The Pharma Innovation Journal 2022; SP-11(7): 3291-3295

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(7): 3291-3295

www.thepharmajournal.com
Received: 01-04-2022
Accepted: 05-05-2022

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Response of mustard to different levels and sources of sulphur on growth, yield attributes, yield and economics of mustard in north Gujarat

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Abstract
A field experiment was carried out at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *rabi* 2019-20. The experiment comprising of twelve treatment combinations comprising four sources (Gypsum; Bentonite; SSP and Cosavet) and three levels (20 kg S/ha; 40 kg S/ha and 60 kg S/ha) of sulphur evaluated in Randomized Block Design (RBD) with factorial concept and replicated three times. With regard to the effect of different sources of sulphur on mustard, all growth attributes such as plant height at harvest, number of primary and secondary branches per plant as well as yield and yield attributes *viz.*, number of siliquae per plant, number of seeds per siliqua, length of siliqua, seed yield per plant, seed and stover yield showed significant improvement due to application of gypsum. Among the different sources of sulphur, gypsum fetched the highest net realization and benefit : cost ratio. Significantly higher yield attributes and yields *viz*., number of siliquae per plant, number of seeds per siliqua, length of siliqua, test weight, seed yield per plant, seed yield and stover yield were recorded with 60 kg S/ha, but statistically at par with 40 kg S/ha except seed yield per plant and seed yield. Application of 60 kg S/ha realized maximum net returns whereas, B:C ratio was maximum with 40 kg S/ha. Among all the possible interaction, treatment combination gypsum x 60 kg S/ha recorded significantly the maximum value of siliquae per plant, seed yield per plant and seed yield. Maximum net realization with a B: C ratio was achieved with the treatment combination of application of gypsum + 60 kg S/ha, followed by application of gypsum + 40 kg S/ha.

Keywords: Mustard, sulphur, gypsum, bentonite, SSP and cosavet

Introduction
Rapeseed-mustard is the third most important edible oilseed crop in India having 30 to 48 per cent oil content after soybean and groundnut. Mustard seed has 28 to 36 percent protein content with a high nutritive value. Mustard is one of the major sources of oil in India. Mustard is the most important winter season oilseed crop, which thrives best in light to heavy loam soil in areas having 25 to 40 cm rainfall. Rapeseed-mustard is the major source of income especially to the marginal and small farmer in rain-fed areas. Since these crops are cultivated mainly in the rain-fed and resource scarce regions of the country, their contribution to livelihood security of the small and marginal farmer in these regions is also very important. By increasing the domestic production of oilseeds, substantial import substitution can be achieved.

Sulphur is considered as the fourth major plant nutrient after nitrogen, phosphorus and potassium for Indian agriculture. Sulphur deficiencies in India are widespread and scattered. About 90 districts of the country have been found deficient in sulphur. Sulphur deficiency and consequent crop responses have been observed in many crops, especially in oilseed crops. Deficiency of sulphur in Indian soils has to increase due to intensification of agriculture with high yielding varieties and multiple cropping coupled with the use of high analysis sulphur free fertilizer along with the restricted or no use of organic manures accrued in the depletion of the soil sulphur reserve. Crops generally absorb sulphur and phosphorus in similar amounts. On an average, the sulphur absorbed per tonne of grain production is 3-4 kilograms in cereals, 8 kilograms in pulses, and 12 kilograms in oilseeds (Tandon, 1991) [12]. Soils, which are deficient in sulphur, cannot provide adequate sulphur on their own to meet crop demand resulting in sulphur deficient crops and sub-optimal yields (Chattopaddhyay and Ghosh, 2012) [2]. Indian mustard markedly responded to sulphur fertilization in oilseeds. Sulphur plays a vital role in the quality and development of seed.

