The Ecoscan 10(3&4): 527-534, 2016
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES
www.theecoscan.com

EFFECT OF SULPHUR AND ZINC WITH AND WITHOUT FYM ON YIELD, CONTENT AND UPTAKE OF NUTRIENTS AFTER HARVEST OF MUSTARD [*BRASSICA JUNCEA* L. CZERN & COSS] GROWN ON LIGHT TEXTURED SOIL OF KACHCHH

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ABSTRACT

The experiment conducted on mustard crop during the *Rabi* season 2007-08 and 2008-09 with four levels each of S, three levels of Zn and two levels of FYM showed that mustard responded significantly to the application of sulphur, zinc and FYM. The seed and stover yields increased significantly in the linear order up to 60 kg S ha^{-1} and 5 kg Zn ha^{-1}. The highest seed (2021kg/ha) was recorded in comparison to control. Lowest yield was recorded at control. The N, P, K, S and Zn content and uptake at maturity were significantly affected with treatments.

KEY WORDS
Sulphur
Zinc
Indian mustard
yield

Received : 19.03.2016
Revised : 10.05.2016
Accepted : 15.09.2016

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INTRODUCTION

In India consumption of oil and fats is continuously increasing due to increase in population at an annual growth rate of 2.1 per cent and improved standards of living due to accelerated economic development in the base scenario of per capita growing by 4.0 per cent annually, an average Indian's yearly edible oil requirement is fated to rise from 9.81 kg in 1999-2000 to 16 kg in 2015 (Hegde, 2004).

In recent years, sulphur deficiency has been aggravated in the soil due to continuous removal by crops and use of high analysis sulphur devoid fertilizers coupled with intensive cropping with high yielding varieties and reduction in use of organic manure and sulphur containing fungicides and insecticides resulted in sulphur deficiency in soils. Sulphur deficiency is as high as 81 per cent in the light textured soils of North and North West zone of Gujarat (Sadasania, 1992). Sulphur plays direct and prominent role in fatty acid synthesis. In oleic ferrous brassicas, it is required in the formation of flavouring compounds known as glucosinolates. It is a constituent of amino acids *viz*., cysteine and methionine (Marschner, 1995).They reported that sulphur deficiency tends to affect adversely on growth and which reduces the crop yield to the extent of 10-30 per cent.

Zinc being one of the essential micronutrient, plays significant role in various enzymatic and physiological activities of the plant system. The available zinc in Gujarat soils ranges between 0.25 to 2.58 mgkg-1 . (Dangarwala *et al*., 1983). As nearly half of the Indian soil are Zn deficient and 24 % soils of Gujarat state are Zn deficient and 58 % soils of North and North Gujarat found deficient to medium in available zinc status. Soils of India had multiple nutrient deficiencies, mainly of N, P, K, S and Zn and their use have become essential to obtain optimum crop yield. The paper deals with the effect of sulphur and zinc with and without FYM on seed and straw of mustard and uptake of nutrients by mustard.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of two consecutive years 2007-08 and 2008-09 at Agricultural Research Station, Sardarkrushinagar Dantiwada Agricultural University, Bhachau, Kachchh. It is located in the North-West Gujarat Agro-climatic zone and characterized by sub-tropical monsoon type arid climate with extreme cold winter, hot and dry windy summer. The soil was loamy sand in texture and alkaline in reaction (pH 8.03 and 8.15). The soils were low in available nitrogen (161.0 kg ha^{-1}) and the available sulphur (9.90 mg kg^{-1}), medium in available phosphorus (29.5 kg ha^{-1}) and available potash (219.0 kg ha^{-1}). The soils were low in DTPA extractable Zn (0.48 mg kg^{-1}), Fe (3.51 mg kg-

^{1}), Cu (0.32 mg kg^{-1}) and Mn (4.97 mg kg^{-1}). Treatments comprising combinations of sulphur (0, 20, 40 and 60 kg S ha^{-1}), Zinc (0, 2.5 and 5.0 kg Zn ha^{-1}) and FYM (0 and 10 t FYM ha^{-1}) were replicated three times in factorial randomized block design. The crop was sown on 30 October 2007 and 23 October 2008. During both the years, the crop was fertilized with recommended dose of 75 kg N and 50 kg P_2O_5 ha^{-1}. Half dose of N and full dose of P_2O_5 were applied as basal application through urea and DAP and remaining 25 kg N ha^{-1} was applied as top dressing at 25-30 days after sowing. Sulphur and zinc were applied through gypsum and $ZnCl_2$, respectively as well as FYM were applied in soil as per treatments. Yield was recorded at the time of harvest and the soil samples were collected at 0-5.0cm depth of soil and analyzed by standard method of analysis. The BCR value was computed by dividing to net return by total expenditure of each level of sulphur, zinc and FYM under study.

