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Influence of doses and source of sulphur on yield, quality and economics of mustard (*Brassica camprestris* var toria) in red soil of Odisha

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ABSTRACT

A field experiment was conducted during rabi season of 2014-15 and 2015-16 at Instructional Farm of KrishiVigyan Kendra , Umerkote, Nabarangpur ,Odisha to study the effect of dose and source of sulphur on its yield ,quality and economics of mustard (Brassica camprestris var. toria) in red soil of Odisha .The experiment was laid out in randomized block design with three replications .The results revealed that significantly highest oil yield (559.3 kg ha^{-1}) was obtained with 60 kg S ha^{-1} as single superphosphate, which was 115.7 % more in comparison to that of control(259.32 kg ha^{-1}) .Similarly application of 45 kg S ha^{-1} as single superphosphate resulted second highest oil yield (539 kg ha^{-1}) with advantage of 107.9 % over control. The oil yield due to application of 45kg and 60 kg S ha^{-1} as gypsum , 45kg and 60 kg S ha^{-1} as elemental sulphur were 91.1, 92.9, 67.6 and 86.7 % higher respectively as against the control . The uptake of sulphur with application of 45 kg and 60 kg S ha^{-1} as SSP, 45 kg and 60 kg S ha^{-1} as gypsum, 45 kg and 60 kg S ha^{-1} as elemental sulphur were 101.0, 107.7, 90.9 ,97.0 ,65.1 and 79.0 % higher over control (9.89 kg ha^{-1}) respectively . Application of 60 kg S ha^{-1} as SSP resulted significantly highest B: C ratio (2.97) which was 106.3 % higher over control.

Key words: Brassica campestris var toria , sulphur , source, sulphur uptake ,oil yield ,B:C ratio.

INTRODUCTION

Oil seed plays a vital role in Indian economy. Almost it occupies 5 % of the gross national product and 10 % of the value of agricultural product. In India, rape seed and mustard account for 16.61% of the total oil seeds area , produces 11.47 % of total oil seeds occupying 2nd position in area next to soybean and 3rd position in production next to soyabean (1st) and groundnut (2nd) . The per capita consumption of vegetable oil is rising continuously and likely to touch 16.97 kg per year requiring 28.51 million tons of vegetable oil by 2050. Toria is an important oilseed crop of Odisha. It is cultivated in 116 thousand ha of land in Odisha in *rabi* season .The soils are mostly red soils facing high annual rainfall. In red soils, owing to its low organic matter content and water holding capacity, sulphur is leached to deeper soil layer due to high rainfall, thus making the soil deficient in sulphur. In addition to this , extensive use of sulphur free fertilizers and limited use of organic manures aggravated S deficiency in these soils .The sulphur fertility status of soils in oil seed growing regions is poor and wide spread sulphur deficiency has been observed in crops and soils in 120 districts of India (Tandon 1991). In Odisha condition most of the soils are deficient in sulphur (Mishra *et al*, 2016).Sulphur is regarded as the fourth major plant nutrient. It is required for synthesis of sulphur containing amino acids methionine (21 % S), cystein (26 % S) and cystine (21 % S), which are essential components of protein. Approximately 90 % of plant sulphur is present in these amino acids (Tandon and Messick, 2002). Sulphur is also needed for synthesis of metabolites such as coenzyme A, biotin, thiamine and glutathione. Sulphur is involved in the formation of chlorophyll, glucosides, glucosinolates, activation of enzymes and sulphydryl (-SH) linkages that are the source of pungency in oils .Sulphur increases root growth and stimulates seed formation. Oil seed crops have relatively higher S requirement owing to their high contents of S containing amino acids and essential oils. It has been reported that removal of sulphur

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per tone of grain is 3 kg in cereals as against 12 kg in oilseeds. Oil yield can be increased by application of sulphur in rapeseed and mustard (Singh *et al*., 2017) In Odisha condition, being a short duration crop *toria* draws less attention for sulphur application .So there is great scope to increase the productivity of toria in Odisha by sulphur application. The average yield of toria is 422 kg ha^{-1} in Odisha, which is much lower than the national average 1188 kg ha^{-1}. The oil content is around 35 %. Therefore, the study was undertaken to know the effect of graded doses and source of sulphur on its uptake, oil yield and economics of toria and to compare relative efficiency of SSP and Gypsum.

