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Original Research Article

Studies on Impact of Sulphur with and without FYM on Yield, Uptake and Methionine Content in Mustard

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Keywords

Mustard, Sulphur, FYM, Yield, Uptake, Methionine

A B S T R A C T

An experiment was conducted at the field of Department of Soil Science and Agril. Chemistry, JNKVV, Jabalpur (M.P) during *Rabi* season of 2013-14 and 2014-15 under AICRP on MSN in a Factorial randomized block design with three replications and ten treatments comprising viz., T_1 (Control), T_2 (15 Kg S ha^{-1}), T_3 (30 Kg S ha^{-1}), T_4 (45 Kg S ha^{-1}), T_5 (60 Kg S ha^{-1}), T_6 (FYM 5 t ha^{-1}), T_7 (15 Kg S ha^{-1}+ FYM 5 t ha^{-1}), T_8 (30 Kg S ha^{-1} + FYM 5 tha^{-1}), T_9 (45 Kg S ha^{-1} + FYM 5 t ha^{-1}) and T_{10} (60 Kg S ha^{-1} + FYM 5t ha^{-1}). Highest seed (1684.70 kg ha^{-1}) and Stover (4739.82 kg ha^{-1}) yields was recorded with the application of Sulphur 60 kg ha^{-1} + FYM 5 t ha^{-1} over rest of the treatments. Treatment combination of Sulphur 60 kg ha^{-1}+ FYM 5 t ha^{-1} S_4F_1 was recorded maximum 16.63, 12.84 and 29.47 kg ha^{-1} sulphur uptake by seed, Stover and plant, respectively. Treatment combination of Sulphur 60 kg ha^{-1}+ FYM 5 t ha^{-1} recorded maximum percentage of Methionine (3.09 mg g^{-1}) in seed. However, better improvements in yields were exhibited when S and FYM were integrated together. This increase might be due to steady decomposition of FYM and release of nutrients throughout the crop growth period coupled with better assimilation of nutrients.

Introduction

Mustard is the third most important oilseed crop after groundnut and soybean in India. In Indian agricultural economy, oilseeds are important next to cereals in terms of area, production and value with accounting for about 1.5% of gross domestic production and 8% of value of all agricultural products (Hegde, 2009). Sulphur is best known for its role in the synthesis of proteins with the formation of amino acids methionine (21% S) and cysteine (27% S), chlorophyll, oil content of the seeds and nutritive quality of forages (Jamal *et al.*, 2005) Integrated use of sulphur and farmyard manure improves the availability of sulphur in soils and plays a significant role in improving quality and seed development (Ghosh *et al.*, 2002). Sulphur uptake and assimilation in rapeseed-mustard are crucial for determining yield, oil, quality and resistance to various stresses. Among the oilseed crops, rapeseed-mustard has the highest requirement of sulphur. Sulphur increases the yield of mustard by 12 to 48% under irrigated and 17 to 24% under rain-fed condition (Aulakh and Pasricha, 1988). More sulphur is therefore, required need for their oil and protein synthesis in oilseed crops. Sulphur nutrition in oilseeds

indicated a considerable increase in yield and quality of oilseeds (Chauhan *et al.*, 2002). Sulphur deficiency in crops is gradually becoming widespread in different soils of the country due to use of high analysis sulphur-free fertilizers coupled with intensive cropping, higher crop yields and higher sulphur removals. Because of its involvement in vital function in the plant metabolism, sulphur deficiency would lead to adverse effect on growth and yield of many crops. However, organic manures, particularly FYM are important components of integrated nutrient management (Patra *et al.*, 1998) not only supply macronutrients but also meet the requirement of micronutrients, besides improving soil health. Keeping this in view, the present investigation was planned to studies on the effect of sulphur with and without FYM on yield and quality of mustard crop in Vertisols.

