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A study on effect of sulphur fertilization on yield, quality and economics of mustard (*Brassica campestris*) in Chotanagpur region of Jharkhand

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Abstract
A field experiment of two years was conducted in Rabi season 2015-16 and 2016-17 at Holy Cross Farm Dipugarda Hazaribag, Jharkhand India to study the effect of sulphur fertilization on yield, quality and economics of Mustard crop. The experiment was laid out in split plat design with three replicates, two main factors, three and five sub factors consisting of three sources of sulphur viz., SSP (Single Super Phosphate), Phosphogypsum and Elemental sulphur (Bntonite Sulphur) and four levels of sulphur i.e. 10kg sulphur/ha, 20kg sulphur/ha, 30 kg sulphur/ha and 40 kg/ha& control. Almost all the yield and quality attributes were significantly highest with application of SSP at 40kg of sulphur/ha, while maximum net return and BCR was recorded with application of SSP, sulphur levels at 20 kg/ha gave highest benefits in both the years.

Keywords: SSP, phosphogypsum, elemental sulphur, yield, quality and mustard

Introduction
Mustard (*Brassica campestris*) play a vital role in Indian economy & it occupies almost 5% of gross national productand10% of the value of agricultural product. In India, mustard and rape seed account for 16.61% of the total oil seed area (40010.22 thousand ha), produces 11.47% of total oil seeds (68651.4 thousand MT) and it also occupies the second position in the area next to soyabean and the third position in production next to soyabean and groundnut, (Ministry of agriculture, GOI 2014) [1]. Mustard is a important crop of Jharkhand and It is cultivated in 177.6 thousand ha of land in Jharkhand, (DAC & FW 2016-17) in the rabi season in an upland and medium land soil condition. The soil is mostly sandy and sandy loam soil, acidic, low in organic carbon, low in available nitrogen, low to medium in available phosphorous, low to medium in available potassium and deficient in available sulphur. The average production of mustard and rape seed is 686 kg/ha in 2015-16 in Jharkhand is much lower than the national average 1184 kg/ha (DAC & FW 2016-17). The average oil content of the mostly cultivated mustard is around 35%.
Sulphur deficiency is widespread in many Indian soil. Sulphur resembles to nitrogen in its role and function in plant and its requirement by crops is as much to that of phosphorous. Sulphur performs many physiological functions in oil seeds like synthesis of S containing amino-acid, namely, cysteine (21% S), cysteine (26% S) and methionine (21% S). Sulphur increases the oil content in oil seeds (Kumar and Trivedi 2012) [8]. The sulphur requirement in oil seeds is fairly high in comparison to cereals and millets. There is drastic change in the production and nutritive value of crop produce due to absence of sulphur.

In sulphur deficient soils, generally all crops respond to sulphur application but in case of oilseed and pulses, the response is higher. Average removal of sulphur by one tonne of oilseeds ranges between 8-12kg by pulses 4-8 kg as compared to 3.5 kg sulphur by cereals. Similarly, oilseeds from one ha removes sulphur between 10 and 25 kg and that of pulses 5-10 kg/ha annually which depends upon the crops, soil and environmental factors.
In Jharkhand condition less attention in given for sulphur application to mustard. So there is a great scope to increase the productivity and oil content of mustard in Jharkhand by sulphur application. Therefore, the study was under taken to know a study the effect of sulphur fertilization on yield, quality and economy of Mustard crop in Jharkhand soil.

Materials and Methods
A field experiment was conducted during the rabi season 2015-16 and 2016-17 at Holy Cross Farm Hazaribag, Jharkhand. The soil of experimental field was sandy in texture low in available nitrogen (251.25 kg/ha) and available phosphorous (24.5 kg/ha) and low in available potash. The experiment was laid out in split plat design with three replicates, two main factors, three and five sub- factors consisting of three sources SSP (Single Super Phosphate), Phosphogypsum and Elemental Sulphur (Bntonite Sulphur) and four levels of sulphur10kg sulphur/ha, 20kg sulphur/ha, 30 kg sulphur/ha and 40 kg/ha and control. Mustard variety Shivani was selected for investigation.
Furrow was opened manually in each plot by keeping spacing (25X15cm) line to line 25 cm and plant to plant 15cm. Recommended dose of fertilizers use for mustard was 100:60:40 NPK/ha the crop was fertilized with half the dose of nitrogen (50 kg/ha), full dose of phosphorous (60 kg/ha) and full dose of potash (40 kg/ha) as the basal and rest of the half dose of nitrogen (50kg/ha) was applied after the Ist irrigation. The Nitrogen, Phosphorous and Potash was applied through Urea, DAP (Diammonium Phosphate), MOP (Muriate of Potash). SSP was used as a sulphur and its Phosphorous content was adjusted with DAP as per treatment. The crop was raised following all the recommended agronomic practices and harvested in the last week of February month during 2015-16 and 2016-17.
The protein content was determined by nitrogen content multiplied by 6.25 conversion factor.

