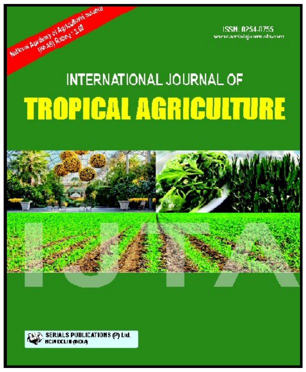

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Effect of Gypsum and Zinc Sulphate Application on Yield, Nutrient Content and Uptake by Mustard (*Brassiccajuncea L.*)

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Abstract: A field experiment was conducted to study the "Effect of gypsum and zinc sulphate application on yield, nutrient content and uptake by mustard (*Brassiccajuncea L.*)" at Research Farm of Agriculture College, Nagpur. Twelve treatment combinations were studied in FRBD design with three replications, which comprises four levels of gypsum (0, 18, 36 and 54 kg ha^{-1}) and three levels of zinc sulphate (0, 5 and 10 kg ha^{-1}). The experimental site was medium black, moderately alkaline in reaction, clayey in texture, medium in organic carbon, low in available N, medium in available P, high in available K, low in available S and Zn. The significant increase in seed and stover yield of mustard were recorded due to application of gypsum at 36 kg ha^{-1} and zinc sulphate at 5 kg ha^{-1}. The content and uptake of N, P, K, S and Zn improved in seed and stover of mustard significantly due to application of gypsum up to 36 kg gypsum ha^{-1} and zinc sulphate up to 5 kg $ZnSO_4$ ha^{-1}.

Key words: Gypsum, zinc sulphate, yield, nutrient content, uptake, mustard.

INTRODUCTION

Mustard is cool weather loving crop, grown either as a sole crop or mixed with wheat, gram and linseed. The traditionally grown oilseed crop such as linseed with low yield potential even under irrigated conditions is being replaced by mustard crop. Now a days, with the availability of irrigation in Maharashtra, the potential of this crop can be exploited during rabi season.Enhanced removal of micronutrients as a result of adoption of high yielding varieties, intensive cropping with high analysis NPK fertilizers, limited use of organic manures and less recycling of crop residues led to the depletion of secondary and micronutrients from the soil reserves. There are reports of decline in yield even use of recommended NPK fertilizers. The reduction in yield is generally accounted to deficiency of secondary and micronutrients. Oilseed crops have been reported to deplete the soil sulphur (S) relatively to a greater extent because S uptake per tonne of grain production is high in oilseed. It is 3 to 4 kg for cereals, 8 kg for pulses and 12 kg for oilseeds (Tandon, 1995). Due to continuous use of sulphur and zinc free high analysis NPK fertilizers over a long period may cause sulphur and zinc deficiencies and are being encountered in different parts of India (Kumar and Singh, 1980). Vertisols have less physiological available sulphur for plants (Singh and Singh, 1984). Therefore, applied sulphur and zinc will enhance growth and contribute to increase seed yield and oil content by exploiting genetic potential of mustard.

The area under mustard in Maharashtra is very less as compare to other states and having low productivity. Mustard crop can grow in temperate as well as tropical climate, so there is good scope for increasing cultivation of mustard in Maharashtra specially in Vidarbha region. To meet the increasing demand of oil products for the growing population and economy of India. This will require more investment in agricultural research and in the promotion of modern technologies including increasing fertilizer use. With the improvement of land productivity through the adoption of high yielding varieties and multiple cropping systems, fertilizer use has become more and more important to increase oil crop yield and quality. Sulphur and zinc are essential plant nutrients for oilseed crop production and requires more in quantity than cereal grain crops. So, there is good scope to increase the productivity of mustard in Vidarbha region with balanced fertilizer.

MATERIALS AND METHODS

A field experiment was conducted at Farm of Agriculture College, Nagpur which is situated at 21° 10′ North latitude and 79° 10′ East latitude at the elevation of 321.26 m above mean sea level and lies under sub tropical zone. Nagpur is characterized by hot and dry summer and fairly cold winter. This area shows wide duirnal fluctuation in temperature. The maximum and minimum temperature ranged from 29.6°C to 34.1°C and 9.9°C to 19.4°C, respectively, whereas the relative humidity varied from 20 to 72 per cent during the crop growth period, mean annual precipitation is about 938.4 mm. The soil of experimental field had pH 8.01, EC 0.32 dSm^{-1}, organic carbon 5.3 g kg^{-1}, available nitrogen 222.6 kg ha^{-1}, available phosphorus 14.58 kg ha^{-1}, available potassium 368.80 kg ha^{-1}, available sulphur 8.16 mg kg^{-1} and DTPA-extractable micronutrients Zn, Fe, Mn and Cu 0.59, 3.86, 2.53 and 1.36 mg kg^{-1}, respectively. The experiment was laid out in factorial randomized block design with twelve treatment combinations each replicated thrice. The treatments consisting of four levels of gypsum (0,18,36 and 54 kg ha^{-1}) and three levels of zinc sulphate (0,5 and 10 kg ha^{-1}).

