
**EFFECT OF SULPHUR AND ZINC ON MACRONUTRIENT (N, P, K & S)
CONTENT AND UPTAKE BY MUSTARD ON USTOCHREPTS****JAT, J. S.* AND CHAUDHARY, M.G.**

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ABSTRACT

A field experiment was conducted for two years (i.e. 2001-02 and 2002-03) with mustard [*Brassica juncea* (L.) Czern and Coss.] as a test crop on clay loam soil with five doses of sulphur (i.e 0, 20, 40, 60 and 80 kg S ha⁻¹) and zinc (i.e. 0, 2.5, 5.0, 7.5 and 10.0 kg Zn ha⁻¹). Application of 60 kg S ha⁻¹ and 2.5 kg Zn ha⁻¹ significantly increased nitrogen, phosphorus, potassium and sulphur content at all the stages of growth and years of experimentation. The seed and stover produced by the crop fertilized with 60 kg S ha⁻¹ and 5.0 kg Zn ha⁻¹ accumulated significantly higher amount of nutrients (N, P, K and S) except nitrogen and potassium contents in seed where significant increase was recorded only upto 40 kg S ha⁻¹.

KEY WORDS: Sulphur, Zinc, Mustard, Content, Uptake**INTRODUCTION**

The declined soil fertility is the main cause of low productivity of the cultivated lands. So far the emphasis has been to supplement the soil with the major nutrients viz. N, P, K and the crop requirements for secondary and micronutrients could be met with soil reserve. According to soil test analysis use of high grade fertilizers, limited recycling of plant residues and gap between the removal and supplementation of secondary and

micro-nutrients have resulted in widespread multiple nutrient deficiencies, specially for N, P, K, S and Zn along with other nutrients. In recent years sulphur deficiency has been aggravated in the soil due to continuous crop-removal and use of sulphur and zinc free high analysis N, P, K fertilizers. Leaching and erosion losses also contribute to sulphur deficiencies. Saalbach (1973) reported that sulphur deficiency tends to affect adversely the growth and yield of seed crop, which reduces the crop yield to an extent of 10-30 per cent. The present study was undertaken to evaluate the effect of sulphur and zinc on macronutrient content and uptake by 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 levels of sulphur (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. Soil samples were drawn from each experimental plot upto 15 cm depth with the help of screw auger in zigzag pattern from four points in each plot after the harvest of mustard crop. The ground seed and stover samples were digested with nitric-perchloric (9 : 4) di-acid mixture for the analysis of all other elements except N. Nitrogen was determined by colorimetric method using Nessler's reagent (Jackson, 1973). Phosphorus was estimated by vanadomolybdate yellow colour method (Jackson, 1973). Potassium was estimated flame photometrically. Sulphur was determined by turbidimetric method of Chesnin and Yien (1951).

RESULTS AND DISCUSSION

Nitrogen Content and Uptake

It is evident from the data (Table – 1) that successive increase in sulphur application from 0 to 60 kg ha⁻¹ increase nitrogen content in plant at 30, 60 and 90 DAS and in seed and stover at harvest. Application of 60 kg S ha⁻¹ was significantly superior over control and 20 kg S ha⁻¹ at 30 and 60 DAS and in seed. While the difference in nitrogen content at 90 DAS and in stover was significant only up to 40 kg S ha⁻¹. Nitrogen uptake by mustard seed increased significantly upto the level of 40 kg S ha⁻¹ but in stover significant uptake was recorded upto 60 kg S ha⁻¹ during both the years of experimentation. The content and uptake of nitrogen increased significantly by application of sulphur. This increase in N content is attributed to application of sulphur to plants which in turn provide in vigorous root and shoot growth resulting into greater absorption of nitrogen from soil. This is further supported by the fact that sulphur deficiency prevents utilization of nitrogen and also brings about an accumulation of soluble nitrogen within plants. The increased accumulation of nitrogen in plants thus checks further absorption of nitrogen leading to decrease in N content in plant (Charlier and Carpentiers, 1956). The increased N content and its uptake due to sulphur application has also been reported by Sharma *et al.* (1990) and Chauhan (1998).

