
**EFFECT OF SULPHUR AND ZINC ON GROWTH, CHLOROPHYLL
CONTENT, YIELD ATTRIBUTES AND YIELDS OF MUSTARD
(*BRASSICA JUNCEA*) ON CLAY LOAM SOIL OF RAJASTHAN**

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ABSTRACT

A field experiment was conducted during the winter (rabi) seasons of 2001-02 and 2002-03 to study the effect of sulphur and zinc on growth, chlorophyll content, yield attributes and yield of Indian mustard [*Brassica juncea* (L.) Czern and Coss]. Application of 20 kg S ha⁻¹ and 2.5 kg Zn ha⁻¹ significantly increased in plant height over control at all the stages of growth except at 30 DAS. Chlorophyll content, dry matter accumulation per plant at all the stages of growth except at 30 DAS, number of primary and secondary branches per plant, all the yield attributes (Siliquae /plant seeds /siliqua and test weight), yield (seed and stover) increased significantly with increasing rates of sulphur upto 40 kg ha⁻¹ and zinc upto 5.0 kg ha⁻¹ application. But the biological yield increased significantly upto 60 kg S ha⁻¹ and 5.0 kg Zn ha⁻¹ application.

KEY WORDS: Sulphur, Zinc, Mustard

INTRODUCTION

India's share in the world production of oil seeds is sizeable but the productivity in the form of average yield per unit area is much lower probably due to cultivation on marginal and submarginal lands with poor soil fertility. Introduction of high yielding cultivars, increased cropping intensity, application of sulphur and zinc free fertilizers and limited addition of organic manures have caused sulphur and zinc deficiency in most of the soils. Judicious use of fertilizers have played a vital role in increasing the production of oil

seed crops. Oil seed crops particularly belonging to “Cruciferae” have relatively higher sulphur requirement owing to their high content of sulphur containing amino acids and essential oil (Aulakh *et al.* 1980). Zinc application also influences the oil content in oil seed crop (Muralidharudue and Singh 1990). The present study was undertaken to evaluate the effect of sulphur and zinc on growth, chlorophyll content, yield attributes and yield of mustard.

MATERIALS AND METHODS

A field experiment was conducted during the winter (rabi) seasons of 2001-02 and 2002-03 at Udaipur on clay loam soil. The soil has pH 8.42 and 8.26, EC 0.86 and 0.69 dsm^{-1} , 6.4 and 7.1 g kg^{-1} organic carbon, 280.7 and 292.4 kg ha^{-1} available nitrogen, 22.6 and 21.2 kg ha^{-1} available phosphorus, 365.5 and 370.7 kg ha^{-1} available potassium, 9.4 and 10.2 mg kg^{-1} available sulphur, 0.60 and 0.64 mg kg^{-1} DTPA extractable zinc, 4.20 and 4.42 mg kg^{-1} DTPA Fe, 9.4 and 10.6 mg kg^{-1} DTPA Mn, and 0.65 and 0.69 mg kg^{-1} DTPA Cu during 2001-02 and 2002-03 respectively. The treatments consisting of 5 sulphur levels (0, 20, 40, 60 and 80 kg ha^{-1}) in main plot and 5 levels of zinc (0, 2.5, 5.0, 7.5 and 10.0 kg ha^{-1}) in sub-plot were laid out in split plot design with four replications. Treatments were applied as basal dressing through gypsum and zinc chloride as per treatments. Uniform application of 60 kg nitrogen (half at the time of sowing and half at 35 days of sowing) through urea and DAP and 40 kg phosphorus through DAP at the time of sowing were made. Mustard variety “Pusabold” was sown in rows at 30 cm apart using 5 kg seed ha^{-1} on 3 November in 2001 and 29 October in 2002 and harvested 120 days after sowing. Plant height was observed by taking five randomly selected plant from each net plot and tagged for each stages. The chlorophyll content was determined after 60 days of crop sowing with the help of method as suggested by Arnon (1949). For dry matter accumulation at 30, 60, 90 days after sowing and at harvest, five randomly selected plants from each net plot were cut above ground level and sundried. Thus, samples so obtained were placed for oven drying at 70°C for 48 hr and dry weight was taken. Yield attributes (i.e. siliquae per plant, seed per siliqua and test weight) and yield (seed, stover and biological yield) and harvest index were determined as per the standard methods.

