International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(5): 2363-2367

Received: 01-07-2017
Accepted: 02-08-2017

Vaishali Sharma
Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

BL Sharma
Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

GD Sharma
Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Arpit Suryawanshi
Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Correspondence
Vaishali Sharma
Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Studies on the effect of sulphur with and without FYM on yield and quality of mustard crop in Vertisols

Vaishali Sharma, BL Sharma, GD Sharma and Arpit Suryawanshi

Abstract
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}).The results obtained from the present investigation clearly indicated that yield of seed and straw increased significantly with enhancing sulphur up to highest level of 60 kg ha^{-1} + FYM 5 t ha^{-1}.S X FYM interaction showed significant difference in seed protein content. Treatment combination of Sulphur 60 kg ha^{-1}+ FYM 5 t ha^{-1} recorded maximum percentage of protein (18.85%) and oil (41.29%) content 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. 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.

Keywords: Mustard, Sulphur, FYM, Yield, Quality

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) [13]. 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) [16]. 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) [12]. 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) [2]. 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) [6]. 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) [27] 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.

Material 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) [14] and to determine concentrations of N, P, K and S at harvest using procedure described by (Jackson, 1973) [14]. 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) [36], Available N estimated by alkaline permanganate method (Subbiah and Asija, 1956) [35], available P by Olsen's method (Olsen *et al*., 1954 [23]), available K by ammonium acetate extraction method (Jackson, 1967) [14] and available S by turbid metric method (Chesnin and Yien, 1950) [8].

Result and Discussion

Effect of Sulphur and FYM on Grain and Straw yield of Mustard crop

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 tonnes 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_0at 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) [31], Dongarkar *et al*. (2005) [9], Katkar *et al*. (2009) [18], Sharma *et al*. (2009) [32], Parmar *et al*. (2010) [25], Kapur *et al*. (2010) [17], Chattopaddhyay (2012) [6], Neha *et al*. (2014) [22], Alam *et al* (2014) [4] and Ray *et al*. (2014) [29] for seed yield per hectare.

Straw 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) [9], Sharma *et al*. (2009) [32], Parmar *et al*. (2010) [25], Kapur *et al*. (2010) [17] and Neha *et al*. (2014) [22] for stover yield. 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.

Oil content in seed

Data pertaining to oil content in seed (%) presented in Table 3 revealed that oil content in mustard seed was significantly affected due to sulphur and FYM application. However the interaction effect between levels of sulphur and FYM did not exhibit marked differences in oil content (%). The increase in levels of sulphur showed increasing trend in the oil content (%) in seed However, the maximum oil content (40.58, 42.0 and 41.29%) was recorded in treatment S_4 (60.0 kg S ha^{-1}) followed by S_3 (45.0 kg S ha^{-1}) (40.03, 41.38 and 40.70%) and the minimum oil content (35.23, 36.0 and 35.62%) with the lowest sulphur application i.e. 0 kg ha^{-1} (S_0) in first year, second year and pooled, respectively and treatment S_4 and S_3 were at par. Treatment S_4 (60.0 kg ha^{-1}) was recorded 15.2, 16.7 and 15.9% more oil content in seed over control (S_0 Sulphur 0 kg ha^{-1}) in first year, second year and pooled, respectively. Application of FYM with increasing rates showed a significant increasing trend in oil content (%) in seed. However, the maximum 39.22, 40.39 and 39.80% oil content (%) in seed was recorded with the application of 5 t FYM ha^{-1} (F_1) and the minimum (37.66, 38.82 and 38.24% oil content) with 0 FYM ha^{-1} (F_0) in first year, second year and pooled, respectively. It was apparent from the results that the treatment combination of S_4F_1 (Sulphur 60 kg ha^{-1}+ FYM 5 t ha^{-1}) recorded maximum 41.07, 42.93 and 42.0% oil content in seed, while, it was recorded lowest 34.53, 35.79 and 35.16% 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. The increase in oil content with increase in S level might be due to the involvement of sulphur in electron transport chain and increase in glucoside formation (allyisothiocynate) and also sulphur as a constituent of multi enzyme complex. The findings are in corroborative with earlier findings of Ahmad and Abadin (2000) [3], Abdin*et al*. (2003) [1], Singh *et al*. (2005) [33], Piri and Sharma (2006) [28], Basumatary *et al*. (2006) [5], Faujdar *et al*. (2008) [11], Zizale *et al*. (2008) [37], Kumar *et al*. (2011) [21], Kumar and Trivedi (2012) [19] and Pachauri *et al*. (2012) [24].

