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Response of Sulphur, Zn and FYM Application on Growth, Yield and Nutrient uptake of Mustard (*Brassica juncea* (L.) Czern and Coss.)

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Abstract

The experiment was conducted at the research farm of Department of Agricultural Chemistry and Soil Science, Udai Pratap College (Automous), Varanasi (Uttar Pradesh), during *rabi* season of 2018–2019 in RBD and replicated thrice. The sowing was done on 29th November 2018. The treatments comprised of three Sulphur levels (20, 40 and 60 kg S ha^{-1}), two Zinc levels (2.5 and 5 kg Zn ha^{-1}) under two levels of FYM (0 and 10 t ha^{-1}) with RDF and control. The mustard variety *Varuna* was used as a test crop. Application of maximum doses of 60 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF produced maximum plant height (170.31 cm), number of branches $plant^{-1}$ (8.08), number of siliqua $plant^{-1}$ (117.75), grain yield (855 kg ha^{-1}), straw yield (2480 kg ha^{-1}). whereas control was minimum pronounced, plant height (145.38 cm), number of branch $plant^{-1}$ (5.25), number of siliqua $plant^{-1}$ (66.33), grain yield (580 kg ha^{-1}) and straw yield (878 kg ha^{-1}). However, growth parameters, grain yield, stover yield and 1000 grain weight (g) and nutrient uptake increased significantly with increasing dose of Sulphur up to 40 kg and Zn up to 5 kg ha^{-1}.

Keywords: FYM, nutrient uptake, mustard, sulphur, zinc, yield

1. Introduction

Indian mustard (*Brassica juncea* L.) is a major oilseed crop belonging to Cruciferae family (Singh et al., 2022, Meena et al., 2021). Mustard is the third most important oilseed crops after soybean and groundnut. In India rapeseed–mustard is grown on an area of 6.78 mha with production and productivity of 9.12 mt and 1345 kg ha^{-1}, respectively (Anonymous, 2020). Mustard is nutritionally very rich and its oil content varies from 37–49% (Tiwari et al., 2021). Fermented mustard has been shown to exhibit various health benefits and disease prevention effects (Oh et al., 2017). The oil cake is used as cattle feed and manure, which contains about 4.9% nitrogen, 2.5% phosphorus and 1.5% potash (Singh et al., 2014a). Sulphur is regarded to be the key factor for the synthesis of cystein, methionine, chlorophyll certain vital vitamins viz., (B, Biotin and Thiamine) for the metabolism of carbohydrates, protein, and promotes oil formation and flavour in crucifers (Singh et al., 2022, Najar at al., 2011, Das et al., 2016). In general mustard growing Indian soils are deficient in S (Meena et al., 2017). Therefore, adequate S management is very critical for higher crop productivity and quality. Its deficiency may be responsible for poor flowering, fruiting, cupping of leaves, reddening of stems and petiole and stunted growth (Meena et al., 2021). The Zn is very important essential micronutrient that affects the mustard productivity and quality (Meena et al., 2021). It is involved in most of plant metabolic functions like production of auxin, enzymatic and Physiological activities and control the development of the shoot. From the last decades extensive Zn deficiency was reported in many areas, causing decrease in crop yields, amount of Zn in cereal grain and diminishes its nutritional quality (Sadeghzadeh, 2013). Singh et al. (2022) reported that maximum growth and yield were recorded with 7.5 Kg ha^{-1} Zinc and 60 Kg ha^{-1} Sulphur. Uses of organic sources are one of the yield improving soil amendments, which mediate the plant nutrient dynamics, microbial population and diversity (Singh et al., 2019). Manures are definitely helpful in providing energy for microbes, reducing the losses of nutrient and moisture from soil, increases the organic matter content and water holding capacity and ultimately improving overall soil health, while increases productivity, maintaining

