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Response of Indian mustard {*Brassica juncea* (L.) Czern and Coss} to various sources and levels of sulphur on yield, nutrient content and uptake

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Abstract

A field experiment was carried out during *rabi* 2020 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur to study the Response of Indian Mustard {*Brassica juncea* (L.) Czern and Coss} to various sources and levels of Sulphur on nutrient content or uptake. Experiment consisted of 16 treatment combinations comprised of 5 sulphur levels (20, 30, 40, 50 and 60 kg sulphur ha^{-1}), 3 sulphur sources (Gypsum, Bentonite sulphur and Elemental sulphur) and one absolute control. Result revealed that application of sulphur significantly increased seed yield, straw yield and biological yield by 28.27, 40.03 and 37.06 per cent over control. Application of 40 kg sulphur ha^{-1} increased seed yield by 16.67 and 11.12 per cent, respectively. Sulphur application significantly increased N, P, K and S content in seed and straw by 7.19 and 5.00, 5.42 and 12.16, 6.18 and 1.99, 8.77 and 8.57 per cent respectively over control. Application of 40 kg sulphur ha^{-1} significantly influenced N, P, K and S content and uptake by seed and straw over 20 and 30 kg sulphur ha^{-1}. Application of 40 kg sulphur ha^{-1} was found statically at par with 50 and 60 kg sulphur ha^{-1} in case of seed yield, nutrient content and uptake by seed and straw. Sources of sulphur significantly influence N, P, K and S uptake by plant by 5.93, 6.86, 6.23 and 7.83 per cent respectively over control.

Keywords: Mustard, Sulphur sources, Growth, Bentonite sulphur, Elemental sulphur

Introduction

Mustard (*Brassica juncea* L.) is one of the most important oil seed crops. Mustard commonly called as 'Sarson' or 'Rai' is an important edible *rabi* oilseed crop of India, widely grown on large area. Mustard is nutritionally very rich and its oil content varies from 37-49%. The oil and seeds are broadly used through humans and livestock as different food products and cattle feed. These are also used as condiment in the preparation of pickles and for flavouring curies and vegetables. The mustard oil is utilized for human consumption throughout northern India in cooking and frying purposes. It is also used in the preparation of hair oils and medicines. Sulphur deficiencies in India are widespread and scattered. Deficiency of sulphur in Indian soils is on increase due to intensification of agriculture with high yielding varieties and multiple cropping coupled with the use of high analysis sulphur free fertilizers along with the restricted or no use of organic manures have accrued in depletion of the soil sulphur reserve. Crops generally absorb sulphur and phosphorus in similar amounts.

Sulphate containing fertilizers immediately provide sulphur to plants in the form of sulphate but these fertilizers are susceptible to leaching losses. Ammonium sulphate, ammonium phosphate sulphur (APS) (15%S), single super phosphate (SSP) (12%S), potassium sulphate (18%S), potassium magnesium sulphate (22%S) and gypsum (19%S) are example of sulphate containing fertilizers. But elemental sulphur containing fertilizers needed to convert into sulphate form before the plants can access it. Elemental sulphur containing fertilizers contain very high concentration of sulphur (70-100%). They may offer the benefits of continual and slow release of sulphate during the growth season and thus reduce the leaching losses. Similarly, molten sulphur mixed with sodium/calcium bentonite results in a product that is safe and easy to apply (Singh and Mishra, 2017) [11]. The product works on the principle that the clay absorbs water and swells, which subsequently causes the prills to fracture and disperse into small particles of sulphur. Sulphur must be oxidized to SO_4^{-2} to become available to crop. Some microbes capable of oxidizing sulphur into sulphate in aerobic condition are autotrophic chemolithotrophs, including *Thiobacillus,* heterotrophic bacteria (*Bacillus, Pseudomonas* and *Arthrobacter*) and fungi (*Aspergillus,* and *Penicillium*) (Riley *et al*. 2000) [9]