RESULTS AND DISCUSSION

Effect of Sulphur, Zinc and FYM on Yield

Effect of sulphur

The results of the experiment further indicated that seed and stover yield were influenced significantly due to application of sulphur during individual years and pooled (Table 1). Among the different levels of sulphur, application of sulphur @ 60 kg ha^{-1}(S_3) resulted in significantly higher seed and stover yield, but found at par with 40 kg ha^{-1} (S_2) during 2007-08, 2008-09 and in pooled results. Application of 60 kg S ha^{-1} increased seed yield by 41.86, 13.25 and 3.24 per cent in 2007-08, 35.66, 7.16 and 4.60 per cent in 2008-09 and 38.76, 10.20 and 3.83 per cent in their pooled data over control, 20 and 40 kg S ha^{-1}, respectively. Similarly application of 40 kg S ha^{-1} increased the seed yield by 37.41 and 9.69 per cent in 2007-08 and 29.69 and 2.45 per cent in 2008-09 as well as 33.64 and 6.13 in their pooled data over control and 20 kg S ha^{-1}, respectively. 23.35, 9.08 and 1.79 per cent in 2007-08, 22.65, 8.89 and 3.08 per cent in 2008-09 and 23.02, 8.99 and 2.40 per cent in the pooled results over control, 20 and 40 kg S ha^{-1}, respectively, whereas, application of 40 kg S ha^{-1} increased the stover yield by 21.18 and 7.16 per cent in 2007-08, 18.99 and 5.64 per cent in 2008-09 and 20.14 and 6.44 per cent in pooled results over control and 20 kgS ha^{-1}, respectively. Similarly, application of 20 kg S ha^{-1} increased the stover yield by 13.08 per cent in 2007-08, 12.64 per cent in 2008-09 and 12.87 in pooled over control. The increase in seed and stover yield of mustard might be attributed due to its essential role of S for plant growth and yield through its effect on biochemical functioning related enzyme. Sulphur nutrition also enhances cell multiplication, elongation, expansion and 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 amount of dry matter accumulation in comparison to sulphur deficient plants. These results are in agreement with the findings of Mehriya and Khangarot (2000) and Patel *et al*., 2013. Yield of the crop is sum of seed and stover yield representing vegetative and reproductive growth. The marked increase in both of these with increasing rates of sulphur fertilization ultimately led to this is supported by with the findings of Kokani *et al.,* (2015), Patel *et al*.,(2013), Chaudhary *et al* (2014) Mir *et al*., (2004); Malik *et al*., (2004) , Sahu *et al*., (2004), Kumar *et al*., (2006) , Patel *et al*., (2007), Hassan *et al*., (2007) and Kumar and Yadav (2007).

Effect of Zinc

Seed and stover yields were also affected significantly due to application of zinc during 2007-08, 2008-09 and pooled (Table1). The maximum seed yield was recorded with the application of Zn @ 5.0 kg ha^{-1} which was 14.87, 12.89 and 13.88 per cent higher than zinc @ 2.5 kg ha^{-1} level and 29.87, 38.68 and 34.13 per cent higher than no zinc application during 2007-08, 2008-09 and in pooled results,

Table 1: Effect of sulphur, zinc and FYM on yield and economics of mustard

Treatments	Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Total expenditure	Gross	Net income	BCR return
	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled	(Rs. ha^{-1})	(Rs. ha^{-1})	(Rs. ha^{-1})	
Sulphur										
0 kg S ha^{-1} (S_0)	1326	1290	1308	3409	3055	3232	9918	33308	23390	3.36
20 kg S ha^{-1} (S_1)	1661	1633	1647	3855	3441	3648	10362	41993	31631	4.05
40 kg S ha^{-1} (S_2)	1822	1673	1748	4131	3635	3883	10806	43613	32808	4.04
60 kg S ha^{-1} (S_3)	1881	1750	1815	4205	3747	3976	11250	45731	34481	4.07
SEm±	33.4	37.9	28.7	98.5	97.1	78.7				
CD at 5%	95	107.8	83.1	279.9	276.2	223.8				
Zinc										
0 kg Zn ha^{-1} (Zn_0)	1463	1316	1389	3725	3185	3455	10491	35413	24922	3.38
2.5 kg Zn ha^{-1} (Zn_1)	1654	1618	1636	3833	3508	3670	14112	55069	40958	3.9
5.0 kg Zn ha^{-1} (Zn_2)	1900	1825	1863	4141	3715	3928	9581	42106	32525	4.39
SEm±	33.4	37.9	28.7	98.5	97.1	78.7				
CD at 5%	95	107.8	81.6	279.9	276.2	223.8				
FYM										
No FYM (F0)	1547	1466	1507	3724	3298	3511	9334	37944	28610	4.07
10 t FYM ha^{-1} (F1)	1798	1707	1752	4076	3640	3858	11834	44378	32545	3.75
SEm±	27.3	31	23.4	80.4	79.3	64.3				
CD at 5%	77.6	88	66.6	228.5	225.5	182.7				
Significant interactions	SxZn	SxZn	SxZn	-	-	-				
C.V. (%)	9.79	11.71	10.75	12.37	13.72	13.04				