Materials and Methods

The field experiment was conducted on Research Farm of the Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP) during Rabi 2013-14 and 2014-15. The studies on the effect of sulphur with and without FYM were studied on attributes yield of mustard crop in a Vertisol. The soil *Typic Haplustert*, clayey in texture has pH 7.72, EC 0.24 dSm^{-1}, organic carbon 6.48 g kg^{-1}, available N 299.62 kg ha^{-1}, available P 20.5 kg ha^{-1}, available K 360 kg ha^{-1} and available S 15.6 kg ha^{-1}. The experiment was laid out in a Factorial randomized block design with 10 treatments comprising different combinations of sulphur fertilizers alone and with organic manure in three replications. The details of the treatments were T_1 (Control), T_2 (15 Kg S ha^{-1}), T_3 (30 Kg S ha^{-1}), T_4 (45 Kg S ha^{-1}), T_5 (60 Kg S ha^{-1}), T_6 (FYM 5 t ha^{-1}), T_7 (15 Kg S ha^{-1}+ FYM 5 t ha^{-1}), T_8 (30 Kg S ha^{-1} + FYM 5 tha^{-1}), T_9 (45 Kg S ha^{-1} + FYM 5 t ha^{-1}) and T_{10} (60 Kg S ha^{-1} + FYM 5t ha^{-1}). The sources of NPK fertilizers were nitrogen through urea (46% N), phosphorus through single super phosphate (16% P_2O_5), potash through murate of potash (60% K_2O) and sulphur through single super phosphate (12% S). FYM @ 5 t ha^{-1} was applied prior to sowing in the concerning treatments. Mustard (Pusa Tarak) was sown during fourth week of October and harvested in the last week of February (2013-14 and 2014-15). At harvest samples were collected, oven dried, processed. The chemical analysis of the plant sample was carried out by wet digesting with HNO_3:$HClO_4$ (4:1) di-acid mixture as per the procedure outlined by (Jackson, 1973) and to determine concentrations of N, P, K and S at harvest using procedure described by (Jackson, 1973). The grain and straw yield of mustard were recorded from collected soil samples (0–15 cm) of each plot after harvesting. These samples analyzed for pH using 1:2.5 soil: water suspension, electrical conductivity by conductivity meter. Organic carbon by rapid titration method (Walkley and Black, 1934). Available N estimated by alkaline permanganate method (Subbiah and Asija, 1956). available P by Olsen's method (Olsen *et al.*, 1954), available K by ammonium acetate extraction method (Jackson, 1967) and available S by turbid metric method (Chesnin and Yien, 1950) and estimation of Methionine (Sadasivam and Manickam, 1992) method.

Results and Discussion

Seed Yield

The data on seed yield per hectare in different treatments is given in Table 1. In the application of sulphur 60 kg ha^{-1} (S_4) was significantly superior over other

treatment which was recorded maximum 1754.67, 1799.17 and 1776.92 kg ha^{-1}seed yield per hectare followed by S_3 (1702.83, 1796.67 and 1749.75 kg ha^{-1}) at first year, second year and pooled, respectively S_3 & S_4 were at par with each other. Lowest yield (1159.17, 1256.83 and 1208.0 kg ha^{-1}) was observed with control at first year, second year and pooled, respectively. Highest percent increase in (51.4, 43.2 and 47.1%) seed yield was observed with S_4 over control (S_0 Sulphur 0kg ha^{-1}) at first year, second year and pooled, respectively. The application of 5.0 t FYM ha^{-1} (F_1) exhibited significantly maximum yield of 1645.47, 1723.93 and 1684.70 kg ha^{-1} and minimum 1340.38, 1411.80 and 1376.07 kg ha^{-1} seed yield with treatment F_0 at first year, second year and pooled, respectively.

In case of interaction, the treatment combination of S_4F_1 (Sulphur 60 kg ha^{-1}+ FYM 5 t ha^{-1}) recorded significantly higher yield (1645.47, 1723.93 and 1684.70 kg ha^{-1}) seed yield per hectare and the minimum (933.33, 1036.33 and 984.83 kg ha^{-1}) seed yield was recorded in the treatment combination of S_0F_0 (Sulphur 0 kg ha^{-1}+ FYM 0 t ha^{-1} i.e. control) at first year, second year and pooled. This may be due to application of sulphur attributed to the stimulatory effect in cell division, cell elongation and setting of cell structure and also higher dose may be responsible for increased leaf area and chlorophyll content causing higher photosynthesis and assimilation, metabolic activities responsible for overall reproductive phase and ultimately improved the seed and stover yield. Similar findings have been reported by Sharawat *et al.,* (2002), Dongarkar *et al.,* (2005)' Katkar *et al.,* (2009)' Sharma *et al.,* (2009)' Parmar *et al.,* (2010)' Kapur *et al.,* (2010)' Chattopaddhyay (2012)' Neha *et al.,* (2014), Alam *et al.,* (2014) and Ray *et al.,* (2014) for seed yield per hectare.