Protein content in seed

Data presented in Table 4 indicated that the various levels of sulphur, FYM and their interaction significantly affected the seed protein content (%). Application of sulphur with increasing rates up to the highest dose i.e. 60 kg S ha^{-1} (S_4) significantly increased the protein content (18.55, 19.16 and 18.85%) in seed followed by S_3 (45.0 kg S ha^{-1}) (18.11, 18.67 and 18.39%) and the minimum protein content (13.18, 14.63 and 13.90%) with the lowest sulphur application i.e. 0 kg ha^{-1} (S_0) in first year, second year and pooled, respectively and treatment S_4 and S_3 were at par. Treatment S_4 (60.0 kg ha^{-1}) was recorded highest 40.7, 31.0 and 35.6% increase protein content in seed over control (S_0 Sulphur 0 kg ha^{-1})in first year, second year and pooled, respectively (Table-4).Application of FYM with the increasing rates significantly increased protein content (%) in seed. Treatment F_1 noted maximum seed protein (18.75, 19.32 and 19.03%) and the minimum (14.48, 15.71 and 15.09% protein content) with 0 FYM ha^{-1} (F_0) in first year, second year and pooled, respectively. S X FYM interaction showed significant difference in seed protein content percentage. Treatment combination of S_4F_1 (Sulphur 60 kg ha^{-1} + FYM 5 t ha^{-1}) recorded maximum 20.94, 21.29 and 21.12% protein content in seed followed by S_3F_1 (Sulphur 45 kg ha^{-1}+ FYM 5 t ha^{-1}) (20.71, 21.06 and 20.89%) and S_2F_1(Sulphur 30 kg ha^{-1} + FYM 5 t ha^{-1}) (19.72, 19.98 and 19.85%),while, it was recorded lowest 13.13, 14.44 and 13.78% 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 and treatment S_4F_1, S_3F_1 and S_2F_1 were at par. Reason for increase in protein content due to sulphur fertilization are amply clear because proteins are ling chain compounds of a number of amino acids bound together through peptide linkage. The findings are in close harmony with the result of Abdin *et al*. (2003) [1], Basumatary *et al*. (2006) [5], Singh *et al*. (2010) [33], Kumar *et al*. (2011) [21] and Neha *et al*. (2014) [22].

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: Oil content in seed of mustard as influence by different levels of sulphur and FYM at first year, second year and pooled

Treat. Symbol	Oil content in seed (%)									% increase over control		
	2013			2014			Pooled					
S levels	F0	F1	Mean	F0	F1	Mean	F0	F1	Mean	2013	2014	Pooled
S_0	34.53	35.93	35.23	35.79	36.20	36.00	35.16	36.07	35.62	-	-	-
S_1	36.20	38.67	37.43	37.75	39.57	38.66	36.98	39.12	38.05	6.2	7.4	6.8
S_2	38.27	39.57	38.92	38.90	41.10	40.00	38.59	40.33	39.46	10.5	11.1	10.8

S_3	39.20	40.86	40.03	40.60	42.16	41.38	39.90	41.51	40.70	13.6	15.0	14.3
S_4	40.10	41.07	40.58	41.07	42.93	42.00	40.58	42.00	41.29	15.2	16.7	15.9
Mean	37.66	39.22		38.82	40.39		38.24	39.80				
	S levels	FYM levels	FxS	S levels	FYM levels	FxS	S levels	FYM levels	FxS			
SEm±	0.356	0.562	0.795	0.399	0.631	0.892	0.267	0.423	0.598			
CD at 5% levels	1.057	1.671	NS	1.186	1.874	NS	0.767	1.659	NS			

Table 4: Protein content in seed in mustard as influence by different levels of sulphur and FYM at first year, second year and pooled