MATERIALS AND METHODS

A field trial was conducted during rabi season of 2014-15 and 2015-16 at the Instructional Farm of KrishiVigyan Kendra, Umerkote, Nabarangpur ,Odisha ,India located at latitude 19.34 N , longitude 82.32 E with altitude 195 mt above mean sea level**.** The mean annual rainfall of the experimental site was 1569.5 mm with average summer temp 40^0C and average winter temperature 12^0C. The soil of the experimental site was sandy loam in texture having pH 5.60, non saline with EC 0.04 dSm^{-1}, low in soil organic carbon (3.8 g kg^{-1}) , CEC 3.61 cmole(p^+) kg^{-1} , low in available N (174.5 kg ha^{-1}) , medium in available P(Brays'1, 18.9 kg ha^{-1}) , high in available K (343.4 kg ha^{-1}) , low in 0.01 M $CaCl_2$ extractable S(11.6 kg ha^{-1}) , available Ca (161.3 kg ha^{-1}) and Mg (19.6 kg ha^{-1}). The crop var toria (M 27) wasused as test crop . The experiment was conducted in randomized block design with three replications . Besides the control (T_{10}), there were nine treatments of different doses and sources of sulphur i.e. T_1 30 kg S ha^{-1} as SSP, T_2 45 kg S ha^{-1} as SSP, T_3 60 kg S ha^{-1} as SSP, T_4 30 kg S ha^{-1} as gypsum,T_5 45 kg S ha^{-1} as gypsum, T_6 60 kg S ha^{-1} as gypsum, T_7 30 kg S ha^{-1} as elemental sulphur,T_8 45 kg S ha^{-1} as elemental sulphur, T_9 60 kg S ha^{-1} as elemental sulphur. The crop was fertilized with half the dose of nitrogen (40 kg ha^{-1}) ,full dose of phosphorus (80 kg P_2O_5 ha^{-1}) and potassium (40 kg ha^{-1}) as basal and rest half dose of nitrogen (40 kg ha^{-1}) was applied after the first irrigation. The nitrogen, phosphorus and potassium were applied through the source of urea, SSP, triple superphosphate and muriate of potash, respectively. SSP was used as a source of sulphur and its phosphorus content was adjusted with triple super phosphate as per treatments. Elemental sulphur was applied15 days before sowing for better oxidation of sulphur. The crop at maturity was harvested and seed and stover yields were recorded. Seed and stover samples were digested in HNO_3-$HClO_4$ and the digestion extract was analyzed for sulphur content by turbidimetric method (Chesnin and Yien, 1951). Soxhlet apparatus (Hughes, 1965) determined oil content in seed.