Application of zinc resulted in gradual increase (Table – 1) in nitrogen content in plant with progressive increment of zinc levels upto 7.5 kg Zn ha⁻¹ which was significantly superior over control and 2.5 kg Zn ha⁻¹ application at 30 and 90 DAS and in stover. Application of 7.5 kg Zn ha⁻¹ was found at par with 2.5, 5.0 and 10 kg Zn ha⁻¹ for nitrogen content at 60 DAS and in seed. The beneficial effect of zinc application on nitrogen uptake was observed significantly upto the level of 5.0 kg Zn ha⁻¹ application. The magnitude of significant increase in nitrogen uptake being 23.36 and 8.69, 23.08 and 8.92 per cent in seed, 23.68 and 7.99, 24.45 and 8.61 per cent in stover over control and 2.5 kg Zn ha⁻¹ application in 2001-02 and 2002-03, respectively. The beneficial role of zinc in increasing the CEC of roots helped in increased absorption of nutrients from the soil. Further, the beneficial role of zinc in chlorophyll formation, regulating the auxin concentration and its stimulatory effect on most of physiological and metabolic processes of the plant might have helped the plants in absorption of greater amount of nutrients from soil. Thus, the favourable influence of zinc on photosynthesis and metabolic processes

augment the production of photosynthates and their translocation to different plant parts including grain which ultimately increased the concentration of nutrients in seed and stover. The results are in cognizance with the findings of Sharma and Bhardwaj (1998) and Dwivedi *et al.* (2001).

Phosphorus content and Uptake

It was revealed from the data presented in Table – 2 that phosphorus content and uptake increased significantly with increasing levels of sulphur upto 60 kg S ha⁻¹ except P content in stover in 2001-02, where P content increased significantly upto 80 kg S ha⁻¹, irrespective of stages and years of experimentation. The application of sulphur significantly increases the content and uptake of phosphorus, potassium and micronutrients (especially Zn, Fe, Mn and Cu). The application of sulphur not only acted as a source of sulphur but it influences physical, chemical and biological properties of soil resulting in change like drop in soil pH. Release of nutrients in available forms and other physical properties might have influenced the availability of other nutrients leading to their absorption, thereby showing a higher content with application of sulphur. Increase uptake of nutrients with sulphur application at varying levels have been reported by Sharma (1991) and Mina (2000).

Across the years, with increasing rates of zinc fertilization from 0 to 5.0 kg Zn ha⁻¹ there was an increase in phosphorus content but significant increase was found only upto 2.5 kg Zn ha⁻¹ application in all the stage of growth. Addition of 10 kg Zn ha⁻¹ resulted in significant decrease in phosphorus content over 7.5 kg Zn ha⁻¹ application, irrespective of stages and years of experimentation. It is clear from the data presented in above table that P uptake increased significantly upto the levels of 5.0 kg Zn ha⁻¹. Application of 10 kg Zn ha⁻¹ was found significantly inferior as compare to 5.0 kg Zn ha⁻¹ application. The reduction in the content of phosphorus owing to application of zinc may be due to the antagonistic reaction between zinc and phosphorus. The increased concentration of zinc created hindrance in absorption and translocation of phosphorus from the roots to the above ground parts due to the formation of Zn₃ (PO₄)₂ compounds which is unavailable to plants. Excess of zinc may also change the physiological ability of the plant to absorb phosphorus by change in the permeability of the cell membrane. Phosphorus uptake first increased due to increase in yield but at higher level it decreased due to

reduced phosphorus content in seed and stover. Similar results were also reported by Choudhary *et al.* (1997).

Potassium content and Uptake

A perusal of data in table 3 shows that increasing levels of sulphur significantly increased the potassium content upto 20 kg S ha⁻¹ application in all the stages of growth and in seed and stover of mustard. The application of 60 kg S ha⁻¹ was found at par with 40 and 80 kg S ha⁻¹ but it differed significantly with control and 20 kg S ha⁻¹ irrespective of stages and years of growth. Potassium uptake increased significantly with increasing levels of sulphur upto 60 kg ha⁻¹ except in seed where significant difference was obtained only upto the level of 40 kg S ha⁻¹. The positive influence of sulphur fertilization on nutrient content of the crop seems to be due to improved nutritional environment both in the rhizosphere and the plant system. The increased availability of nutrients in root zone coupled with increased metabolic activity at cellular might have increased uptake of nutrients and their accumulation in vegetative plant parts.

