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Effect of Sulphur and Zinc Levels on Performance and Factor Productivity of Indian Mustard [*Brassica juncea* L.] *Czern and Cosson*] in Malwa Region

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ABSTRACT: A field study was studied on the nutrient managements through different inorganic sources of Sulphur and Zinc in order to achieve the maximum plant height, number of primary branches, number of secondary branches, dry weight (g), grain/seed yield (q/ha), stover yield (q/ha), biological yield (q/ha), crop growth rate, relative growth and absolute growth rate and total cost of cultivation at harvest at different duration and at harvest stage. Amongst the different treatments for the different parameters *viz*., maximum crop growth rate, relative growth and absolute growth rate. The findings of present study indicated that growth attributes of crop significantly influence by integrated use of inorganic fertilizers during the period. Significantly at harvest the maximum crop growth rate, relative growth and absolute growth rate was recorded with Sulphur levels S4 (60 Kg/ha) in plot T4. Similarly, for the Zinc at harvest the best treatments maximum crop growth rate, relative growth and absolute growth rate was recorded with Zinc levels Z4 (7.5 Kg/ha) in plot T8 under Malwa region of Madhya Pradesh.

Keywords: Growth, Inorganic, Mustard, Nutrient, Physiological, Sulphur, Zinc.

INTRODUCTION

Rapeseed-mustard has a place with the Cruciferae which is the significant oilseed yield of India. The Indian Mustard is viewed as the second most noteworthy oil seed crop in India. On its accountability the Mustard is second to the Soyabean as far as oil seed crops in India.

Oil cake or meal has high nutritional values in animal diet. Seed owing to its high content of good quality protein. In general 55g edible oil per day head is essential for human diet. Mustard oil cake is used as high nutrition food in animal diet. Since mustard seeds contain a quite higher amount of quality protein. For human diet generally 55g edible mustard oil is essential. Globally, in terms of oil sector India accounts 7% of the total global share production, 12% in terms of consumption and 20% share of the oil imports from India (USDA, 2018) which is after the United States, Brazil, China.

India is the largest vegetable oil producer after Argentina, Brazil, China, USA. The oilseeds crops in India alone contributes to about 10% in Agricultural GDP gross rate annually. While on the other hand Soyabean, and rapeseed mustard alone contribute to about 79-88% in terms of total area and production respectively. In India Mustard is mainly grown in north western part in India. The major mustard seed producing states are Uttar Pradesh and Rajasthan. The other states which produces mustard seeds *viz*., Assam, Gujarat, Haryana, Madhya Pradesh and West Bengal. The places where the mustard is easily grown in Madhya Pradesh *viz*., central plateau and Chambal valley region. The district such as Bhind, Morena, Gwalior, Sheopur, Shivpuri. In Madhya Pradesh Mustard is well occupied in regions as stated above and has made significant achievements which indeed is termed as ‘Yellow revolution’.

‘Morena’ district in Madhya Pradesh, shares an area 0.53 mha, production 0.077 mt and productivity of 1453 kg ha^{-1} (SEA, 2018). In the last decades ‘Morena’ district have continued to rule and lead amongst the other states of its territory to take the state production share 27 %, bhind 26%, Gwalior 7%, Mandsaur 6% and other remaining districts accounts to state production share 23%. Comparing other states of India ‘Rajasthan’ have the highest area 2.12 mha, production 2.45 mt and productivity of 1155 kg ha^{-1}. Gujarat on the other hands have the highest productivity 1363 kg ha^{-1} in 0.22 mha area with 0.3 mt of production annually.

Sulphur is considered to be the most vital nutrients for growth and development for the oil seeds crop particularly in 'Mustard'. sulphur is known for its physioilogical functioning's such as synthesis of cysteine, methionine, chlorophyll content in oil crops. Sulphur is regarded to be the key factor for the synthesis of certain vital vitamins *viz*., (B, Biotin and Thiamine) for the metabolism of carbohydrates, protein, and oil formation of flavour in crucifers.

Sulphur in soil is depleted due to the fact that farmers ignorance of recommended doses and application of sulphur is quite unknown. Heavy use of Sulphur also depletes the necessary amount of nutrients which is required for the development of the crop. Sulphur devoid fertilizers' 'fungicides' and 'insecticides' resulted in Sulphur deficiency in soil.

In India with the adoption of intensive farming trends earlier in the 90's has yielded a quite heavy loss in terms of sulphur deficiency in soil due the fact that in the past decade's farmers were performing 'inorganic 'farming. It is well documented that 90's the estimated loss incurred by 40% loss of Sulphur deficiency in soil nearly 130 districts and recently 45% have the Sulphur loss in the Indian soil.