Treat. Symbol	Protein content in seed (%)									% increase over control		
	2013			2014			Pooled					
S levels	F0	F1	Mean	F0	F1	Mean	F0	F1	Mean	2013	2014	Pooled
S_0	13.13	13.24	13.18	14.44	14.81	14.63	13.78	14.03	13.90	-	-	-
S_1	13.59	19.13	16.36	14.98	19.46	17.22	14.29	19.30	16.79	24.1	17.7	20.8
S_2	14.00	19.72	16.86	15.83	19.98	17.91	14.92	19.85	17.38	27.9	22.4	25.0
S_3	15.52	20.71	18.11	16.27	21.06	18.67	15.89	20.89	18.39	37.4	27.6	32.3
S_4	16.16	20.94	18.55	17.02	21.29	19.16	16.59	21.12	18.85	40.7	31.0	35.6
Mean	14.48	18.75		15.71	19.32		15.09	19.03				
	S levels	FYM levels	FxS	S levels	FYM levels	FxS	S levels	FYM levels	FxS			
SEm±	0.250	0.395	0.559	0.220	0.348	0.492	0.263	0.166	0.372			
CD at 5% levels	0.742	1.174	1.660	0.654	1.034	1.462	1.033	0.477	1.462			

References

1. Abdin MZ, Khan N, Khan I, Israr M, Jamal A. Nitrogen and sulphur interaction in relation to yield and quality attributes of rapeseed-mustard (*Brassica junceaL.*). 2003; 5(3/4):35-41.
2. Aulakh MS, Pasricha NS. Sulphur fertilization of oilseeds for yield and quality. Sulphur in Indian Agriculture. 1988; SII/3-1-SII/3-14.
3. Ahmad A, Abdin MZ. Effect of sulphur application on lipid, RNA and fatty acid content in developing seeds of rapeseed (*Brassica campestris L.*). Plant Science. 2000; 150:71-76.
4. Alam Md, Mishra AK, Singh K. Response of sulphur and FYM on the soil properties and yield of mustard. NASA - 2014 International symposium, 2014.
5. Basumatary A, Das P, Baruah AM, Borah RC. Integrated effect of inorganic and organic source of sulphur on quality characteristics of rapeseed. Indian J Agric Bio. chem. 2006; 19(2).
6. Chattopaddhyay S, Ghosh GK. Response of rapeseed (*Brassica juncea L.*) to various sources and levels of sulphur in red and lateritic soils of West Bengal, India. International Journal of Plant, Animal and Environmental Sciences. 2012; 2(4):50-59.
7. Chauhan DR, Ram M, Singh I. Response of Indian mustard to irrigation and fertilization with various sources and levels of sulphur. Indian journal of Agronomy. 2002; 47(3):422-426.
8. Chesnin L, Yien CH. Turbidimetric determination of available sulphur in soil. Soil Science Society of America, Proceeding. 1950; 15:149-157.
9. Dongarkar KP, Pawar WS, Khawale VS, Khutate NG, Gudadhe NN. Effect of nitrogen and sulphur on growth and yield of mustard (*Brassica junceaL.*). J. Soils Crops. 2005; 15(1):163-167.
10. Falk KL, Tokuhisa JG, Gershenzon J. The effect of sulfur nutrition on plant glucosinolate content: Physiology and molecular mechanisms. Plant Biology. 2007; 9:573-581.
11. Faujdar RS, Mathur AK, Verma AK. Yield and quality of mustard as influenced by different levels of phosphorus and sulphur. An Asian Journal of Soil Science. 2008; 3(1):207-208.
12. Ghosh PK, Mandal KG, Bandyopadhyay KK, Hati KM, Tripathi AK. Role of plant nutrient management in oilseed production. Fertiliser News. 2002; 47:67-80.
13. Hegde DM. Souvenir, Indian Society of Oilseeds Research, Hyderabad, 2009, 1-15.
14. Jackson ML. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd, New Delhi, 1967, 205.
15. Jackson ML. Soil chemical analysis. Prentice Hall of India Ltd. New Delhi, 1973, 498.
16. Jamal A, Fazli IS, Ahmad S, Abdin MZ, Yun SJ. Effect of sulphur and nitrogen application on growth characteristics, seed and oil yield of soybean cultivars. Korean Journal Crop Science. 2005; 50(5):340-345.
17. Kapur LT, Patel AR, Thakur RF. Yield attributes and yield of mustard *(Brassica juncea L. Czern* and Coss) as affected by sulphur levels. An Asian Journal of Soil Science. 2010; 5(1):216-217.
18. Katkar RN, Sonune BA, Kadu PR. Long-term effect of fertilization on soil chemical and biological characteristics and productivity under sorghum (*Sorghum bicolor*) - wheat *(Triticum aestivum)* system in Vertisol. Indian Journal of Agriculture Science. 2011; 81(8):734-739.
19. Kumar R, Trivedi SK. Effect of levels and sources of sulphur on yield, quality and nutrient uptake by mustard (*Brassica juncea L.*) Progressive Agriculture. 2012; 12(1):69-73.
20. Kumar H, Yadav DS. Effect of phosphorus and sulphur levels on growth, yield and quality of Indian mustard *(Brassica juncea)* cultivars. Ind. J. Agron. 2007; 52(2):154-157.
21. Kumar S, Verma SK, Singh TK, Singh S. Effect of nitrogen and sulphur on growth, yield and nutrient uptake by Indian mustard *(Brassica juncea)*. Indian Journal of Agricultural Sciences. 2011; 81:145-149.
22. Neha Dashora LN, Kaushik MK, Upadhyay B. Yield, nutrient content, uptake and quality of Indian mustard genotypes as influenced by sulphur under southern Rajasthan conditions. Annals of Agri-Bio Research. 2014; 19(1):81-84.
23. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate ($NaHCO_3$), U.S.D.A. Circular. 939: 1-19.
24. Pachauri RK, Trivedi SK, Kumar Y. Effect of sulphur levels on growth, yield and quality of Indian mustard genotypes and their economics. Journal of Soils and Crops. 1954-2012; 22(2):258-263.

