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Effect of Sulphur and Zinc Nutrition on Growth and Yield Performance of Mustard (*Brassica juncea*. L.) and Soil Properties

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ABSTRACT

An experiment was undertaken on sandy loam soil at the research plot of Udai Pratap Autonomous College Varanasi with mustard variety VARUNA as a test crop during *Rabi* season (2019-2020) to study the effect of Sulphur and zinc nutrition on the growth and yield performance of mustard (*Brassica juncea* L.) and soil properties. The experiment comprised of T_1 (control), T_2 (NPK + 8 kg Zn ha^{-1}), T_3 (NPK + 10 kg Zn ha^{-1}), T_4 (NPK + 12kg Zn ha^{-1}), T_5 (NPK + 40 kg S ha^{-1}), T_6 (NPK + 40kg S + 8 kg Zn ha^{-1}), T_7 (NPK + 40 kg S + 10 kg Zn ha^{-1}). Significantly higher plant height (141.62 cm), number of branches (80.40 plant^{-1}), number of seed siliqua^{-1} (14.87), number of siliqua plant^{-1} (117.33 cm), seed yield (13.49 q ha^{-1}) and stover yield (38.35 q ha^{-1}) and nutrients consumption was recorded where 40 kg S + 10 kg Zn ha^{-1} was applied. Application of 40 kg S + 10 kg Zn ha^{-1} registered significantly higher nutrient uptake (NPK S) and soil available nutrients (NPK S and Zn).

***Key words*: Soil properties, Soil fertility, Nutrient uptake, Mustard, Growth, Yield

Among oilseed crops, after soybean (*Glycine max*) and palm (*Elaeis guineensis*), Rapeseed-mustard is the third most prominent crop. India produces around 6.7mt of rapeseed-mustard next to China (11-12mt) and the European Union (10–13mt) with a significant contribution to the world rapeseed-mustard industry. In India mustard (*Brassica juncea* L.) is mostly cultivated in states like Rajasthan, UP, Haryana, Madhya Pradesh, and Gujarat. Apart from that, it is also cultivated in south Indian states like Karnataka, Tamil Nadu, and Andhra Pradesh. This crop can be cultivated under both irrigated and rainfed conditions. Proper nutrient management under mustard increases the seed and oil yields by improving the setting pattern of siliqua on branches, the number of siliqua plant^{-1}, and other yield attributes. Sulphur is a vital component of essential amino acids. In general, the amount of S taken up to produce one ton of economic yield (main produce) is considered to be 12 kg for oilseeds. Sulphur fertilization significantly improves various quality parameters within the plant system. Application of S in combination with balanced amounts of other nutrients significantly increased the oil content of *Brassica* spp. (5-6%) and also the protein content. Zinc is one of the first micronutrients recognized as essential for plants that are transported to plant root surface through diffusion [1]. Zn is a micronutrient and in case of its severe deficiency, the symptoms may last throughout the entire crop season [2]. Zn deficient plant also appears to be stunted [3] as a result approximately 2 billion people suffer from Zn deficiency all over the world [4]. The grain yield can be improved by the addition of Zn fertilization [1]. The highest stover yield (2770 kg ha^{-1}) with Zn and almost the same trend of seed yield [5]. The seed yield can be improved by the addition of Zn fertilization. Keeping above mentioned facts in mind, this experiment has been undertaken to evaluate the effect of Sulphur and zinc nutrition on the growth and yield performance of mustard (*Brassica juncea* L.) and soil properties.

MATERIALS AND METHODS

This field experiment was carried out in Rabi season (2019-20) at the agricultural form of U. P. Autonomous College, Varanasi developed on alluvium deposited soil. The soil was sandy clay loam in texture, slightly saline and non-alkaline in reaction. The initial physiochemical properties of experimental soil were bulk density 1.42 g cm^{-3}, particle density 2.65 g cm^{-3}, pH (1:2.5) 7.85, EC 0.21 dS m^{-1}, organic carbon 0.44%, water holding capacity 43.5%, available nitrogen 259.26 kg ha^{-1}, available phosphorus 12.5 kg ha^{-1}, available potassium 159.26 kg ha^{-1} and available Sulphur 14.58 kg ha^{-1}. The various treatments applied to the mustard crop were Control (T_1), 8 kg Zn ha^{-1} + RDF (T_2), 10 kg Zn ha^{-1} + RDF (T_3), 12 kg Zn ha^{-1} + RDF (T_4), 40 kg S ha^{-1} + RDF (T_5), 40 kg S ha^{-1} + 8 kg Zn ha^{-1} + RDF (T_6) and40 kg S ha^{-1} + 10 kg Zn ha^{-1} + RDF (T_7). The treatments were triplicated in a randomized block design. The recommended dose for mustard was 60:30:40

