up, irrigation pest and disease control, etc. were accomplished for better growth and development of the chili seedlings. Fruits were harvested at 6 to 7 days intervals during the early ripe stage when they attained marketable size. Harvesting was started in mid-March, 2022 and was continued up to mid-April, 2022. Five plants were selected randomly from each plot for data collection. The recorded data on various parameters were statistically analyzed using MSTAT-C statistical package program. The mean for all the treatments was calculated and an analysis of variance for all the characters was performed difference between treatment means was determined by Duncan`s Multiple Range Test (DMRT) according to Gomez and Gomez, (1984) at a 5% level of significance.

Table 1. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy farm, SAU, Dhaka
AEZ No. and name	AEZ-28, Madhupur Tract
General soil type	Shallow Red Brown Terrace Soil
Soil series	Tejgaon
Topography	Fairly leveled
Depth of inundation	Above flood level
Drainage condition	Well drained

Table 2. Physical and chemical properties of the initial soil of the experimental field

Physical properties	Values
%Sand (2-0.02 mm)	30%
%Silt (0.02-0.002 mm)	40%
%Clay (<0.002 mm)	30%
Textural class	Clay loam
Particle density	2.57 g cc^{-1}
Chemical properties	**Values**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.06
Available P(ppm)	20.0
Available S(ppm)	14.7

RESULTS AND DISCUSSION

Effect of S on the growth parameters of Chili

Different levels of S had significant effects on various growth parameters of Chili. Results showed that in terms of the S effect, the highest plant height, leaves $plant^{-1}$, and number of branches $plant^{-1}$ were recorded from S_1 (20 kg S ha^{-1}) treatment. On the other hand lowest plant height, leaves $plant^{-1,}$ and branches $plant^{-1}$ were found from the control treatment, S_0 (0 kg S ha^{-1}).