Table 2: Combined effect of sulphur and zinc on seed yield of mustard (Pooled)

Treatments	Seed yield (kg ha^{-1}) Zn level kg ha^{-1}			
	0	2.5	5	Pooled
Total0 kg S ha^{-1} (S_0)	891	1403	1630	1308
20 kg S ha^{-1} (S_1)	1490	1589	1862	1647
40 kg S ha^{-1} (S_2)	1561	1744	1938	1748
60 kg S ha^{-1} (S_3)	1616	1809	2021	1815
Pooled	1389	1636	1863	
SEm±	49.7			
CD at 5%	141.4			
C.V. (%)	10.7			

Table 3: Effect of different level of sulphur, zinc and FYM on nitrogen content and uptake of musta

Treatment	Nitrogen content (%)						Nitrogen Uptake (gm ha^{-1})					
	Seed			Stover			Seed			Stover		
	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Sulphur(kg ha^{-1})												
0 (S_0)	3.153	3.206	3.18	0.435	0.43	0.433	42.1	41.7	41.9	14.9	13.3	14.1
20 (S_1)	3.314	3.353	3.334	0.448	0.445	0.446	55.2	54.9	55.1	17.3	15.4	16.4
40 (S_2)	3.406	3.423	3.415	0.46	0.457	0.459	62.3	57.4	59.8	19.1	16.8	17.9
60 (S_3)	3.451	3.49	3.471	0.47	0.467	0.468	65.1	61.3	63.2	19.9	17.6	18.7
SEm±	0.028	0.039	0.027	0.004	0.006	0.004	1.38	1.42	1.13	0.44	0.54	0.39
CD at 5%	0.079	0.11	0.076	0.011	0.016	0.012	3.92	4.04	3.2	1.25	1.52	1.12
Zinc (kg ha^{-1})												
0 (Zn_0)	3.24	3.265	3.252	0.435	0.432	0.434	47.7	43.4	45.6	16.3	13.9	15.1
2.5(Zn_1)	3.358	3.405	3.382	0.454	0.451	0.453	55.9	55.2	55.6	17.5	15.9	16.7
5.0 (Zn_2)	3.395	3.435	3.415	0.47	0.466	0.468	64.9	62.9	63.9	19.6	17.5	18.5
SEm±	0.028	0.039	0.027	0.004	0.006	0.004	1.38	1.42	1.13	0.44	0.54	0.39
CD at 5%	0.079	0.11	0.076	0.011	0.016	0.012	3.92	4.04	3.2	1.25	1.52	NS
FYM (t ha^{-1})												
0 (F0)	3.275	3.309	3.292	0.414	0.409	0.412	51.1	48.8	50	15.4	13.6	14.5
10 (F1)	3.387	3.428	3.407	0.492	0.491	0.491	61.3	58.8	60	20.1	18	19
SEm±	0.023	0.032	0.022	0.003	0.005	0.003	1.12	1.16	0.92	0.36	0.44	0.32
CD at 5%	0.064	0.09	0.062	0.009	0.013	0.009	3.2	3.3	2.61	1.02	1.24	0.91
Significant interactions	-	-	-	-	-	-	-	-	SXZn	-	-	SXZn
C.V. (%)	4.07	5.64	4.86	4.25	6.26	5.26	12.01	12.93	12.47	12.14	16.67	14.41

Table4: Effect of different level of sulphur, zinc and FYM on Phosphorus content and uptake of mustard.