The oil yield and protein yield calculated in kg/ha by formula

Oil yield in kg/ha = Seed yield (kg/ha) X Oil content in percentage.
Protein in kg/ha = Seed yield X Protein content in percentage.

The net return was calculated by Gross return-Cost of cultivation and B: C ratio was calculated by the formula given below.

$$\text{B: C ratio} = \frac{\text{Net return (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

Result and discussion
Effect on Seed yield
The seed yield of mustard increased significantly when sulphur was applied through SSP (Single superphosphate) compared to other sources of sulphur (Table 1). The highest seed yield (12.52Q/ha) of mustard was recorded with SSP application. When SSP was applied as source of sulphur percentage increase in seed yield of mustard was 10.99 and 11.49 over Phosphogypsum and Elemental Sulphur (Bentonite Sulphur). Phosphogypsum and Elemental Sulphur (Bentonite Sulphur) as sources of sulphur recorded 11.28 Q/ha and 11.23 Q/ha seed yield of mustard and were statistically at par.
The seed yield increased significantly with increasing levels of sulphur up to 40 kg/ha. The highest seed yield (12.48 Q/ha) of mustard recorded with 40kg sulphur/ha and this was significantly superior to 10kg sulphur/ha and control. When sulphur was applied at rate of 20 kg/ha the seed yield of mustard obtained as 12.13 Q/ha and it was statistically at par with sulphur levels at 30 kg/ha and 40kg/ha but it was significantly higher to 10 kg sulphur/ha and control. The sulphur plays a vital role and promotes metabolic activities in chlorophyll formation, amino acid and protein synthesis. Tomar *et al*. (2007) [13] reported that application of 30 kg sulphur/ha significantly improved the yield attributes, seed and stover yields of mustard.

Effect of sources and levels of sulphur on Quality parameter of Mustard
Effect on oil content (%)
A perusal of data presented in Table no.1 showed significant increase in the oil content of mustard seed with different sources of sulphur. Application of SSP as source of sulphurrecorded highest oil content of 41.38% and it was statistically at par with Phosphogypsum application. The percentage increase in oil content with application of SSP was 0.58% and 2.53% over Phosphogypsum and Elemental Sulphur (Bentonite Sulphur). Phosphogypsum as source of sulphur recorded oil content of 41.14% and it was significantly high over Elemental Sulphur (Bentonite Sulphur) as source of sulphur (40.36%). Tomar *et al*. (2007) [13] reported that application of 30 kg sulphur/ha significantly increased oil content. Malhi *et al*. (2007) [10] reported that oil concentration in seed increased with S fertilization for all Brassica species. Singh and Singh (2007) [14] reported that among sources of sulphur, gypsum proved significantly superior to other sources for oil content of linseed.
The oil content increased significantly with application of sulphur levels up to 40 kg sulphur/ha over control during the trails. The application of sulphur level at 40 kg/ha the oil content recorded maximum 41.89% were statistically at par with sulphur levels at 30kg/ha (41.86%) and 20kg/ha (41.60%). It was statistically significantly superior with sulphur levels 10 kg/ha (40.21%) and control plot (39.24%). Percentage increase of in content with 40 kg sulphur/ha recorded 4.18 and 6.75 over 10 kg sulphur/ha and control. Minimum oil content was recorded 39.24% with control. Bhagat and Soni (2000) [2] found that application of sulphur up to 50 kg /ha significantly increased oil content in mustard.