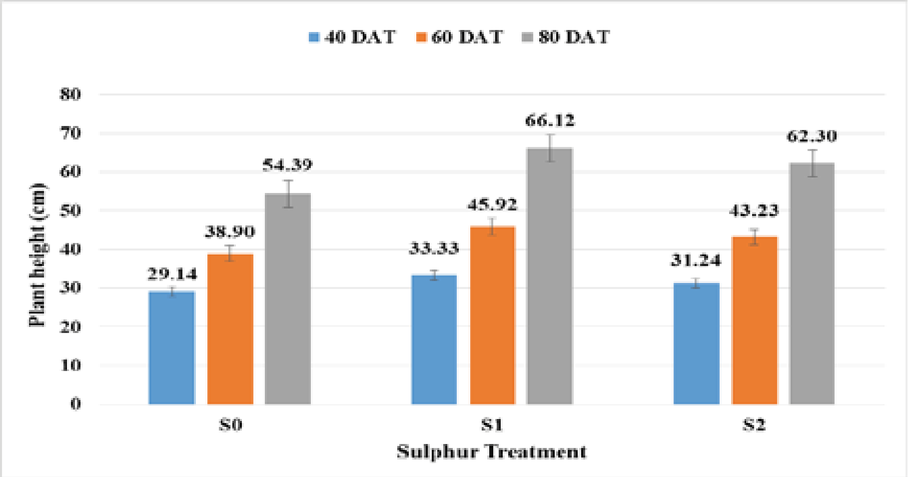

Fig. 1. Effect of sulphur on the plant height of chili at different DAT

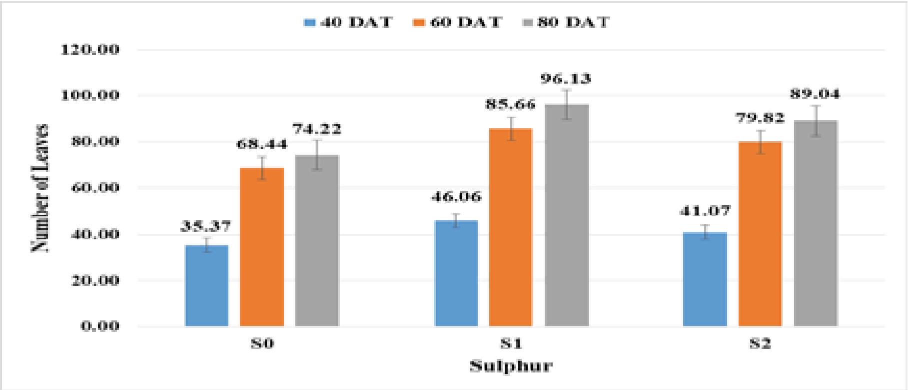

Fig. 2. Effect of sulphur on the number of leaves plant^{-1} at different DAT

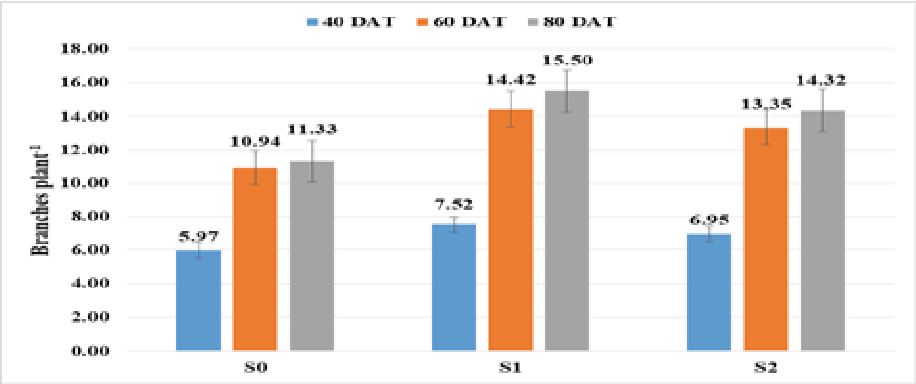

Fig. 3. Effect of sulphur on the number of branches plant^{-1} at different DAT

Effect of S on the yield contributing parameters and yield of Chili

Different levels of S had significant effects on various yield-contributing parameters of Chili. The highest number of flowers plant^{-1} (111.18), number of fruits plant^{-1} (104.57), fruit length (7.10 cm), fruit diameter (0.56 cm), individual fruit weight (1.73 g), average fruit weight plant^{-1} (177.27 g), and fruit yield ha^{-1} (28.21 t) were recorded at S_1 (20 kg S ha^{-1}). In comparison, the lowest number of flowers plant^{-1} (92.45), fruits plant^{-1} (76.29), fruit length (6.04 cm), fruit diameter (0.41 cm), individual weight of fruits (1.51 g), average fruit weight plant^{-1} (119.99 g), and fruit yield ha^{-1} (18.54 t) were obtained from control treatment, S_0 (0 kg S ha^{-1}).

Table 3. Effect of different levels of sulphur application on yield contributing parameters and yield of chili

Treatment	Flowers plant^{-1}	Fruits plant^{-1}	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Average fruits weight plant^{-1} (g)	Fruit yield (t ha^{-1})
S_0	92.45 c	76.29 c	6.04 b	0.41 b	1.51 b	119.99 c	18.54 c
S_1	111.18 a	104.5 a	7.10 a	0.56 a	1.73 a	177.27 a	28.21 a
S_2	102.67 b	96.48 b	6.62 a	0.53 a	1.64 a	159.75 b	25.41 b
Level of significance	**	**	*	*	*	**	**
SE(±)	0.66	0.79	0.15	0.01	0.02	2.90	0.15
CV %	8.14	12.29	9.31	13.58	5.72	7.39	5.04

In a column means having a similar letter(s) are statistically identical and those having a dissimilar letter(s) differ significantly as per 0.05 level of probability. Here, S_0 = 0 kg ha^{-1}, S_1 = 20 kg ha^{-1}, S_2 = 30 kg ha^{-1},SE (±) = Standard Error ; CV (%) = Coefficient of variation

Effect of Zn on the growth parameters of Chili

Different levels of Zn had significant effects on various growth parameters of Chili. Results indicated that the highest plant height, number of leaves plant^{-1}, and number of branches plant^{-1} were obtained from Zn_2 (4.0 kg Zn ha^{-1}). On the other hand, the lowest plant height number of leaves plant^{-1}, and number of branches plant^{-1} were found from control treatment, Zn_0 (0 kg Zn ha^{-1}).