RESULTS AND DISCUSSION

Yield of seed and stover

Data (Table 1) show that application of sulphur significantly increased the seed yield of mustard up to 45 kg ha^{-1} irrespective of the source viz SSP and gypsum . Application of 45 kg of sulphur as SSP increased the seed yield by 75.8, 19.2 % in 2014-15, 72.7, and 19.0 % in 2015-16 over control and 30 kg S ha^{-1} respectively. Gypsum @ 45 kg S ha^{-1} had increased the seed yield of mustard by 62.3, 19.7 % in 2014-15, 59.1, and 19.6 % in 2015-16 over control and 30 kg S ha^{-1} respectively. However,elemental sulphur had resulted an increase in the seed yield up to 60 kg S ha^{-1} which was 58.8 , 18.9 and 7.3 % in 2014-15 and 56.7, 18.8 and 7.1 % in 2015-16 over control , 30 and 45 kg S ha^{-1} respectively . Out of these three sources, SSP resulted better yield over gypsum followed by elemental sulphur which might be due to better solubility of SSP in such soil resulting higher uptake of sulphur which had promoted more seed formation. Similarly the stover yield increased significantly with increasing dose of sulphur from 0- 45 kg ha^{-1} from the sources viz SSP and gypsum . In case of SSP and gypsum, the stover yield of 24.68 and 24.52 q ha^{-1} were obtained due to application of 60 S kg ha^{-1} followed by 45 kg ha^{-1} (24.52 and 24.60 q ha^{-1}) which were *at par*. The elemental sulphur had resulted stover yield of 22.40 q ha^{-1} with 60 kg S ha^{-1} followed by 45 kg ha^{-1} (19.14 q ha^{-1}). 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 more flowers, siliqua and higher seed yield. Increase in stover yield can be ascribed to the overall growth in plant organs associated with faster and uniform vegetative growth of the crop under the effect of sulphur application.The yield of seed and stover due application of sulphur from the source of SSP was found better than Gypsum followed by Elemental sulphur. The results were in conformity with the findings of Chattopaddhyay and Ghosh (2012) and Singh *et al.* (2017).

Table 1: Effect of doses and source of sulphur on yield, quality and economics of *Brassica campestris* var toria

Treatment	Seed Yield (q ha^{-1})		Stover Yield (q ha^{-1})		Oil yield (kg ha^{-1})		Net Profit (INR)		B:C ratio	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1	10.42	10.49	23.04	23.08	413.30	421.60	29735.57	30814.57	2.24	2.29
T_2	12.43	12.49	24.47	24.57	536.50	541.60	45493.49	46157.79	2.88	2.91
T_3	12.52	12.55	24.68	24.67	557.80	560.80	47996.12	48391.97	2.96	2.98
T_4	9.59	9.62	22.65	22.69	375.00	378.50	25231.21	25679.06	2.08	2.1
T_5	11.48	11.51	24.47	24.57	492.70	498.70	40491.46	41275.71	2.72	2.75
T_6	11.57	11.61	24.58	24.62	499.50	501.10	41353.78	41562.48	2.76	2.77
T_7	9.44	9.53	19.07	19.2	364.50	375.10	22323.34	23697.44	1.9	1.95
T_8	10.46	10.57	20.07	20.07	432.70	436.80	30387.88	30926.94	2.18	2.2
T_9	11.23	11.33	22.34	22.47	479.00	489.30	35605.9	36943.6	2.34	2.39
T_{10}	7.07	7.23	15.04	15.07	257.80	260.90	10044.38	10459.51	1.43	1.45
CD (P=0.05)	0.11	0.07	0.45	0.426	5.50	6.40	711.48	825.22	0.03	0.03

Sulphur uptake

The sulphur uptake by seed increased significantly in both the years due to application of 60 kg S ha^{-1} irrespective of the sources of sulphur (Table 2). Single superphosphate increased the sulphur uptake by 112.4, 34.4 and 2.2 % in 2014-15 and 107.9, 33.9 and 1.9 % in 2015-16 over control, 30 and 45 kg S ha^{-1} respectively. The 60 kg S ha^{-1} as gypsum had increased the sulphur uptake by 93.7, 35.0 and 2.4 % in 2014-15 and 89.5, 34, 7 and 2.4 % in 2015-16 over control, 30 and 45 kg S ha^{-1} respectively. The elemental sulphur had resulted an increase in sulphur uptake by 76.4 , 26.3 and 9.7 % in 2014-15 and 74.4, 26.6 and 10.2 % in 2015-16 over control , 30 and 45 kg S ha^{-1} respectively. Out of these three sources, SSP resulted better sulphur uptake over gypsum followed by elemental sulphur. The sulphur uptake by the stover increased with increasing dose of sulphur from 0- 60 kg ha^{-1} from all the sources of sulphur (Table 2)**.** In case of SSP ,the highest uptake by stover (8.72 kg ha^{-1}) was obtained due to application of 60 kg S ha^{-1} followed by application of 45 kg ha^{-1} (8.29 kg ha^{-1}) . Similarly gypsum had resulted an uptake of 8.70 kg ha^{-1} by stover due to application of 60 kg S ha^{-1} followed by 45 kg ha^{-1} (8.35 kg ha^{-1}) which are *at par* .The elemental sulphur had resulted an uptake of 7.83 kg ha^{-1} by stover for application of 60 S kg ha^{-1} followed by 45 kgha^{-1} (7.35 kg ha^{-1}). The total uptake of sulphur increased significantly in both the years due to application of sulphur up to 45 kg ha^{-1} irrespective of the source of sulphur (Table 2). Mustard is a high sulphur-demanding crop. The soil of the experimental site was deficient in sulphur. Therefore, the sulphur uptake by seed as well as stover increased with increasing dose of sulphur added externally. Such types of positive effects of application of that fertilizer with different doses on sulphur uptake by mustard were in conformity with the findings of Chattopaddhyay and Ghosh (2012) and Singh *et al.* (2017).