Further, reference to data in above table indicates that across the years and stages of experimentation, there was a significant increase in potassium content upto 2.5 kg Zn ha⁻¹ application. A significant increase was also obtained in potassium content at 7.5 kg Zn ha⁻¹ over control and 2.5 kg Zn ha⁻¹ application. Increase in potassium uptake was found significantly upto 5.0 kg Zn ha⁻¹ application. The magnitude of significant increase in potassium uptake from 5.0 kg Zn ha⁻¹ were 23.98, 9.09 per cent and 24.69, 10.17 per cent in seed and 22.06, 7.76 per cent and 22.53, 8.93 in stover over control and 2.5 kg Zn ha⁻¹ application in 2001-02 and 2002-03, respectively.

Sulphur content and Uptake

It is explicit from data (Table – 4) that maximum sulphur content was recorded under 80 kg S ha⁻¹ but application of 60 kg S ha⁻¹ was significantly superior over control, 20 and 40 kg S ha⁻¹ at all the stages of growth and years of experimentation. Sulphur uptake also increased significantly with increasing levels of sulphur upto 60 kg S ha⁻¹ in both seed and stover. The increase in sulphur content might be due to increased concentration of sulphur in soil solution with the application of sulphur. The higher sulphur content in seed and stover might have

resulted into greater uptake of sulphur in plant. The result of present investigation are corroborate with the findings of Chauhan (1998).

The maximum sulphur content (other nutrient also) in mustard plant was observed at early stages of growth and it decreased gradually with the advancement of crop growth stages. Higher values of nutrients at early stage could be due to greater root vicinity and less plant growth and also due to basal application of sulphur, resulting in more soil sulphur concentration and its availability which increased its absorption by plant roots. The low absorption of sulphur (other nutrient also) in the latter growth stage might be due to dilution effect (Aulakh *et al.* 1977).

Further, reference to data in above table indicate that there was a significant increase in sulphur content of mustard during all the stages of growth including seed and stover with the application of zinc upto 2.5 kg ha⁻¹. Significantly higher sulphur content was obtained at 2.5 kg Zn ha⁻¹ the increase being 3.53 and 3.62 3.67 and 3.59, 3.46 and 3.74, 3.75 and 3.52, 3.62 and 3.70 per cent at 30 DAS, 60 DAS, 90 DAS, in seed and stover over control in 2001-02 and 2002-03, respectively. Sulphur uptake increased significantly upto the level of 5.0 kg Zn ha⁻¹ application.

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Table 1: Effect of sulphur and zinc levels on nitrogen content and uptake of mustard

Treat.	Nitrogen content (%)										Nitrogen uptake (kg ha ⁻¹)			
	30 DAS		60 DAS		90 DAS		Seed		Stover		Seed		Stover	
	2001-02	2002-03	2001-02	2002-03	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	3.614	3.630	2.657	2.675	2.179	2.203	2.939	2.967	0.740	0.758	47.86	50.55	34.25	36.86
20	3.821	3.839	2.799	2.823	2.291	2.324	3.095	3.127	0.803	0.825	57.44	60.58	42.37	45.19
40	3.915	3.922	2.864	2.894	2.361	2.386	3.170	3.185	0.844	0.868	64.41	67.83	49.30	51.91
60	3.972	3.946	2.891	2.905	2.373	2.402	3.193	3.228	0.850	0.886	68.98	72.84	53.04	56.71
80	3.920	3.947	2.875	2.905	2.363	2.390	3.174	3.191	0.857	0.878	67.68	69.73	51.86	54.68
SEm±	0.032	0.030	0.025	0.026	0.019	0.020	0.031	0.029	0.008	0.007	1.74	1.89	1.11	1.40
CD at 5%	0.100	0.092	0.078	0.081	0.060	0.061	0.097	0.088	0.024	0.021	5.37	5.82	3.41	4.32
Zinc (kg ha⁻¹)														
0.0	3.740	3.713	2.718	2.744	2.232	2.255	3.009	3.037	0.777	0.800	52.39	55.07	38.77	41.26
2.5	3.828	3.840	2.808	2.831	2.304	2.330	3.104	3.132	0.810	0.837	59.46	62.23	44.40	47.28
5.0	3.875	3.891	2.843	2.851	2.333	2.360	3.141	3.166	0.827	0.853	64.63	67.78	47.95	51.35
7.5	3.909	3.922	2.860	2.892	2.353	2.383	3.169	3.193	0.844	0.866	66.03	69.35	50.62	53.56
10.0	3.889	3.918	2.853	2.883	2.345	2.371	3.149	3.171	0.836	0.860	63.85	67.11	49.07	51.91
SEm±	0.022	0.026	0.020	0.022	0.016	0.019	0.026	0.025	0.007	0.006	1.48	1.55	0.98	1.12
CD at 5%	0.061	0.075	0.056	0.063	0.045	0.053	0.073	0.070	0.019	0.018	4.20	4.40	2.77	3.17