Stover yield

The stover yield increased significant due to the different levels of sulphur and FYM on mustard. The data on stover yield in different treatments is given in Table 2. The application of sulphur 60 kg ha^{-1} (S_4) was significantly superior which recorded maximum yield of stover 4387.0, 4486.75 and 4436.88 kg ha^{-1} followed by S_3 (4084.17, 4209.33 and 4146.75 kg ha^{-1}) at first year, second year and pooled, respectively S_3 & S_4 were statistically at par with each other. Lowest yield (2640.33, 2919.83 and 2780.08 kg ha^{-1}) was recorded in S_0 (Sulphur 0 kg ha^{-1}) at first year, second year and pooled, respectively Treatment S_4 (60.0 kg ha^{-1}) was recorded highest 66.2, 53.7 and 59.6% increase stover yield per hectare over control (S_0 Sulphur 0 kg ha^{-1}) at first year, second year and pooled, respectively.

As regards to FYM, the application of 5.0 tonnes FYM ha^{-1} (F_1) exhibited significantly maximum (3904.4, 4049.17 and 3976.78 kg ha^{-1}) stover yield per hectare, however, minimum (3369.4, 3537.0 and 3453.20 kg ha^{-1}) stover yield in treatment F_0 (FYM 0 ha^{-1}) at first year, second year and pooled, respectively. In case of interaction, the treatment combination of S_4F_1 (Sulphur 60 kg ha^{-1}+ FYM 5 t ha^{-1}) was recorded significantly maximum (4683.33, 4796.50 and 4739.82 kg ha^{-1}) stover yield per hectare and the minimum (2336.0, 2725.33 and 2530.67 kg ha^{-1}) Stover yield per hectare was recorded in the treatment combination of S_0F_0 (Sulphur 0 kg ha^{-1}+ FYM 0 t ha^{-1} i.e. control) at first year, second year and pooled, respectively. Dongarkar *et al.,* (2005)' Sharma *et al.,* (2009)' Parmar *et al.,* (2010)' Kapur *et al.,* (2010) and Neha *et al.,* (2014) for Stover yield. However, better improvements in yields were exhibited when S and FYM were integrated together.

Table.1 Seed yield (kg ha^{-1}) in mustard as influence by various doses of sulphur and FYM at first year, second year and pooled

Treat. Symb.	Seed yield per hectare (kg ha^{-1}) at									% increase over control		
	2013			2014			Pooled					
S levels	F0	F1	Mean	F0	F1	Mean	F0	F1	Mean	2013	2014	Pooled
S_0	933.33	1385.00	**1159.17**	1036.33	1477.33	**1256.83**	984.83	1431.17	**1208.00**	-	-	-
S_1	1243.33	1501.67	**1372.50**	1314.67	1568.67	**1441.67**	1279.00	1535.17	**1407.08**	18.4	14.7	16.5
S_2	1313.33	1637.33	**1475.33**	1391.33	1698.67	**1545.00**	1352.33	1668.00	**1510.17**	27.3	22.9	25.0
S_3	1575.67	1830.00	**1702.83**	1642.67	1950.67	**1796.67**	1609.17	1890.33	**1749.75**	46.9	43.0	44.8
S_4	1636.00	1873.33	**1754.67**	1674.00	1924.33	**1799.17**	1655.00	1898.83	**1776.92**	51.4	43.2	47.1
Mean	1340.33	1645.47		1411.80	1723.93		1376.07	1684.70				
	S levels	FYM levels	FxS	S levels	FYM levels	FxS	S levels	FYM levels	FxS			
SEm±	66.38	41.98	93.88	68.94	43.60	97.50	61.20	38.70	86.55			
CD at 5% level	195.85	123.86	N.S.	203.38	128.63	N.S.	180.54	114.18	N.S.			