The treatments were applied as basal dressing through gypsum and zinc sulphate as per treatments. Recommended dose of nitrogen and phosphorus was applied through urea and DAP, respectively. Nitrogen was applied in two split doses, 1st dose at the time of sowing and 2nd at 30 DAS. Full dose of phosphorus, gypsum and zinc sulphate was given at the time of sowing. The crop was harvested at maturity and yield data were recorded. 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. The nitrogen from plant was determined bymicro-Kjeldahl's method as described by Piper (1966), phosphorus was estimated by vanadomolybdate yellow colour method (Jackson, 1967), potassium was estimated flame photometrically, sulphur was determined by turbidity method (Jackson, 1967) and zinc was determined from di-acid digested extract by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Seed Yield of Mustard

The results obtained in respect of seed and stover yield of mustard as influenced by gypsum and zinc sulphate application are presented in table 1. The yield (seed and stover) of mustard were significantly influenced due to different gypsum and zinc sulphate levels. From the data presented in table 1, revealed that the highest seed yield of mustard (8.13 q ha^{-1}) was obtained with application of 54 kg gypsum ha^{-1}, which was found to be at par with application of 36 kg gypsum ha^{-1}(8.02 q ha^{-1}). The significant increase in seed yield of mustard was recorded up to application of 36 kg gypsum ha^{-1}. With the increase in supply of sulphate the process of tissue differentiation from somatic reproduction, meristimatic activity and development of floral primordial might have increase resulting in more flowers and siliqua, longer siliqua and higher siliqua yield. Similar results were reported by Singh *et al.* (1998).

Application of zinc sulphate was significantly increased the seed yield up to application of 5 kg $ZnSO_4$ ha^{-1}. Application of 5 kg $ZnSO_4$ ha^{-1} shows the significant increase in seed yield over control (7.12 q ha^{-1}). Increase in yield due to increase level of growth hormone such as auxin, promotes starch formation and seedmaturation. Similar results were also reported by Balusamy*et al.* (1996). The interaction effect between gypsum and zinc sulphate in respect to seed yield was found to be significant. The maximum seed yield (8.49 q ha^{-1}) was noticed with $G_{54}Zn_{10}$ treatment combination which was found to be at par with $G_{54}Zn_5$ (8.38 q ha^{-1}), $G_{36}Zn_{10}$ (8.36 q ha^{-1}) and $G_{36}Zn_5$ (8.24 q ha^{-1}) treatment combinations.

Stover Yield of Mustard

A perusal of data in table 1, revealed that there was significant increase in stover yield of mustard up to 36 kg gypsum ha^{-1}. The highest stover yield of mustard (23.16 q ha^{-1}) was observed with the application of 54 kg gypsum ha^{-1} which was found to be at par with 36 kg gypsum ha^{-1} (22.74 q ha^{-1}). Application of 36 kg gypsum ha^{-1} showed the significant increased in stover yield of mustard over 18 kg gypsum ha^{-1} (20.50 q ha^{-1}) and control (19.19 q ha^{-1}). Similar results were also recorded by Kumar and Singh (1980). Application of zinc sulphate significantly influenced the stover yield up to 5 kg zinc sulphate ha^{-1}. The highest stover yield (22.14 q ha^{-1}) was recorded with 10 kg $ZnSO_4$ ha^{-1} which was

Table 1
Seed and stover yield (q ha^{-1}) of mustard as influenced by gypsum and zinc sulphate levels

Treatments	*Seed yield (q ha^{-1})*	*Stover yield (q ha^{-1})*
Levels of Gypsum (kg ha^{-1})		
G_0	6.74	19.19
G_{18}	7.21	20.50
G_{36}	8.02	22.74
G_{54}	8.13	23.16
'F' test	Sig.	Sig.
SE (m) ±	0.18	0.38
CD at 5%	0.56	1.16
Levels of Zinc sulphate (kg ha^{-1})		
Zn_0	7.12	20.30
Zn_5	7.67	21.76
Zn_{10}	7.78	22.14
'F' test	Sig.	Sig.
SE (m) ±	0.14	0.29
CD at 5%	0.45	0.90