'Zinc' is well known for the proper growth and development in the plant system and also replenishing the vital requirement of Zinc in the soil. The basic knowledge of 'Zinc' and its dynamics in soil must be clearly understood in order to trace out the deficiency mechanism. Zinc deficiency distribution and factors responsible for the 'Zinc' deficient soil must be treated out very carefully by application of 'Zinc' amendments mainly fertilizers that can hold the recommended nutrients into the soil by increasing the Zinc uptake mechanism. Zinc plays an important role in plant system for the proper growth and development. Zinc is an important constituent of several enzymes which regulate various metabolic process in the plant and also influences the formation of several growth hormone like IAA in the plant. Zinc stimulates the pod setting, seed formation and oil synthesis in the seed of mustard and it increase the biological seed/stover. Zinc also have the role in photosynthesis and nitrogen metabolism and it helps in regulating the auxin concentration in plant. It promotes flower setting and help in proper development of fruits. It also helps in carbohydrates transformation and sulphur metabolism.

MATERIALS AND METHODS

The present experiment was conducted at Research Farm, under Mandsaur University, Mandsaur (Madhya Pradesh). Mandsaur (Madhya Pradesh) which is situated at latitude 24°C 4′36.61″N, longitude 75°4′9.46″ E and at an altitude of 442.16 meters above the mean sea level. Mustard [*Brassica juncea* L.] *czern* and *cosson*] DRMRIJ-31 (Giriraj) with sulphur levels S1 0kg/ha, S2 20kg/ha, S3 40kg/ha, S4 60kg/ha and Zinc levels Z1 0kg/ha, Z2 2.5kg/ha, S3 5.0kg/ha, S4 7.5kg/ha, using factorial RBD design with 16 treatment under 3 replications accommodating space of 45 ×15cm, Plot size 3.60 × 4.20 m = 15.12 m^2. The fertilizer application was 60:30:20 NPK kg/ha, respectively. The Gross plot size 4.50 × 5.10m = 22.95 m^2 and net plot size 3.60 × 4.20m =15.12 m^2 with net experimental area 27.60 × 14.40 m^2 = 397.44 m^2. *Physico-chemical* composition of the soil sample of the experimental site. The experiment field was well drained, with black texture soil and physical characters *viz.*, (Fine sand 55; Silt 25; Clay 20)%. The chemical composition *viz*., soil pH 7.79 Blackman's Glass Electrode pH meter. Electrical conductivity (dsm) 0.77; available nitrogen (220.11kgN/hac); Alkaline $KMnO_4$. Available potash (26.92kg K_2O_5/ha) Flame-photometer method. The available phosphoros (370.56 Kg P_2O_5/ha) Olsen extraction method (Olsen *et.al* 1954), available S (10.046 ppm) calcium extracted method and available Zn (1.79 ppm) atomic absorption spectrophotometer. It is more important to elucidate the strategy to combat the 'Zinc' and 'Sulphur' deficiency problem in Indian soil.

Data collection. Observation on various growth parameters *viz.*, plant height, dry weight, branches primary, secondary branch, Crop growth rate (CGR), Relative growth rate (RGR) and Agronomical growth rate (AGR) were collected at harvest. The data on yield characters such as grain yield, the plants from each net plot were harvested and grain yield obtained in each plot were weighed in quintal and represented as (qha^{-1}). Straw/stover yield (q/ha) were recorded at harvest.

The harvest index was assessed at harvest.

$$\text{Harvest Index} = \frac{\text{Economical Yield (seed yield plant kg ha}^{-1}\text{)}}{\text{Total biological Yield (shoot dry weight kg ha}^{-1}\text{)}} \times 100$$

B:C ratio were collected at harvest

$$\text{B: C Cost ratio} = \frac{\text{Net return (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}} \times 100$$

The parameters on as Soil nutrition (NPK, pH, S and Zn) were also recorded.

Statistical analysis. The experiment was laid out in factorial randomized block design with 16 treatments with thrice time replicated. The result were analysed using (ANOVA) as proposed by Fisher, 1950. The significant difference between the mean were tested against the critical difference at 5% level of significance.

RESULT AND DISCUSSION

The data on plant height at final harvest in days, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was **(**150.958) cm. While the minimum was recorded with control plot (134.558) cm. Similarly, the data on plant height at harvest in days, the data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was **(**147.225) cm. While the minimum was recorded with control plot (137.558) cm (Table 1). The interaction effect between Sulphur and Zinc at on plant height at harvest in days, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 Kg/ha) was (159.367) cm. While the minimum was recorded with control plot (126.267) cm (Table 2). These finding are in close vicinity with Chaubey *et al.*(2008); Farhad *et al.* (2010); Kavya *et al.* (2021); Kumar *et al.* (2011).

Significantly, the data on number of primary branches at harvest in days, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (17.683). While the minimum was recorded with control plot (14.898). Similarly, the data on number of primary branches at harvest in days, the data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (16.666). While the minimum was recorded with control plot (15.846). The interaction effect between Sulphur and Zinc at on number of primary branches at harvest in days, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 Kg/ha) was (17.917). While the minimum was recorded with control plot (13.677). These finding are in close similarity Kaur *et al.* (2019); Mani *et al.* (2006); Baudh *et al.* (2012); Dubey *et al.* (2013).

Significantly, the data on number of secondary branches at harvest in days, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (27.584). While the minimum was recorded with control plot (19.708). Similarly, the data on number of secondary branches at harvest in days, the data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was **(**25.223). While the minimum was recorded with control plot (22.243).