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kg $N:P_2O_5:K_2O$ ha^{-1}. The crop received a differential dose of Zn and S from inorganic fertilizer as per treatments. Nitrogen from urea was given as 50% basal, 25% after 45days of transplanting and 25% after 60 days. The full dose of P, K Zn and S through single super phosphate, muriate of potash, zinc oxide and elemental Sulphur were applied at the time of sowing as basal dressing. Soil samples from 0-15 cm depth were collected in a plastic bag from individual plots at 30 DAT and after harvest of the crop. One soil sample of each plot was air-dried, processed to pass through a 2mm round hole sieve and analyzed for oxidizable organic carbon (1N $K_2Cr_2O_7$), available N (0.32% alkaline $KMnO_4$ oxidizable), P (0.5 M $NaHCO_3$ extractable), K (1N neutral ammonium acetate extractable) S (0.15% $CaCl_2$) and S (Turbidimetric) following the methods described by Walkley and Black method [6], Subbiah and Asija [7], Olsen's *et al.* [8], Hanway and Heidel [9] respectively. Soil pH was determined in 2:1 soil: water suspension with the help of glass electrode in digital pH meter and electrical conductivity of soil was measured in the supernatant liquid of soil water suspension (1:2) by conductivity bridge [10]. Bulk density in undisturbed samples collected with metal cores of 4.2 cm diameter and 5.8 cm height was measured [11]. Variety VARUNA of mustard was selected as the test crop. Five plants are marked randomly in each replicated plot and height was measured from the base of the plant to the tip of the uppermost fully matured and stretched leaf before the emergence of siliqua and from the base of the plant to the tip of siliqua after its emergence for calculating mean plant height at 30 and 120 days after sowing. After harvesting and threshing, the weight of the grain was recorded. The straw yield was calculated by subtracting grain yield from biological yield. The number of branches leaves per plant and oil content in seeds were also recorded. Plant samples (grain and leaf) drawn at harvesting were dried in shade and then kept in an oven at 70°C for 12 hours to make them free from moisture. After there, samples were grinded and the total P, K and S content in plant samples were determined by digesting the samples with di–acid (HNO_3:$HClO_4$ in 10:4) mixture [10] while N and Zn were determined by chromic acid method [12], respectively. Plant uptake of NPKS and Zn were computed by multiplying the yield with the respective nutrient content. The data collected from the field and laboratory were analyzed statistically using the standard procedure of randomized block design [13]. Critical difference and standard error of the mean were calculated to determine the significance among treatment means.

RESULTS AND DISCUSSION

Effect of Sulphur and zinc on growth and yield attributes

The plant height and number of branches plant^{-1} was increased with the increasing the amount of Sulphur and Zn. The maximum value of both parameters was recorded with the application of 40 kg S ha^{-1} + 10 kg Zn ha^{-1} (T_7) which was significantly superior over the rest of the doses of Sulphur and zinc at both the growth stages (Table 1). Maximum plant height and the number of branches plant^{-1} were recorded with the application of 40 kg S ha^{-1} + 10 kg Zn ha^{-1} (T_7) might be due to balance nutrition, biosynthesis of Indole acetic acid (IAA) and accumulation of the chlorophyll content [14].