Oil yield

The oil yield of mustard increased in both the years due to application of sulphur up to 60 kg ha^{-1} irrespective of the source of sulphur (Table 1). Application of 60 kg S ha^{-1} as SSP increased the oil yield by 116.4, 35.0 and 4.0 % in 2014-15 and 114.9, 33.0 and 3.5 % in 2015-16 over control, 30 and 45 kg S ha^{-1} respectively. Application of 60 kg S ha^{-1} as gypsum had increased the oil yield of mustard by 93.8, 33.2

Table 2: Effect of doses and source of sulphur on its (S) uptake of *Brassica campestris* var toria

Treatment	Seed(kg ha^{-1})			Stover(kg ha^{-1})			Total(kg ha^{-1})		
	2014-15	2015-16	pooled	2014-15	2015-16	pooled	2014-15	2015-16	pooled
T_1	8.79	8.85	8.82	7.76	7.93	7.17	16.55	16.78	15.99
T_2	11.56	11.63	11.59	8.57	8.77	8.29	20.13	20.39	19.88
T_3	11.81	11.85	11.83	8.64	8.8	8.72	20.44	20.64	20.54
T_4	7.98	8.02	8	7.63	7.79	7.27	15.61	15.81	15.27
T_5	10.52	10.55	10.54	8.57	8.77	8.35	19.09	19.32	18.88
T_6	10.77	10.8	10.78	8.61	8.79	8.7	19.37	19.58	19.48
T_7	7.77	7.85	7.81	5.98	6.15	6.69	13.75	14	14.5
T_8	8.94	9.02	8.98	6.56	6.69	7.35	15.49	15.71	16.33
T_9	9.81	9.94	9.88	7.38	7.57	7.83	17.19	17.5	17.7
T_{10}	5.56	5.7	5.63	4.26	4.27	4.27	9.82	9.96	9.89
CD(P=0.05)	0.139	0.190	0.152	0.521	0.471	0.446	0.542	0.527	0.475

and 1.4 % in 2014-15 and 92.1, 32.4 and 0.5 % in 2015-16 over control, 30 and 45 kg S ha^{-1} respectively. The corresponding increases in oil yield due to 60 kg S ha^{-1} as elemental sulphur were 85.8, 31.4 and 10.7 % in 2014-15 and 87.5, 30.4 and 12.0 %. Out of these three sources, Single superphosphate resulted better oil yield over Gypsum followed by Elemental sulphur. As sulphur is a constituent of glutathione, which plays a vital role in oil synthesis the oil yield increased with increasing uptake of sulphur by seed in such soil. Such type of positive effects of application of that fertilizer with different doses on oil yield of mustard had also been found by, Chattopaddhyay and Ghosh (2012). These results were also corroborated with the findings of Pandey and Ali (2012), Kumar and Trivedi (2012).

