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EFFECT OF SULPHUR LEVELS AND SOURCES ON GROWTH, YIELD AND QUALITY OF MUSTARD IN *TERAI* REGION OF WEST BENGAL

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ABSTRACT

A field experiment was conducted using Indian mustard [Brassica juncea (L.) Czern & Coss.] as a test crop with S levels (15, 20, 25, 30 kg ha^{-1}) each from two sources (bentonite-S and single superphosphate) to evaluate the effect on the yield parameters during rabi season of 2013-2014. Results revealed that the most of the growth parameters and yield attributes were significantly influenced by different doses of sulphur. The growth and yield parameters increased with increasing levels of sulphur up to 25 kg S ha^{-1} followed by reduction at higher level (30 kg S ha^{-1}). All the growth (plant height, leaves and branches per plant) and yield parameters (siliquae per plant, seeds per siliqua, length of siliqua, 1000 seed weight) seed yield and stover yield, oil content were found maximum with 25 kg S ha^{-1} as SSP, which was at par with 30 kg S ha^{-1} as Bentonite-S. The Agronomic use efficiency of sulphur decreased with the successive addition of S in the form of both sources. Plant S uptake was maximum with 30 kg S ha^{-1} as Bentonite but it was decreased with increasing dose from 25 to 30 kg ha^{-1} as SSP. Soil available S was increased with SSP than the Bentonite-S.

Key words: Source, sulphur, yield, quality, mustard.

INTRODUCTION

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is an important *rabi* oilseed crop in India. The average yield (1145 kg ha^{-1}) is relatively low due to the improper fertilization and other agronomic practices. The average productivity of mustard needs to be enhanced up to 2562 kg ha^{-1} by 2030 for ensuring self sufficiency in edible oil (DRMR, 2011). Mustard is nutritionally very rich and its oil content varies from 37-49%. Mustard belongs to the family of Cruciferae. Crucifers containing high amounts of glucosinolates have a high sulfur demand (Rathore *et al.*, 2015). To meet up the growing demand of oilseed, it is urgent to ensure its higher production. It is almost impossible to increase production by increasing area because of crop competitions. Therefore, production per unit area can be increased by adopting improved technology and inputs. Mustard is responsive to sulphur in comparison to other crops. Sulfur fertilization has also been shown to increase the oil content in seeds of rapeseed-mustard (Singh *et al.*, 2015). Sulphur is the key component of balanced nutrient application for higher yields and superior quality produce of mustard. Sulphur plays a vital role in the synthesis of amino acids (Rathore *et al.*, 2015), chlorophyll and certain vitamins (Havlin *et al.* 2004; Tiwari and Gupta 2006) in mustard plant. In view of these facts, present study was conducted to assess the effect of different sulfur (S) fertilizers in varied doses on mustard yield in *terai* region of west Bengal.

MATERIALS AND METHODS

The field experiment was conducted at the Instructional Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India (26° 19'86"N, 89° 23'53"E, altitude of 43 m a.s.l.) during rabi season of 2013-2014. The soil texture of experimental field was sandy loam that contained 9.8 g kg^{-1} organic carbon, 163 kg ha^{-1} N, 8.9 kg ha^{-1} available phosphorus, 154 kg ha^{-1} available K and 14 kg ha^{-1} available S with pH 5.2. The climatic condition was highly suitable with average air temperature of 18^{0}C and the relative humidity of 74% with no rainfall during crop growth period. The experiment was laid out in randomized complete block design consisting of three replications. The crop was sown in the last week of November, 2013 using the variety B-9 and harvested on February 28, 2014. Seeding was done in the row spacing 30cm and plant to plant spacing 10 cm apart. Urea, di-ammonium phosphate and muriate of potash were used as a source of N, P and K, respectively. A standard dose for phosphorus (30 kg ha^{-1}). Potassium (30 kg ha^{-1}) and half of the recommended dose (60 kg ha^{-1}) of nitrogen

