



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating: 5.20
www.agronomyjournals.com
2025; 8(7): 203-208
Received: 17-05-2025
Accepted: 19-06-2025

KM Priyanka
M.Sc. Scholar, Faculty of
Agriculture Science and Allied
Industries, Rama University,
Kanpur, Uttar Pradesh, India

Ravikesh Kumar Pal
Faculty of Agricultural Science and
Allied Industries, Rama
University, Mandhana, Kanpur,
Uttar Pradesh, India

Mandeep Kumar
Faculty of Agricultural Science and
Allied Industries, Rama
University, Mandhana, Kanpur,
Uttar Pradesh, India

Kishan Kumar
Senior Technical Assistant Group
A, Soil Survey Office, Department
of Agriculture, Lucknow, Uttar
Pradesh, India

Akhilesh Verma
Senior Technical Assistant Group
A, Soil Survey Office, Department
of Agriculture, Lucknow, Uttar
Pradesh, India

Corresponding Author:
KM Priyanka
M.Sc. Scholar, Faculty of
Agriculture Science and Allied
Industries, Rama University,
Kanpur, Uttar Pradesh, India

Effect of different sulphur sources and doses on productivity and profitability of mustard in central Uttar Pradesh

**KM Priyanka, Ravikesh Kumar Pal, Mandeep Kumar, Kishan Kumar and
Akhilesh Verma**

DOI: <https://www.doi.org/10.33545/2618060X.2025.v8.i7c.3202>

Abstract

Central Uttar Pradesh, a major mustard-growing region, holds substantial potential for enhancing mustard productivity through improved nutrient management practices, particularly with regard to secondary nutrients like sulphur (S). Hence an experiment was conducted at the research farm of Rama University, Mandhana, Kanpur - 209217 (U.P.), India, during 2024-2025, located at 26.56°N latitude, 80.21°E longitude, with an elevation of 125.9 meters above sea level to assess the impact of sulphur application from various sources and rates on growth, yield characters, yield, and economics of Indian mustard (*Brassica juncea* L.). The experiment comprised 11 treatments viz., T₁: Recommended NPK with no sulphur application; T₂: Recommended NPK with sulphur through elemental sulphur @15 kg/ha; T₃: Recommended NPK with sulphur through gypsum 1 @5 kg/ha; T₄: Recommended NPK with sulphur through ammonium sulphate @15 kg/ha; T₅: Recommended NPK with sulphur through bentonite sulphur @15 kg/ha; T₆: Recommended NPK with sulphur through single super phosphate @15 kg/ha; T₇: Recommended NPK with sulphur through elemental sulphur @30 kg/ha; T₈: Recommended NPK with sulphur through gypsum @30 kg/ha; T₉: Recommended NPK with sulphur through ammonium sulphate @30 kg/ha; T₁₀: Recommended NPK with sulphur through bentonite sulphur @30 kg/ha; T₁₁: Recommended NPK with sulphur through single super phosphate @30 kg/ha. Results revealed that sulphur rates significantly increased the observed parameters, of which bentonite sulphur at 30 kg/ha showed overall maximum responses. Yield attributes such as siliquae per plant, seeds per silique, and 1000-seed weight also attained maximum values under 30 kg/ha bentonite sulphur. Seed yield was significantly influenced by different sulphur sources and levels over control; the yield ranged from 15.00 q/ha in T₁ to 17.70 q/ha in T₁₀. Oil yield varied significantly across treatments, ranging from 615.32 kg/ha in T₁ to 743.35 kg/ha in T₁₀, statistically significant enhancement. The highest gross return was recorded in T₁₀ (₹1,02,483/ha), followed by T₉ (₹1,01,614/ha), T₁₁ (₹1,01,006/ha), and T₇ (₹1,00,746/ha). The B:C ratio improved from 1.75 in T₁ to 2.07 in T₆, which was significantly higher than the control. In conclusion, the study finds that sulphur application, particularly bentonite at 30 kg/ha, significantly enhances the yield attributes, productivity, and profitability of Indian mustard in central Uttar Pradesh.

Keywords: Bentonite sulphur, elemental sulphur, gypsum, mustard, sulphur

Introduction

Mustard (*Brassica juncea* L.) is one of the most important oilseed crops grown during the *rabi* season in India specially in north India. Area and production of mustard in India are ~9.2 million hectares and 11.15 million tonnes, respectively (SEA, 2025) [22]. Major mustard producing states in India are Rajasthan, Madhya Pradesh and Uttar Pradesh etc. It plays a vital role in meeting the edible oil requirements of the country and contributes significantly to rural livelihoods and national agricultural income. Central Uttar Pradesh, a major mustard-growing region, holds substantial potential for enhancing mustard productivity through improved nutrient management practices, particularly with regard to secondary nutrients like sulphur (S).