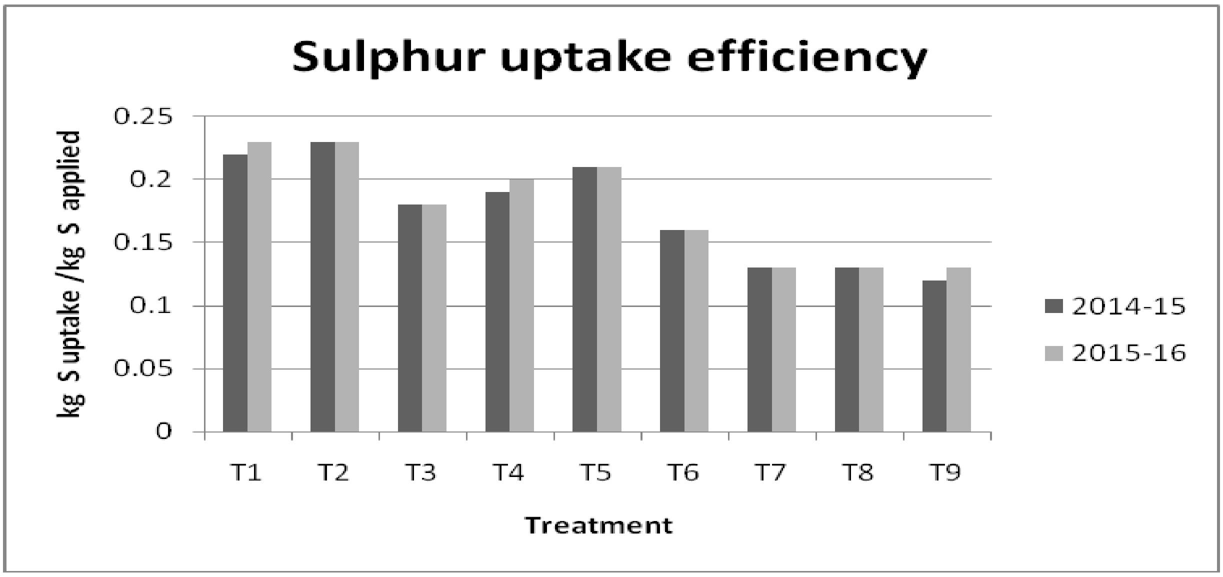

Fig 1: Effect of graded dose and source of sulphur on sulphur uptake efficiency of *Brassica campestris* var toria

Efficiency indices

The sulphur uptake efficiency increased with increasing dose of sulphur from 0 to 45 kg ha^{-1} followed by a decrease with higher dose of sulphur (60 kg ha^{-1}) (Fig 1). The sulphur uptake efficiency was 0.22, 0.20 and 0.23, 0.21 for 45 kg S ha^{-1} as SSP and gypsum during 2014-15 and 2015-16 respectively .Incase of elemental sulphur, higher sulphur uptake efficiency (0.13) in both the years was obtained for 30kg S ha^{-1} in comparision to 45 and 60 kg ha^{-1}. This is obvious because uptake is limited to the rate of solubilisisation of the fertilizer in soil and size of the sink. Such type of findings might be due to different rates of solubilisation of SSP, gypsum and elemental sulphur with different doses in such soil. Piri *et al.* (2006) reported similar results. The sulphur use efficiency increased with increasing dose of sulphur from 0 to 45 kg ha^{-1} followed by a decrease at higher dose of sulphur (60 kg ha^{-1}) (Fig. 2). The sulphur use efficiencies were 11.9, 11.7 and 9.8, 9.5 during 2014-15 and 2015-16 for SSP and gypsum for application of 45 kg S ha^{-1}. However incase of elemental sulphur, the sulphur use efficiency was 7.9 and 7.7 in corresponding years with 30 kg S ha^{-1} followed by 45 and 60 kg ha^{-1}. Increase in seed yield due to higher rate of sulphur application up to an optimum dose had increased the sulphur use efficiency, which decreased with increasing dose of sulphur due to lower rate of increase in seed yield. Similar results were reported by Piri *et al.* (2006).