Material and Method

The experiment was conducted *rabi* 2020 at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur. The soil of the experimental site was clay loam in texture with 260.5, 18.1, 270.9 and 9.51 available nitrogen, phosphorus, potassium and sulphur, respectively, in 0-30 cm soil depth with pH 7.5 consisting 16 treatment combinations comprised of 5 sulphur levels (20, 30, 40, 50 and 60 kg sulphur ha^{-1}), 3 sulphur sources (Gypsum, Bentonite sulphur and Elemental sulphur) and one absolute control. These treatments combinations were assessed under factorial randomized block design with three replications using the variety Giriraj following standard package of practices for this zone. Plant analysis had been done for the determination of Nutrient content according to the standard procedures *viz.*, N by colorimetric method using Nesslers' reagent (Snell and Snell, 1949) [14], P by Vanado-molybdo phosphate yellow colour method (Jackson, 1967) [3], K by Flame Photometer (Jackson, 1973) [4] and S by 0.15% $CaCl_2$ extractable S turbidimetric method in spectrophotometer (Williams and Steinbergers 1959) [15]. The nutrient uptake was calculated by using the formula:

$$\text{Total Uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) in seed} \times \text{Seed Yield (kg ha}^{-1}) + \text{Nutrient Content in straw (\%)} \times \text{Straw yield (kg ha}^{-1})}{1000}$$

Result and Discussion

Effect of treatment on seed yield

Data (Table 1) show that application of sulphur significantly increased seed yield by 30.35 per cent over control. Of the five levels of sulphur tried 40 kg sulphur ha^{-1} proved significantly superior to 20 and 30 kg sulphur ha^{-1} in respect to seed yield, straw yield and biological yield. When compared with 20 and 30 kg sulphur ha^{-1}, application of 40 kg sulphur ha^{-1} increased seed yield, straw yield and biological yield by 16.67 and 11.12, 14.73 and 10.41, 15.26 and 10.61 per cent, respectively. Application of 40 kg sulphur ha^{-1} being on par with 50 and 60 kg ha^{-1}. The data further show that different sources of sulphur application did not bring about any significant differences in seed yield, straw yield and biological yield. Increase in value of these yield contributing characters with higher levels of sulphur was due to the facts that the adequate sulphur was available during the entire period of crop growth for better vegetative growth and development of mustard plants. The beneficial effects of sulphur on the various yield contributing characters have also been reported by Meena *et al.* (2018), Kumar *et al.* (2019) [8, 6].

Table 1: Effect of various sources and levels of sulphur on K and S uptake (kg ha^{-1}) by seed, straw and plant of mustard

Treatments	Yield			S Uptake (kg ha^{-1})		
	Seed yield	**Straw yield**	**Biological yield**	**Seed**	**Straw**	**Plant**
Control vs Rest						
Control	1297	2915	4212	3.99	3.07	7.07
Sulphur (mean)	1665	4082	5747	5.58	4.66	10.24
F test at 5%	Significant	Significant	Significant	Significant	Significant	Significant
Levels of sulphur (kg ha^{-1})						
20	1499.38	3707	5207	4.79	4.01	8.81
30	1573.82	3852	5426	5.10	4.22	9.32
40	1749.38	4253	6002	5.96	4.92	10.88
50	1750.14	4298	6048	6.01	5.02	11.03
60	1752.06	4301	6053	6.03	5.11	11.15
S.Em ±	31.928	101	111	0.11	0.13	0.18
CD (P=0.05)	92.215	291	321	0.31	0.39	0.51
Sources of sulphur						
Gypsum	1627	3950	5577	5.42	4.41	9.83
Bentonite sulphur	1701	4182	5883	5.74	4.85	10.57
Elemental sulphur	1666	4116	5782	5.58	4.70	10.28
S.Em ±	25	78	86	0.08	0.10	0.14
CD (P=0.05)	NS	NS	NS	0.24	0.30	0.39

Effect of treatments on nutrient content and uptake

Nutrient content (%) in seed and straw

Data (Table 1) show that soil application of sulphur significantly increased nitrogen content in seed and straw over control. Application of 40 kg sulphur ha^{-1} increased the nitrogen concentration in seed over 20 and 30 kg sulphur ha^{-1}. Whereas, in term of concentration in straw, 40 kg sulphur improved it by 7.19 and 5.00 per cent over 20 and 30 kg sulphur ha^{-1}, respectively. Though, it remained statistically on par with 50 and 60 kg sulphur ha^{-1}. The significant increase in nitrogen content in seed and straw due to sulphur may be attributed to increase in sulphur content which in turn might have stimulated protein synthesis, sulphur and nitrogen are said to increase the concentration of each other in mustard. Different sources of sulphur application failed to bring about any significant different in nitrogen content in seed. The significantly increase in nitrogen content in seed and straw due to sulphur may be attributed to increase in sulphur content which in turn might have stimulated protein synthesis, sulphur and nitrogen are said to increase the uptake and concentration of each other in mustard. Soil application of sulphur significantly increased P content in seed and straw by 5.42 and 12.16 per cent over control application of 40 sulphur ha^{-1} significantly influenced the phosphorus concentration in seed and straw of mustard over 20 and 30 kg sulphur by 5.65 and 3.20 per cent in seed and 6.75 and 3.26 per cent in straw, respectively. Application of 40 kg sulphur ha^{-1} being on par with 50 and 60 kg ha^{-1}. The data further show that different sources of sulphur application did not bring about any significant differences in straw yield.