a better energy and environmental balance as well (Meena et al., 2021, Alam et al., 2014, Singh et al., 2014b). During the mineralization process of organic substances, micro-organism produce organic acids, which are reduced soil pH, increase plant nutrient concentrations and enhancement of biological activities in soil (Dotaniya and Meena, 2013, Meena et al., 2017). These release nutrients slowly but steadily for longer duration thus preventing their losses by leaching and other means. Similarly, organic materials also having buffering effect on soil reaction (Meena et al., 2021). The combined application of FYM and mineral nutrients further improved the nutrient uptake mainly due to better growth and dry matter accumulation and also increases oil and protein content (Singh et al., 2017, Alam et al., 2014). The combined application of l0 t FYM ha^{-1} and 40 kg S ha^{-1}+25 kg $ZnSO_4$ ha^{-1}+50 kg $FeSO_4$ ha^{-1} was found to be optimum for nutrient uptake in mustard crop (Jat et al., 2013). The experiment was conducted with an objective to examine the optimum doses of Sulphur, Zn and FYM application on Mustard under sub-tropical climate of eastern Uttar Pradesh.

2. Methods and Materials

A field experiment was carried out during *rabi* season in 2018 at the research farm of Department of Agricultural Chemistry and Soil Science, Udai Pratap College (Automous), Varanasi, Uttar Pradesh. Varanasi is situated at an altitude of 80.71 m above mean sea level and located between 25°14' and 25°23' N latitude and 82°56' and 83°03' E longitude and falls in a semi-arid to sub humid climate. The distribution of average annual rain fall is 966.50 cm of which 80% from June to September, 5.7% from October to December, 3.3% from January to February and 3.0% from March to May. The mean ambient temperature ranged between 8.9° and 39.85°C, respectively, whereas relative humidity ranged between 21.24 and 87.30%.

The experimental soil had bulk density 1.40 Mg m^{-3}, pH 8.00 1:2.5 soil: water suspension (Sparks, 1996), Electrical Conductivity EC 0.21 dsm^{-1} (Sparks 1996), Organic carbon 0.39% by rapid titration methods of Walkley and Black (1934), Available N 260.25 kg ha^{-1} alkaline potassium permanganate (Subbiah and Asija, 1956), Available P 12.0 kg ha^{-1} sodium bicarbonate ($NaHCO_3$) extractable-P (Olsen et al., 1954) by spectrophotometer, Available K 190.40 kg ha^{-1} ammonium acetate-extractable K (Hanway and Heidal, 1952) by flame photometer and Available S 14.38 kg ha^{-1} 0.15% calcium chloride (CaCl2) extractable S (Chesin and Yien, 1950). Nitrogen content in plant samples were estimated by semi-auto nitrogen analyzer after digesting the plant material by H_2SO_4. Total P, K and S contents were determined after digesting the plant material with diacid mixture on the ratio of 9:4 (HNO_3:$HClO_4$) (Bhargava and Raghupathi, 1993).

The experiment consisted 7 treatment combinations laid out in randomized block design RBD. The mustard variety used in the experiment was Varuna evolved in 1954 from U.P. Institute of Agriculture Science, Kanpur (presently known as CSAUA&T, Kanpur). Mustard crop variety 'Varuna' was sown on 29 November 2018 with seed rate of 5 kg ha^{-1} at spacing of 45×15 cm^2, weed control was carried out by one mechanical-cum-manual weeding at 4 weeks' stage of the crop. Recommended agronomic practices were followed to raise the crop. The data noted were analyzed following standard statistical procedure to draw a valid conclusion.