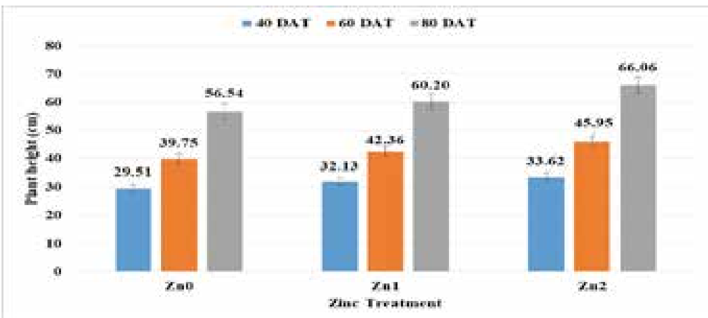

Fig. 4. Effect of Zinc on the plant height of chili at different DAT

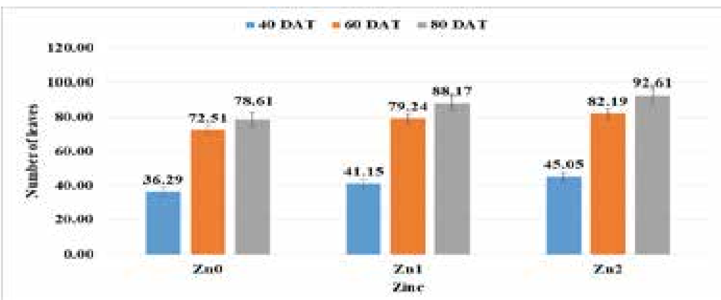

Fig. 5. Effect of zinc on the number of leaves plant^{-1} at different DAT

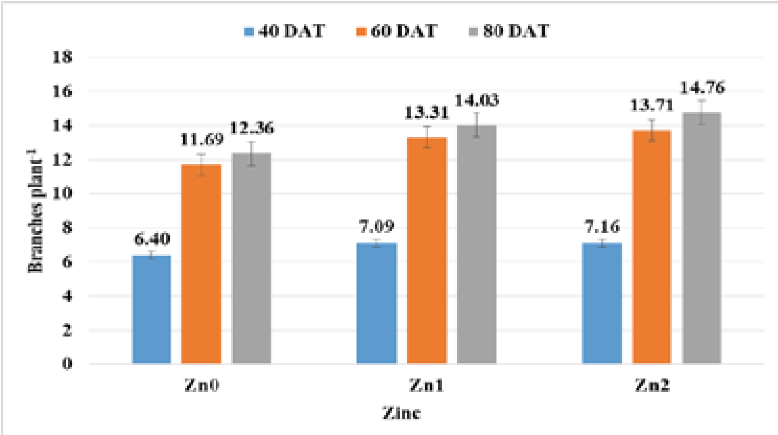

Fig. 6. Effect of zinc on the number of branches plant^{-1} at different DAT

Effect of Zn on the yield contributing parameters and yield of Chili

In the case of different levels of Zn fertilizer application, the highest number of flowers plant^{-1} (109.24), number of fruits plant^{-1} (98.81), fruit length (6.93 cm), fruit diameter (0.58 cm), individual fruit weight (1.69 g), average fruit weight (169.05 g), fruit yield ha^{-1} (27.35 t) were found at Zn_2 (4 kg Zn ha^{-1}). Whereas the lowest number of flowers plant^{-1} (94.64), number of fruits plant^{-1} (80.26), length of fruit (6.01cm), fruit diameter (0.43 cm), individual weight of fruits (1.48 g), average fruit weight (126.99 g), fruit yield ha^{-1} (19.88 t) were found from the control treatment Zn_0 (0 kg Zn ha^{-1}) (Table 4).