Sulphur is an essential nutrient for oilseed crops, being directly involved in protein synthesis, enzyme activation, chlorophyll formation, and most importantly, the synthesis of oil and glucosinolates (Chahal *et al.*, 2020; Heikal, *et al.*, 2022) [5, 11]. Mustard has a high sulphur requirement due to its high protein and oil content (Ahmad and Abdin, 2000; Chandel *et al.*,

2003; Mohiuddin *et al.*, 2011) ^[1, 6, 17]. However, soils in central Uttar Pradesh are increasingly becoming sulphur-deficient due to intensive cropping like rice-wheat, rice mustard, bajra-mustard, maize-potato etc, inadequate use of sulphur-containing fertilizers, and a general focus on primary macronutrients such as nitrogen by urea, nitrogen and phosphorus by diammonium phosphate (DAP). This deficiency has emerged as a major constraint limiting mustard yields and oil content if mustard is included in any new existing exhaustive cropping system like maize-potato or rice-wheat. Under this situation farmers get less yield of mustard over wheat etc. and again shifted toward previous cropping system.

Sulphur is a crucial element for rapeseed-mustard in determining its seed yield, oil content, quality, and resistance to various biotic and abiotic stresses (Chahal *et al.*, 2020; Heikal, *et al.*, 2022) ^[5, 11]. Sulphur has numerous physiological roles such as synthesis of oil, sulphur containing amino acids (cysteine and methionine), chlorophylls, certain vitamins and the glucosinolates (Bones and Rossiter, 1996) ^[4]. Sulphur is also involved in the synthesis of various fatty acids (Dimree and Dwivedi, 1994) ^[8]. Sulphur increases the seed yield of mustard by 12-48% under irrigated and 17-124% under rainfed conditions (Rathore *et al.*, 2015) ^[21]. Intensification of agriculture with high yielding crop varieties and multiple cropping, coupled with use of high analysis S-free fertilizers and restricted use of organic manures, has accelerated the deficiencies of S in arable lands. Based on consolidating data (n=135,000) 42.3% of Indian soils were found to be deficient of S (Tondon, 2011) ^[24]. Among the oilseed crops, rapeseed-mustard has the highest requirement of S. In terms of agronomic efficiency, each kilogram of S increases the yield of mustard by 7.7 kg (Katyal *et al.*, 1997) ^[13]. Rapeseed-mustard are sensitive to sulphur supply, and poor yields and quality are obtained on S deficient soils (Govahi and Saffari, 2006; Malhi *et al.*, 2007) ^[10, 14]. Variations in seed yield of rape and mustard with S has been earlier reported by various researchers in different parts of the world (Misra, 2003; Ahmad *et al.*, 2007 ^[16, 2]). The various sources of S also have impact on different yield attributes and yield. Application of bentonite S gave significantly higher growth, yield attributes, seed yield, than to gypsum and wettable S.

The choice of sulphur source and its appropriate dose plays a

crucial role in determining the efficiency of sulphur uptake and utilization by mustard plants (Rathore *et al.*, 2015) ^[21]. Common sources include elemental sulphur, gypsum (calcium sulphate), and sulphur-enriched fertilizers like ammonium sulphate and single super phosphate (Rathore *et al.*, 2015) ^[21]. Each source varies in terms of solubility, nutrient availability, and residual effects on soil fertility (Jordan and Ensminger, 1959; Dick *et al.*, 2008) ^[12, 7]. Moreover, determining the optimum sulphur dose is critical for maximizing yield and profitability without causing nutrient imbalances or environmental harm (Tabatabai, 1984; Aulakh, 2003) ^[23, 3].

Therefore, this study aims to evaluate the effect of different sulphur sources and application rates on the productivity and economic returns of mustard cultivation in the agro-climatic conditions of central Uttar Pradesh. The findings will help formulate region-specific sulphur management strategies to sustainably enhance mustard yield, quality, and farmer profitability.

Keeping these facts in view, a study has been planned to evaluate the “Effect of different sulphur sources and doses on productivity and profitability of mustard in central Uttar Pradesh” with the following objectives: To assess the effect of different sources and doses of sulphur on yield and yield attributes, biochemical, and profitability of mustard.

Materials and Methods

Experimental site: The experiment was conducted using a Randomized Block Design (RBD) with 11 treatments and 3 replications at the research farm of Rama University, Mandhana, Kanpur - 209217 (U.P.), India, during 2024-2025, located at 26.56°N latitude, 80.21°E longitude, with an elevation of 125.9 meters above sea level. This situated in the Central Gangetic Plains. The region has a monsoon-influenced humid subtropical and hot semi-arid climate, with three distinct seasons: a hot summer (March-June, up to 47.2 °C), a monsoon season (July-September,), and a cool winter (November-February, minimum ~8 °C with occasional frost). Annual rainfall ~815.9 mm. The area records an annual mean temperature of 25.2°C and average relative humidity of 54%. Mustard (*Brassica juncea* L.), variety Pusa Mustard-28 (NPJ-124) was used. Each experimental unit size was 20 m².