Table 1: Details of treatments

Treatments	Treatment details
T_1	Control
T_2	20 kg S ha^{-1}+2.5 kg Zn ha^{-1}+RDF
T_3	20 kg S ha^{-1}+2.5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF
T_4	40 kg S ha^{-1}+5kg Zn ha^{-1}+RDF
T_5	40 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF
T_6	60 kg S ha^{-1}+5 kg Zn ha^{-1}+RDF
T_7	60 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF

3. Results and Discussion

3.1. Effect of S, Zn and FYM application on growth parameters of mustard

Result pertaining to the effect of different levels S, Zn and FYM on growth parameters are presented in Table 2. Maximum plant height (25.00 cm), (68.75 cm) and (170.31 cm.) was recorded with application of 60 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF treatment (T_7) which was statistically at par with the treatments T_5- 40 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF whereas, minimum plant height (19.58 cm), (57.50 cm) and (145.38 cm) was recorded under control (T_1) after 30, 60 and 90 days of sowing respectively. The maximum number of branches $plant^{-1}$ (5.00) and (8.08) was observed with a dose of 60 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF treatment (T_7) and minimum number of branches $plant^{-1}$ (3.29) and (5.25) were recorded 60 and 90 days after sowing (DAS) under control treatment (T_1). Maximum plant height and number of branches $plant^{-1}$ was recorded with application of 60 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF (T_7) might be due to balance nutrition under the favorable environment helped in increasing growth and branches of the mustard crop at different growing stages. Significantly higher number of branches was found with application of S, Zn and FYM might be attributed due to higher and continuous supply of nutrients. It was evident that addition of FYM+S+Zn had significant increasing effect on number of primary branches. Branching is a major yield contributory character. Similar findings were reported by Tiwari et al. (2021).

Maximum number of siliqua $plant^{-1}$ (Table 2) (117.75) was recorded with the application of 60 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF (T_7) which is at par with treatments T_5- 40 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF (115.41) whereas

Table 2: The data demonstrated synergistic effect of S, Zn and FYM fertilization on growth and yield characters of mustard

Treatment	Plant Height			No. of branches plant^{-1}		No. of siliqua plant^{-1}	No.of seeds siliqua^{-1}	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
	30 DAS	60 DAS	90 DAS	60 DAS	90 DAS					
T_1	19.58	57.50	145.38	3.29	5.25	66.33	7.23	4.12	580	878
T_2	21.83	60.25	145.45	3.33	5.91	79.41	10.48	4.32	616	1264
T_3	23.75	60.15	164.25	3.60	6.51	108.00	13.58	4.56	634	1675
T_4	23.00	63.75	164.16	3.41	6.00	88.25	12.66	4.49	632	1430
T_5	24.91	66.83	167.70	4.95	6.88	115.41	14.60	4.67	770	2150
T_6	24.58	64.50	165.43	4.38	6.75	114.62	14.34	4.60	741	1835
T_7	25.00	68.75	170.31	5.00	8.08	117.75	15.85	4.74	855	2480
SEm ±	0.59	1.85	0.72	0.158	0.378	7.864	0.299	0.13	0391	0410
CD (p=0.05%)	1.77	5.72	2.15	0.48	1.15	24.23	0.92	0.36	1020	1265

T_1: Control; T_2: 20 kg S ha^{-1}+2.5 kg Zn ha^{-1}+RDF; T_3: 20 kg S ha^{-1}+2.5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF, T_4: 40 kg S ha^{-1}+5 kg Zn ha^{-1}+RDF; T_5: 40 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF; T_6: 60 kg S ha^{-1}+5 kg Zn ha^{-1}+RDF; T_7: 60 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF (RDF=Recommended doses of fertilizer)

minimum number of siliqua plant^{-1} (66.33) was recorded under control treatment (T_1). Maximum number of seeds siliqua^{-1} (15.58) recorded with T_7 and minimum number of seeds siliqua^{-1} (7.23) observed in control. Significant effect of treatment T_7 (60 kg S ha^{-1}+5kg Zn ha^{-1}+10 t FYM ha^{-1}) over the other treatment was observed at all growth and yield attributes. The increase in growth parameters may be attributed mainly due to the fact that sulphur application improved the nutritional environment for plant growth at active vegetative stage as a result of improvement in root growth, cell multiplication, elongation and cell expansion in the plant body which ultimately increased the plant height and branches plant^{-1}.. As a result, the number of siliqua plant^{-1} increased as the number of branches increased. Plants that are well supplied with sulphur will have a larger photosynthesizing area, accumulating higher quantities of photosynthates that will be translocated to the sink site, siliqua and seeds, with higher quantities being accumulated in the siliqua and seeds, increasing the size of the siliqua, the number of seeds siliqua^{-1}, and the test weight of seeds. Similar finding was also reported by Indira et al. (2021).