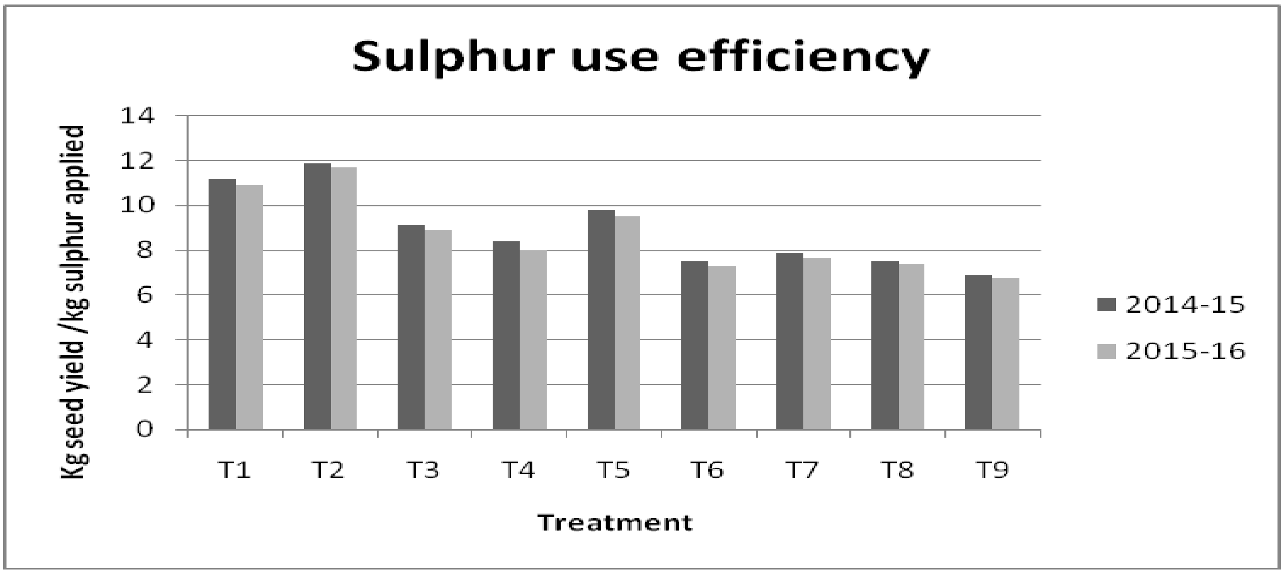

Fig. 2: Effect of graded dose and source of sulphur on sulphur use efficiency of *Brassica campestris* var toria

Economics

The net profit increased significantly in both the years due to application of sulphur up to 45 kg ha^{-1} irrespective of the source (Table 1) beyond which it was almost *at par*. Application of 45 kg of sulphur as SSP increased the net profit by 352.9 ,34.6 % and 341.3 ,33.2 % over control and 30 kg S ha^{-1} during 2014-15 and 2015-16 respectively . Simillarly gypsum had resulted an increase in net profit by 303.1, 37.7 % and 287.1, 36.6 % over control and 30 kg S ha^{-1} during 2014-15 and 2015-16 respectively. However the elemental sulphur @ 60 kg ha^{-1} had resulted increase in net profit 254.4, 37.3 and 14.7 % in 2014-15 and 253.2 , 35.9 and 16.3 % in 2015-16 over control , 30 and 45 kg S ha^{-1} respectively . Out of these three sources, SSP resulted better net profit than gypsum followed by elemental sulphur .The B:C ratio increased markedly with increasing dose of sulphur from 0 to 45 kg ha^{-1} irrespective of the source (Table 1) . However significant increase in B:C ratio was obtained with elemental sulphur upto 60 kg S ha^{-1} during both the years .The results were in agreement with the findings of Pachauri *et al* . (2012).

It may be concluded from the results that the application of sulphur in increasing doses from 0 to 45 kg ha^{-1} had significantly increased the seed yield, sulphur uptake, oil yield, net profit and B:C ratio irrespective of the source. Single superphosphate as a source of sulphur proved superior to gypsum followed by elemental sulphur in respect of yield, quality and economics of the crop.

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