Table.2 Stover yield (kg ha^{-1}) in mustard as influence by various doses of sulphur and FYM at first year, second year and pooled

Treat. Symbol	Stover yield (kg ha^{-1})									% increase over control		
	2013			2014			Pooled					
S levels	F0	F1	Mean	F0	F1	Mean	F0	F1	Mean	2013	2014	Pooled
S_0	2336.00	2944.67	**2640.33**	2725.33	3114.33	**2919.83**	2530.67	3029.50	**2780.08**	-	-	-
S_1	3104.33	3630.67	**3367.50**	3276.67	3788.67	**3532.67**	3190.50	3709.67	**3450.08**	27.5	21.0	24.1
S_2	3450.33	3960.67	**3705.50**	3554.67	4079.00	**3816.83**	3502.50	4019.83	**3761.17**	40.3	30.7	35.3
S_3	3865.67	4302.67	**4084.17**	3951.33	4467.33	**4209.33**	3908.50	4385.00	**4146.75**	54.7	44.2	49.2
S_4	4090.67	4683.33	**4387.00**	4177.00	4796.50	**4486.75**	4133.83	4739.92	**4436.88**	66.2	53.7	59.6
Mean	3369.40	3904.40		3537.00	4049.17		3453.20	3976.78				
	S levels	FYM levels	FxS	S levels	FYM levels	FxS	S levels	FYM levels	FxS			
SEm±	150.76	95.35	213.20	157.44	99.57	222.66	126.86	80.23	179.41			
CD at 5% level	444.75	281.28	N.S.	464.47	293.75	N.S.	374.25	236.70	N.S.			

Table.3 Sulphur uptake by Seed (kg ha^{-1}) in mustard as influence by different levels of sulphur and FYM at first year, second year and pooled

Treat. Symb.	Sulphur uptake by seed (kg ha^{-1})									% increase over control (sulphur)		
	2013			2014			Pooled					
S levels	F0	F1	Mean	F0	F1	Mean	F0	F1	Mean	2013	2014	Pooled
S_0	5.08	8.01	**6.55**	6.00	9.35	**7.68**	5.54	8.68	**7.11**	0	0	0.00
S_1	7.69	10.07	**8.88**	8.55	11.02	**9.79**	8.12	10.55	**9.33**	35.7	27.5	31.3
S_2	8.94	12.09	**10.52**	10.23	13.31	**11.77**	9.59	12.70	**11.15**	60.7	53.4	56.7
S_3	11.71	14.38	**13.04**	12.63	16.06	**14.34**	12.17	15.22	**13.69**	99.2	86.9	92.6
S_4	13.36	16.09	**14.73**	13.85	17.18	**15.51**	13.61	16.63	**15.12**	125.0	102.1	112.6
Mean	**9.36**	**12.13**		**10.25**	**13.38**		**9.81**	**12.76**				
	S levels	**FYM levels**	**FxS**	**S levels**	**FYM levels**	**FxS**	**S levels**	**FYM levels**	**FxS**			
SEm±	**0.349**	**0.482**	**0.682**	**0.356**	**0.563**	**0.795**	**0.234**	**0.234**	**0.524**			
CD at 5% levels	**0.906**	**1.432**	**NS**	**1.057**	**1.671**	**NS**	**0.672**	**0.672**	**NS**			

Table.4 Sulphur uptake by Stover in mustard as influence by different levels of sulphur and FYM at first year, second year and pooled

Treat. Symb.	Sulphur uptake by (kg ha^{-1}) Stover									% increase over control (sulphur)		
	2013			2014			Pooled					
S levels	F0	F1	Mean	F0	F1	Mean	F0	F1	Mean	2013	2014	Pooled
S_0	4.40	5.60	**5.00**	4.64	5.93	**5.28**	4.52	5.76	**5.14**	0	0	0.00
S_1	5.34	6.25	**5.80**	6.97	9.48	**8.22**	6.16	7.86	**7.01**	16.0	55.6	36.4
S_2	5.83	7.12	**6.48**	8.56	11.75	**10.15**	7.19	9.44	**8.32**	29.6	92.1	61.7
S_3	7.53	8.42	**7.97**	11.21	14.30	**12.76**	9.37	11.36	**10.37**	59.5	141.4	101.6
S_4	8.20	9.12	**8.66**	13.46	16.56	**15.01**	10.83	12.84	**11.83**	73.3	184.0	130.2
Mean	**6.26**	**7.30**		**8.97**	**11.60**		**7.61**	**9.45**				
	S levels	**FYM levels**	**FxS**	**S levels**	**FYM levels**	**FxS**	**S levels**	**FYM levels**	**FxS**			
SEm±	**0.143**	**0.227**	**0.321**	**0.301**	**0.476**	**0.673**	**0.503**	**0.318**	**0.711**			
CD at 5% levels	**0.426**	**0.673**	**NS**	**0.894**	**1.413**	**NS**	**1.974**	**0.912**	**NS**			