Table 1 Effect of Sulphur and Zn application on plant height (cm) and number of branches plant^{-1}

Treatment	Plant height (cm)			Number of branches plant^{-1}	
	Days after sowing			Days after sowing	
	30 DAS	60 DAS	90 DAS	60 DAS	90 DAS
T_1	19.97	49.86	101.66	10.77	41.40
T_2	20.15	51.54	105.67	12.78	42.78
T_3	21.26	52.56	111.68	13.80	47.79
T_4	21.54	55.80	116.80	14.58	58.59
T_5	21.68	62.26	128.89	15.39	60.18
T_6	21.80	63.60	131.87	16.20	69.60
T_7	21.98	67.06	141.62	18.00	80.40
SEm±	0.1598	0.6898	0.1206	0.0811	0.3065
CD (5%)	0.4924	2.1256	0.3717	0.2498	0.9444

Table 2 Effect of Sulphur and Zn application on number of siliqua plant^{-1}, number of grain siliqua^{-1}, grain and stover yield (q ha^{-1}) of mustard crop

Treatment	Number of siliqua plant^{-1}	Number of grains siliqua^{-1}	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})
T_1	50.23	6.21	4.10	19.87
T_2	65.86	8.11	6.95	21.95
T_3	79.13	9.48	7.67	24.55
T_4	100.13	10.39	9.40	26.10
T_5	109.20	11.56	10.95	28.60
T_6	113.86	13.22	12.60	32.87
T_7	117.33	14.87	13.49	38.35
SEm±	2.2884	0.3183	0.5595	0.6799
CD (5%)	7.0512	0.9808	1.7240	2.0951

The increasing level of Sulphur and zinc up to 40 kg S ha^{-1} and 10 kg Zn ha^{-1} significantly increased the number of grain siliqua^{-1}. Maximum values (14.87) were observed with the application of 40 kg S ha^{-1} +10 kg Zn ha^{-1} which was significantly higher to control and other lower doses (Table 2) [15-17]. Application of 40 kg S ha^{-1} + 10 kg Zn ha^{-1}(T_7) recorded a significantly higher number of siliqua plant^{-1} (117.33) of mustard as compared to control and other treatments but statistically at par with 40 kg S ha^{-1} + 8 kg Zn ha^{-1} + RDF. Increases in siliqua plant^{-1} and seed siliqua^{-1}, were higher under the higher rate of Sulphur and Zinc because of the higher translocation of food material for the formation of seeds [18-19]. Application of Zn alone or in combination with Sulphur increased the grain and stover yield of mustard significantly over control (Table 2). Further, the yield was significantly superior under the conjoint use of Zn and S over zinc alone. A significant increase in grain and stover yield of mustard was recorded up to 40 kg S ha^{-1} + 10 kg Zn ha^{-1} (T_7) applications. Under the present study, maximum yield (13.49q ha^{-1}) was observed with 40 kg S ha^{-1} + 10 kg Zn ha^{-1} which were 23.24 per cent higher than control. The increase in yield might be due to biosynthesis of indole acetic acid (IAA) influenced by Sulphur and zinc application led by the initiation of primordial for reproductive parts and better flowering and fruiting [20]. Notably, maximum grain yield was recorded in 40 kg S ha^{-1} + 10 kg Zn ha^{-1} treated area might be also due to increased fertility [21].

Table 3 Effect of Sulphur and Zn application on nutrients (NPK) uptake (kg ha^{-1}) under mustard crop

Treatment	Nutrient uptake (kg ha^{-1})		
	N	P	K
T_1	108.16	7.80	71.50
T_2	110.61	16.20	74.13
T_3	112.67	19.40	77.12
T_4	115.88	23.50	80.07
T_5	119.10	25.60	83.75
T_6	122.50	27.40	87.48
T_7	126.10	28.70	90.44
SEm ±	0.6140	0.4119	0.5592
CD (5%)	1.8919	1.2693	1.7232

Impact of Sulphur and Zn nutrition on nutrients uptake by the mustard crop

Nutrients (NPK) uptake by mustard increased significantly consistently with the addition of S and Zn over control. Effects on various treatment on the consumption of nutrients could be arranged as $T_7>T_6>T_5>T_4>T_3>T_2>T_1$ (Table 3). Application of 40 kg S ha^{-1} + 10 kg Zn ha^{-1} + RDF has recorded significantly higher NPK uptake as compared to other treatments. Data indicated that nutrient uptake followed the trend similar to grain and stover yield of mustard, the nutrient uptake was significantly superior under the conjoint use of Zn and S over alone. The substantial improvement in nutrient uptake indicates the requirement of Sulphur and zinc for the mustard crop [22].