Table 4. Effect of different levels of Zinc application on yield contributing parameters and yield of chili

Treatment	Flowers plant^{-1}	Fruits plant^{-1}	Fruit length(cm)	Fruit diameter(cm)	Individual fruit weight (g)	Average fruits weight plant^{-1} (g)	Fruit yield (t ha^{-1})
Zn_0	94.64c	80.26b	6.01b	0.43b	1.48b	126.99c	19.88c
Zn_1	102.41b	98.26ab	6.45 a	0.52a	1.65a	160.97b	24.94b
Zn_2	109.24a	98.81a	6.93a	0.58a	1.69a	169.05a	27.35a
Level of significance	**	**	*	**	*	**	**
SE(±)	0.66	0.79	0.15	0.01	0.02	2.90	1.59
CV %	8.14	12.29	9.31	13.58	5.72	7.39	5.04

In a column means having a similar letter(s) are statistically identical and those having a dissimilar letter(s) differ significantly as per 0.05 level of probability. Zn_0 = 0 kg ha^{-1}, Zn_1 = 2 kg ha^{-1}, Zn_2 = 4 kg ha^{-1} SE (±) = Standard Error; CV (%) = Coefficient of variation

Combined effects of S and Zn Effect of S and Zn on growth parameters of Chili

In the case of, the interaction effect of S and Zn results signified that the highest plant height was observed from S_1Zn_2. Statistically identical results were observed from Sn_2Zn_2 at 40 and 60 DAT. On the other hand, the shortest plant height was recorded from the S_0Zn_0 treatment combination. The maximum number of leaves plant^{-1} was recorded from S_1Zn_2 which was closely followed by S_2Zn_2 at 60 and 80 DAT, whereas the minimum number of leaves plant^{-1} was observed from S_0Zn_0 followed by S_0Zn_1 at 40 and 60 DAT. The highest number of branches plant^{-1} was observed from S_1Zn_2 while the lowest number of branches plant^{-1} was recorded from S_0Zn_0 statistically similar to S_0Zn_1.

Table 5. Combined effects of S and Zn Effect of S and Zn on growth parameters of Chili

Treatment	Plant Height (cm)			number of leaves plant^{-1}			number of branches plant^{-1}		
	40 DAT	60 DAT	80 DAT	40 DAT	60 DAT	80 DAT	40 DAT	60 DAT	80DAT
S_0Zn_0	25.81 i	36.76 hi	51.51 i	32.24 h	64.52 h	68.57 hi	5.70 gh	10.36 g	10.48 gh
S_0Zn_1	29.08 h	37.38 gh	54.60 h	35.63 gh	70.27 g	72.46 h	5.99 g	10.64 fg	10.72 g
S_0Zn_2	32.95 de	41.40 e	59.43 ef	39.72 e	78.26 def	88.55 e	6.64 def	13.32 d	14.18 e
S_1Zn_0	33.04 cde	43.77 de	61.91 d	42.74 d	80.32 cd	93.54 d	6.82 de	13.78 cd	14.63 de
S_1Zn_1	33.30 cd	46.54 c	64.09 bcd	43.55 cd	83.68 bc	94.86 cd	7.16 c	14.43 bc	15.57 cd
S_1Zn_2	35.39 a	50.76 a	74.83 a	53.37 a	92.34 a	101.32 a	8.82 a	15.52 a	16.74 a
S_2Zn_0	29.69 gh	38.54 fgh	57.05 g	36.90 g	75.47 ef	78.70 fg	6.28 fg	11.39 f	12.42 f
S_2Zn_1	32.53 def	40.47 ef	58.70 efg	38.22 f	77.52 de	81.63 f	6.57 ef	11.82 ef	12.78 f
S_2Zn_2	34.02 ab	48.55 ab	66.30 bc	45.07 b	87.12 ab	98.51 ab	7.38 bc	14.88 ab	15.92 bc
Level of significance	*	*	*	*	*	*	*	**	**
SE (±)	1.04	2.38	1.58	1.37	1.27	1.40	0.43	0.30	0.30
CV (%)	5.98	9.15	4.52	2.85	6.16	2.69	8.66	4.34	4.07