3.2. Effect of S, Zn and FYM application on yield parameters of mustard

Data (Table 2) showed maximum seed yield (855 kg ha^{-1}) and stover yield (2480 kg ha^{-1}) was recorded with the application of 60 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF which is at par with the application of 40 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF treatment (T_5) with seed yield (770 kg ha^{-1}) and stover yield (2150 kg ha^{-1}) and lowest yield was recorded under control (T_1). This might be due to S, Zn and FYM application coupled with transport of photosynthesis toward reproductive structure might have increased the yield attributes. Significantly higher grain yield was recorded in 60 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1} treated plots might be due to increased fertility (Singh and Pal, 2011). The maximum test weight of mustard crop (4.74 g) was found in treatment T_7-60 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF and at par with (4.67 g) treatment T5- 40 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF and minimum test weight (4.12 g) was recorded in under control. Seed yield and test weight increased due to enhanced rate of photosynthesis and carbohydrate metabolism as influenced by sulphur application. Sulphur, augmented the translocation of photosynthate to sink site. Similar finding was also reported by Meena et al. (2021).

3.3. Effect of S, Zn and FYM application on nutrient uptake of mustard crop

Data (Figure 1) showed that the application of S, Zn and FYM with RDF had significant effect on nutrient uptake of mustard. The total N, P and K uptake by mustard was increased considerably with application of 60kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF in treatment (T_7) over the control. An application of 60 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF was found significantly maximum uptake of total nitrogen

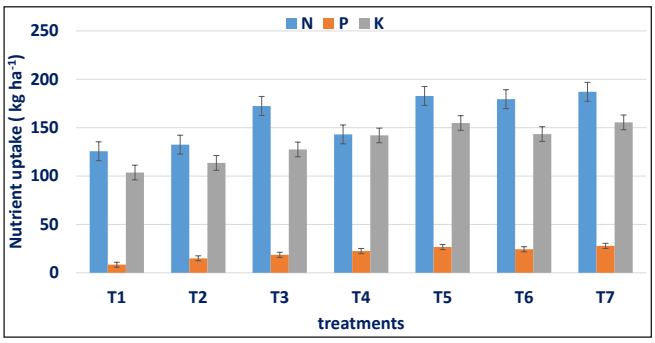

Figure 1: Measuring fibre traits

(187.00 kg ha^{-1}), phosphorous (27.80 kg ha^{-1}) and potassium (155.46 kg ha^{-1}) and followed by the application of 40 kg S ha^{-1}+5 kg Zn ha^{-1}+10 t FYM ha^{-1}+RDF in treatment (T_5) was noted uptake of total nitrogen (182.80 kg ha^{-1}), phosphorous (26.73 kg ha^{-1}) and potassium (154.83 kg ha^{-1}) as compare to control and the minimum uptake of total-N (125.60 kg ha^{-1}), P (8.40 kg ha^{-1}) and K (104.50 kg ha^{-1}) was recorded in control (without fertiliser). The uptake may be due to profused vegetative and increase nutrient concentration. Because of the combined effect of S and Zn, the bioavailability of all nutrients in seed and stover was significantly increased. When S and Zn were used in combination with FYM, the optimum uptake of N, P, K, S and Zn was observed (Sipai et al., 2017, Singh et al., 2017).

4. Conclusion

The suitable dose of Sulphur, zinc and FYM was observed as 40 kg, 5 kg and 10 t ha^{-1}, respectively for mustard crop in irrigated ecosystem of eastern Uttar Pradesh. But application of S @ 60 kg ha^{-1}+Zn @ 5 kg ha^{-1} combined with FYM @ 10 t ha^{-1} generated the maximum growth, yield attributes and yield as well as nutrient uptake by mustard.

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