RESULTS AND DISCUSSION

Response to sulphur

Plant height increased significantly with increasing rates of sulphur upto 20 kg ha⁻¹ application over control at all the stages of growth except at 30 DAS but the highest plant height was observed under the treatments of 60 kg S ha⁻¹ application (Table 1). A better nutritional environment in plants under the applications 20 kg S ha⁻¹ seems to have enhanced metabolic activities in plants resulting in higher meristematic activities leading towards division, enlargement and elongation of cells which might have helped in attaining higher plant height. The results are in agreement with those of Buganova *et al.* (1975).

The data (Table 1) demonstrated synergistic effect of sulphur fertilization on synthesis of chlorophyll in mustard leaves at 60 days of sowing of crop growth during each year. Chlorophyll content increased significantly with its higher level (80 kg S ha⁻¹) but significant upto 40 kg S ha⁻¹. Sulphur being a constituent of succinyl co-enzymes A involved in chlorophyll formation. Higher chlorophyll content of leaves in presence of sulphur might be on account of enhanced synthesis fertilization containing amino acids particularly methionine which is involved in iron metabolism and is an important component of cell for chlorophyll synthesis. The results confirm with the findings of Imsande (1998).

Sulphur significantly increased the dry matter production per plant up to 40 kg ha⁻¹ application at all the stages of growth except at harvest in 2001-02 where significant increase was only upto 20 kg S ha⁻¹ and 30 DAS (Table 2) where biomass production did not reach the level of significance. Sulphur enhanced cell multiplication, elongation and expansion, imparts a deep green colour to leaves due to better chlorophyll synthesis, which in turn increases the effective area for photosynthesis, resulting in relatively greater dry matter accumulation at 40 kg S ha⁻¹ application in comparison to sulphur deficient plant. The results are in similar to the findings of Renneberg and Lomoureaux (1990).

Number of primary and secondary branches per plant increased significantly under the treatments of 40 kg S ha⁻¹ application as compared to control and 20 kg S ha⁻¹ application (Table 3) which was at par with 60

and 80 kg S ha⁻¹ during both the years of experimentation. It is due to better nutritional environment for plant growth at active vegetative growth which helped in better development and thickening of xylem and collenchymas tissues. Such favourable effects might have resulted in stronger stem similar results have been recorded by Dewal *et al.* (2000).

Successive increase in sulphur fertilization upto 40 kg ha⁻¹ tended to increase yield attributes of mustard (Siliquae /plant seed /siliqua and test weight). Consequently, the crop fertilized with 40 kg S ha⁻¹ produced significantly higher seed and stover yield but biological yield increased significantly upto 60 kg S ha⁻¹. The seed yield increased by 24.86 percent in 2001-02 and 24.81 percent in 2002-03 over no sulphur application (Table 3 and 4). The marked improvement in number of siliquae per plant seem to enhanced branching which facilitated greater flower formation later on provide adequate supply of metabolites and nutrients matching to demands of reproductive structures. The increment in test weight might be attributed to have been favourably influenced by the activation of enzymes and chlorophyll synthesis as well as increased carbohydrate metabolism and thus leads to increased translocation of photosynthates towards seeds resulting in formation of bold seeds (Jat 1994). With increasing supply of sulphur the process of tissue differentiation from somatic to reproductive, meristematic activity and development of floral primordial might have increased, resulting in more flowers and siliquae, robust siliqua and better seeds. The sum total effect will be higher seed yield (Singh and Verma, 1989). Increase in stover yield can be ascribed due to direct effect on dry matter accumulation as successive stages and indirectly via increase in various morphological components of crop growth. This is in close confirmily with the findings of Singh (2001).

Response to zinc

Application of 2.5 kg Zn ha⁻¹ significantly increased in plant height over control (Table 1) which was at par with 5.0, 7.5 and 10.0 kg Zn ha⁻¹ application, at (60, 90 days after sowing and at harvest) at all the stages of growth except 30 days after sowing. The increase in plant growth might be attributed to better activation of enzymes such as triphosphatage, dehydrogenase, tryptophan synthetase, proteinage and peptidase etc. and better photosynthetic activity. The results are closely related with Singh and Yadav (1997).