In a column means having a similar letter(s) are statistically identical and those having a dissimilar letter(s) differ significantly as per 0.05 level of probability. Here, S_0 = 0 kg ha^{-1}, S_1 = 20 kg ha^{-1}, S_2 = 30 kg ha^{-1} and Zn_0 = 0 kg ha^{-1}, Zn_1 = 2 kg ha^{-1}, Zn_2 = 4 kg ha^{-1}, SE (±) = Standard Error ; CV (%) = Coefficient of variation

Effect of S and Zn on yield contributing parameters and yield of Chili

In the case of, the interaction effect of S and Zn results revealed that the highest number of flowers plant^{-1} (121.26), fruits plant^{-1} (114.09), fruit length (7.79 cm), fruit diameter (0.63 cm), fruit weight (1.78 g), highest average fruit weight (203.49 g), and the highest fruit yield ha^{-1} (33.52 t) was recorded in the treatment combination of S_1Zn_2. On the other hand, the lowest number of flowers plant^{-1} (88.07), number of fruits plant^{-1} (66.26), fruit length (5.90 cm), fruit diameter (0.37 cm), fruit weight (1.51 g), average fruit weight (99.96 g), and fruit yield ha^{-1} (15.59 t) was observed from S_0Zn_0 treatment.

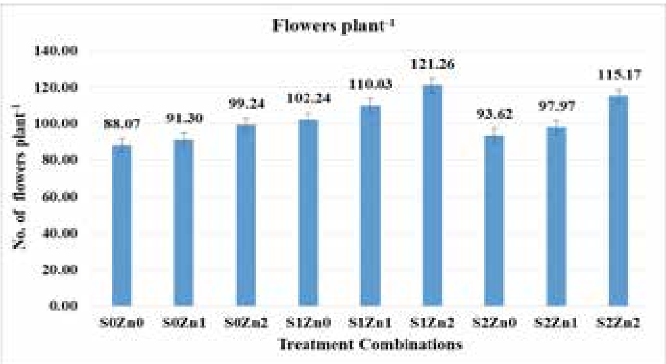

Fig. 7. Combined effect of S and Zn on the number of flowers plant^{-1} of chili

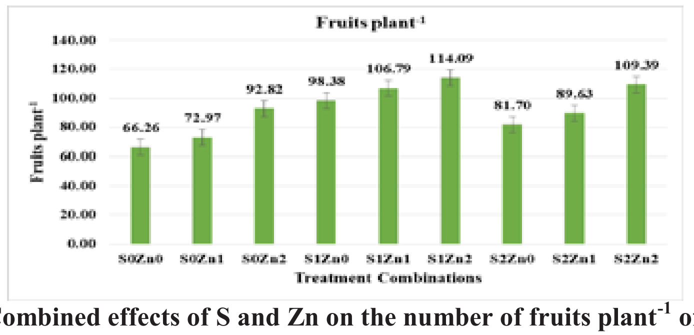

Fig. 8. Combined effects of S and Zn on the number of fruits plant^{-1} of chili

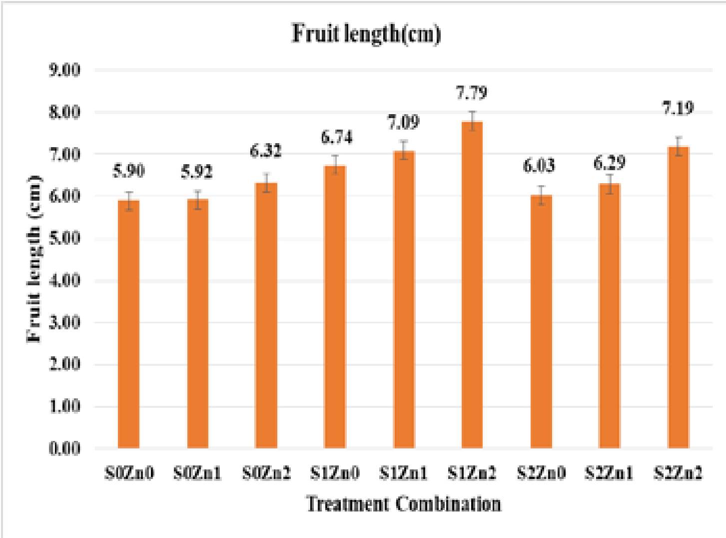

Fig. 9. Combined effects of S and Zn on the number of fruit lengths of chili

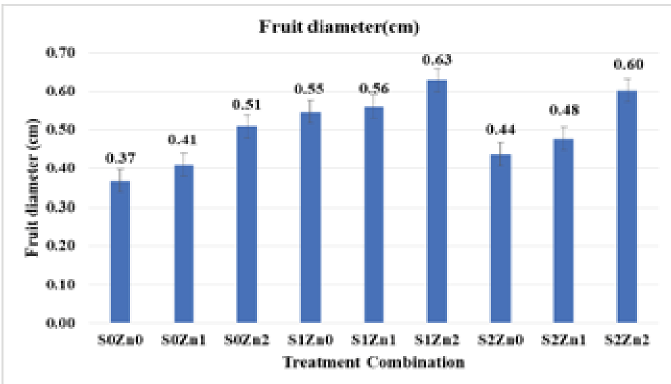

Fig. 10. Combined effects of S and Zn on the number of fruit diameter of chili

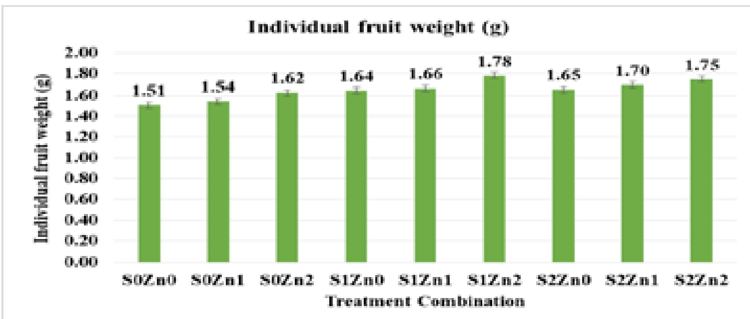