Interaction (Gypsum × Zinc sulphate)	*Zn_0*	*Zn_5*	*Zn_{10}*	*Zn_0*	*Zn_5*	*Zn_{10}*
G_0	6.52	6.82	6.88	18.48	19.36	19.73
G_{18}	6.94	7.27	7.41	19.84	20.62	21.06
G_{36}	7.47	8.24	8.36	21.23	23.30	23.68
G_{54}	7.53	8.38	8.49	21.64	23.77	24.09
'F' test		Sig.			Sig.	
SE (m) ±		0.30			0.62	
CD at 5%		0.91			1.92	

found to be at par with 5 kg zinc sulphate ha^{-1} (21.76 q ha^{-1}). Application of 5 kg $ZnSO_4$ ha^{-1} showed the significant increased in stover yield over control (20.30 q ha^{-1}). The increased yield might be due to the role of zinc in biosynthesis of Indole acetic acid (IAA) and especially due to its role in initiation of primordial for productive parts and partition in photosynthates towards fruiting. The findings of present investigation are supported by Singh *et al.* (1996).The data presented in table 1, indicated that, the interaction effect between gypsum and zinc sulphate in respect to stover yield was found to be significant. The highest stover yield (24.09 q ha^{-1}) was recorded with the treatment combination $G_{54}Zn_{10}$ followed by $G_{54}Zn_5$ (23.77 q ha^{-1}), $G_{36}Zn_{10}$ (23.68 q ha^{-1}), $G_{36}Zn_5$ (23.30 q ha^{-1}) and these treatment combinations were found at par with each other.

Nutrient Content

Nitrogen being the basic nutrient element of plant, its content in seed and stover can be taken as indicative parameter of balance fertilization and efficient fertilizer use. The data pertaining to effect of gypsum and zinc sulphate on content of nitrogen is presented in table 2. The results showed that nitrogen concentration in mustard seed and stover influenced significantly due to graded levels of gypsum and zinc sulphate. The nitrogen concentration influenced due to levels of gypsum ranged from 2.92 to 3.19 per cent in seed. The nitrogen concentration in mustard seed influenced due to addition of zinc sulphate ranged between 3.02 to 3.12 per cent which was increased with increasing levels of $ZnSO_4$.The concentration of nitrogen in stover of mustardvaried from 0.73 to 0.85 per cent with application of different levels of gypsum from 0 to 54 kg ha^{-1}. The concentration of nitrogen in stover and seed was significantly increased up to 36 kg gypsum ha^{-1}, further it was slightly increased up to the level of 54 kg gypsum ha^{-1} but statistically it was found at par with 36 kg gypsum ha^{-1}. The beneficial role of zinc in increasing in CEC of roots helped in increase 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 process of plant might have helped the plants in enhance absorption of nutrients in soil, thus the favorable influence of zinc on photosynthesis and metabolic process augment the production of photosynthates and their translocation to different plant part including grain, which ultimately increase concentration of nutrient in seed and stover. The results are in accordance to the findings of Dwiwedi*et al.* (2001).

Data presented in table 2 showed that phosphorus content increased significantly with the graded levels of gypsum and zinc sulphate. The concentration of phosphorus in seed which was ranged from 0.559 to 0.664 per cent whereas in stover it was ranged from 0.182 to 0.230 per cent. The highest content of phosphorus in seed (0.664%) and in stover (0.230%) was associated with the treatment 54 kg gypsum ha^{-1}, followed by application of 36 kg gypsum ha^{-1} in seed (0.644%) and stover (0.218%) and lowest content was recorded in control *viz.*, 0.559% in seed and 0.182% in stover of mustard crop. The results are in conformity with the findings of Rathore and Manohar (1990).

Data given in table 2 showed that, increasing levels of gypsum significantly increased the potassium content up to 54 kg gypsum ha^{-1} in seed and stover of mustard over control. The application of 54 kg gypsum ha^{-1} shows maximum content of K (0.835% in seed and 1.123% in stover) followed by application of 36 kg gypsum ha^{-1} (0.825% in seed and 1.104% in stover). with increasing rates of zinc sulphate fertilization from 0 to 10 kg zinc sulphate ha^{-1}, there was significant increase in potassium content up to 5 kg $ZnSO_4$ ha^{-1} in seed and stover of mustard. The higher percentage of potassium was recorded in seed (0.810%) and in stover (1.090%) with the application of 10 kg $ZnSO_4$ ha^{-1}, which was found to be at par with application of 5 kg $ZnSO_4$ ha^{-1}. The positive influence of sulphur fertilization on nutrient content