Table 2: Effect of sulphur and zinc levels on phosphorus content and uptake of mustard

Treatments	Phosphorus content (%)										Phosphorus uptake (kg ha ⁻¹)			
	30 DAS		60 DAS		90 DAS		Seed		Stover		Seed		Stover	
	2001-02	2002-03	2001-02	2002-03	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	0.472	0.506	0.390	0.406	0.282	0.297	0.560	0.570	0.182	0.209	9.12	9.72	8.40	10.13
20	0.511	0.548	0.416	0.436	0.306	0.330	0.590	0.606	0.202	0.216	10.93	11.73	10.63	11.79
40	0.556	0.590	0.448	0.466	0.338	0.350	0.644	0.658	0.218	0.232	13.08	14.02	12.72	13.86
60	0.576	0.606	0.462	0.479	0.350	0.359	0.666	0.678	0.230	0.245	14.39	15.28	14.34	15.66
80	0.587	0.614	0.466	0.484	0.354	0.362	0.670	0.682	0.236	0.251	14.29	14.93	14.28	15.60
SEm±	0.006	0.005	0.003	0.004	0.003	0.003	0.006	0.006	0.002	0.002	0.36	0.36	0.27	0.40
CD at 5%	0.018	0.014	0.011	0.012	0.009	0.009	0.019	0.018	0.006	0.007	1.11	1.09	0.82	1.24
Zinc (kg ha⁻¹)														
0.0	0.528	0.562	0.425	0.444	0.316	0.328	0.610	0.625	0.207	0.224	10.66	11.39	10.35	11.58
2.5	0.550	0.586	0.446	0.465	0.332	0.347	0.636	0.649	0.217	0.234	12.25	12.95	11.93	13.23
5.0	0.561	0.595	0.451	0.472	0.338	0.352	0.645	0.659	0.221	0.237	13.33	14.17	12.87	14.30
7.5	0.552	0.587	0.445	0.466	0.333	0.348	0.636	0.648	0.218	0.234	13.32	14.11	13.15	14.51
10.0	0.511	0.534	0.415	0.425	0.312	0.323	0.600	0.615	0.205	0.223	12.24	13.06	12.08	13.42
SEm±	0.005	0.004	0.003	0.003	0.003	0.003	0.005	0.004	0.002	0.002	0.31	0.33	0.25	0.28
CD at 5%	0.013	0.012	0.008	0.009	0.007	0.008	0.013	0.012	0.005	0.005	0.88	0.93	0.71	0.79

Table 3: Effect of sulphur and zinc levels on potassium content and uptake of mustard