Fig. 11. Combined effects of S and Zn on individual fruit weight of chili

Table 6. Combined Effect of S and Zn on average fruit weight plant^{-1} and fruit yield ton ha^{-1}

Treatment	Average fruit weight plant^{-1} (g)	Fruit yield (t ha^{-1})
S_0Zn_0	99.96 i	15.59 h
S_0Zn_1	112.51 h	17.83 gh
S_0Zn_2	150.62 ef	23.43 de
S_1Zn_0	157.72 de	24.91 cde
S_1Zn_1	177.69 cd	27.69 bc
S_1Zn_2	203.49 a	33.52 a
S_2Zn_0	130.39 g	20.62 ef
S_2Zn_1	147.50 efg	22.21 e
S_2Zn_2	191.15 ab	30.70 ab
Level of significance	**	**
SE	5.03	.27
CV (%)	7.39	5.04

In a column means having a similar letter(s) are statistically identical and those having a dissimilar letter(s) differ significantly as per 0.05 level of probability. Here, S_0 = 0 kg ha^{-1} , S_1 = 20 kg ha^{-1}, S_2 = 30 kg ha^{-1}, Zn_0 = 0 kg ha^{-1} , Zn_1 = 2 kg ha^{-1} , Zn_2 = 4 kg ha^{-1}, SE (±) = Standard Error; CV (%) = Coefficient of variation

CONCLUSION

The individual effect of S and Zn on the growth and yield of chili plants were found significant in this study. In the case of sulphur (S) application, S_1 treatment (20 kg S ha^{-1}) was found suitable dose which gave the highest yield (28.21 t ha^{-1}). In the case of zinc (Zn) application, Zn_2 treatment (4 kg Zn ha^{-1}) was a suitable dose that gave the highest yield (27.35 t ha^{-1}). Finally, for the interactive effect of sulphur (S) and zinc (Zn), the S_1Zn_2 treatment combination (20 kg S ha^{-1} with 4 kg Zn ha^{-1}) was found most suitable dose which gave the highest yield (33.52 t ha^{-1}).

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