Oil yield (kg/ha)
The oil yield was significanttly influenced by different sources of sulphur application. When sulphur was applied as source of single superphosphate (SSP) the oil yield was recorded 519.3 kg/ha and it was significantly superior over Phosphogypsum (464.7kg/ha) and Elemental Sulphur (Bentonite Sulphur) (453.6 kg/ha). Percentage increase in seed yield of mustard with application of SSP was recorded 11.75% and 14.48% over Phosphogypsum and Elemental Sulphur (Bentonite Sulphur). Phosphogypsum application

recorded 2.44 percentage increases in seed yield of mustard over elemental sulphur.

It is revealed from the data presented in Table no.1 that application of sulphur levels up to 40 kg sulphur/ha significantly influenced the oil yield of mustard during the observation. All the application of 40 kg sulphur/ha the oil yield of mustard recorded was 522.7 kg/ha and it was statistically at par with levels of sulphur at 30kg/ha (512.6 kg/ha) and 20 kg/ha (504.6kg/ha). The maximum oil yield was recorded at 40kg sulphur/ha and minimum oil yield was recorded with control (415.03 kg/ha). Percentage increase of oil yield recorded with application of 40 kg sulphur/ha were 1.97%, 3.59%, 18.2%, 25.90% over 30kg sulphur/ha, 20kg sulphur/ha, 10kg sulphur/ha and control respectively. Bhagat and Soni (2000) [2] found that application of sulphur up to 50 kg /ha significantly increased oil yield in mustard.

Protein Content (%)

The protein content increased with application of different sources of sulphur in mustard seed. When SSP applieds as source of sulphur the protein content recorded maximum 21.73% compared to Phosphogypsum (21.40%) and Elemental Sulphur (21.09%). The percentage increase in of protein content recorded was 1.54% and 3.03% compared to Phosphogypsum and Elemental Sulphur (Bentonite Sulphur). Phosphogypsum was observed as second best source of sulphur than Elemental sulphur (Bentonite Sulphur). Sharma *et al*. (1991) [12] reported that ammonium sulphate and ammonium sulphate nitrate were most effective sulphur sources as compared to single super phosphate, elemental sulphur and gypsum in increasing seed yield, oil and protein contents of mustard.

The protein content significantly increase with increasing levels of sulphur up to 40 kg/ha (Table 1). The highest protein content (22.56%) was recorded with application at 40 kg sulphur/ha being statistically at par with sulphur levels at 30 kg/ha and 20kg/ha. Application of 20 kg sulphur /ha recorded protein content of 21.69% and at 30 kg /ha of sulphur it was recorded as 21.84%. Percentage increase of protein content with application 20kg sulphur/ha was recorded as 3.89% and 5.91% over 10kg sulphur/ha and control, respectively. Kumar *et al.* (2001) [9] observed that protein content in seed of mustard significantly increased with increasing levels of sulphur up to 40 kg ha/ha.

Table 1: Effect of sources and levels of sulphur on Seed Yield, Oil Content, Oil Yield, Protein Content and Protein yield of Mustard

Treatments					
Sources of sulphur	**Seed yield Q/ha**	**Oil content in %**	**Oil yield in kg/ha**	**Protein content in %**	**Protein yield in kg/ha**
SSP	12.52	41.38	519.30	21.72	272.27
Phosphogypsum	11.28	41.14	464.70	21.40	241.90
Bentonite Sulphur	11.23	40.36	453.60	21.09	237.38
CD Value	1.01	0.67	46.48	NS	28.63
Levels of Sulphur kg/ha					
0	10.57	39.24	415.03	20.48	216.60
10	10.97	40.21	441.20	20.88	229.39
20	12.13	41.6	504.60	21.69	263.05
30	12.23	41.86	512.60	21.84	267.06
40	12.48	41.89	522.70	22.56	277.50
CD Value	0.458	1.12	21.70	1.02	14.52

Protein Yield (Kg/ha)

The application of different sources of sulphur significantly influenced the protein yield in seed of mustard. SSP application as sources of sulphur recorded highest protein yield (272.27 kg/ha) in seed of mustard. It was significantly superior over Phosphogypsum and Elemental Sulphur (Bentonite Sulphur). Percentage increase of protein yield with application of SSP was 12.55% and 14.70% over Phosphogypsum and Elemental Sulphur (Bentonite Sulphur), respectively. Phosphogypsum application recorded 237.38% protein yield/ha and it was the second best source of sulphur than SSP.