Treatments	Potassium content (%)										Potassium uptake (kg ha ⁻¹)			
	30 DAS		60 DAS		90 DAS		Seed		Stover		Seed		Stover	
	2001-02	2002-03	2001-02	2002-03	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	1.796	1.806	1.366	1.393	1.183	1.193	0.769	0.779	1.046	1.068	12.52	13.29	48.38	51.83
20	1.868	1.896	1.428	1.449	1.240	1.246	0.803	0.813	1.076	1.122	14.93	15.76	56.75	61.44
40	1.915	1.932	1.455	1.484	1.266	1.274	0.825	0.835	1.104	1.149	16.75	17.83	64.47	68.65
60	1.928	1.955	1.478	1.511	1.288	1.297	0.836	0.853	1.124	1.166	18.08	19.26	70.08	74.57
80	1.910	1.926	1.448	1.474	1.254	1.259	0.815	0.829	1.110	1.155	17.39	18.12	67.09	71.95
SEm±	0.016	0.015	0.011	0.013	0.012	0.013	0.008	0.008	0.010	0.009	0.47	0.55	1.36	1.70
CD at 5%	0.050	0.047	0.035	0.039	0.038	0.041	0.023	0.024	0.029	0.029	1.45	1.69	4.19	5.23
Zinc (kg ha⁻¹)														
0.0	1.812	1.833	1.381	1.407	1.200	1.207	0.779	0.790	1.053	1.094	13.55	14.34	52.36	56.32
2.5	1.862	1.892	1.424	1.452	1.238	1.246	0.803	0.815	1.085	1.123	15.40	16.23	59.31	63.35
5.0	1.893	1.922	1.448	1.476	1.262	1.266	0.818	0.834	1.105	1.148	16.80	17.88	63.91	69.01
7.5	1.927	1.950	1.470	1.492	1.276	1.284	0.828	0.844	1.115	1.158	17.27	18.33	66.79	71.42
10.0	1.922	1.920	1.451	1.481	1.256	1.265	0.820	0.827	1.103	1.137	16.64	17.48	64.39	68.32
SEm±	0.013	0.013	0.010	0.011	0.010	0.009	0.006	0.007	0.008	0.009	0.40	0.42	1.33	1.48
CD at 5%	0.037	0.036	0.028	0.030	0.029	0.024	0.018	0.020	0.022	0.024	1.13	1.20	3.76	4.18

Table 4: Effect of sulphur and zinc levels on sulphur content and uptake of mustard

Treatments	Sulphur content (%)										Sulphur uptake (kg ha ⁻¹)			
	30 DAS		60 DAS		90 DAS		Seed		Stover		Seed		Stover	
	2001-02	2002-03	2001-02	2002-03	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	0.520	0.531	0.424	0.436	0.308	0.326	1.136	1.156	0.193	0.210	18.48	19.70	8.92	10.21
20	0.587	0.596	0.477	0.491	0.337	0.362	1.262	1.292	0.215	0.236	23.46	25.02	11.31	12.90
40	0.635	0.647	0.520	0.531	0.367	0.394	1.366	1.396	0.235	0.257	27.75	29.76	13.72	15.39
60	0.661	0.678	0.549	0.560	0.386	0.420	1.418	1.438	0.248	0.271	30.68	32.45	15.45	17.32
80	0.674	0.691	0.559	0.575	0.396	0.428	1.446	1.466	0.253	0.277	30.87	32.02	15.31	17.25
SEm±	0.005	0.006	0.004	0.005	0.004	0.003	0.013	0.012	0.002	0.002	0.72	0.77	0.34	0.35
CD at 5%	0.015	0.018	0.014	0.016	0.011	0.010	0.039	0.038	0.007	0.008	2.23	2.37	1.05	1.09
Zinc (kg ha⁻¹)														
0.0	0.595	0.608	0.490	0.501	0.347	0.374	1.282	1.306	0.221	0.243	22.45	23.82	11.07	12.57
2.5	0.616	0.630	0.508	0.519	0.359	0.388	1.330	1.352	0.229	0.252	25.62	27.03	12.62	14.27
5.0	0.627	0.642	0.515	0.529	0.367	0.395	1.351	1.380	0.233	0.257	27.96	29.74	13.59	15.51
7.5	0.625	0.637	0.512	0.528	0.362	0.389	1.342	1.366	0.231	0.253	28.17	29.79	13.92	15.70
10.0	0.613	0.626	0.504	0.516	0.358	0.383	1.323	1.344	0.230	0.248	27.02	28.57	13.51	15.03
SEm±	0.004	0.005	0.004	0.004	0.003	0.003	0.009	0.011	0.002	0.002	0.71	0.70	0.24	0.32
CD at 5%	0.013	0.014	0.010	0.012	0.009	0.008	0.026	0.031	0.005	0.006	2.00	1.98	0.67	0.91