Treatment	Phosphorus content (%)						Phosphorus Uptake (gm ha^{-1})					
	Seed			Stover			Seed			Stover		
	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Sulphur(kg ha^{-1})												
0 (S_0)	0.615	0.7	0.658	0.186	0.163	0.175	8.1	9	8.6	6.3	4.9	5.6
20 (S_1)	0.654	0.722	0.688	0.233	0.182	0.207	10.9	11.8	11.3	9	6.3	7.6
40 (S_2)	0.674	0.744	0.71	0.253	0.204	0.229	12.2	12.4	12.4	10.5	7.5	9
60 (S_3)	0.69	0.758	0.723	0.269	0.218	0.244	13.1	13.3	13.1	11.4	8.2	9.8
SEm±	0.007	0.006	0.005	0.002	0.002	0.002	0.27	0.3	0.23	0.24	0.22	0.19
CD at 5%	0.019	0.017	0.015	0.006	0.006	0.005	0.78	0.85	0.66	0.67	0.64	0.53
Zinc (kg ha^{-1})												
0 (Zn_0)	0.675	0.744	0.71	0.248	0.206	0.227	10	9.9	9.9	9.4	6.7	8
2.5(Zn_1)	0.65	0.726	0.688	0.229	0.186	0.208	10.8	11.8	11.3	8.9	6.6	7.7
5.0 (Zn_2)	0.649	0.723	0.686	0.228	0.184	0.206	12.4	13.2	12.8	9.6	6.9	8.2
SEm±	0.007	0.006	0.005	0.002	0.002	0.002	0.3	0.3	0.23	0.24	0.22	0.19
CD at 5%	0.019	0.017	0.015	0.006	0.006	0.005	0.8	0.85	0.66	NS	NS	NS
FYM (t ha^{-1})												
0 (F0)	0.643	0.722	0.683	0.218	0.184	0.201	10	10.6	10.3	8.2	6.1	7.1
10 (F1)	0.673	0.74	0.707	0.252	0.2	0.226	12.1	12.6	12.4	10.4	7.3	8.8
SEm±	0.006	0.005	0.004	0.002	0.002	0.001	0.22	0.25	0.19	0.19	0.18	0.15
CD at 5%	0.016	0.014	0.012	0.005	0.005	0.004	0.64	0.7	0.54	0.55	0.52	0.43
Significant interactions	-	-	-	-	-	-	-	-	SXZn	-	-	SXZn
C.V. (%)	5.07	4.03	4.55	4.27	5.58	4.92	12.15	12.65	12.4	12.49	16.33	14.41

respectively. The highest stover yield was observed with the application of Zn @ 5.0 kg ha^{-1} which was 8.04, 5.90 and 7.03 per cent higher than Zn_1 level and 11.17, 16.64 and 13.69 per cent over no zinc application during 2007-08, 2008-09 and in pooled results, respectively. The findings are in accordance with those of reported by Husain and Kumar (2006). The findings of present investigations are supported by Singh *et al*. (1993); and Kumawat and Pathan (2002), Chaudhary *et al*. (2014) Kumar *et al*.(2016) Chanchal Verma *et al* (2016), who observed increase in seed and stover yield of mustard due to zinc application.

Effect of FYM

The results further indicated that there was significant increase in seed and stover yield due to application of FYM (Table 1). The significantly higher seed yield of 1798, 1707 and 1752

Table5 : Effect of different level of sulphur, zinc and FYM on Potassium content and uptake of mustard.

Treatment	Potassium content (%)						Potassium Uptake (gm ha^{-1})					
	Seed			Stover			Seed			Stover		
	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Sulphur(kg ha^{-1})												
0 (S_0)	0.789	0.786	0.787	1.241	1.242	1.241	10.5	10.2	10.3	42.3	38	40.2
20 (S_1)	0.828	0.83	0.829	1.284	1.291	1.288	13.8	13.6	13.7	49.5	44.5	47
40 (S_2)	0.832	0.836	0.834	1.288	1.301	1.294	15.2	14	14.6	53.3	47.4	50.3
60 (S_3)	0.835	0.84	0.837	1.292	1.301	1.297	15.7	14.7	15.2	54.3	48.8	51.5
SEm±	0.008	0.009	0.007	0.011	0.013	0.01	0.34	0.37	0.28	1.25	1.42	1.08
CD at 5%	0.022	0.026	0.019	0.03	0.038	0.028	0.96	1.05	0.81	3.57	4.04	3.06
Zinc (kg ha^{-1})												
0 (Zn_0)	0.819	0.823	0.821	1.274	1.277	1.275	12	10.9	11.5	47.5	40.8	44.1
2.5(Zn_1)	0.821	0.821	0.821	1.277	1.286	1.281	13.6	13.3	13.5	49	45.2	47.1
5.0 (Zn_2)	0.823	0.825	0.824	1.278	1.288	1.283	15.7	15.1	15.4	53	48	50.5
SEm±	0.008	0.009	0.007	0.011	0.013	0.01	0.34	0.37	0.28	1.25	1.42	1.08
CD at 5%	NS	NS	NS	NS	NS	NS	0.96	1.05	0.81	3.57	4.04	NS
FYM (t ha^{-1})												
0 (F0)	0.809	0.812	0.81	1.264	1.266	1.265	12.6	12	12.3	47.1	41.9	44.5
10 (F1)	0.833	0.834	0.833	1.289	1.301	1.295	15	14.3	14.6	52.6	47.4	50
SEm±	0.006	0.008	0.006	0.009	0.011	0.008	0.28	0.3	0.23	1.02	1.16	0.88
CD at 5%	0.018	0.022	0.016	0.024	0.031	0.022	0.78	0.85	0.66	2.91	3.3	2.5
Significant interactions	-	--	-	- -	-	-	SXZn	-	-	SXZn		
C.V. (%)	4.57	5.53	5.05	4.03	5.04	4.54	11.97	13.76	12.87	12.33	15.59	13.96