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were side dressed at the sowing time and remaining half nitrogen was top dressed at flowering stage with irrigation. The treatments comprised of four doses of S each from two sources namely bentonite-S (T_2 - 15 kg ha^{-1} S; T_3 – 20 kg ha^{-1} S; T_4 – 25 kg ha^{-1} S; T_5 - 30 kg ha^{-1} S) and single super phosphate (SSP) (T_6 - 15 kg ha^{-1} S; T_7 – 20 kg ha^{-1} S; T_8 –25 kg ha^{-1} S; T_9 - 30 kg ha^{-1} S) while in T_1 no sulphur was added. Weeds were kept under control by manual weeding when needed. Thinning was done after two weeks of sowing to maintain plant to plant spacing of 10 cm. Seed yield was recorded at harvest. The yield attributes were noted at 60 days after sowing. At the harvest, seeds per siliqua, 1000 seed weight, seed yield and stover yield were calculated. Agronomic use efficiency (kg kg^{-1}) was calculated by appropriate formula. The samples of grain and straw were collected at the stage of harvest to analyze the content of S in it. The data were analyzed statistically using statistical analysis system (version 9.2, SAS Institute Inc., Cary, North Carolina, USA).

RESULTS AND DISCUSSION

The data (Table 1) revealed that the plant height at 60 days after sowing increased progressively with increase in S application irrespective of the sources. On comparing the sources, it was noted that the maximum height (*i.e.*, 92.47 cm) was obtained at 25 kg ha^{-1} applied as SSP. Solanki and Sharma (2016) reported that plant height was increased with S application and the maximum plant height was recorded in plots where 60 kg S ha^{-1} was applied. The leaves per plant at 60 DAS also increased with the application of S up to 20 kg ha^{-1} in both the sources over the control. But there were no such significant variation among the treatments with more than 15 kg ha^{-1} of S. The branches per plant showed the similar result as plant height. The number of siliquae per plant also increased over the control with addition of S and this increment notably jumped with the S dose of 20 kg ha^{-1} from 15 kg ha^{-1} in both the sources. The siliquae number per plant, individual siliqua length increaseD with the addition of S over the control irrespective of the sources. The highest siliqua length (5.57 cm) was observed at 25 and 30 kg ha^{-1} as Bentonite-S. The highest average number of grain per siliqua (25.97) was found at 25 kg S ha^{-1} as SSP. The test weight also increased progressively with the higher doses of S applied through both the sources and highest test weight (3.19g) was recorded with 30 kg S ha^{-1} as Bentonite-S.

Table 1: Effect of level sources of sulphur on growth and yield attributes of mustard

Treatment	Plant height (60 DAS) (cm)	Leaves / plant (60 DAS)	Branches /plant (At harvest)	Siliqua /Plant	Siliqua length (cm)	Grain/ siliqua	1000-grain wt (g)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Oil content (%)	Harvest Index (%)
Control	82.2	10.7	3.6	61.7	4.6	20.8	2.82	11.21	26.56	35.57	42.89
15 kg ha^{-1} as Bentonite	86.9	13.5	4.3	91.7	4.9	23.8	3.09	12.03	28.96	38.80	42.87
20 kg ha^{-1} as Bentonite	88.5	17.1	4.9	119.7	5.2	25.3	3.12	12.33	30.59	40.80	41.86
25 kg ha^{-1} as Bentonite	91.4	17.2	5.3	127.4	5.5	25.6	3.16	12.39	34.11	41.60	38.03
30 kg ha^{-1} as Bentonite	91.6	17.2	5.3	129.4	5.5	25.9	3.19	12.40	36.30	40.17	34.55
15 kg ha^{-1} as SSP	86.8	13.1	4.2	95.0	5.1	23.7	2.86	11.95	28.71	38.23	44.08
20 kg ha^{-1} as SSP	89.6	17.2	5.2	125.2	5.2	25.4	3.15	12.38	31.22	39.93	41.76
25 kg ha^{-1} as SSP	92.4	17.6	5.4	131.3	5.6	25.9	3.19	12.42	36.45	41.34	35.23
30 kg ha^{-1} as SSP	89.3	17.6	5.1	123.4	5.4	25.5	3.13	12.34	30.63	41.75	39.88
S Em ±	0.82	0.18	0.06	1.22	0.17	0.92	0.02	3.17	48.78	0.37	0.68
LSD(0.05)	2.46	0.53	0.18	3.56	3.26	3.72	0.07	9.50	146.26	1.10	2.05