Table 4 Effect of Sulphur and Zn application on soil organic content (%), soil pH and EC (dSm^{-1}) under mustard crop

Treatment	Days after sowing					
	Organic content (%)		Soil pH		EC (dSm^{-1})	
	30 DAS	At harvest stage	30 DAS	At harvest stage	30 DAS	At harvest stage
T_1	0.42	0.40	8.21	8.43	0.48	0.262
T_2	0.47	0.42	7.58	8.32	0.45	0.49
T_3	0.49	0.43	7.55	7.60	0.44	0.47
T_4	0.45	0.44	7.52	7.55	0.42	0.45
T_5	0.53	0.46	6.65	6.70	0.39	0.43
T_6	0.54	0.49	6.63	6.67	0.37	0.39
T_7	0.60	0.51	6.60	6.65	0.36	0.39
SEm±	0.0067	0.0028	0.0944	0.2242	0.0044	0.0160
CD (5%)	0.0205	0.0087	0.2908	0.6907	0.0134	0.0492

Effect of Sulphur and Zn application on soil properties under mustard crop

Application of 40 kg S ha^{-1} + 10 kg Zn ha^{-1} recorded the maximum organic carbon content (0.60). Based on organic carbon content of soil, the various treatments could be arranged as $T_7>T_6>T_5>T_4>T_3>T_2>T_1$ (Table 4) and their values were observed 0.51, 0.49, 0.46, 0.44, 0.43, 0.42, 0.40% at harvesting under the respective treatment. Significantly higher organic carbon content was recorded in treatments consisting of both zinc and Sulphur as compared to zinc alone. The data revealed a definite buildup of organic carbon in all the treatment except T_1 (Control) over the initial value of 0.42 per cent recorded at the start of the experiment. Improvement in soil organic carbon status in treatment receiving Zn and S may be due to their stimulating effect on the growth and activity of micro-organisms. The addition of fertilizers improves the root and shoot growth which could contribute biomass to the soil might have increased the organic carbon content of the soil [23-24].

Like organic carbon, significantly higher available nitrogen content was recorded in treatment consisting of both zinc and Sulphur as compared to zinc alone (Table 5). Maximum available N content (340.46 kg ha^{-1}) was observed with 40 kg S ha^{-1} + 10 kg Zn ha^{-1} application. Zn and S application remarkably increased the available nitrogen content over control due to improvement in physiochemical properties of soil under treated plots. The suitable soil condition under S and Zn application might have assisted the mineralization of soil nitrogen leading to grow up to higher obtainable nitrogen. Significantly higher available phosphorus was recorded (Table 5) in 40 kg S ha^{-1} + 10 kg Zn ha^{-1} treated plot over other treatment might be due to higher incorporation of plant residue [25]. It was observed that the combined application of Zn and S significantly increased the available phosphorus content over Zn alone. The build-up in available phosphorus content with conjoint use of Zn and S was ascribed to the release of sulphuric acid during oxidation of Sulphur which is in turn to help in releasing native phosphorus through solubilizing action of this acid [26]. Integrated application of 40 kg S ha^{-1}+10 kg Zn ha^{-1}was recorded significantly higher available K content over other treatment (Table 5). The increased available K content of the soil was also observed with the increasing level of zinc. The data further revealed that the application of zinc and Sulphur recorded an increase in the available potassium content of the soil over control. An increase in available K due to the addition of zinc and Sulphur may be ascribed to the reduction of K fixation and release of K due to interaction of an acid with clay, besides the direct K addition to the soil [27]. The available Sulphur content of the soil was significantly influenced by the application of different treatments of S and Zn (Table 5). Data further revealed that the application of Sulphur and zinc recorded an increase in the available S content of the soil over control. Application of 40 kg S ha^{-1} + 10 kg Zn ha^{-1}(T_7) has shown a remarkable significant increase in available S content of experimental soil. The increase in the available Sulphur content of the soil in the S applied plot due to the direct addition of Sulphur and Zn doses. The use of Sulphur along with zinc significantly reduced the soil pH and EC as compared to zinc alone and control so it has an ameliorating effect. Sulphur treated plots showed low pH and EC as compared to zinc alone may be due to the release of sulphuric acid during oxidation of applied Sulphur which neutralizes the salt on the surface soil. Decreased soil pH and EC recorded under mustard crop due to increasing level of S and Zn due to release of acid during the reaction of fertilizer with water [28].

