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Effect of various sources and doses of Sulphur on yield and economics of Indian mustard (*Brassica juncea* L.)

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Abstract
A field experiment was conducted during *Rabi* season 2023-24 at Crop Research centre-1, ITM University, Gwalior, M.P., Effect of Various Sources and Doses of Sulphur on yield and economics of Indian Mustard (*Brassica juncea* L.). The experiment comprised of ten (10) treatment combinations laid out in factorial randomized block design with three replications. The Main plot consisted of three sources of sulphur (Gypsum, SSP, and Bentonite S) and the sub plots include three doses of sulphur (20, 40 and 60 kg S ha^{-1}). Results revealed that Among the different sources of sulphur, gypsum fetched the highest yield, net realization and benefit: cost ratio. Significantly higher yield viz., seed yield and stover yield were recorded with the application of T_3 40 kg S through gypsum recorded grain yield (1721 kg ha^{-1}), stover yield (4906 kg ha^{-1}), biological yield (6627 kg ha^{-1}) and harvest index (25.97%) and along with maximum values of gross return (Rs. 118209 ha^{-1}), net return (Rs. 86400 ha^{-1}) and benefit cost ratio (2.76) and lowest results record in control.

Keywords: Sulphur, sources, mustard, yield, gross return net return

Introduction
Mustard are the third most important edible oilseed crops of the world after soybean and oil palm. Mustard (*Brassica juncea* L.) is the major *Rabi* season oilseed crop of India, which belongs to the family of cruciferae. crucifers containing high amounts of glycosylates have a high sulphur demand (Rathore *et al*., 2015) [7]. The seeds and oil are used for preparing pickles, cooking and frying purposes, preparation of soap, grease, hair oil and medicines, *etc*. The oil cakes are used for cattle feed and manure. The seeds are highly nutritive containing 38-57 percent erucic acid, 5-13 percent linolic acid and 27 percent oleic acid. The oil content in mustard seeds varies from 37-49 percent (Bhowmik *et al.,* 2014) [1]. 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. In Madhya Pradesh, mustard was found to be cultivated in 675.079 thousand ha area with production 1038.35 thousand tonnes and productivity of mustard was found to be 1538 kg ha^{-1} (Bareliya *et al.,* 2023) [6]. 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. Sulphur levels significantly influenced the seed, stover yield and sulphur uptake of mustard (Sharma *et al.,* 2009) [8].

Materials and Methods
A field experiment was conducted during the *Rabi* season 2023-24 at school of agriculture ITM University at crop research centre-1, Gwalior (25°50' N, 87°19' E; 52.73 m above mean sea level), Madhya Pradesh, India. The soil of the experimental field was sandy loam with pH 7.42

having organic carbon 0.52%, available nitrogen 160.50 kg ha^{-1}, available phosphorus 15.2 kg P_2O_5 ha-^{1,} available potassium 230.60 kg K_2O ha^{-1} and available sulphur 11.84 kg ha^{-1}. The experiment comprised of ten treatment combinations laid out in factorial randomized block design with three replications. Main plot consisted of three sources of sulphur (gypsum, SSP, and bentonite S) and the sub plots include three doses of sulphur (20, 40 and 60 kg S ha^{-1}).

Yield

Biological yield (Kg ha^{-1})

All above the ground plant parts of the net plot were dried and weighed in kg per plot to represent the biological yield and finally converted into Kg ha^{-1}.

Grain yield (Kg ha^{-1})

From the individual plot, the net plot area was harvested and produce was sun dried. After drying the crop was threshed and cleaned separately on the plot basis. The final weight was recorded in kg per net plot area converted into kg ha^{-1}.

Stover yield (Kg ha^{-1})

Stover yield was computed by subtracting the grain yield from total produce on the net plot basis. S Stover yield was recorded in kg per net plot area and converted into kg ha^{-1}.

Biological yield – Grain yield = Stover yield

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

Harvest index (%)

The ratio of economic yield to the total biological yield was computed by using the formula:

Harvest index is represented in percentage always.

Economic analysis

Net Return

In order to determine which treatment would yield the highest profit, the economics of each treatment were calculated using the current market rate and net return (₹ ha^{-1}). This allowed the most lucrative treatment to be suggested.