The interaction effect between Sulphur and Zinc at on number of secondary branches at harvest in days, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 Kg/ha) was (27.950). While the minimum was recorded with control plot (14.567). These finding are in close similarity Kaur *et al.* (2019); Mani *et al.* (2006); Baudh *et al.* (2012); Dubey *et al.* (2013).

Significantly, the data on dry weight (g) at harvest in days, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (111.508) g. While the minimum was recorded with control plot (90.275) g. Similarly, the data on dry weight (g) at final harvest in days, the data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (25.223). While the minimum was recorded with control plot (22.243).The interaction effect between Sulphur and Zinc at on dry weight (g) at harvest in days, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 Kg/ha) was (27.950) g. While the minimum was recorded with control plot 14.567) g. These finding are in close similarity Kaur *et al.* (2019); Mani *et al.* (2006); Baudh *et al.* (2012); Dubey *et al.* (2013); Jat *et al.* (2008); Farhad *et al.* (2010).

Significantly, the data on crop growth rate (CGR) at harvest in days, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (4.516). While the minimum was recorded with control plot (2.707). Similarly, the data on crop growth rate (CGR) at harvest in days, the data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (4.790). While the minimum was recorded with control plot (2.760) (Table 5). The interaction effect between Sulphur and Zinc at crop growth rate (CGR) at harvest in days, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 Kg/ha) was (0 4.790). While the minimum was recorded with control plot (0.367) (Table 6). These finding are in close conformity with the findings of Kaur *et al.* (2019); Mani *et al.* (2006); Baudh *et al.* (2012); Dubey *et al.* (2013). Jat *et al.* (2008); Farhad *et al.* (2010).

Significantly, the data on crop growth rate (RGR) at 30, 60, 90 and harvest in days, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was 0.075). While the minimum was recorded with control plot (0.026). Similarly, the data on relative growth rate (RGR) at 30, 60, 90 and harvest in days, the data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was **(**0.053). While the minimum was recorded with control plot (0.047). The interaction effect between Sulphur and Zinc at relative growth rate (RGR) at harvest in days, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 Kg/ha) was (0.090). While the minimum was recorded with control plot (0.007). These finding are in close conformity with the findings of Baudh *et al.* (2012); Dubey *et al.* (2013). Jat *et al.* (2008); Farhad *et al.* (2010); Makeen *et al.* (2008); Mani *et al.* (2006).

Significantly, the data on absolute growth rate (CGR) at 30, 60, 90 and harvest in days, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (4.516). While the minimum was recorded with control plot (2.707). Similarly, the data on absolute growth rate (AGR) at harvest in days, the data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (3.388). While the minimum was recorded with control plot (2.760). The interaction effect between Sulphur and Zinc at absolute growth rate (AGR) at harvest in days, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 Kg/ha) was (0.925). While the minimum was recorded with control plot (0.034). Similar finding was with the findings of Kaur *et al.* (2019); Mani *et al.* (2006); Baudh *et al.* (2012); Dubey *et al.* (2013). Jat *et al.* (2008); Farhad *et al.* (2010).

Significantly, the data on seed yield (q/ha), the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was **(**12.003). The data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (9.453). While the minimum seed yield (q/ha) was recorded with control plot (7.801) (Table 3). The interaction effect between Sulphur and Zinc on seed yield (q/ha), at harvest, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 kg/ha) was (13.387). While the minimum seed yield (q/ha) was recorded with control plot (4.810) (Table 4). The results of present investigation strongly support the findings of Upadhyay *et al.* (2016); Verma *et al.* (2012).

The data on stover yield (q/ha), the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (64.101). While the minimum was recorded with control plot (41.783). The data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (57.323). While the minimum stover yield (q/ha) was recorded with control plot (50.961). The interaction effect between Sulphur and Zinc on stover yield (q/ha), at harvest, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 kg/ha) was (66.100). While the minimum stover yield (q/ha) was recorded with control plot (34.627) (Table 4). The results of present investigation strongly support the findings of Upadhyay *et al.* (2016); Verma *et al.* (2012).

The data on biological yield (q/ha), the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (75.058). While the minimum was recorded with control plot (47.458). The data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (65.799). While the minimum biological yield (q/ha) was recorded with control plot (58.058). The interaction effect between Sulphur and Zinc on stover yield (q/ha), at harvest, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 kg/ha) was (77.633). While the minimum biological yield (q/ha) was recorded with control plot (38.753).

The data on harvest index, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was **(**15.962). While the minimum was recorded with control plot (12.819). The data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (14.164). While the minimum harvest index was recorded with control plot (13.226). The interaction effect between Sulphur and Zinc on stover yield (q/ha), at harvest, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 kg/ha) was (17.262). While the minimum harvest index was recorded with control plot (12.484). The results of present investigation strongly support the findings of Upadhyay *et al.* (2016); Verma *et al.* (2012).

Maximum cost of cultivation was 22,450 Rs/ha. calculated in plot T4. The other which were significantly minimum 19,510 Rs/ha. was calculated in plot T3 and also in plot T2 followed with 18,035 Rs/ha. and 16,435Rs./ha. respectively. The results are on line with those of Verma *et al.* (2012).