Table 5 Effect of Sulphur and Zn application on available NPK and S (kg ha^{-1}) of soil under mustard crop

Treatment	Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})			Available Sulphur (kg ha^{-1})		
	30 DAS	60 DAS	At harvest stage	30 DAS	60 DAS	At harvest stage	30 DAS	60 DAS	At harvest stage	30 DAS	60 DAS	At harvest stage
T_1	261.16	245.00	234.79	13.25	12.28	9.87	192.25	182.42	179.63	13.20	10.80	8.24
T_2	274.28	265.68	249.12	19.75	13.80	11.45	226.32	215.53	186.30	17.68	14.61	10.55
T_3	308.42	301.62	284.47	23.06	19.25	18.26	238.36	223.32	206.36	22.18	20.18	18.00
T_4	287.47	275.25	246.30	21.26	20.64	13.25	232.60	225.60	204.72	16.05	14.63	12.43
T_5	318.46	301.22	288.68	25.74	22.26	19.06	246.55	230.54	221.40	21.90	20.05	19.50
T_6	336.12	307.82	290.52	27.68	23.42	22.64	247.50	238.46	229.40	24.64	22.59	18.55
T_7	340.46	319.55	297.34	28.48	24.47	23.55	265.60	245.54	240.23	25.65	23.53	20.22
SEm±	3.5202	1.1572	2.0733	0.3679	0.2844	0.5436	1.3189	2.9663	2.8636	0.5620	0.5933	0.5369
CD (5%)	10.8469	3.5656	6.3886	1.1335	0.8762	1.6750	4.0638	0.1402	8.8237	1.7318	1.8281	1.6545

CONCLUSION

Results of this study revealed that application of 40 kg S ha^{-1} and 10 kg Zn ha^{-1} in combination with RDF positively affected growth, yield, nutrients uptake and nutrients availability under mustard crop. It can be concluded that the application of 40 kg S ha^{-1} and 10 kg Zn ha^{-1} along with RDF would help in the sustainable production of mustard.

LITERATURE CITED

1. Maqsood MA, Rahmatullah S, Kanwal T, Aziz Ashraf M. 2009. Evaluation of Zn distribution among grain and straw of twelve indigenous wheat, *Triticumaestivum*L. genotypes. *Pak. Jr. Botany* 41(1): 225-231.
2. Asad A, Rafique R. 2000. Effect of zinc, copper, iron, manganese and boron on the yield and yield components of wheat crop in Tehsil Peshawar. *Pakistan Journal of Biological Science* 3(10): 1815-1820.
3. Torun A, Gultekin I, Kalayci M, Yilmaz A, Eker S. 2001. Effects of zinc fertilization on grain yield and shoot concentrations of zinc, boron, and phosphorus of 25 wheat cultivars grown on a zinc-deficient and boron-toxic soil. *Journal of Plant Nutrition* 24(11): 1817-1829.
4. Asad A, Rafique R. 2002. Identification of micronutrient deficiency of wheat in the Peshawar valley, Pakistan. *Communications in Soil Science and Plant Analysis* 33(3/4): 349-364.
5. Bora PC, Hazarika V. 1997. *Brassica campestrissub* sp. oleifera var. toria. *Indian Jr. Agronomy* 42: 361-364.
6. Walkley A, Black CA. 1934. An examination of digestion method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science* 37: 29-37.
7. Subbaih BV, Asija GL. 1956. A rapid procedure for determination of available nitrogen in soil. *Current Science* 60: 1-7.
8. Olsen SR, Cole CV, Watanable FS, Dean LA. 1994. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *Department of Agriculture Circular*. pp 939.
9. Honway JJ, Heidel H. 1952. Soil analysis method as used in soil testing laboratory. *Low State College of Agriculture Bulletin* 57: 1-13.
10. Jackson ML. 1973. *Soil Chemical Analysis*. Prentice Hall of India Private Limited, New Delhi.
11. Black CA, Evans DD, Ensminger LE, White JL, Clark FE. 1965. *Methods of Soil Analysis.* American Society of Agronomy, Madison, USA. pp 1569.
12. Hatcher JT, Wilcox LV. 1950.Colorimetric determination of boron using carmine. *Analytical Chemistry* 22: 250-252.
13. Cochran WG, Cox GM. 1957. *Experimental Designs*. Second Edition, New York. John Wiley & Sons, Inc
14. Singh R, Singh V. 2005. Effect of Sulphur on growth and yield of Indian mustard under saline condition. *Indian Journal of Agronomy* 50(2): 110-113.

