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Original Research Article

Effect of Sources and Doses of Sulphur on S Uptake and Yield of Mustard (*Brassica juncea* L.)

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Keywords

Dose of sulphur, Mustard, Source of sulphur and Uptake of sulphur

A B S T R A C T

A field experiment was conducted during 2013-2014 at Research farm of Bihar Agricultural College, Sabour, Bhagalpur to evaluate the effect of sources and doses of sulphur on S uptake and yield of mustard. The experiment comprised of twelve treatment combinations laid out in factorial randomized block design with three replications. Main plot consisted of three sources of sulphur (gypsum, iron pyrite, and bentonite S) and the sub plots include four doses of sulphur (0, 20, 40 and 60 kg S ha^{-1}). Results revealed that the optimum dose of sulphur was computed to be 49.6 kg ha^{-1} for bentonite source in mustard which was followed by 53.4 kg ha^{-1} for iron pyrite and 57.1 kg ha^{-1} for gypsum source of sulphur. Sulphur content in plant was registered maximum with bentonite S significantly as compared to remaining sources of sulphur at all the growth stages except at 21 days after sowing where non-significant difference in S content was observed. S content in plant was progressively enhanced with each increase in S dose from 0 to 60 kg S ha^{-1} resulting maximum value at 60 kg S ha^{-1} which registered significance over 40 kg S ha^{-1} except at 42 days after sowing. Sulphur uptake increased linearly with simultaneous increase in S doses resulting maximum value at 60 kg S ha^{-1} which exhibited significance over rest of sulphur doses at all the growth stages except at 42 days after sowing.

Introduction

Rapeseed and mustard are the third most important edible oilseed crops of the world after soybean and oil palm. Sulphur is the fourth most important nutrient after nitrogen, phosphorus and zinc for Indian agriculture. Sulphur is best known for its role in the synthesis of proteins, oils, vitamins and flavoured compounds in plants. Three amino acids viz. Methionine (21%S), Cysteine (26%S), and Cystine (27%S) contain S which are the building blocks of proteins. About 90% of sulphur is present in these amino acids. Sulphur is also involved in the formation of chlorophyll, glucosides and glucosinolates (mustard oils), activation of enzymes and sulphydryl (SH-) linkages that are the source of pungency in oilseeds. Area under mustard in Bihar is 0.82 lakh hectares with 0.76 lakh tonnes production and 926 kg ha^{-1} productivity (FAI, 2012). Adequate sulphur is therefore very much crucial for oilseed crops. Sulphur is associated with the production of oilseed crops of superior nutritional and market quality. Soils, which are deficient in sulphur, cannot on their own provide adequate sulphur to meet crop demand resulting in sulphur deficient crops and sub-optimal yields (Chattopaddhyay *et al.,* 2012). Continuous removal of S from soils by plant uptake has led to widespread S deficiency and soil S budget (Aulakh *et al.,* 1977) all over the world.

Sulphur levels significantly influenced the seed, stover yield and sulphur uptake of mustard (Sharma *et al.,* 2009). Sulphur is associated with the production of crops of superior nutritional and market quality. Sulphur deficiencies have been reported from over 70 countries worldwide including India. Deficiency of sulphur in Indian soils is on increase due to intensification of agriculture.

The productivity of mustard is very low mainly because of imbalanced use of fertilizers. Most of the farmers are not aware of importance and application time of commercially available sulphur containing fertilizers in nearby market. Sulphur is essential for synthesis of proteins, vitamins and sulphur containing essential amino acids and is also associated with nitrogen metabolism. Besides, sulphur application in mustard has also been reported to increase the yield and oil per centage. To achieve this objective, agricultural scientists have laid more emphasis on improving production of oilseeds through proper nutrition. However, to achieve high yields and the rates of S fertilizer should be recommended on the basis of available soil S and crop requirement.