Table 2
Effect of gypsum and zinc sulphate on nutrient content in seed and stoverby mustard

	N content (%)		*P content (%)*		*K content (%)*		*S content (%)*		*Zn content (%)*	
Treatments	*Seed*	*Stover*	*Seed*	*Stover*	*Seed*	*Stover*	*Seed*	*Stover*	*Seed*	*Stover*
Levels of Gypsum (kg ha^{-1})										
G_0	2.92	0.73	0.559	0.182	0.769	1.046	0.964	0.332	36.66	29.11
G_{18}	3.04	0.80	0.590	0.201	0.803	1.076	1.060	0.344	38.47	31.20
G_{36}	3.16	0.84	0.644	0.218	0.825	1.104	1.124	0.357	40.04	32.31
G_{54}	3.19	0.85	0.664	0.230	0.835	1.123	1.162	0.362	37.69	30.65
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.015	0.010	0.003	0.002	0.002	0.003	0.005	0.003	0.47	0.28
CD at 5%	0.045	0.030	0.010	0.006	0.007	0.009	0.016	0.010	1.42	0.86
Levels of Zinc sulphate (kg ha^{-1})										
Zn_0	3.02	0.77	0.613	0.206	0.805	1.083	1.068	0.344	31.56	26.06
Zn_5	3.09	0.81	0.620	0.214	0.808	1.088	1.086	0.352	39.38	31.92
Zn_{10}	3.12	0.83	0.611	0.204	0.810	1.090	1.078	0.349	43.71	34.59
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.013	0.009	0.002	0.0015	0.001	0.002	0.004	0.002	0.40	0.24
CD at 5%	0.039	0.027	0.006	0.0045	0.004	0.006	0.014	0.006	1.21	0.74
Interaction (Gypsum × Zinc sulphate)										
'F' test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SE (m) ±	0.026	0.018	0.005	0.003	0.003	0.004	0.008	0.004	0.81	0.48
CD at 5%	–	–	–	–	–	–	–	–	–	–

of crops seems to be due to improved nutritional environment both in rhizosphere and plant system. The increased availability of nutrient in root zone coupled with increase metabolic activity at cellular level might have increase the uptake of nutrients and their augmentation in vegetative plant parts. Similar findings were reported by Lallu and Saxena (1995).

It is explicit from the data in table 2 that, the maximum sulphur content 1.162 and 0.362 % in seed and stover, respectively were recorded with the application of 54 kg gypsum ha^{-1} followed by 36 kg gypsum ha^{-1} having sulphur content 1.124 and 0.357 % in seed and stover, respectively. There was significant increase in S content of mustard including seed and stover with the increasing level of $ZnSO_4$. The increase in sulphur content might be due to increase in concentration of sulphur in soil with the application of gypsum. The results of the present investigation are corroborating with the findings of Chauhan*et al.* (1998).

Data presented in table 2 showed that, zinc content in seed and stover increased significantly with the increasing levels of gypsum up to 36 kg gypsum ha^{-1}, further increase in rates of gypsum there was significant decrease in Zn content in seed as well as stover (37.69 and 30.65 mg kg^{-1} in seed and stover, respectively), whereas lowest content of zinc was recorded where there was no application of gypsum (36.66 and 29.11 mg kg^{-1} in seed and stover, respectively). With the increasing rates of zinc sulphate fertilization from 0 to 10 kg $ZnSO_4$ ha^{-1}, there was an increase in zinc content in seed and stover. The maximum Zn content in seed and stover was recorded with application of $ZnSO_4$ at 10 kg ha^{-1} (43.71 and 34.59 mg kg^{-1} in seed and stover, respectively) followed by 5 kg $ZnSO_4$ ha^{-1} (*viz.*, 39.38 and 31.92 mg kg^{-1} in seed and stover, respectively). The increase in content of Zn in seed and stover with application of $ZnSO_4$ might be due to increase in availability of Zn in soil. Similar results were also reported by Shrikrishna and Singh (1992).

Nutrient Uptake

The data presented in table 3 revealed that, the highest total uptake of N (45.69 kg ha^{-1}) was obtained with the application of gypsum at 54 kg ha^{-1} which was significantly superior over lower levels of gypsum application. The total uptake of N was increased by 13.26, 31.27 and 34.69 % with the application of gypsum @18, 36 and 54 kg ha^{-1}, respectively over no supply of gypsum.