Material and Methods

A field experiment was conducted at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *rabi* season of the year 2019-20. The soil of the experimental field was loamy sand in texture, low in organic carbon (0.17%) and available nitrogen (174 kg/ha), medium in available P_2O_5 (40.5 kg/ha) and low in available sulphur (7.62 kg/ha) with soil pH of 7.42. The experiment comprising of twelve treatment combinations comprising four sources (Gypsum; Bentonite; SSP and Cosavet) and three levels (20 kg S/ha; 40 kg S/ha and 60 kg S/ha) of sulphur evaluated in Randomized Block Design (RBD) with factorial concept and replicated three times. The mustard was planted at 45 × 10 cm spacing. Crops were raised with their recommended package of practices. The total quantity of sulphur as per treatments was applied in opened furrow at the time of sowing (From gypsum containing 23.3% Ca and 18.5% S, bentonite containing 90% S and 10% bentonite clay, SSP containing 14.5% P_2O_5, 11% S and 21% Ca and cosavet containing 80% S). The recommended fertilizer dose for mustard is 50-50-00 N-P_2O_5-K_2O kg/ha. Full dose of P_2O_5 (50 kg/ha) and half dose of N (25 kg/ha) applied in basal and other half dose of nitrogen (25 kg/ha) was top dressed in two split at 25 DAS and 55 DAS. The observation on plant growth, yield attributes and yield were recorded as per standard procedure. Economics was worked out on the basis of prevailing market prices of inputs and output obtained from each treatment. The data were statistically analyzed for various characters as described by (Panse and Sukhatme, 1967) [6].

Results and Discussion

The data pertaining to effect of sources and levels of sulphur on growth attributes, yield attributes and yield are presented in Table 1 to 7.

Effect of sources of sulphur

An appraisal of data presented in Table 1.0 showed that the effect of different sources of sulphur on mustard, growth attributes such as plant height at harvest and number of primary as well secondary branches per plant showed significant improvement due to application of gypsum. However, it was statistically at par with treatment cosavet and bentonite, whereas, significantly the lowest plant height at harvest and number of primary as well as secondary branches per plant were exhibited under treatment SSP. However, plant population 30 DAS and at harvest, days taken to maturity, test weight and harvest indexdid not vary significantly due toapplication of different sources of sulphur. Similarly, application of sulphur in form of gypsum surpassed other sources by recording higher values of yield and yield attributes *viz.*, number of siliquae per plant (373.44), number of seeds per siliqua (14.04), length of siliqua (5.88 cm), seed yield per plant (17.14 g), seed (2476 kg/ha) and stover (7151 kg/ha) yields. High response to gypsum in respect of seed and stover yield might be due to its readily available So_4^{2-} S and high calcium content. Maximum seed and stover yield associated with gypsum application might be due to improvement in growth and yield attributing characters was found with gypsum over other sources of sulphur. These results are in conformity with the results reported by Singh and Singh (2007) [11], Ceh *et al*. (2008) [1], Rao *et al*. (2013) [7] and Adkine *et al*. (2017). On an average, the application of gypsum, cosavet and bentonite increased seed yield (kg/ha) to the tune of 24.99, 16.10 and 13.23 per cent and stover yield (kg/ha) to the tune of 14.36, 7.76 and 5.85 per cent over the SSP, respectively.

Effect of levels of sulphur

The results of the present investigation indicated that different dosed of sulphur did not affect significantly on plant population 30 DAS and at harvest, days taken to maturity. Whereas, significantly higher value of yield attributing characters and yields *viz*., number of siliquae per plant (373.83), number of seeds per siliqua (13.83), length of siliqua (5.88 cm) and test weight (5.18 g), as well as seed yield per plant (17.30 g) seed yield (2493 kg/ha) and stover yield (7034 kg/ha) were recorded with 60 kg S/ha, but statistically at par with 40 kg S/ha except seed yield per plant and seed yield. The positive response of higher doses of sulphur could be due to increased absorption of sulphur from the soil resulting in improvement in reproductive structure of sink strength thereby increasing growth parameters and yield attributes as well as production of assimilates to fill the seed and finally the seed and stover yield. Similar results were also reported by Lakshman *et al.* (2017) [8], Dharmendra Kumar *et al.* (2018) [3] and Ravindra *et al*. (2018) [8]. Application of 60 kg S/ha and 40 kg S/ha correspondingly increase seed yield to the tune of 29.91 and 21.83 per cent and stover yield to the tune of 11.72 and 7.05 per cent over 20 kg S/ha, respectively.