In S-deficient soil, the efficiency of applied NPK fertilizers may be seriously affected and crop yield may not be sustainable (Ahmad *et al.,* 1999). Probably for these reasons mustard crop needs comparatively higher amount of sulphur for proper growth and development and higher yields. Application of different S fertilizers at 10-50 kg S ha^{-1} significantly increased the seed yield of rapeseed and mustard crops ranging from 5.2-26.7% as compared to control (Ahmad *et al.,* 1999). Information available on the suitability of S-containing fertilizers in mustard is very few. Keeping these issues in view, the present investigation was carried out to evaluate effect of sources and doses of sulphur on S uptake and yield of mustard.

Materials and Methods

A field experiment was conducted during *rabi* season 2013-14 at Bihar Agricultural University farm, Sabour (25°50' N, 87°19' E; 52.73 m above mean sea level), Bhagalpur, Bihar, India. The soil of the experimental field was sandy loam with pH 7.42 having organic carbon 0.52%, available nitrogen 227.2 kg ha^{-1}, available phosphorus 24.2 kg P_2O_5 ha^{-1}, available potassium 152.1 kg K_2O ha^{-1} and available sulphur 10.31 ppm. The experiment comprised of twelve treatment combinations laid out in factorial randomized block design with three replications. Main plot consisted of three sources of sulphur (gypsum, iron pyrite, and bentonite S) and the sub plots include four doses of sulphur (0, 20, 40 and 60 kg S ha^{-1}). This experiment was undertaken to find out the yield response, uptake and content of sulphur by mustard under different sources as well as levels of sulphur. Mustard was fertilized uniformly with 80:40:40 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. Half N along with full P and K was applied as basal. Remaining N was top dressed in two equal splits at 25 and 45 days after sowing. Different doses of sulphur were applied through treatment wise sulphur sources as basal. Mustard crop was sown on 13 November 2013 having row to row distance 30 cm with seed rate of 5 kg ha^{-1} and harvested on 10 March 2014. Plant samples for analysis of S were collected at 21 DAS, 42 DAS, 50% flowering and at harvest stage. Plant samples were washed with distilled water, dried in hot air-oven at 60^0C and ground in a stainless steel mill. The ground straw samples were digested with nitric and perchloric (4:1) acid mixture for the analysis of sulphur. Sulphur content in plant was estimated by turbidimetric method. Sulphur uptake by crop was calculated on the basis of sulphur concentration in plant and dry matter accumulation by plant at 21 DAS, 42 DAS, 50% flowering and at harvest stage. Yield response curve was worked out by plotting yield of the crop under different doses of sulphur by using yield response equation ($y= a+bx+cx^2$).

The experimental data recorded in respect of different observations in the present experiment were analyzed statistically with the help of following procedures for factorial randomized block design to test the significance of the overall differences among treatments by using the F test and conclusions were drawn at 5% probability level

Results and Discussion

Effect of sulphur sources and doses on sulphur uptake by mustard

Data on S uptake by plant at different growth stages of crop are presented in Table 1. In general, the sulphur uptake by plant increased progressively with advancement of crop growth stages. In all the growth stages, sulphur uptake was recorded highest with bentonite S significantly as compared to rest two sources of sulphur which might be attributed to higher seed and stover yield as well as high S content found in bentonite S. As far as doses of sulphur was concerned, sulphur uptake increased with simultaneous increase in S doses resulting maximum value at 60 kg S ha^{-1} which exhibited significance over rest of sulphur doses at all the growth stages except at 42 days after sowing. Application of 30 kg S ha^{-1} in individually resulted in maximum uptake (0.78 kg S ha^{-1} at 30 DAS, 3.69 kg S ha^{-1} at 60 DAS and 16.24 kg S ha^{-1} at harvest) of sulphur by mustard (Mani *et al.,* 2006). The higher content of sulphur in seed and stover together with higher seed and stover yield resulted in higher uptake of sulphur. Similar findings were also in agreement with Sreemannarayan and Raju (1995) who reported that application of S @ 20, 40 and 60 kg ha^{-1} led to an increase in uptake of 33.5, 68.7 and 95.0% S over control, respectively. These findings confirmed the results of Chaubey and Dwivedi (1995). Enhanced uptake of S with 60 kg S ha^{-1} in mustard has also been reported by Choudhary *et al.,* (2003).