Maximum gross return 12,000 Rs./ha. was calculated in plot T4. The other which were significantly maximum with respect to gross income were in plot T3 with 9,000Rs./ha. Significantly minimum 6,157 Rs/ha. was calculated in plot T1 (Table 7). The results of present investigation strongly support the findings of Rana *et al.* (2021); Sharma *et al.* (2007). The maximum net return 10,512.00 Rs/ha with C:B ratio 2.227 was calculated in plot T4. Significantly maximum 10,484.83 Rs./ha. with C:B ratio 1.85875 was calculated in plot T3. The results of present investigation strongly support the findings of Rana *et al.* (2021); Sharma *et al.* (2007).

Soil available nutrients. The soil pH, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (7.571) soil pH. While the minimum soil pH was recorded with control plot (6.995). The data observed for soil pH was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (7.505). While the minimum soil pH was recorded with control plot (7.158) (Table 8). The interaction effect between Sulphur and Zinc on soil pH, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 kg/ha) was (7.790). While the minimum soil pH was recorded with control plot S1Z1 (6.190) (Table 9). These finding are in close conformity with the findings of Rana *et al.* (2005); Sharma *et al.* (2003); Sipai *et al.* (2015); Upadhyay *et al.* (2016); Verma *et al.* (2012).

Significantly higher with sulphur levels S4 (60 Kg/ha) was (216.313) nitrogen content While the minimum nitrogen content was recorded with control plot (189.098). The data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was **(**208.084). While the minimum nitrogen content was recorded with control plot (199.065). The interaction effect between Sulphur and Zinc on nitrogen content the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 kg/ha) was (222.353). While the minimum nitrogen content was recorded with control plot S1Z1 (177.693). These finding are in close similarity Kaur *et al.* (2019); Mani *et al.* (2006); Baudh *et al.* (2012); Dubey *et al.* (2013).

The Phosphorus content, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (25.523) phosphorus content. While the minimum phosphorus content was recorded with control plot (18.582). The data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (23.870). While the minimum phosphorus content was recorded with control plot (20.960). The interaction effect between Sulphur and Zinc phosphorus content, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 kg/ha) was **(**26.443). While the minimum phosphorus content was recorded with control plot (14.230). These finding are in close conformity with the findings of Rana *et al.* (2005), Sharma *et al.* (2003); Sipai *et al.* (2015); Upadhyay *et al.* (2016); Verma *et al.* (2012).

The potash content, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (339.394) potash content. While the minimum potash content was recorded with control plot (305.844). The data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (336.723). While the minimum potash content was recorded with control plot (319.859). The interaction effect between Sulphur and Zinc on potash content, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 kg/ha) was (370.460). While the minimum potash content was recorded with control plot (288.057). These finding are in close similarity Kaur *et al.* (2019); Mani *et al.* (2006); Baudh *et al.* (2012); Dubey *et al.* (2013).

The available sulphur, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (9.388) available sulphur. While the minimum available sulphur was recorded with control plot (6.794). The data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (8.716). While the minimum available sulphur was recorded with control plot (7.685) (Table 10). The interaction effect between Sulphur and Zinc on Sulphur content, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5kg/ha) was (10.046). While the minimum available sulphur was recorded with control plot (5.041).

The available zinc, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (1.456) available zinc. While the minimum available zinc was recorded with control plot (0.735). The data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (1.141). While the minimum available zinc was recorded with control plot (1.030). The interaction effect between Sulphur and Zinc on Zinc content, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 kg/ha) was (1.790). While the minimum available zinc was recorded with control plot (0.190). These finding are in close similarity Kapur *et al.* (2010); Kaur *et al.* (2019); Mani *et al.* (2006); Baudh *et al.* (2012); Bepari *et al.* (2020); Dubey *et al.* (2013).

The available EC, the data observed was significantly higher with sulphur levels S4 (60 Kg/ha) was (0.697) potash content. While the minimum available EC was recorded with control plot (0.566). The data observed was significantly higher with Zinc levels Z4 (7.5Kg/ha) was (0.688). While the minimum available EC was recorded with control plot (0.612). The interaction effect between Sulphur and Zinc on available EC, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 kg/ha) was (0.770). While the minimum available EC was recorded with control plot (0.427) (Table 11). These finding are in close similarity Faujdar *et al*. (2008); Nayak *et al*. (2020); Neha *et al.* (2014).

Table 1: Effect of different levels of Sulphur and Zinc on growth characters at harvest in Indian Mustard [*Brassica juncea* (L.) *czern and cosson*].