Gypsum+ 60 kg S /ha (S_1L_3)

Gypsum+ 40 kg S /ha (S_1L_2)

Interaction effect

Interaction effect of sources and levels of sulphur was found significant in case of a number of siliquae per plant, seed yield per plant and seed yield except this all other parameters recorded non-significant during the course of the investigation. Among all the possible interaction, treatment combination gypsum x 60 kg S/ha recorded significantly the maximum value of siliquae per plant (396.33), seed yield per plant (18.03 g) and seed yield (2694 kg/ha).

Economics

The data pertaining to effect of sources and levels of sulphur on economics are presented in Table 8 and 9.

Effect of sources of sulphur

A critical observation of data elucidated that the different sources of sulphur, gypsum fetched the highest net realization of ₹ 61234/ha and benefit : cost ratio (BCR) of 3.11 followed by treatment cosavet in case of net realization. The results are in agreement with the finding of Virendra *et al.* (2008) [13] and Kumar and Trivedi (2012) [4].

Effect of levels of sulphur

Among the different level of sulphur, application of 60 kg S/ha realized maximum net returns (₹ 53532/ha) whereas, B:C ratio (2.66) was maximum with 40 kg S/ha. The similar findings have also been reported by Sah *et al.* (2013) [9] and Singh and Pandey (2017) [10].

Interaction effect

Maximum gross realization (₹ 97948/ha) and net realization (₹ 68516/ha) with a B: C ratio of 3.33 was achieved with the treatment combination of application of gypsum + 60 kg S/ha, followed by application of gypsum + 40 kg S/ha, having net realization (₹ 59865/ha) and B: C ratio of 3.06.

Table 1: Plant population andplant height at harvest (cm) of mustard as influenced by sources and levels of sulphur

Treatments	Plant population (per metre row length)		Plant height at harvest (cm)
	30 DAS	At harvest	
Sulphur sources (S)			
S_1 : Gypsum	6.94	6.67	214.96
S_2 : Bentonite	6.79	6.56	196.56
S_3 : SSP	6.63	6.53	179.23
S_4 : Cosavet	6.83	6.60	203.62
S.Em.±	0.11	0.14	7.73
C.D. (P = 0.05)	NS	NS	22.67
Sulphur levels (L)			
L_1 : 20 kg S/ha	6.78	6.55	183.18
L_2 : 40 kg S/ha	6.80	6.60	200.78
L_3 : 60 kg S/ha	6.82	6.62	211.82
S.Em.±	0.10	0.12	6.69
C.D. (P = 0.05)	NS	NS	19.64
Interaction			
S.Em.±	0.20	0.23	13.39
C.D. (P = 0.05)	NS	NS	NS
C.V. (%)	5.00	6.13	11.68

Table 2: Number of primary and secondary branches per plantand days to maturity of mustard as influenced by sources and levels of sulphur

Treatments	Number of primary branches/plant	Number of secondary branches/plant	Days to maturity(Days)
Sulphur sources (S)			
S_1 : Gypsum	5.73	20.22	115.22
S_2 : Bentonite	5.47	18.85	114.67
S_3 : SSP	4.75	16.12	114.56
S_4 : Cosavet	5.58	19.20	115.00
S.Em.±	0.16	0.50	0.28
C.D. (P = 0.05)	0.46	1.46	NS
Sulphur levels (L)			
L_1 : 20 kg S/ha	4.65	15.88	114.67
L_2 : 40 kg S/ha	5.59	19.35	114.92
L_3 : 60 kg S/ha	5.91	20.56	115.00
S.Em.±	0.13	0.43	0.24
C.D. (P = 0.05)	0.40	1.26	NS
Interaction			
S.Em.±	0.27	0.86	0.49
C.D. (P = 0.05)	NS	NS	NS
C.V. (%)	8.70	8.02	0.73