Table.5 Sulphur uptake by total biomass (kg ha^{-1}) in mustard as influence by different levels of sulphur and FYM at first year, second year and pooled

Treat. Symb.	Total Sulphur uptake by plant (kg ha^{-1})									% increase over control (sulphur)		
	2013			2014			Pooled					
S levels	F0	F1	Mean	F0	F1	Mean	F0	F1	Mean	2013	2014	Pooled
S_0	9.48	13.61	**11.55**	10.64	15.28	**12.96**	10.06	14.44	**12.25**	0	0	0.00
S_1	13.03	16.32	**14.68**	15.52	20.50	**18.01**	14.28	18.41	**16.35**	27.1	39.0	33.5
S_2	14.77	19.21	**16.99**	18.79	25.06	**21.93**	16.78	22.14	**19.46**	47.1	69.2	58.9
S_3	19.24	22.80	**21.02**	23.84	30.36	**27.10**	21.54	26.58	**24.06**	82.0	109.1	96.4
S_4	21.56	25.21	**23.39**	27.31	33.74	**30.53**	24.44	29.47	**26.96**	102.5	135.6	120.1
Mean	**15.62**	**19.43**		**19.22**	**24.99**		**17.42**	**22.21**				
	S levels	**FYM levels**	**FxS**	**S levels**	**FYM levels**	**FxS**	**S levels**	**FYM levels**	**FxS**			
SEm±	**0.395**	**0.624**	**0.883**	**0.576**	**0.910**	**1.287**	**0.981**	**0.621**	**1.388**			
CD at 5% levels	**1.173**	**1.855**	**2.624**	**1.711**	**2.705**	**3.825**	**3.852**	**1.780**	**5.448**			

Table.6 Methionine content in Seed in mustard as influence by different levels of sulphur and FYM at first year, second year and pooled

Treat. Symb.	Methionine content in seed (mg g^{-1})									% increase over control (sulphur)		
	2013			2014			Pooled					
S levels	F0	F1	Mean	F0	F1	Mean	F0	F1	Mean	2013	2014	Pooled
S_0	2.36	2.42	**2.39**	2.49	2.74	**2.61**	2.42	2.58	**2.50**	-	-	-
S_1	2.58	2.68	**2.63**	2.69	3.19	**2.94**	2.63	2.94	**2.78**	10.0	12.5	11.3
S_2	2.66	2.80	**2.73**	2.76	3.30	**3.03**	2.71	3.05	**2.88**	14.3	15.9	15.1
S_3	2.83	3.05	**2.94**	2.95	3.52	**3.23**	2.89	3.28	**3.09**	23.0	23.8	23.4
S_4	2.78	2.96	**2.87**	2.84	3.32	**3.08**	2.81	3.14	**2.97**	20.2	17.8	18.9
Mean	**2.64**	**2.78**		**2.74**	**3.21**		**2.69**	**3.00**				
	S levels	**FYM levels**	**FxS**	**S levels**	**FYM levels**	**FxS**	**S levels**	**FYM levels**	**FxS**			
SEm±	0.021	0.034	0.048	0.028	0.044	0.062	0.028	0.018	0.109			
CD at 5% levels	0.064	0.100	NS	0.083	0.131	NS	0.039	0.050	0.154			

This increase might be due to steady decomposition of FYM and release of nutrients throughout the crop growth period coupled with better assimilation of nutrients.