Table 6: Effect of different level of sulphur, zinc and FYM on Sulphur content and uptake of mustard.

Treatment	Sulphur content (%)						Sulphur Uptake (gm ha^{-1})					
	Seed			Stover			Seed			Stover		
	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Sulphur(kg ha^{-1})												
0 (S_0)	1.109	1.1	1.104	0.242	0.235	0.238	15	14.5	14.7	8.3	7.2	7.7
20 (S_1)	1.263	1.254	1.259	0.256	0.248	0.252	21.1	20.7	20.9	9.9	8.6	9.2
40 (S_2)	1.361	1.352	1.357	0.259	0.252	0.255	25	22.7	23.9	10.7	9.2	10
60 (S_3)	1.406	1.398	1.402	0.263	0.255	0.259	26.6	24.6	25.6	11.1	9.6	10.3
SEm±	0.011	0.015	0.01	0.002	0.003	0.002	0.5	0.53	0.42	0.26	0.29	0.22
CD at 5%	0.03	0.041	0.029	0.007	0.007	0.006	1.43	1.51	1.18	0.73	0.83	0.63
Zinc (kg ha^{-1})												
0 (Zn_0)	1.194	1.185	1.19	0.25	0.242	0.246	17.8	15.9	16.9	9.4	7.8	8.6
2.5(Zn_1)	1.309	1.3	1.305	0.256	0.248	0.252	22	21.3	21.6	9.8	8.8	9.3
5.0 (Zn_2)	1.351	1.343	1.346	0.259	0.252	0.255	26	24.7	25.3	10.8	9.4	10.1
SEm±	0.011	0.015	0.01	0.002	0.003	0.002	0.5	0.53	0.42	0.26	0.29	0.22
CD at 5%	0.03	0.041	0.029	0.007	0.007	0.006	1.43	1.51	1.18	0.73	0.83	0.63
FYM (t ha^{-1})												
0 (F0)	1.227	1.219	1.223	0.249	0.234	0.242	19.3	18.2	18.8	9.3	7.8	8.5
10 (F1)	1.342	1.333	1.338	0.261	0.261	0.261	24.5	23.1	23.8	10.7	9.5	10.1
SEm±	0.009	0.012	0.008	0.002	0.002	0.002	0.08	0.08	0.06	0.11	0.12	0.09
CD at 5%	0.024	0.034	0.023	0.005	0.006	0.005	0.22	0.23	0.18	0.32	0.34	0.27
Significant interactions	-	-	-	-	-	-	-	-	SXZn	-	-	SXZn
C.V. (%)	4.01	5.59	4.8	4.45	5.07	4.76	11.24	12.56	11.9	12.67	16.51	14.59

Table7: Effect of different level of sulphur, zinc and FYM on Zinc content and uptake of mustard.