It is apparent from the data showed in table 1 that soil application of sulphur significantly increased K content in seed and straw by 6.18 and 1.99 per cent over control, respectively. Application of 40 kg sulphur ha^{-1} increased the K concentration in seed over 20 and 30 kg sulphur ha^{-1} by 6.39 and 4.91 per cent, respectively. Whereas, in term of K concentration in straw, 40 kg sulphur improved it by 2.23 and 1.06 per cent over 20 and 30 kg sulphur ha^{-1}, respectively. Though, it remained statistically on par with 50 and 60 kg sulphur ha^{-1}. Different sources of sulphur application failed to bring about any significant different in nitrogen content in seed. Soil application of sulphur significantly increased S content in seed and straw by 8.77 and 8.57 per cent over contro l. application of 40 sulphur ha^{-1} significantly influenced the S concentration in seed and straw of mustard over 20 and 30 kg sulphur by 6.56 and 5.25 per cent in seed and 7.4 and 5.45 per cent in straw, respectively. Application of 40 kg sulphur ha^{-1} being on par with 50 and 60 kg ha^{-1}. The data further show that different sources of sulphur application did not bring about any significant differences in sulphur content in seed and straw. Similar results were also noticed by Bansal et al. (2000), Dewal and Pareek (2004), Jaga (2013), Singh *et al.* (2017), Singh *et al* (2021) [1, 2, 5, 11, 12].

Nutrient uptake by seed, straw and plant

It is apparent from the data showed in table 4.2 that soil application of sulphur significantly increased N uptake by seed, straw and plant by 37.57, 47.31 and 39.46 per cent, respectively over control. Further, when compared with 20 and 30 kg sulphur ha^{-1} application of 40 kg sulphur significantly increased N uptake by 23.85 and 14.82 per cent by seed, 20.34 and 14.15 per cent by straw, 23.11 and 14.67 per cent by plant respectively. There was non-significantly different between 40, 50 and 60 kg sulphur ha^{-1}. With respect to sources of sulphur application, it can be seen from data that N uptake by seed and straw remained uninfluenced, but significant differences was observed in N uptake by plant. Application of bentonite sulphur recorded significantly higher N uptake by plant 5.93 per cent over gypsum, respectively. However, bentonite sulphur was found at par with elemental sulphur soil application of sulphur significantly increased P uptake by seed, straw and plant by 35.27, 57.58 and 48.65 per cent over control, respectively. Further, when compared with 20 and 30 kg sulphur ha^{-1} application of 40 kg sulphur significantly increased P uptake by 23.46 and 14.58 per cent by seed, 22.30 and 14.00 per cent by straw, 22.72 and 14.21 per cent by plant, respectively. Application of 40 kg sulphur ha^{-1} being on par with 50 and 60 kg ha^{-1}. With respect to sources of sulphur application, it can be seen from data that P uptake by seed and straw remained uninfluenced, but significant differences was observed in P uptake by plant. Application of bentonite sulphur recorded significantly higher P uptake by plant 7.02 per cent over gypsum, respectively. However, bentonite sulphur was found at par with elemental sulphur.

Data (Table 3) show that soil application of sulphur significantly increased K uptake by seed, straw and plant by 36.26, 42.86 and 41.61 per cent over control, respectively. Further, when compared with 20 and 30 kg sulphur ha^{-1} application of 40 kg sulphur significantly increased K uptake by 23.99 and 16.49 per cent by seed, 17.22 and 11.57 per cent by straw, 18.39 and 12.43 per cent by plant, respectively. With respect to sources of sulphur application, it can be seen from data that K uptake by seed and straw remained uninfluenced, but significant differences was observed in K uptake by plant. Application of bentonite sulphur recorded significantly higher K uptake by plant 6.23 per cent over gypsum, respectively. However, bentonite sulphur was found at par with elemental sulphur. soil application of sulphur significantly increased S uptake by seed, straw and plant by 39.85, 51.79 and 44.84 per cent over control, respectively. Further, when compared with 20 and 30 kg sulphur ha^{-1} application of 40 kg sulphur significantly increased S uptake by 24.42 and 16.86 per cent by seed, 22.69 and 16.59 per cent by straw, 23.49 and 16.74 per cent by plant, respectively. 40 kg sulphur ha^{-1} was found at par with 50 and 60 kg sulphur ha^{-1}. With respect to sources of sulphur application, it can be seen from data that application of bentonite sulphur recorded significantly higher S uptake by seed straw and plant by 4.74, 9.98 and 7.83 per cent over gypsum, respectively. However, bentonite sulphur was found at par with elemental sulphur. The result is similar with a finding of Kumar and Trivedi (2011), Singh *et al* (2012), Jaga (2013), Debnath *et al.* (2014), Jat *et al.* (2017), Singh *et al* (2017) [7, 12, 5, 10].