		Main effect at harvest			
Sr. No.	**Levels of Sulphur**	**Plant height (cm)**	**Number of primary branches**	**Number of secondary branches**	**Dry weight (g)**
T1	S1 (0 Kg/ha) Control	134.558	14.898	19.708	90.275
T2	S2 (20 Kg/ha)	142.117	15.888	23.296	98.217
T3	S3 (40 Kg/ha)	146.608	16.868	25.456	104.750
T4	S4 (60 Kg/ha)	150.958	17.683	27.584	111.508
	SE(m)±	0.222	0.004	0.016	1.016
	C.D. (p=0.05)	0.643	0.013	0.047	0.350
	Levels of Zinc sulphate	**30 DAS**	**45 DAS**	**60 DAS**	**At harvest**
T5	Z1 (0 Kg/ha) Control	137.558	15.846	22.243	85.200
T6	Z2 (2.5 Kg/ha)	144.992	16.262	23.872	113.342
T7	Z3 (5.0 Kg/ha)	144.467	16.565	24.705	86.450
T8	Z4 (7.5 Kg/ha)	147.225	16.666	25.223	119.758
	SE(m)±	0.222	0.004	0.016	1.016
	C.D. (p=0.05)	0.643	0.013	0.047	0.350

Table 2: Interaction effect of different levels of Sulphur and Zinc on growth characters Indian Mustard [*Brassica juncea* (L.) *czern and cosson*].

	Interaction	At harvest							
Sr. No.	(Sulphur × Zinc)	Plant height (cm)		Number of primary branches		Number of secondary branches		Dry weight (g)	
T1	S1Z1	126.267		13.677		14.567		14.567	
T2	S1Z2	140.133		14.687		20.243		20.243	
T3	S1Z3	136.067		15.570		21.567		21.567	
T4	S1Z4	135.767		15.660		22.453		22.453	
T5	S2Z1	132.167		15.730		22.843		22.843	
T6	S2Z2	144.500		15.840		23.057		23.057	
T7	S2Z3	143.767		15.947		23.687		23.687	
T8	S2Z4	148.033		16.037		23.597		23.597	
T9	S3Z1	148.467		16.583		24.580		24.580	
T10	S3Z2	146.233		16.880		24.660		24.660	
T11	S3Z3	146.000		16.960		25.690		25.690	
T12	S3Z4	145.733		17.050		26.893		26.893	
T13	S4Z1	143.333		17.393		26.983		26.983	
T14	S4Z2	149.100		17.640		27.527		27.527	
T15	S4Z3	152.033		17.783		27.877		27.877	
T16	S4Z4	159.367		17.917		27.950		27.950	
	Factors	**C.D.**	**S.E.**	**C.D.**	**S.E.**	**C.D.**		**C.D.**	**S.E.**
	Factor (Sulphur)	0.643	0.013	0.013	0.004	0.047	0.016	0.047	0.016
	Factor (Zinc)	0.643	0.013	0.013	0.009	0.047	0.016	0.047	0.016
	Factor (S × Z)	1.286	0.025	0.025	0.004	0.093	0.032	0.093	0.032

Table 3: Effect of different levels of Sulphur and Zinc on post - harvest studies in Indian Mustard [*Brassica juncea* (L.) *czern and cosson*].

		Post harvest studies (At harvest)			
Sr. No.	Levels of Sulphur	Seed yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Harvest index
T1	S1 (0 Kg/ha) Control	6.157	41.783	47.458	12.819
T2	S2 (20 Kg/ha)	7.709	52.143	59.913	12.990
T3	S3 (40 Kg/ha)	9.003	60.162	68.590	13.101
T4	S4 (60 Kg/ha)	12.003	64.101	75.058	15.962
	SE(m)±	0.024	0.191	0.019	0.004
	C.D. (p=0.05)	0.069	0.553	0.055	0.011
	Levels of Zinc sulphate				
T5	Z1 (0 Kg/ha) Control	7.801	50.961	58.058	13.226
T6	Z2 (2.5 Kg/ha)	8.553	54.307	62.728	13.541
T7	Z3 (5.0 Kg/ha)	9.067	55.598	64.434	13.941
T8	Z4 (7.5 Kg/ha)	9.453	57.323	65.799	14.164
	SE(m)±	0.024	0.191	0.019	0.004
	C.D. (p=0.05)	0.069	0.553	0.055	0.011

Table 4: Interaction effect of different levels of Sulphur and Zinc on Post harvest studies in Indian Mustard [*Brassica juncea* (L.) *czern* and *cosson*].

	Interaction	Post harvest studies							
Sr. No.	(Sulphur × Zinc)	Stover yield (q/ha)		Biological yield (q/ha)		Seed yield (q/ha)		Harvest index	
T1	S1Z1	34.627		38.753		4.810		12.484	
T2	S1Z2	41.707		47.270		6.200		13.157	
T3	S1Z3	44.127		51.230		6.687		13.139	
T4	S1Z4	46.673		52.577		6.930		13.181	
T5	S2Z1	48.933		55.627		7.017		12.597	
T6	S2Z2	51.413		59.220		7.517		12.623	
T7	S2Z3	53.147		61.517		8.073		13.074	
T8	S2Z4	55.077		63.290		8.230		12.982	
T9	S3Z1	58.390		67.087		8.687		12.921	
T10	S3Z2	59.897		68.267		8.990		13.164	
T11	S3Z3	60.917		69.310		9.073		13.087	
T12	S3Z4	61.443		69.697		9.263		13.231	
T13	S4Z1	61.893		70.763		10.690		14.902	
T14	S4Z2	64.210		76.157		11.503		15.220	
T15	S4Z3	64.200		75.680		12.433		16.464	
T16	S4Z4	66.100		77.633		13.387		17.262	
	Factors	**C.D.**	**SE(m) ±**	**C.D.**	**SE(m) ±**	**C.D.**	**SE(m) ±**	**C.D.**	**SE(m) ±**
	Factor (Sulphur)	0.553	0.191	0.055	0.019	0.069	0.024	0.011	0.004
	Factor (Zinc)	0.553	0.191	0.055	0.019	0.069	0.024	0.011	0.004
	Factor (S × Z)	1.107	0.381	0.110	0.038	0.139	0.048	0.022	0.007