Treatment	Zinc content (ppm)						Zinc Uptake (gm ha^{-1})					
	Seed			Stover			Seed			Stover		
	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Sulphur(kg ha^{-1})												
0 (S_0)	19	20.8	19.9	12.3	14.1	13.2	25.3	27	26.2	42	43.5	42.7
20 (S_1)	20.3	22	21.2	13.3	15.2	14.3	33.8	36	34.9	51.4	52.2	51.8
40 (S_2)	20.9	22.8	21.9	13.8	15.6	14.7	38.3	38.3	38.3	56.9	56.7	56.8
60 (S_3)	21	22.9	22	13.8	15.7	14.8	39.7	40.3	40	58	59.1	58.5
SEm±	0.29	0.36	0.26	0.17	0.15	0.13	1	1	0.8	1.4	1.5	1.1
CD at 5%	0.82	1.01	0.74	0.47	0.42	0.37	2.7	2.8	2.2	4	4.1	3.3
Zinc (kg ha^{-1})												
0 (Zn_0)	19.2	21[redacted]	20.2	12.7	14.4	13.6	28.3	28	[redacted]8.1	47.7	46.2	46.9
2.5(Zn_1)	20.6	22[redacted]	21.5	13.3	15.3	14.3	34.3	36.3	[redacted]5.3	51.1	53.5	52.3
5.0 (Zn_2)	21.1	22[redacted]	22	13.8	15.8	14.8	40.3	42	[redacted]1.1	57.5	58.9	58.2
[redacted]	0.29	0.3[redacted]	0.26	0.17	0.15	0.13	1	1	[redacted].8	1.4	1.5	1.1
[redacted]%	0.82	1.0[redacted]	0.74	0.47	0.42	0.37	2.7	2.8	[redacted].2	4	4.1	3.3
[redacted]a-1)												
[redacted]	20	21[redacted]	20.9	13.2	15.2	14.2	31.3	32.3	[redacted]1.8	49.4	50.2	49.8
[redacted]	20.6	22[redacted]	21.5	13.3	15.2	14.3	37.3	38.5	[redacted]7.9	54.7	55.5	55.1
[redacted]	0.23	0.2[redacted]	0.21	0.14	0.12	0.1	0.8	0.8	[redacted].6	1.1	1.2	0.9
[redacted]%	NS	NS[redacted]	NS	NS	NS	NS	2.2	2.3	[redacted].8	3.2	3.4	2.7
[redacted]nt i[redacted]te[redacted]actions	-	-	-	-	-	-	-	-	[redacted]XZn	--	SXZn	
[redacted]	6.93	7.8[redacted]	7.4	6.12	4.72	5.42	13.69	13.6	[redacted]3.64	13.11	13.48	13.3

Table 8: Effect of different level of sulphur, zinc and FYM on Fe content and uptake of mustard.

Treatment	Fe content (ppm)						Fe Uptake (gm ha^{-1})					
	Seed			Stover			Seed			Stover		
	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Sulphur(kg ha^{-1})												
0 (S_0)	150.5	154.6	152.5	179.2	184.3	181.7	201	200	201	616	566	591
20 (S_1)	157.3	162.1	159.7	186	190.4	188.2	262	266	264	717	656	686
40 (S_2)	159.8	167.3	163.6	188.5	194.2	191.4	292	281	286	779	705	742
60 (S_3)	162.3	163.7	163	191	196.7	193.8	306	288	297	804	739	772
SEm±	2.38	1.96	1.75	2.38	2.31	1.89	7.1	7	5.7	21.8	21	17.2
CD at 5%	6.77	5.57	4.97	6.77	6.56	5.59	20.3	19.8	16.2	62	59.6	48.9
Zinc (kg ha^{-1})												
0 (Zn_0)	152.6	156.3	154.5	181.3	185.5	183.4	225	208	216	676	593	635
2.5(Zn_1)	159.2	162.7	160.9	187.9	193.6	190.8	265	264	264	724	680	702
5.0 (Zn_2)	160.6	166.8	163.7	189.3	195	192.1	306	305	306	786	726	756
SEm±	2.38	1.96	1.75	2.38	2.31	1.89	7.1	7	5.7	21.8	21	17.2
CD at 5%	6.77	5.57	4.97	6.77	6.56	5.63	20.3	19.8	16.2	62	59.6	48.9
FYM (t ha^{-1})												
0 (F0)	155.7	160.4	158	184.4	190.7	187.5	242	237	239	687	631	659
10 (F1)	159.3	163.5	161.4	188	192.1	190	288	281	285	771	702	736
SEm±	1.95	1.6	1.43	1.95	1.88	1.54	5.8	5.7	4.6	17.8	17.1	14.1
CD at 5%	NS	NS	NS	NS	NS	NS	16.6	16.2	13.2	50.6	48.7	40
Significant interactions	-	-	-	-	-	-	-	-	SXZn	-	-	SXZn
C.V. (%)	7.41	5.93	6.67	6.27	5.91	6.09	13.21	13.19	13.2	14.66	15.42	15.04