The seed yield of the mustard was significantly affected with the application of S from both the sources. The application of S in different doses increased the seed yield of the crop over the control plot. It was observed that the seed yield increased by 9.1%, 12.2%, 13.6%, and 10.2% with the application of 15, 20, 25 and 30 kg Sha^{-1} as Bentonite-S, respectively. The corresponding increases in seed yield with SSP were 11.1%, 13.9%, 12.7% and 7.3%. Kumar and Trivedi (2012) and Singh *et al.* 2014) also reported an increase in seed yield of mustard with the application of S levels. With increasing supply of sulphur the process of tissue differentiation from somatic to reproductive, meristematic activity and development of floral primordial might have increased, resulting in more flowers and siliqua, longer siliqua and higher seed yield. The highest stover yield (3645.33 kg ha^{-1}) was recorded in 25 kg S ha^{-1} as SSP. Increase in stover yield can be ascribed to the overall improvement in plant organs associated with faster and uniform vegetative growth of the crop with S application (Singh, 2001, Solanki and Sharma, 2016). The oil content of the seed significantly increased with the successive application of S in the form of both Bentonite-S and SSP (Table 1). The highest oil content was found with 25 kg S ha^{-1} as SSP. The same dose of S as Bentonite-S yielded almost similar oil content. Such increase in oil content may be ascribed to the enhanced protein synthesis (acetyl-CoA carboxylase) and increased oil accumulation in the developing seeds (Rathore *et al.*, 2015) by the S application. Somnath and Goutam (2012) reported that the highest oil content was obtained with 45 kg S ha^{-1} as single superphosphate. Such increase of oil content is in with the findings of other researchers (Kumar and Trivedi, 2012; Das and Ghosh, 2012). Sulphur addition showed significant difference for HI under different doses (Table 1). The highest harvest index (44.04%) was obtained with 15 kg S ha^{-1} as SSP.The lowest value was found at 25 kg S ha^{-1}. This may be ascribed to the irrational increase in the seed (economical) and stover (biological) yield.

Sulphur use efficiency

The S use efficiency decreased with the increase in dose of S by both the sources (Table 2). The SSP had greater S use efficiency under all treatments compared to Bentonite-S. The highest S-use efficiency was found at 15 kg S ha^{-1} as SSP. The decrease in S use efficiency (or any other nutrient) is due to different types of losses like leaching, sorption, immobilization and fixation in soil when applied as basal (Kumar and Trivedi, 2012).

Table 2: Effect of sources and levels of S on yield, uptake and S use efficiency

Treatments	Grain (mg g^{-1})	Total S uptake (kg ha^{-1})	S use efficiency by mustard (kg seed kg S^{-1})
Control	6.4	20.34	-
15 kg ha^{-1} (Bentonite-S)	9	29.97	6.8
20 kg ha^{-1} (Bentonite-S)	9.2	32.96	7.0
25 kg ha^{-1} (Bentonite-S)	10.4	40.86	6.2
30 kg ha^{-1} (Bentonite-S)	12	49.13	3.8
15 kg ha^{-1} (SSP)	8.7	28.71	8.4
20 kg ha^{-1} (SSP)	9.3	33.58	7.9
25 kg ha^{-1} (SSP)	10.3	43.14	5.8
30 kg ha^{-1} (SSP)	10.9	37.96	2.8
S Em ±	0.03	1.34	0.51
LSD(0.05)	0.09	4.02	1.54

Total uptake of S

The total S uptake by plant increased with all treatments over the control (Table 2). The S uptake increased from 20.34 kg ha^{-1} in control to 29.97, 32.96, 40.86 and 49.13 kg ha^{-1} for Bentonite and 28.71, 33.58, 43.14, 37.96 kg ha^{-1} for SSP @ 15, 20, 25 and 30 kg ha^{-1}, respectively. The maximum S uptake was found at 30 kg ha^{-1} as Bentonite-S. This may be ascribed to increase in seed and stover yield and concentrations of respective nutrients in mustard seed and straw. This is obvious because higher rate of sulphur application leads to higher losses and nutrient uptake is also limited to size of sink (Kumar and Trivedi, 2012). It was observed that the S use efficiency decreased with the increase in dose of S by both the sources (Bentonite-S and single superphosphate). The best performance was observed when S was applied @ 25 kg S ha^{-1}. The most excellent performance was observed with single superphosphate followed by Bentonite S.

It was concluded that the application of 25 kg S ha^{-1} through SSP was found beneficial and effective dose for increasing productivity of Indian mustard under irrigated condition of *terai* region of West Bengal.

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