The total uptake of P by mustard was significantly increased up to the application of 5 kg $ZnSO_4$ ha^{-1} (Table 3). The highest total uptake of P (9.42 kg ha^{-1}) was observed with the application of 5 kg $ZnSO_4$ ha^{-1}, further, it was decreased with the application of zinc sulphate.

The reduction in content of phosphorus in seed as well as stover of mustard crop owing to application of $ZnSO_4$ may be due to antagonistic reaction between zinc and phosphorus as reported by Kumar (2003). The increase concentration of zinc created hinderance in absorption and translocation of phosphorus from the roots above the ground parts due to formation of $Zn_3(PO_4)_2$ compounds, which makes zinc unavailable to plants. Similar results were also reported by Choudhary *et al.* (1997). The total uptake of K was significantly increased with the increasing levels of gypsum (Table 3). The total uptake of K was found maximum (32.83 kg ha^{-1}) with application of gypsum @ 54 kg ha^{-1}, followed by gypsum applied at 36 kg ha^{-1}(31.72 kg ha^{-1}). The total uptake of K was increased by 10.64, 26.02 and 30.43% with application of gypsum @ 18, 36 and 54 kg ha^{-1}, respectively over no application of gypsum.

Table 3
Effect of gypsum and zinc sulphate on total nutrient uptake by mustard

Treatments	*N uptake (kg ha⁻¹)*	*P uptake (kg ha⁻¹)*	*K uptake (kg ha⁻¹)*	*S uptake (kg ha⁻¹)*	*Zn uptake (g ha⁻¹)*
Levels of Gypsum (kg ha⁻¹)					
G_0	33.92	7.19	25.17	12.86	80.86
G_{18}	38.42	8.38	27.85	14.68	92.05
G_{36}	44.53	10.11	31.72	17.13	106.03
G_{54}	45.69	10.73	32.83	17.83	102.25
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.25	0.07	0.11	0.15	0.90
CD at 5%	0.76	0.22	0.34	0.47	2.70
Levels of Zinc sulphate (kg ha⁻¹)					
Zn_0	37.44	8.54	27.71	14.65	75.33
Zn_5	41.57	9.42	29.95	16.04	99.85
Zn_{10}	42.91	9.33	30.50	16.18	110.72
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.22	0.06	0.10	0.12	0.77
CD at 5%	0.68	0.18	0.30	0.37	2.31
Interaction (Gypsum × Zinc sulphate)					
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.44	0.12	0.20	0.24	1.55
CD at 5%	1.34	0.36	0.60	0.74	4.65

The maximum total uptake of S (17.83 kg ha^{-1}) was recorded with the application of 54 kg gypsum ha^{-1} followed by 36 kg gypsum ha^{-1} (17.13 kg ha^{-1}). The results revealed that, total uptake of sulphur was significantly increased from 12.86 to 17.83 kg ha^{-1} with increase in gypsum level from 0 to 54 kg ha^{-1}. The total uptake of S (Table 3) was significantly increased from 14.65 to 16.18 kg ha^{-1} with increase in zinc sulphate levels from 0 to 10 kg ha^{-1}. The highest uptake of S (16.18 kg ha^{-1}) was observed with application of 10 kg $ZnSO_4$ ha^{-1} followed by 5 kg $ZnSO_4$ ha^{-1} (16.04 kg ha^{-1}). The higher sulphur contentin seed and stover resulted in greater uptake of sulphur in plant. The results of the present investigation are corroborating with the findings of Chauhan*et al.* (1998).

The data depicted in table 3, revealed that, the highest total uptake of Zn (106.03 g ha^{-1}) was observed with application of 36 kg gypsum ha^{-1}, further increase in gypsum level i. e. 54 kg gypsum ha^{-1} resulted in decrease the total uptake of zinc (102.25 g ha^{-1}). The highest total uptake of zinc (110.72 g ha^{-1}) was recorded with application of 10 kg $ZnSO_4$ ha^{-1} followed by application of 5 kg $ZnSO_4$ ha^{-1} (99.85 g ha^{-1}) and lowest total uptake of zinc (75.33 g ha^{-1}) was obtained in control treatment where there was no application of $ZnSO_4$. The total uptake of zinc was increased significantly with increase in $ZnSO_4$ level. Similar results were also reported by Shukla *et al.* (1983).

CONCLUSIONS

On the basis of results it is concluded that the application of gypsum up to 36 kg ha^{-1} and zinc sulphate up to 5 kg ha^{-1} significantly influence the seed and stover yield of mustard. The concentration and uptake of N, P, K, S and Zn also improved in seed and stover of mustard.

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