Protein yield in seed of mustard significantly increased with application of sulphur up to 40 kg/ha. Application of sulphur at 40 kg/ha recorded highest protein yield (277.50 kg/ha) in mustard seed and it was statistically superior over 10 kg sulphur/ha (20.88 kg/ha) and control (20.48 kg/ha). Percentage increase in protein yield recorded with application of 40 kg sulphur/ha were 3.90%, 5.48%, 20.97% and 28.11% over 30 kg/ha, 20 kg/ha, 10kg/ha of sulphur and control, respectively. Minimum protein yield of 216.6kg/ha was recorded with control. Kumar and Trivedi (2011) [6] found that protein content increased significantly with increasing level of sulphur up to the highest level of 60 kg S/ ha.

Effect of sources and levels of sulphur on economics

A perusal of data presented in Table no.2 clearly revealed that 20kg/ha sulphur through SSP recorded maximum net return (Rs.34713.65) followed by 30kg/ha sulphur through SSP (Rs.34674.10) giving a B: C ratio of 1.22 and 1.20 respectively. When sulphur applied through Phosphogypsum at the rate of 40 kg/ha it gave net return (Rs.28960.72) followed by 30kg/ha sulphur through Phosphogypsum (Rs. 25798.06) giving B: C ratio 1.01 and 0.90, respectively. Application of sulphur through Elemental sulphur (Bentonite Sulphur) at the rate of 20 kg/ha gave net return (Rs.25929.50) followed by 30 kg/ha sulphur through Elemental sulphur (Rs. 25723.72) giving B: C ratio 0.89 and 0.86, respectively. Kumar and Yadav (2007) [7] reported that highest net return of Rs. 13,734 ha^{-1} was recorded with 45 kg S/ha. However, B: C ratio was highest (1.18) at 30 kg sulphur/ha. The increase in the levels of S increased the cost of cultivation. Net returns were also higher with increase in S levels.

Table 2: Effect of sources and levels of sulphur on cost of cultivation, Gross return, Net return and B: C Ratio of Mustard

Treatments	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C Ratio
SSP 0 kg/ha	28278.44	50652.50	22374.06	0.79
SSP 10 kg/ha	28103.48	55037.50	26934.02	0.96
SSP 20 kg/ha	28367.35	63081.00	34713.65	1.22
SSP 30 kg/ha	28951.90	63626.00	34674.10	1.20
SSP4 0 kg/ha	29779.75	63749.50	33969.75	1.14
Phosphogypsum 0 kg/ha	28278.44	49566.00	21287.56	0.75
Phosphogypsum 10 kg/ha	28411.78	50724.50	22312.72	0.79
Phosphogypsum 20 kg/ha	28545.12	54252.50	25707.38	0.90
Phosphogypsum 30 kg/ha	28678.44	54476.50	25798.06	0.90
Phosphogypsum 40 kg/ha	28811.78	57772.50	28960.72	1.01
Bentonite Sulphur 0kg/ha	28278.44	48625.50	20347.06	0.72
Bentonite Sulphur 10kg/ha	28811.72	49939.50	21127.78	0.74
Bentonite Sulphur 20kg/ha	29345.00	55274.50	25929.50	0.89
Bentonite Sulphur 30kg/ha	29878.28	55602.00	25723.72	0.86
Bentonite Sulphur 40kg/ha	30411.65	55720.00	25308.35	0.84

Conclusion

The increase in Seed yield, Oil content, Oil yield, Protein content and Protein yield of Mustard were significantly higher for each successive addition of sulphur up to 40 kg/ha irrespective of its sources viz; SSP, Phosphogypsum and Elemental Sulphur (Bentonite Sulphur). However, the application of sulphur at the rate of 40kg/ha gave significantly best result in the yield, oil content (%), oil yield (kg/ha), protein content (%) and protein yield (kg/ha) in seed of mustard. SSP as source of sulphur significantly best result in all the parameter like yield, Oil content, Oil yield, Protein content and Protein yield of Mustard. SSP as source of sulphur was the best source and it was followed by Phosphogypsum which in turn was followed by Elemental sulphur.

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