Effect of sulphur sources and doses on sulphur content in mustard

Data pertinent to S content in plant at different growth stages of crop are presented in Table 2. In general, the sulphur content decreased with the advancement of growth stages of crop. In all cases, sulphur content in plant was registered maximum with bentonite S significantly as compared to remaining two sources at all the growth stages except at 21 days after sowing where non-significant difference in S content was observed. So far as doses of sulphur was concerned, S content in plant was progressively enhanced with each increase in S dose from 0 to 60 kg S ha^{-1} resulting maximum value at 60 kg S ha^{-1} which registered significance over 40 kg S ha^{-1} except at 42 days after sowing. It might be ascribed to higher sulphur concentration in bentonite S and also due to slow release readily available sulphur fertilizer.

Table.1 Sulphur uptake by mustard at different stages as influenced by different treatments

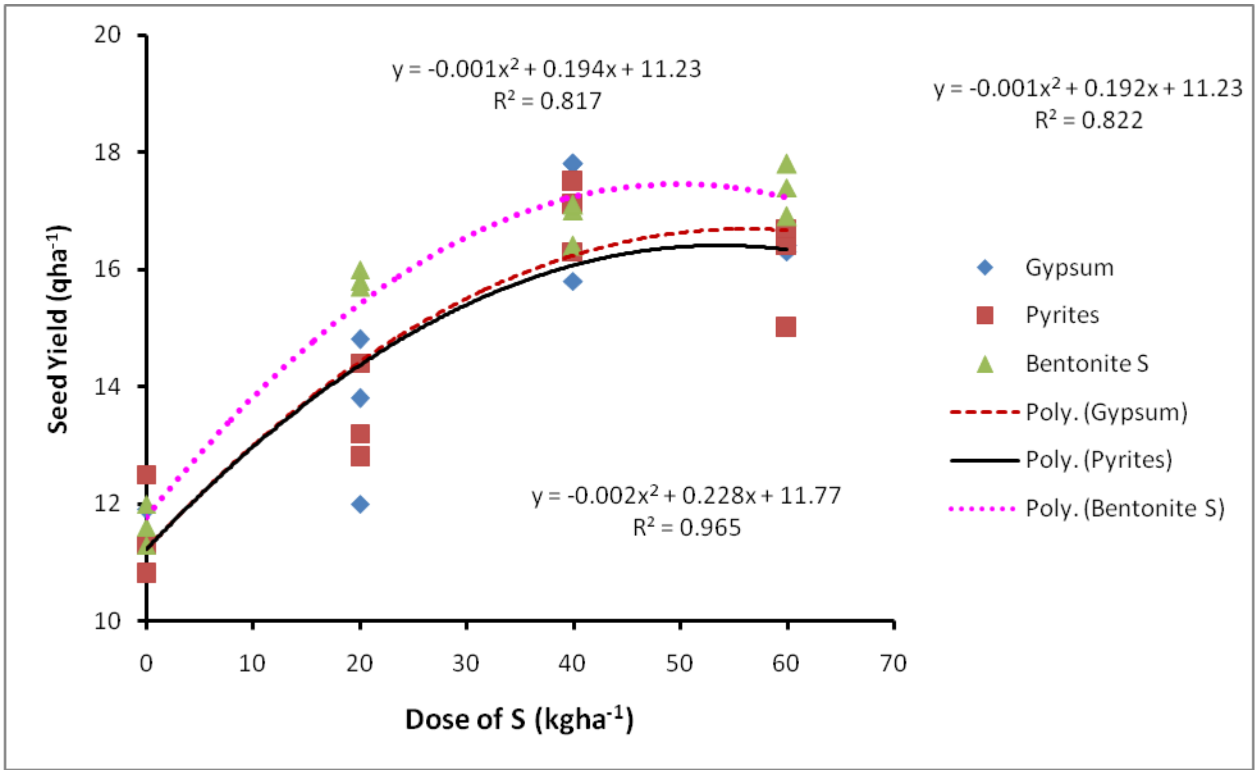
Treatments	S uptake (kg ha^{-1})			
	21 DAS	**42 DAS**	**Flowering**	**Harvest**
Sources of sulphur				
S_1- Gypsum	1.46	3.33	15.60	26.31
S_2- Iron pyrite	1.33	3.21	15.47	23.75
S_3- Bentonite S	1.60	3.87	16.95	30.71
SEm±	0.06	0.19	0.28	0.55
CD (P=0.05)	0.17	0.55	0.81	1.62
Doses of sulphur (kg S ha^{-1})				
D_1 - 0	0.95	3.01	13.22	20.50
D_2 - 20	1.12	3.23	14.49	26.31
D_3 - 40	1.78	3.65	16.32	29.35
D_4 - 60	2.00	3.98	19.99	31.53
SEm±	0.07	0.22	0.32	0.64
CD (P=0.05)	0.20	0.63	0.94	1.87