Table 5: Effect of different levels of Sulphur and Zinc on different growth rate in Indian Mustard [*Brassica juncea* (L.) *czern and cosson*].

Sr. No.	Levels of Sulphur	Crop growth rate (CGR)	Relative growth rate Ag (RGR)	Absolute or ronomical growth rate (AGR)
T1	S1 (0 Kg/ha) Control	2.707	0.026	0.332
T2	S2 (20 Kg/ha)	1.856	0.060	0.870
T3	S3 (40 Kg/ha)	3.235	0.044	0.384
T4	S4 (60 Kg/ha)	4.516	0.075	1.069
	SE(m)±	0.011	0.003	0.002
	C.D. (p=0.05)	0.033	0.008	0.006
	Levels of Zinc sulphate	**At harvest**	**At harvest**	**At harvest**
T5	Z1 (0 Kg/ha) Control	2.760	0.047	0.433
T6	Z2 (2.5 Kg/ha)	2.795	0.050	0.721
T7	Z3 (5.0 Kg/ha)	3.371	0.052	0.633
T8	Z4 (7.5 Kg/ha)	3.388	0.053	0.870
	SE(m)±	0.011	0.003	0.002
	C.D. (p=0.05)	0.033	0.008	0.006

Table 6: Interaction effect of different levels of Sulphur and Zinc on different growth rate in Indian Mustard [*Brassica juncea* (L.) *czern and cosson*].

Sr. No.	(Sulphur × Zinc) Interaction	Crop growth rate At harvest		Absolute growth rate		Relative growth rate	
T1	S1Z1	0.367		0.034		0.007	
T2	S1Z2	0.397		0.177		0.080	
T3	S1Z3	1.833		0.154		0.033	
T4	S1Z4	1.840		0.154		0.037	
T5	S2Z1	3.517		0.153		0.083	
T6	S2Z2	3.637		0.151		0.017	
T7	S2Z3	1.732		0.612		0.047	
T8	S2Z4	3.330		0.613		0.046	
T9	S3Z1	2.890		0.613		0.039	
T10	S3Z2	2.903		0.141		0.038	
T11	S3Z3	3.557		0.241		0.049	
T12	S3Z4	3.590		0.840		0.049	
T13	S4Z1	4.267		0.827		0.073	
T14	S4Z2	4.243		0.807		0.065	
T15	S4Z3	4.763		0.924		0.077	
T16	S4Z4	4.790		0.925		0.090	
	Factors	**C.D.**	**SE(m) ±**	**C.D.**	**SE(m) ±**	**C.D.**	**SE(m) ±**
	Factor (Sulphur)	0.033	0.006	0.006	0.002	0.008	0.003
	Factor (Zinc)	0.033	0.006	0.006	0.002	0.008	0.003
	Factor (S × Z)	0.066	0.012	0.012	0.004	0.015	0.005

Table 7: Economics of the different treatments in Indian Mustard [*Brassica juncea* (L.) *czern* and *cosson*].

Sr. No.	Treatments	Cost of cultivation	Gross return	Net return	B:C ratio
T1	S1 (0 Kg/ha)	16,000	45,343.25	29,343.25	1.83
T2	S2 (20 Kg/ha)	17,700	50,333.4	32,633.4	1.84
T3	S3 (40 Kg/ha)	19,200	65,928.75	46,728.75	2.43
T4	S4 (60 Kg/ha)	20,800	81,454.75	60,654.75	2.91
T5	Z1 (0 Kg/ha)	16,000	56,659.05	40,659.05	2.54
T6	Z2 (2.5 Kg/ha)	16,300	61,494.25	45,194.25	2.77
T7	Z3 (5.0 Kg/ha)	16,220	64,400.75	48,180.75	2.97
T8	Z4 (7.5 Kg/ha)	16,900	66,885.65	49,985.65	2.95
	SE(m)±	1.810	5.751	13.332	0.003
	C.D. (p=0.05)	5.543	17.612	40.831	0.001

Table 8: Effect of different levels of Sulphur and Zinc on soil available nutrients in Indian Mustard [*Brassica juncea* (L.) *czern and cosson*].