Sulphur uptake

By Seed

It is evident from the data presented in the Table 3 noted that uptake of sulphur by seed was significantly influenced due to application of sulphur and FYM. Their interaction effects were not affected significantly. Significantly maximum (14.73, 15.51 and 15.12 kg $ha^{-1)}$ sulphur uptake by seed was recorded in the treatment of S_4 (60.0 kg S ha^{-1}) followed by S_3 (45.0 kg S ha^{-1}), (13.04, 14.34 and 13.69 kg ha^{-1}) as compared to other treatments in first year, second year and pooled, respectively. Highest (125.0, 102.1 and 112.6%) increase in sulphur uptake in seed was recorded under the treatment S_4 (60 kg S ha^{-1}) over control (S_0 Sulphur 0kg ha^{-1}) in first year, second year and pooled, respectively. Treatment F_1 (FYM 5 t ha^{-1}) noted maximum sulphur uptake by seed (12.13, 13.38 and 12.76 kg ha^{-1}) and the minimum (9.36, 10.25 and 9.81 kg ha^{-1} sulphur uptake with zero FYM ha^{-1} (F_0) in first year, second year and pooled, respectively. Treatment combination of S_4F_1 (Sulphur 60 kg ha^{-1}+ FYM 5 t ha^{-1}) was recorded maximum 16.09, 17.18 and 16.63 kg ha^{-1}.sulphur uptake by seed followed by S_3F_1 Sulphur 45 kg ha^{-1}+ FYM 5 t ha^{-1} (14.38, 16.06 and 15.22 kg ha^{-1}), while, it was recorded lowest 5.08, 6.00 and 5.54 kg ha^{-1}in treatment S_0F_0 (Sulphur 0 kg ha^{-1}+ FYM 0 t ha^{-1} i.e. control) in first year, second year and pooled, respectively.

By Stover

A perusal of the data in Table 4 revealed that various levels of sulphur and FYM significantly increase in sulphur uptake by stover. Interaction of both the factor did not exhibit any significant effect on this character. Significantly maximum (8.66, 15.01 and 11.83 kg ha^{-1}) sulphur uptake by stover was recorded in the treatment of S_4 (60.0 kg S ha^{-1}) followed by S_3 (45.0 kg S ha^{-1}) (7.97, 12.76 and 10.37 kg ha^{-1}) in first year, second year and pooled, respectively which were at par with each other in pooled. The lowest (5.0, 5.28 and 5.14 kg ha^{-1}) sulphur uptake by Stover was recorded in treatment S_0 (Sulphur 0 kg ha^{-1}) in first year, second year and pooled, respectively. Treatment S_4 (60 kg S ha^{-1}) was recorded highest (73.3, 184.0 and 130.2%) increase in sulphur uptake in stover over control (S_0 Sulphur 0 kg ha^{-1}) in first year, second year and pooled, respectively. Treatment F_1 (FYM 5 t ha^{-1}) noted maximum sulphur uptake by stover (7.30, 11.60 and 9.45 kg ha^{-1}) and the minimum (6.26, 8.97 and 7.61 kg ha^{-1} sulphur uptake) with F_0 (0 t FYM ha^{-1}) in first year, second year and pooled, respectively. Treatment combination of S_4F_1 (Sulphur 60 kg ha^{-1}+ FYM 5 t ha^{-1} was recorded maximum 9.12, 16.56 and 12.84 kg ha^{-1} sulphur uptake by stover followed by S_3F_1 (Sulphur 45 kg ha^{-1} + FYM 5 t ha^{-1}) (8.42, 14.30 and 11.36 kg ha^{-1}), while, it was recorded lowest 4.40, 4.64 and 4.52 kg ha^{-1} in treatment S_0F_0 (Sulphur 0 kg ha^{-1} + FYM 0 t ha^{-1} i.e. control) in first year, second year and pooled, respectively.

Total Sulphur uptake

A perusal of the data in Table 5 revealed that various levels of sulphur, FYM and interaction effect significantly increase in total sulphur uptake by plant. Significantly maximum (23.39, 30.53 and 26.96 kg $ha^{-1)}$ sulphur uptake by total biomass was recorded in the treatment of S_4 (60.0 kg S ha^{-1}) followed by S_3 (45.0 kg S ha^{-1}) (21.02, 27.10 and 24.06 kg ha^{-1}) in first year, second year and pooled, respectively and which