Table.2 Sulphur content in plant of mustard at different stages as Influenced by different treatments

Treatments	S content in plant (%)			
	21 DAS	**42 DAS**	**Flowering**	**Harvest**
Sources of sulphur				
S_1- Gypsum	1.40	0.92	0.69	0.44
S_2- Iron pyrite	1.32	0.84	0.64	0.48
S_3- Bentonite S	1.44	1.03	0.72	0.59
SEm±	0.05	0.05	0.02	0.01
CD (P=0.05)	NS	0.13	0.06	0.04
Doses of sulphur (kg S ha^{-1})				
D_1 - 0	1.13	0.77	0.59	0.37
D_2 - 20	1.27	0.89	0.64	0.49
D_3 - 40	1.47	0.96	0.67	0.53
D_4 - 60	1.68	1.10	0.82	0.62
SEm±	0.05	0.05	0.02	0.02
CD (P=0.05)	0.16	0.15	0.07	0.05

Fig.1 Yield response curve as influenced by sources and doses of sulphur

Gypsum		Pyrite		Bentonite	
2c	-0.0034	2c	-0.0036	2c	-0.0046
B	0.1942	b	0.1925	b	0.2285
Xopt	57.11765	Xopt	53.47222	Xopt	49.67391



Ghosh *et al.*, (1999) also reported an increase in S concentration of raya (*Brassica juncea*) along with the increase in doses of S. The higher concentration of S in mustard grain than stover clearly indicates the mobilization of S from plant parts to grain.

Yield response curve as influenced by sources and doses of sulphur

The yield response equation as influenced by sources and doses of sulphur are given in Fig. 1. The optimum dose of sulphur for mustard was computed which was inferred from this curve. The yield response curve of mustard to sources and doses of sulphur were found to be of quadratic nature during the period of experimentation.

Data pertinent to yield vs dose of sulphur for different sources of S were depicted in Fig. 1 revealed that the seed yield of mustard showed second polynomial increase ($y= a+bx+cx^2$) with successive increase in sulphur doses. The optimum dose of sulphur was computed to be 49.6 kg ha^{-1} for bentonite source in mustard which was followed by 53.4 kg ha^{-1} for iron pyrite and 57.1 kg ha^{-1} for gypsum source of sulphur.

Hence it might be concluded that the optimum dose of sulphur for mustard was computed from yield response curve were found to be of quadratic nature. The seed yield of mustard showed second polynomial increase ($y= a+bx+cx^2$) with successive increase in sulphur doses. The optimum dose of sulphur was computed to be 49.6 kg ha^{-1} for bentonite source in mustard which was followed by 53.4 kg ha^{-1} for iron pyrite and 57.1 kg ha^{-1} for gypsum source of sulphur. Sulphur content and uptake was recorded highest with bentonite S with simultaneous increase in S doses resulting maximum value at 60 kg S ha^{-1}.

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