Net Returns (₹. ha^{-1}) = Gross Returns (₹. ha^{-1}) – Total cost of cultivation (₹. ha^{-1})

Gross Returns (₹. ha^{-1}) = sale cost of mustard seed (₹. ha^{-1}) + sale cost of stover (₹. ha^{-1})

Benefit cost ratio

The following formula was used to calculate each treatment's benefit cost ratio in order to determine its economic viability:

$$\text{Benefit Cost ratio} = \frac{\text{Net returns (₹ ha}^{-1})}{\text{Total cost of cultivation (₹ ha}^{-1})}$$

Results and Discussion

Data pertinent to yield, dose of sulphur for different sources were depicted in Table.1 revealed that the grain and stover yield and harvest index of mustard showed increase with successive increase in sulphur doses. The application of 40 kg ha^{-1} S through gypsum recorded highest mean grain yield (1798 kg ha^{-1}), mean stover yield (5031 kg ha^{-1}), mean biological yield (6829 kg ha^{-1}) and mean harvest index (25%).

Table 1: Yield response as influenced by sources and doses of sulphur

Treatments	Grain yield	Straw yield	Biological yield	Harvest index
Sources of sulphur				
S_1- Gypsum	1876.32	5156.63	7032.95	26.67
S_2- SSP	1569.64	4749.33	6318.97	24.84
S_3- Bentonite S	1421.92	4423.05	5844.97	24.32
S.Em±	51.79	106.82	156.44	-
CD (P=0.05)	153.86	317.39	468.80	-
Doses of sulphur (kg S ha^{-1})				
20	1360.11	4363.10	5723.21	23.76
40	1721.78	4906.02	6627.8	25.97
60	1826.99	5059.88	6886.87	26.52
S.Em±	51.79	106.82	156.44	-
CD (P=0.05)	153.86	317.39	464.80	-
Control	1201.23	3942.09	5143.32	23.35

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 increment with successive increase in sulphur doses.

Sulphur content and uptake was recorded highest with gypsum S with simultaneous increase in S doses resulting maximum value at 60 kg S ha^{-1}. The findings were same as of kumar *et al.*, (2015) [4].

Economics

Data pertinent to yield of dose of sulphur for different sources of S were depicted in Table.2 Application of 40 kg sulphur ha^{-1} through Gypsum (18% S) significantly enhanced Net return (86400), Gross return (118209) B:C ratio (2.76) of mustard over rest of the treatments. This might be possible due to the fact that availability of sulphur had increased the seed yield, straw yield and quality of mustard. The above-mentioned results in accordance with the findings of Kumar *et al.*, (2012) [5].

Table 2: Effect of various sources and levels of sulphur on relative economics of mustard

Treatments	Common cost	Treatment cost	Total cost of cultivation	Gross return	Net return	B: C ratio
T_1 (control)	30836.19	0	30836	69752	38916	1.26
T_2 (Gypsum @20 kg ha^{-1})	30836.19	186.42	31023	86224	54802	1.74
T_3 (Gypsum @40 kg ha^{-1})	30836.19	372.84	31209	118209	86400	2.76
T_4 (Gypsum @60 kg ha^{-1})	30836.19	559.26	31395	118583	81380	2.55
T_5 (ssp @20 kg ha^{-1})	30836.19	400	31236	66565	34929	1.10
T_6 (ssp @40 kg ha^{-1})	30836.19	800	31636	100322	68086	2.11
T_7 (ssp @60 kg ha^{-1})	30836.19	1200	32036	106117	73281	2.23
T_8 (Bentonite @20 kg ha^{-1})	30836.19	1000	31836	77206	44970	1.40
T_9 (Bentonite @40 kg ha^{-1})	30836.19	2000	32836	79742	46306	1.38
T_{10} (Bentonite @60 kg ha^{-1})	30836.19	3000	33836	88911	54275	1.57

Conclusion

It can be concluded that better crop yield and highest net returns and B:C ratio could be obtained by application of 40 kg S ha^{-1} through gypsum was significant on the yield and economics of Indian mustard in north Madhya Pradesh under irrigated condition.

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