15. Singh M, Yadav BL. 2008. Effect of zinc and organic materials on transformation of zinc and chemical properties in sodic soil. *An Asian Journal of Soil Science* 3(1): 45-48.
16. Zizala VJ, Jadav NB, Gorfad PS. 2008. Effect of Sulphur and zinc on yield, quality and its concentration on mustard. *An Asian Journal of Soil Science* 3(1): 173-177.
17. Yadav N, Singh S.K, Kumawat R, Yadav K. 2018. Evaluation of sewage-sludge, zinc, boron and sulphur application for increasing productivity and quality of mustard (*Brassica juncea* L.) in an inceptisol. *International Journal of Current Microbiology and App. Science* 7(8): 713-721.
18. Prasad K, Singh RK, Pyare. 2004. Studies on intercropping of mustard varieties with chickpea. *Indian Journal of Pulses Research* 19(1): 73-75.
19. Kumar S, Verma SK, Singh TK, Shyambeer SS. 2011. Effect of nitrogen and Sulphur on growth, yield and nutrient uptake by Indian mustard (*Brassica juncea*) under rainfed condition. *The Indian Journal of Agricultural Sciences* 81(2): 145-149.
20. Yang M, Shi L, Xu FS, Lu JW, Wang YH. 2009. Effects of B, Mo, Zn, and their interactions on seed yield of rapeseed (*Brassica napus* L.). *Pedosphere* 19(1): 53-59.
21. Singh SP, Pal MS. 2011. Effect of integrated nutrient management on productivity, quality, nutrient, uptake and economics of mustard. *Indian Journal of Agronomy* 56(4): 381-387.
22. Gajghane PG, Toncher SS, Raut MM. 2015. Effect of potassium and Sulphur levels on soil fertility status after harvest of mustard. *Journal of the Indian Society of Soil Science* 15(1): 347-351.
23. Bajpai RK, Chitale S, Upadhyay SK, Urkurkar JS. 2006. Long term studies on soil physico-chemical properties and productive of rice-wheat as influenced by integrated nutrient management in inceptisol. *Journal of the Indian Society of Soil Science* 54: 24-29.
24. Sharma SK, Monchanda HR, Kapoor AK. 2007. Phosphorus requirement of wheat under chloride and sulphate dominated solinities. *Journal of the Indian Society of Soil Science* 55: 509-514.
25. Shah S, Ghani G, Khan H, Muhammad A, Qahar A, Inamullah AA, Ahmad M. 2015. Response of maize cultivars to phosphorus and zinc nutrition. *Pakistan Journal of Botany* 47: 289-292.
26. Sharma U, Subbehia SK. 2014. Effect of long-term integrated nutrient management on rice (*Oryza sativa* L.) wheat (*Triticum sativa* L.) productivity and soil properties in north-western Himalaya. *Journal of the Indian Society of Soil Science* 62(3): 248-254.
27. Subehia SK, Sepehya S. 2012. Influence of long-term nitrogen substitution through organics on yield, uptake and available nutrients in a rice-wheat system in an acidic soil. *Indian Journal of Agriculture Science* 60: 213-217.
28. Jat G, Sharma K, Choudhary RN. 2013. Effect of FYM and mineral nutrients on yield, content and uptake of nutrients in mustard. *Ann. Agric. Research* 34(2): 1-5.