Table 3: Number of seeds per siliqua, number of siliquae per plant, length of siliqua and test weight of mustard as influenced by sources and levels of sulphur

Treatments	Siliquae/plant	Seeds/siliqua	Length of siliqua (cm)	Test weight (g)
Sulphur sources (S)				
S_1 : Gypsum	373.44	14.04	5.68	5.06
S_2 : Bentonite	342.22	13.51	5.34	4.92
S_3 : SSP	269.89	12.19	4.78	4.79
S_4 : Cosavet	349.78	13.59	5.42	4.96
S.Em.±	11.10	0.39	0.19	0.16
C.D. (P = 0.05)	32.55	1.15	0.55	NS

Sulphur levels (L)						
L_1	:	20 kg S/ha	279.33	12.53	4.62	4.56
L_2	:	40 kg S/ha	348.33	13.63	5.43	5.06
L_3	:	60 kg S/ha	373.83	13.83	5.88	5.18
S.Em.±			9.61	0.34	0.16	0.14
C.D. (P = 0.05)			28.19	1.00	0.48	0.40
Interaction						
S.Em.±			19.22	0.68	0.33	0.27
C.D. (P = 0.05)			56.4	NS	NS	NS
C.V. (%)			9.97	8.85	10.69	9.55

Table 4: Interaction effect of sources and levels of sulphur on number of siliquae per plantof mustard

Sources Levels	**S_1:Gypsum**	**S_2:Bentonite**	**S_3:SSP**	**S_4:Cosavet**	**Mean**
L_1: 20 kg S/ha	335.33	303.00	160.33	318.67	279.33
L_2:40 kg S/ha	388.67	343.00	316.67	345.00	348.33
L_3:60 kg S/ha	396.33	380.67	332.67	385.67	373.83
Mean	373.44	342.22	269.89	349.78	
S.Em.±	19.22				
C.D. (P = 0.05)	56.4				
C.V. (%)	9.97				

Table 5: Seed yield per plant (g), seed yield (kg/ha), stover yield (kg/ha) and harvest index (%) of mustard as influenced by sources and levels of sulphur

Treatments			**Seed yield/plant(g)**	**Seed yield (kg/ha)**	**Stover yield (kg/ha)**	**Harvest index (%)**
Sulphur sources (S)						
S_1	:	Gypsum	17.14	2476	7151	25.87
S_2	:	Bentonite	16.30	2243	6619	25.29
S_3	:	SSP	13.95	1981	6253	23.85
S_4	:	Cosavet	16.63	2300	6738	25.41
S.Em.±			0.37	55	207	0.77
C.D. (P = 0.05)			1.11	160	607	NS
Sulphur levels (L)						
L_1	:	20 kg S/ha	14.43	1919	6296	23.24
L_2	:	40 kg S/ha	16.28	2338	6740	25.88
L_3	:	60 kg S/ha	17.30	2493	7034	26.20
S.Em.±			0.33	47	179	0.66
C.D. (P = 0.05)			0.96	139	526	1.94
Interaction						
S.Em.±			0.65	95	358	1.33
C.D. (P = 0.05)			1.90	278	NS	NS
C.V. (%)			7.08	7.29	9.28	9.15

Table 6: Interaction effect of sources and levels of sulphur on seed yield per plantof mustard