Irrespective of the year, the leaves of crop synthesized higher chlorophyll content to the application of 7.5 kg Zn ha⁻¹ (Table 1) but the significant increase was noted only upto 5.0 kg Zn ha⁻¹ application. Zinc is an essential component of enzymes responsible for assimilation of nitrogen, help in chlorophyll formation and plays an important role in nitrogen metabolism. Similar results were obtained by Islam *et al.* (1998).

Dry matter production per plant increased significantly with increasing rates of zinc upto 5.0 kg ha⁻¹ (Table 2) irrespective of the years of experimentation and stages of growth except at 30 DAS where dry matter production did not touch the level of significance. Khuje (1992) observed that growth hormone and tryptophan, a precursor of auxin and metabolism of auxin and in turn enhance growth through cell elongation process. Similar results have been recorded by Raghuwansni *et al.* (1997).

Increasing levels of zinc upto 5.0 kg ha⁻¹ significantly increased number of primary and secondary branches per plant, yield attributes (siliquae /plant, seeds /silique and test weight) (Table 3) and yield (seed, stover and biological yield) of Indian mustard (Table 4) during both the years of experimentation. The seed yield increased by 18.15 and 18.19 percent and stover yield 16.27 and 16.70 percent in 2001-02 and 2002-03, respectively. The increase in yield attributes is due to increased supply of available zinc to plants resulting in proper growth and development of plant system. Zinc have role in biosynthesis of Indole acetic acid and especially due to its role in initiation of primordial for reproductive parts and partitioning of photosynthates towards them, which resulted in better flowering and fruiting. The increase in yield attributes resulted in increase in seed, stover and biological yield of mustard. These results are close conformity with the findings of Singh *et al.* (1996) and Sharma *et al.* (2000).

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Table 1: Effect of sulphur and zinc levels on plant height and chlorophyll of mustard

Treat.	Plant height (cm)								Chlorophyll content (mg g ⁻¹ Fr. Wt.) at 60 DAS	
	30 DAS		60 DAS		90 DAS		At harvest			
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Sulphur (kg ha ⁻¹)										
0	14.02	14.14	84.39	86.44	143.70	148.30	163.20	168.27	2.541	2.590
20	14.42	14.55	89.89	94.34	153.40	158.40	174.04	179.08	2.652	2.710
40	14.73	14.85	95.07	97.41	157.60	163.20	178.83	184.84	2.732	2.800
60	14.84	14.97	96.88	99.01	160.10	166.40	182.35	187.39	2.765	2.840
80	14.77	14.91	93.76	97.95	158.90	164.20	181.27	186.53	2.779	2.850
SEm±	0.36	0.37	1.99	2.11	2.80	3.00	2.78	2.96	0.021	0.025
CDat 5%	NS	NS	6.13	6.51	8.60	9.10	8.55	9.13	0.065	0.078
Zinc (kg ha ⁻¹)										
0.0	14.24	14.37	86.79	89.11	147.10	152.30	168.05	172.70	2.583	2.618
2.5	14.47	14.60	91.88	94.35	154.00	159.20	175.46	180.80	2.652	2.718
5.0	14.63	14.77	93.23	96.62	156.50	162.00	170.73	183.17	2.749	2.798
7.5	14.73	14.87	94.33	97.86	158.50	163.90	179.75	185.25	2.757	2.848
10.0	14.72	14.82	93.76	97.21	157.50	162.90	178.69	184.19	2.730	2.808
SEm±	0.34	0.27	1.77	1.83	2.40	2.40	2.61	2.83	0.020	0.023
CD at 5%	NS	NS	4.99	5.18	6.80	6.80	7.37	8.02	0.056	0.064

Table 2: Effect of sulphur and zinc levels on dry matter accumulation per plant of mustard