25. Parmar RM, Parmar JK, Patel MK. Effect of nitrogen and sulphur on yield and yield attributes of mustard under the loamy sand soil of North Gujarat. An Asian Journal of Soil Science. 2010; 5(2):295-299.
26. Patel GM, Patel BT, Dodia IN, Bhatt VK, Bhatt RK. Effect of sources and levels of sulphur on yield, quality and nutrient uptake of mustard *(Brassica juncea L.)* varieties in loamy sand soil. Journal of Soils and Crops. 2009; 19:30-35.
27. Patra AP, Panda D, Patra BC, Karmakar AJ. Effect of FYM, zinc and NPK fertilizers on yield components and yield of wheat after winter rice in West Bengal. Journal of Intracademicia. 1998; 2(1/2):1-6.
28. Piri ISSA, Sharma SN. Effect of levels and sources of sulphur on yield attributes, yield and quality of Indian mustard (*Brassica juncea L*.). Indian Journal of Agronomy. 2006; 51(3):217-220.
29. Ray K, Pal AK, Banerjee H, Phonglosa A. Correlation and path analysis studies for growth and yield contributing traits in Indian mustard *(Brassica juncea L.).* International Journal of Bio-resource and Stress Management. 2014; 5(2):200-206.
30. Sekar A. Studies on the evaluation of sugarcane variety and production technologies for animating sugarcane productivity in coastal region of Tamil Nadu. Ph.D. thesis, Annamalai University, Annamalainagar, Tamil Nadu, 2003.
31. Sharawat S, Singh TP, Singh JP. Effect of nitrogen and sulphur on the yield and oil content of Indian mustard (*Brassica juncea L*.). Progre. Agric. 2002; 2(2):177.
32. Sharma A, Sharma P, Brar MS, Dhillon NS. Comparative response to sulphur application in raya (*Brassica juncea*) and wheat (*Triticum aestivum*) grown on light textured alluvial soils. Journal of Indian Society Soil Science. 2009; 57(1):62.
33. Singh H, Singh G, Deol JS. Nodulation and Uptake of Nitrogen and Potassium by Grain and Straw of Soybean *[Glycine Max (L.) Merrill]* as affected by Potassium and Split Application of Nitrogen. Legume Research - An International Journal. 2010; 33(4):249-255.
34. Subbiah BV, Asiija EC. A rapid procedure for estimation of available nitrogen in soil. Current Science. 1956; 25(8):259-260.
35. Walkley A, Black IA. Estimation of soil organic carbon by the chromic acid titration method. Soil Science. 1934; 37:29-38.
36. Yadav SS, Sharma OP. Effect of levels and sources of sulphur on yield and quality of mustard varieties. Annals of Plant and Soil Research. 2002; 4(1):52.
37. Zizale VJ, Jadav NB, Gorphrfed PS. Effect of sulphur and zinc on yield, quality and its concentration on mustard. An Asian Journal of Soil Science. 2008; 3(1):173-177.