Table 2: Effect of various sources and levels of sulphur on N and P uptake (kg ha^{-1}) by seed, straw and plant of mustard

Treatments	N Uptake (kg ha^{-1})			P Uptake (kg ha^{-1})			K Uptake (kg ha^{-1})		
	Seed	Straw	Plant	Seed	Straw	Plant	Seed	Straw	Plant
Control vs Rest									
Control	36.12	8.73	44.85	4.31	6.46	10.77	8.19	35.16	43.35
Sulphur (mean)	49.69	12.86	62.55	5.83	10.18	16.11	11.16	50.23	61.39
F test at 5%	Significant	Significant	Significant	Significant	Significant	Significant	Significant	Significant	Significant
Levels of sulphur (kg ha^{-1})									
20	42.79	11.26	54.04	5.03	8.79	13.82	9.63	44.84	54.47
30	46.15	11.87	58.02	5.42	9.43	14.85	10.25	47.11	57.36
40	52.99	13.55	66.53	6.21	10.75	16.96	11.94	52.56	64.49
50	53.14	13.78	66.92	6.24	10.93	17.17	11.97	53.32	65.29
60	53.40	13.84	67.24	6.27	10.99	17.26	12.01	53.35	65.36
S.Em ±	1.036	0.324	1.164	0.118	0.275	0.305	0.229	1.254	1.320
CD (P=0.05)	2.993	0.936	3.361	0.340	0.793	0.880	0.663	3.621	3.811
Sources of sulphur									
Gypsum	48.32	12.38	60.70	5.68	9.75	15.44	10.87	48.48	59.34
Bentonite sulphur	51.03	13.27	64.30	5.98	10.52	16.50	11.45	51.59	63.04
Elemental sulphur	49.73	12.92	62.65	5.84	10.26	16.10	11.17	50.64	61.81
S.Em ±	0.803	0.251	0.901	0.091	0.213	0.236	0.178	0.971	1.022
CD (P=0.05)	NS	NS	2.603	NS	NS	0.682	NS	NS	2.952

Table 3: Effect of various sources and levels of sulphur on N and P content (%) in seed, straw and plant of mustard

Treatments	N content (%)		P content (%)		K content (%)		S content (%)	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
Control vs Rest								
Control	2.784	0.300	0.332	0.222	0.631	1.206	0.308	0.105
Sulphur (mean)	2.980	0.315	0.350	0.249	0.669	1.230	0.335	0.114
F test at 5%	Significant	Significant	Significant	Significant	Significant	Significant	Significant	Significant
Levels of sulphur (kg ha^{-1})								
20	2.856	0.304	0.336	0.237	0.642	1.209	0.320	0.108
30	2.932	0.308	0.344	0.245	0.651	1.223	0.324	0.110
40	3.027	0.319	0.355	0.253	0.683	1.236	0.341	0.116
50	3.036	0.321	0.357	0.254	0.684	1.240	0.343	0.117
60	3.050	0.322	0.358	0.255	0.686	1.240	0.345	0.119
S.Em ±	0.030	0.003	0.003	0.002	0.007	0.004	0.003	0.002
CD (P=0.05)	0.087	0.007	0.008	0.005	0.020	0.011	0.008	0.004
Sources of sulphur								
Gypsum	2.965	0.313	0.349	0.247	0.667	1.227	0.332	0.112
Bentonite sulphur	2.993	0.317	0.351	0.251	0.672	1.233	0.337	0.116
Elemental sulphur	2.982	0.314	0.350	0.249	0.669	1.229	0.334	0.114
S.Em ±	0.023	0.002	0.002	0.001	0.005	0.003	0.002	0.001
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

On the basis of one year field experimentation, it may be inferred that mustard application of 40 kg sulphur ha^{-1} recorded maximum N, P, K and S content and uptake by seed and straw over 20 and 30 kg sulphur ha^{-1} while found at par with 50 and 60 kg sulphur ha^{-1}. Among the various sources of sulphur, Bentonite sulphur proved superior over others in increasing the uptake but failed to enhance the concentration of N, P, K and S in plant.

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