Sources Levels	**S_1:Gypsum**	**S_2:Bentonite**	**S_3:SSP**	**S_4:Cosavet**	**Mean**
L_1: 20 kg S/ha	16.29	15.42	10.54	15.92	14.54
L_2:40 kg S/ha	17.33	16.72	15.06	16.81	16.48
L_3:60 kg S/ha	18.03	17.50	16.18	17.62	17.33
Mean	17.22	16.55	13.93	16.79	
S.Em.±	0.647				
C.D. (P = 0.05)	1.9				
C.V. (%)	6.96				

Table 7: Interaction effect of sources and levels of sulphur on seed yield (kg/ha)of mustard

SourcesLevels	**S_1:Gypsum**	**S_2:Bentonite**	**S_3:SSP**	**S_4:Cosavet**	**Mean**
L_1: 20 kg S/ha	2300	1968	1392	2015	1919
L_2:40 kg S/ha	2435	2352	2172	2393	2338
L_3:60 kg S/ha	2694	2410	2379	2490	2493
Mean	2476	2243	1981	2300	
S.Em.±	95				
C.D. (P = 0.05)	278				
C.V. (%)	7.29				

Table 8: Economics of mustard as influenced by sources and levels of sulphur

Treatments			Seed yield (kg/ha)	Stover yield (kg/ha)	Gross realization (₹/ha)	Cost of cultivation (₹/ha)	Net Realization (₹/ha)	BCR
Sulphur sources (S)								
S_1	:	Gypsum	2476	7151	90236	29002	61234	3.11
S_2	:	Bentonite	2243	6619	81815	37476	44339	2.18
S_3	:	SSP	1981	6253	72462	28754	43708	2.52
S_4	:	Cosavet	2300	6738	83869	33143	50726	2.53
Sulphur levels (L)								
L_1	:	20 kg S/ha	1919	6296	70313	30030	40283	2.34
L_2	:	40 kg S/ha	2338	6740	85200	32012	53188	2.66
L_3	:	60 kg S/ha	2493	7034	90772	34240	53532	2.65

(**Note:** Sell price: Mustard seed: ₹35.0/ kg and Stover: ₹0.5/kg)

Table 9: Economics of mustard as influenced by different treatment combination of sources and levels of sulphur

Treatment Combinations		Seed yield (kg/ha)	Stover yield (kg/ha)	Gross realization (₹/ha)	Cost of cultivation (₹/ha)	Net Realization(₹/ha)	BCR
S_1L_1	Gypsum @20kgS/ha	2300	6853	83927	28573	55354	2.94
S_1L_2	Gypsum @40 kgS/ha	2435	7284	88867	29002	59865	3.06
S_1L_3	Gypsum @60 kgS/ha	2694	7315	97948	29432	68516	3.33
S_2L_1	Bentonite @20 kgS/ha	1968	6158	71959	32810	39149	2.19
S_2L_2	Bentonite @40kgS/ha	2352	6685	85663	37476	48187	2.29
S_2L_3	Bentonite @60 kgS/ha	2410	7015	87858	42143	45715	2.08
S_3L_1	SSP @20 kg S/ha	1392	5939	51690	28093	23597	1.84
S_3L_2	SSP @40 kg S/ha	2172	6273	79157	28427	50730	2.78
S_3L_3	SSP @60 kg S/ha	2379	6548	86539	29743	56796	2.91
S_4L_1	Cosavet @20 kgS/ha	2015	6237	73644	30643	43001	2.40
S_4L_2	Cosavet @40 kgS/ha	2393	6717	87114	33143	53971	2.63
S_4L_3	Cosavet @60 kg S/ha	2490	7259	90780	35643	55137	2.55

(Note: Sell price: Mustard seed: ₹ 35.0/ kg and Stover: ₹ 0.5/kg**)**

Conclusion

It can be concluded that better crop yield and highest net returns could be obtained from mustard (cv. Gujarat Mustard 4) by fertilizing the crop with 40 kg S/ha through gypsum in addition to RDF (50-50-00 kg NPK/ha) in loamy sand soil under North Gujarat Agro-climatic conditions.

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