kg ha^{-1} was registered with the application of FYM @ 10 t ha^{-1} which was 16.22, 16.44 and 16.26 per cent higher over no FYM during 2007-08, 2008-09 and pooled results, respectively. Similarly, application of FYM @ 10 t ha^{-1} also significantly increased the stover yield of mustard (Table 2). The significantly higher stover yield of 4076, 3640 and 3858 kg ha^{-1} was registered with the application of FYM @ 10 t ha^{-1} which was 9.45, 10.37 and 9.88 per cent higher as compared to no FYM during 2007-08, 2008-09 and pooled results, this results supported by Patel *et al*. (1996). Nagdive *et al*. (2007).The increase in seed and stover yield of mustard might be attributed due to its essential role of all nutrients present in FYM for plant growth attributes and yield through its effect as a good source of soil organic matter which improves the physico-chemical and biological properties of soil. Application of FYM also increases cation exchange capacity and microbial activity in soil besides supplying macro and micro plant nutrients. It helps in minimizing leaching losses, improving buffering capacity and influencing the redox conditions in the soil. Results of the present investigation are in line with earlier findings Kumar *et al*. (2007); Deshmukh *et al*. (2005) and Patel *et al*. (2007) and Chanchal Verma *et al*. (2016)

Combined effect of sulphur zinc and FYM

Application of sulphur along with zinc had significant effect on seed yield (Table 2). The highest seed yield of 2093, 1948 and 2021 kg ha^{-1} was recorded under 60 kg S ha^{-1} in combination with 5.0 kg Zn ha^{-1}, but it was found at par with S_2Zn_2 during 2007-08 and pooled and S_2Zn_2, S_2Zn_1, S_1Zn_2 and S_3Zn_1 in 2008-09. Combined application of 40 kg S ha^{-1} and 5.0 kg Zn ha^{-1} resulted in increase in seed yield to the extent of 118.09, 116.85 and 117.51 per cent where neither sulphur [redacted]c was applied during 2007-08, 2008-09 and in pooled [redacted] respectively.

[redacted]nergi[redacted]tic effect of combined application of sulphur and [redacted]p to[redacted] certain levels on mustard positively has been [redacted]d by Prasad *et al*. (2003); Akbari *et al*. (2003); Meena [redacted]a; Subhash and Yadav (2007); Singh *et al*. (2007))

[redacted] on [redacted]utrient Content and Uptake

Effect of sulphur

The nutrients content and uptake of N, P, K, S, Fe and Zn by seed, stover and total were significantly increased due to application of 60 kgS ha^{-1} which showed significantly superiority over the rest of levels of sulphur for P and S content and their uptake by seed, stover and total uptake during 2007-08, 2008-09 and in pooled results(Table 3,4,5,6,7,8) except P content in seed as well as S uptake by stover, but it was also found at par with 40 kg S ha^{-1} for N content and its uptake by seed, stover and total , K, Zn and Fe uptake by seed, stover and total uptake during 2007-08, 2008-09 and pooled. Application of 60 kg S ha^{-1} was also found at par with S_2 and S_1 for K and S content in seed and stover, Zn content in seed and Fe content in stover during both the years and pooled.

The results are in accordance with those of reported by earlier workers Ram and Pareek, (2000); and Kumar *et al*. (2001) who observed increase in content and uptake of nutrient by seed and stover of mustard due to different levels of sulphur. The positive effect of sulphur on Zn uptake might be due to more solubilization and mobilization of Zn in the presence of sulphate ions (Dixit and Shukla, 1984). Sulphur applied upto 60 kg ha^{-1} increased the content and uptake of Fe by seed and stover during both years and pooled (Table 8). This synergistic effect may be due to the effect of H_2SO_4, formed by oxidation of S in the Soil, on solubilization of bound iron, increase Fe content and uptake of crop. Similar results were also reported by Yasari *et al*. (2009) who observed increase in the concentrations of N, P, K, S and Zn in seeds of rapeseed due to inclusion of S in the integrated nutrient management. Patel *et al*. (2007), Kumar and Yadav (2007) also observed positive significant effect of added sulphur on nutrients content and their uptake by mustard.

Effect of zinc

The nutrients content of N, P, K, S, Fe and Zn (except P content in seed and stover) and their uptakes (Table 3,4,5,6,7,8) by seed, stover and total were significantly improved due to addition of zinc during 2007-08, 2008-09 and pooled. The nutrient contents in seed and stover (except P content in seed and stover) were significantly higher due to addition of zinc @ 5.0 kg Zn ha^{-1}, but it was at par in case of N content in stover during 2007-08 and pooled, K content in seed and stover , N, S and Zn content in seed, S content in stover , Fe content in seed and stover and Zn content in stover during 2007-08, 2008-09 and pooled. While, no addition of zinc showed its significant superiority for increasing P content in seed and stover over rest of zinc levels during 2007-08, 2008-09 and pooled. The maximum uptake of N, P, K, S, Fe and Zn by seed, stover and total was significantly higher due to application of zinc @5.0 kg ha^{-1}, but it was found at par with addition of Zn @ 2.5 kg ha^{-1} for N, K and S uptake by stover during 2008-09.