Treatment	Dry matter accumulation plant ⁻¹ (g)							
	30 DAS		60 DAS		90 DAS		At harvest	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Sulphur (kg ha⁻¹)								
0	0.90	0.93	21.96	22.27	31.66	33.81	40.29	41.83
20	0.97	1.00	23.97	24.40	34.17	36.47	44.71	45.39
40	0.99	1.00	25.71	26.26	36.52	38.93	47.79	48.69
60	1.00	1.01	26.69	26.50	37.02	39.39	48.61	49.63
80	1.00	1.00	26.17	26.19	36.67	38.98	47.74	49.05
SEm±	0.03	0.03	0.56	0.59	0.75	0.78	1.07	1.04
CD at 5%	NS	NS	1.72	1.83	2.31	2.41	3.29	3.20
Zinc (kg ha⁻¹)								
0.0	0.93	0.94	22.42	22.47	32.36	34.59	41.59	42.46
2.5	0.96	0.98	24.34	24.42	34.46	36.71	44.69	45.60
5.0	0.99	1.01	25.79	26.14	36.27	38.62	47.67	48.78
7.5	1.00	1.02	26.12	26.52	36.63	39.02	47.96	49.20
10.0	0.99	1.01	25.84	26.08	36.31	38.64	47.24	48.54
SEm±	0.02	0.02	0.50	0.59	0.63	0.67	0.92	1.03
CD at 5%	NS	NS	1.43	1.67	1.79	1.89	2.60	2.92

Table 3: Effect of sulphur and zinc levels on number of primary and secondary branches plant⁻¹, siliquae plant⁻¹, seeds siliqua⁻¹ and test weight of mustard

Treatments	Primary branches plant ⁻¹		Secondary branches plant ⁻¹		Siliquae plant ⁻¹		Seeds siliqua ⁻¹		Test weight (g)	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Sulphur (kg ha⁻¹)										
0	4.74	4.79	12.59	12.70	274.10	279.10	13.20	13.75	4.58	4.71
20	5.37	5.42	14.32	14.39	312.10	318.30	15.02	15.67	5.18	5.50
40	5.95	5.96	15.77	15.85	341.20	351.00	16.65	17.22	5.70	5.89
60	6.20	6.25	16.65	16.76	364.90	374.30	17.29	17.88	5.81	6.01
80	6.03	6.10	16.08	16.23	352.60	355.30	16.94	17.35	5.74	5.86
SEm±	0.12	0.13	0.31	0.35	8.30	7.80	0.22	0.23	0.04	0.05
CD at 5%	0.36	0.39	0.97	1.09	25.40	24.10	0.69	0.72	0.13	0.16
Zinc (kg ha⁻¹)										
0.0	5.01	5.06	13.36	13.52	292.10	298.10	14.03	14.53	4.79	4.96
2.5	5.52	5.55	14.68	14.76	320.60	326.70	15.39	15.93	5.26	5.47
5.0	5.86	5.93	15.51	15.60	340.80	349.10	16.36	16.89	5.61	5.81
7.5	6.02	6.07	16.08	16.20	349.30	355.90	16.76	17.38	5.72	5.90
10.0	5.88	5.91	15.78	15.85	342.50	348.20	16.55	17.15	5.63	5.83
SEm±	0.10	0.11	0.25	0.27		7.10	0.17	0.21	0.04	0.04
CD at 5%	0.28	0.32	0.72	0.77		20.00	0.47	0.58	0.12	0.12

Table 4: Effect of sulphur and zinc levels on seed, stover and biological yields and harvest index of mustard

Treatments	Seed yield (q ha ⁻¹)		Stover yield (q ha ⁻¹)		Biological yield (q ha ⁻¹)		Harvest index (%)	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Sulphur (kg ha⁻¹)								
0	16.25	17.05	46.17	48.52	62.42	65.57	26.23	26.12
20	18.54	19.36	52.70	54.71	71.24	74.07	26.05	26.18
40	20.30	21.28	58.32	59.70	78.62	80.98	25.82	26.27
60	21.60	22.54	62.20	63.82	83.83	86.37	25.84	26.15
80	21.31	21.85	60.37	62.18	81.68	84.04	26.08	26.00
SEm±	0.48	0.59	1.27	1.37	1.41	1.51	0.63	0.66
CD at 5%	1.49	1.81	3.91	4.22	4.34	4.65	NS	NS
Zinc (kg ha⁻¹)								
0.0	17.36	18.09	49.59	51.32	66.95	69.41	26.04	26.08
2.5	19.10	19.84	54.53	56.25	73.63	76.08	26.01	26.11
5.0	20.51	21.38	57.66	59.89	78.18	81.27	26.32	26.35
7.5	20.78	21.67	59.71	61.47	80.48	83.14	25.83	26.11
10.0	20.24	21.11	58.30	60.01	78.53	81.12	25.81	26.08
SEm±	0.46	0.49	1.09	1.25	1.16	1.46	0.63	0.53
CD at 5%	1.32	1.39	3.08	3.54	3.27	4.12	NS	NS