were at par with each other in pooled. The lowest (11.55, 12.96 and 12.25 kg ha^{-1}) total sulphur uptake plant was recorded in treatment S_0 (Sulphur 0 kg ha^{-1}) in first year, second year and pooled, respectively. Treatment S_4 (60 kg S ha^{-1}) was recorded (102.5, 135.6 and 120.1%) higher total sulphur uptake by plant over control (S_0 Sulphur 0 kg ha^{-1}) in first year, second year and pooled, respectively. Treatment F_1 (FYM 5 t ha^{-1}) observed significantly maximum sulphur uptake by total biomass (19.43, 24.99 and 22.21 kg ha^{-1}) and the minimum (15.62, 19.22 and 17.42 kg ha^{-1} sulphur uptake with F_0 (0 t FYM ha^{-1}) in first year, second year and pooled, respectively. Treatment combination of S_4F_1 (Sulphur 60 kg ha^{-1} + FYM 5 t ha^{-1}) was recorded significantly maximum 25.21, 33.74 and 29.47 kg ha^{-1} total sulphur uptake by plant followed by S_3F_1 Sulphur 45 kg ha^{-1} + FYM 5 t ha^{-1} (22.80, 30.36 and 26.58 kg ha^{-1}) in first year, second year and pooled, respectively which were at par with each other in first year and pooled only, while, it was recorded lowest (9.48, 10.64 and 10.06 kg ha^{-1}) in treatment S_0F_0 (Sulphur 0 kg ha^{-1} + FYM 0 t ha^{-1} i.e. control) in first year, second year and pooled, respectively.

A study of data pertaining to the utilization of sulphur by mustard revealed that The highest uptake of sulphur by both seed and stover of mustard was recorded with soil test based NPK application + 60 kg S ha^{-1} as compared to other treatments could be due to the synergetic relationship between nitrogen and sulphur, which improved sulphur availability in root zone as well as the content in plant leading to enhance translocation of sulphur to reproductive organs of plant. The improved sulphur content coupled with the higher biomass accumulation resulted in increased the uptake of sulphur. The findings are in close harmony with the result of Raut *et al.,* (2000), Giri *et al.,* (2003), Singh and Meena (2003), Shah *et al.,* (2006), Zizale *et al.,* (2008), Jat and Chaudhary (2012) and Chattopaddhyay and Ghosh (2012) for Seed & Stover, Kumar and Yadav (2007), Kumar and Trivedi (2012), Pachauri *et al.,* (2012) and Sharma (2013) for plant.

Methionine content in seed

The data for various levels of sulphur, FYM and their interaction with respect to the methionine content in seed are summarized in Table 6.Methionine content in seed was increased with increasing rates of sulphur up to the dose of 45 kg S ha^{-1} (S_3). Significantly maximum (2.94, 3.23 and 3.09 mg g^{-1}) methionine content in seed was recorded in treatment S_3 followed by S_4 (60.0 kg S ha^{-1}) (2.87, 3.08 and 2.97%) and the minimum methionine content (2.39, 2.61 and 2.50%) with the lowest sulphur application i.e. 0 kg ha^{-1} (S_0) in first year, second year and pooled, respectively. Treatment S_3 (45.0 kg S ha^{-1}) was recorded 23.0, 23.8 and 23.4% higher methionine content in seed over control (S_0 Sulphur 0 kg ha^{-1}) in first year, second year and pooled, respectively. Application of FYM with the increasing rates significantly increased methionine content in seed. Treatment F_1 noted maximum seed methionine (2.78, 3.21 and 3.0 mg g^{-1}) and the minimum (2.64, 2.74 and 2.69 mg g^{-1} methionine content) with zero FYM/ha (F_0) in first year, second year and pooled, respectively. S X FYM interaction showed significant difference in seed methionine content on pooled basis only. Treatment combination of S_3F_1 (Sulphur 45 kg ha^{-1} + FYM 5 t ha^{-1}) and S_4F_1 (Sulphur 60 kg ha^{-1}+ FYM 5 t ha^{-1}) were recorded maximum 3.28 and 3.14 mg g^{-1} methionine content in seed, respectively which were at par with each other. While, it was recorded lowest 2.42 mg g^{-1} in treatment S_0F_0 (Sulphur 0 kg ha^{-1} + FYM 0 t ha^{-1}). Reason

for this may be due to synergic effects of both the nutrients. The findings are in close harmony with the result of Basumatary *et al.,* (2006), Singh *et al.,* (2008a). Kumar *et al.,* (2011) and Neha *et al.,* (2014)

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