The beneficial effect of zinc addition on nutrient content except P observed in the present study could be attributed to higher uptake of all the nutrients on account of correction of deficiencies like zinc resulting in elimination of factor, which was limiting the growth and uptake of nutrients in the control. Balanced nutrition also stimulates the metabolic activities resulting in better growth of shoot and roots helping in utilization of nutrients absorbed by plants leading to dry matter production for diversion to seed at seed development. The significant increase in the uptake of nutrients by the addition of zinc was related with increase in concentration of nutrients in seed and stover as well as due to significant increase in seed and stover yield of mustard. The findings are in agreement with earlier findings of Samui *et al*. 1980; Akbari (1990); Singh *et al*. (1994) and who also observed that the increase in the content and uptake of nutrients by seed and stover of mustard due to amended with zinc and Similar result was found by Kumar *et al*., 2016, Chaudhary *et al*. (2014), Kumar *et al*., 2016 in soybean.

Reduction in P content in seed and stover of mustard with an increase in the levels of zinc could be attributed to hindrance effect caused by the increased concentration of Zn in the absorption and translocation of P from the roots to the above ground parts and likewise, antagonistic relationship between zinc and phosphorus is established in soil. The antagonistic relationship of zinc and phosphorus has been reported by who reported that higher levels of zinc had adverse effect on P concentration in mustard. An application of zinc had positive significant effect on content and uptake of N, S, Fe and Zn by seed and stover of mustard . Increase in S content and uptake by seed and stover of mustard due to application of Zn @ 15 kg ha^{-1} was also observed by Husain and Kumar (2006).

Effect of FYM

Positive significant effect of FYM @ 10 t ha^{-1} was found on N, P, K and S content of mustard over no FYM (Table 3,4,5,6), while FYM application had non significant effect on Zn and Fe content(Table7,8) of mustard during 2007-08, 2008-09 and pooled results. The results (Table) showed that significant effect of FYM application @ 10 t ha^{-1} on N, P, K, S, Fe and Zn uptake by mustard seed, stover and total during 2007-08, 2008-09 and pooled.

The addition of FYM helped in increasing P and S utilization on account of chelation of Fe and Al cations, which are known to prevent the availability of P and S by forming insoluble Fe and Al phosphates and sulphates (Lal and Dravid 1990a). Increased dry matter yield with the addition of FYM might also have caused increased utilization of sulphur. Similarly, application of FYM alone showed an enhancement of P absorption by mustard. Patel (1995) had shown positive significant influence of FYM @ 10 ton ha^{-1} on contents of N, P, K and their uptake by seed and stover of mustard. Verma Chanchal *et al*. (2014).

Combined effect of sulphur and zinc

Application of sulphur in conjunction with zinc exhibited significant effect on the uptake of N, P, K, S, Zn and Fe by seed, stover and total in pooled results (Table 3,4,5,6,7,8). Further, results showed that combined effect of SxZn, SxFYM, ZnxFYM and SxZnxFYM on nutrients contents of N, P, K, S, Zn and Fe in seed and stover found non-significant during 2007-08, 2008-09 and pooled as well as uptake of N, P, K, S, Zn and Fe by seed, stover and total during 2007-08 and 2008-09. The maximum uptake of N, P, K, S, Zn and Fe by seed, stover and total uptake in pooled results was recorded under 60 kg S ha^{-1} along with 5.0 kg Zn ha^{-1} which was significantly higher, but it was found at par with S_2Zn_2 and superior to rest of the treatment combinations. Whereas, the lowest uptake of all the nutrients were recorded under control (S_0Zn_0). This might be due to the facts that soils of experimental plot were deficient in available S as well as DTPA-extractable Zn status of soil. The combined application of both these nutrients promote the growth of plant *viz*., no. of primary branches plant^{-1} and test weight which favorably reflected on higher yield and balanced uptake of plant nutrients reported that N, P, K, S, Zn content and their total uptake increased due to 40 kg S ha^{-1} along with 4 kg Zn ha^{-1}. These results are in conformity with the earlier findings of and Babulkar *et al*. (2000) and Meena *et al*. (2006)

ACKNOWLEDGEMENT

This Research was supported by Department of Soil Chemistry and Soil Science, C.P. College of Agriculture, Sardarkrushinagar Dantiwada. Agricultural University, Sardarkrushinagar-Gujarat carried out under the direct supervision of Dr. J.J. Patel, Research Scientist. Centre For Natural Resource Management, Sardarkrushinagar Dantiwada. Agricultural University, Sardarkrushinagar-Gujarat

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