		Soil available nutrients			
Sr. No.	Levels of Sulphur	Soil (pH)	Nitrogen Content (Kgha^{-1})	Phosphorus content (Kgha^{-1})	Potash content (Kgha^{-1})
T1	S1 (0 Kg/ha) Control	6.995	189.098	18.582	305.844
T2	S2 (20 Kg/ha)	7.444	204.423	23.248	337.152
T3	S3 (40 Kg/ha)	7.373	207.854	21.268	323.869
T4	S4 (60 Kg/ha)	7.571	216.313	25.523	339.394
	SE(m)±	0.067	0.765	0.464	1.880
	C.D. (p=0.05)	0.023	2.220	1.345	5.456
	Levels of Zinc sulphate				
T5	Z1 (0 Kg/ha) Control	7.158	199.065	20.960	319.859
T6	Z2 (2.5 Kg/ha)	7.338	205.123	21.381	321.551
T7	Z3 (5.0 Kg/ha)	7.383	205.416	22.410	328.127
T8	Z4 (7.5 Kg/ha)	7.505	208.084	23.870	336.723
	SE(m)±	0.067	0.765	0.464	1.880
	C.D. (p=0.05)	0.023	2.220	1.345	5.456

Table 9: Interaction effect of different levels of Sulphur and Zinc on soil available nutrients in Indian Mustard [*Brassica juncea* (L.) *czern and cosson*].

	Interaction	Soil available nutrients							
Sr. No.	(Sulphur × Zinc)	Soil (pH)		Nitrogen Content (Kgha^{-1})		Phosphorus content (Kgha^{-1})		Potash content (Kgha^{-1})	
T1	S1Z1	6.190		177.693		14.230		288.057	
T2	S1Z2	7.180		193.287		18.440		299.753	
T3	S1Z3	7.280		197.023		19.147		315.773	
T4	S1Z4	7.330		188.387		22.510		319.793	
T5	S2Z1	7.427		195.073		22.863		329.793	
T6	S2Z2	7.450		209.020		23.973		336.167	
T7	S2Z3	7.423		199.213		22.610		335.783	
T8	S2Z4	7.477		214.383		23.547		346.863	
T9	S3Z1	7.523		211.443		23.587		354.227	
T10	S3Z2	7.253		204.407		16.230		327.723	
T11	S3Z3	7.293		208.353		21.440		303.753	
T12	S3Z4	7.423		207.213		23.813		309.773	
T13	S4Z1	7.490		212.050		24.843		314.127	
T14	S4Z2	7.470		213.777		25.197		315.793	
T15	S4Z3	7.533		217.073		25.610		357.197	
T16	S4Z4	7.790		222.353		26.443		370.460	
	Factors	**C.D.**	**SE(m) ±**	**C.D.**	**SE(m) ±**	**C.D.**	**SE(m) ±**	**C.D.**	**SE(m) ±**
	Factor (Sulphur)	0.067	0.023	2.220	0.765	1.345	0.464	5.456	1.880
	Factor (Zinc)	0.067	0.023	2.220	0.765	1.345	0.464	5.456	1.880
	Factor (S × Z)	0.133	0.046	4.439	1.530	2.691	0.927	10.912	3.760

Table 10: Effect of different levels of Sulphur and Zinc on soil available nutrients in Indian Mustard [*Brassica juncea* (L.) *czern and cosson*].

		Soil available nutrients	
Sr. No.	Levels of Sulphur	Available Sulphur (mgkg^{-1})	Availabe Zinc (mgkg^{-1})
T1	S1 (0 Kg/ha) Control	6.794	0.735
T2	S2 (20 Kg/ha)	9.059	1.323
T3	S3 (40 Kg/ha)	7.293	1.072
T4	S4 (60 Kg/ha)	9.388	1.456
	SE(m)±	0.147	0.025
	C.D. (p=0.05)	0.426	0.072
	Levels of Zinc sulphate		
T5	Z1 (0 Kg/ha) Control	7.685	1.030
T6	Z2 (2.5 Kg/ha)	7.829	1.069
T7	Z3 (5.0 Kg/ha)	8.304	1.346
T8	Z4 (7.5 Kg/ha)	8.716	1.141
	SE(m)±	0.147	0.025
	C.D. (p=0.05)	0.426	0.072

Table 11: Interaction effect of different levels of Sulphur and Zinc on soil available nutrients in Indian Mustard [*Brassica juncea* (L.) *czern and cosson*].

Sr. No.	Interaction (Sulphur × Zinc)	Soil available nutrients: Available Sulphur ($mgkg^{-1}$)		Availabe Zinc ($mgkg^{-1}$)	
T1	S1Z1	5.041		0.190	
T2	S1Z2	7.046		0.780	
T3	S1Z3	7.049		0.880	
T4	S1Z4	8.042		1.090	
T5	S2Z1	8.843		1.260	
T6	S2Z2	9.049		1.310	
T7	S2Z3	8.945		1.290	
T8	S2Z4	9.399		1.433	
T9	S3Z1	8.713		1.587	
T10	S3Z2	5.706		0.770	
T11	S3Z3	7.375		0.860	
T12	S3Z4	7.377		1.070	
T13	S4Z1	8.718		1.240	
T14	S4Z2	8.941		1.260	
T15	S4Z3	9.847		1.533	
T16	S4Z4	10.046		1.790	
	Factors	**C.D.**	**SE(m) ±**	**C.D.**	**SE(m) ±**
	Factor (Sulphur)	0.426	0.147	0.072	0.025
	Factor (Zinc)	0.426	0.147	0.072	0.025
	Factor (S × Z)	0.852	0.294	0.145	0.050

CONCLUSION

All the treatments showed significant differences for most of the traits under study. The maximum yield per ha was recorded with sulphur levels S4 (60 Kg/ha) significantly maximum with sulphur levels S4 (60 Kg/ha) and the Zinc levels Z4 (7.5Kg/ha). The interaction effect between Sulphur and Zinc at harvest, the data observed was significantly higher with Sulphur and Zinc levels S4Z4 (40 Kg/ha and 5 kg/ha). While minimum yield per ha was recorded with control plot. Despite the fact that other treatments fairly yielded good production but in terms of economics and cost benefit analysis the above discussed treatments T15 and T16 were cost effective under the present study, as they yielded and generated the desired net income and thus economical for the present study. Therefore, it can be concluded that combination of sulphur levels S4 (60 Kg/ha) and the Zinc levels Z4 (7.5Kg/ha) doses is best suited for the present study. Hence, the above treatment can be suggested as a combination for getting higher yield with greater quantity on sustainable basis.

FUTURE SCOPE

Following future line of work is suggested for obtaining maximum growth and yield for benefit to growers.

I. Since, it was the first year of trail it is suggested that, finding of present study must be tested over years and locations for confirmation.

II. More number of doses with different combinations and concentrations may be tested for improving growth and yield of Mustard

REFERENCES

Baudh, A. K. and Prasad, G. (2012). Interaction effect of different dose of Sulphur and zinc with nitrogen, phosphorus and organic manure on growth and productivity of mustard (*Brassica campestris*). *Indian Journal of Scientific Research*, *1*, 141-5.

Chaubey, M. K., Singh, P. C. and Kumar, R. (2008). Effect of integrated nutrient management on yield of mustard and soil fertility. *Annal. Pl. Soil Res., 10*(2), 143-145.

Dubey, S. K., Tripathi, S. K., Singh, B. (2013). Effect of Sulphur and zinc levels on growth, yield and quality of mustard [*Brassica juncea* (L.) Czern & Coss.]. *Journal of Crop Science and Technology*, *2*(1), 2319-3395.

Farhad, I. S., Islam, M. N., Hoque, S., Bhuiyan, M. S. (2010). Role of potassium and Sulphur on the growth, yield and oil content of soybean (*Glycine max* L.).*An Academic Journal of Plant Sciences*, *3*(2), 99-103.

Faujdar, R. S., Mathur, A. K. and Verma, A. K. (2008). Yield and quality of mustard as fertilizers, *Prentice Hall of India Pvt. Ltd., New Delhi*, 67.

Jat, G., Sharma, K. K., Choudhary, R. (2013). Effect of FYM and mineral nutrients on yield, content and uptake of nutrients in mustard. *Ann. Agric. Res. New Series*, *34*(3), 236-40.

Kaur, M., Kumar, S., & Kaur, A. (2019). Effect of foliar application of nitrogen, phosphorus and sulphur on growth and yield of Gobhi Sarson (*Brassica napus* L.) in central Punjab. *Journal of Oilseed Brassica*, *10*(1), 47-50.

Kavya, P., Singh, S., Hinduja, N., Tiwari, D., and Sruthi, S. (2021). Effect of Foliar Application of Micronutrients on Growth and Yield of Green gram (*Vigna radiata* L.). *Legume Research-An International Journal*, *44*(12), 1460-4.

Kumar, S., Tewari, S. K., & Singh, S. S. (2011). Effect of sources and levels of sulphur and spacing on the growth, yield and quality of spring sunflower (*Helianthus annuus*). *Indian Journal of Agronomy*, *56*(3), 242-246.

Mani, D., Kumar, A., Kumar, C., & Kumar, R. (2006). Effect of ammonium sulphate and DAP on yield and sulphur and phosphorus uptake by mustard. *New Agriculturist*, *17*(1&2), 163-166.

SEA. (2018). Publishers (Solvent Extractors' Association of India).

Upadhyay, Y. O. G. E. S. H., Swaroop, N. A. R. E. N. D. R. A., Sahu, Y. K., Dhruw, S. S., & Verma, P. D. (2016). Interaction effects of different doses of sulphur and zinc with npk on physic-chemical properties of soil in yellow mustard (*Brassica compestris* L.) Cv. Krishna super goldi. *Int. J. Agril. Sci. Res.*, *6*(2), 215-220.

USDA (2018). Oilseeds: world markets and trade. United Stated of Department of Agriculture, Foreign Agricultural Service. Available at *Usdagov / psdonline / circulars / oilseeds.*

Verma, C. K., Prasad, K., & Yadav, D. D. (2012). Studies on response of sulphur, zinc and boron levels on yield, economics and nutrients uptake of mustard [*Brassica juncea* (l.) czern & coss.]. *Crop Research*, *44*(1and 2), 75-78.

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