Table 1: Treatments details

Treatment	Description
T ₁	Recommended NPK with no sulphur application
T ₂	Recommended NPK with sulphur through elemental sulphur @15 kg/ha
T ₃	Recommended NPK with sulphur through gypsum 1 @5 kg/ha)
T ₄	Recommended NPK with sulphur through ammonium sulphate @15 kg/ha
T ₅	Recommended NPK with sulphur through bentonite sulphur @15 kg/ha
T ₆	Recommended NPK with sulphur through single super phosphate @15 kg/ha
T ₇	Recommended NPK with sulphur through elemental sulphur @30 kg/ha
T ₈	Recommended NPK with sulphur through gypsum @30 kg/ha
T ₉	Recommended NPK with sulphur through ammonium sulphate @30 kg/ha
T ₁₀	Recommended NPK with sulphur through bentonite sulphur @30 kg/ha
T ₁₁	Recommended NPK with sulphur through single super phosphate @30 kg/ha

Table 2: Standard agronomic practices followed during the experimentation

Date	Operation	Details
30 th October	Pre-sowing irrigation	Moisture ensured for seedbed preparation; essential for proper seed germination and seedling emergence.
3 rd November	Secondary tillage operations	Tillage using cultivator followed by planking to create fine tilth and weed-free field.
4 th November	Field layout, bunding, channel preparation, and sowing	Manual sowing of <i>Brassica juncea</i> var. Pusa Mustard 28 by Pora method (spacing: 45 cm x 10 cm). Applied 50% N, 100% P, and 100% K basally. Sulphur applied as per treatments.
5 th November	Pre-emergence herbicide application	Applied Oxadiargyl @ 0.09 kg/ha to control broadleaf and grassy weeds. Applied immediately after sowing before seed germination.
20 th November	Thinning and gap filling	Ensured optimal plant population and uniform spacing. Weaker and extra seedlings removed; gaps filled with healthy seedlings.
2 nd December	Hand weeding	Manual removal of remaining weeds to reduce crop-weed competition.
3 rd December	First irrigation	To support early growth and nutrient uptake.
5 th December	Top-dressing of remaining nitrogen	Applied remaining 50% N to support robust vegetative growth.
2 nd January	Second irrigation	Irrigation critical during flower initiation to promote better flowering and siliqua formation.
31 st January	Pest and disease management	Flowering to pod formation stage. Sprayed insecticides like imidacloprid 17 SL @ 1.0 ml/L for mustard aphid (<i>Lipaphis erysimi</i>). Fungicide Mancozeb 75 WP @ 2.5 g/L applied for powdery mildew (<i>Erysiphe cruciferarum</i>) and rust (<i>Puccinia</i> spp.).
3 rd February	Third irrigation	Maintains seed filling and oil content. Critical for final yield.
13 th March	Harvesting	Maturity stage. Harvested when siliques turned yellow-brown and seeds hardened. Timely harvesting prevents shattering losses.
20 th March	Threshing	Dried plants threshed manually or mechanically. Seeds cleaned and stored properly to maintain viability and quality.

Yield attributes: Number of siliques (nos), silique length (cm), and seeds per silique (Nos) were measured from five representative plants, average was taken. Test weight of 1,000 seeds of mustard was measured using automatic seed counter and recording their weight and expressed in g.

Yield: For accurate yield assessment and minimize the border effects, one row is removed from each side of the experimental unit at harvest, plants in the net area were harvested and sun-dried for three days. After drying, the bundles were weighed to determine biological yield, and then threshing and cleaning. After cleaning seed yield was measured. Yield of mustard is reported at 11% moisture content. Stover yield was calculated by subtracting seed yield from biological yield. Harvest index was calculated by dividing seed yield by biological yield.

$$\text{Seed yield (q ha}^{-1}\text{)} = \left(\frac{(\text{Seed Yield} \times \{100 - \text{actual moisture \% in seed}\})}{(100 - \text{moisture \% at which yield to be adjusted})} \right)$$

$$\text{Stover yield (q ha}^{-1}\text{)} = \text{Biological yield (q ha}^{-1}\text{)} - \text{Seed yield (q ha}^{-1}\text{)}$$

$$\text{Harvest Index} = \left(\frac{\text{Seed yield (q ha}^{-1}\text{)}}{\text{Biological yield (q ha}^{-1}\text{)}} \times 100 \right)$$

Biochemical: Oil content in the mustard seeds was measured by following the rapid and non-destructive method using the pulsed nuclear magnetic resonance technique developed by (Tiwari *et al.*, 1974)^[25]. Oil yield was calculated by multiplying seed yield (kg/ha) with oil content (%) and dividing by 100, and expressed as kilograms per hectare (kg/ha).

$$\text{Oil yield(kg/ ha)} = \frac{\text{Seed Yield (kg/ha)} \times \text{Oil content (\%)}}{100}$$

The nitrogen content was multiplied by Jones Factor (5.12) to determine the protein percentage (Tkachuk, 1969)^[26]. Protein yield was calculated by multiplying seed yield (kg/ha) with protein content (%) and dividing by 100, and expressed as

kilograms per hectare (kg/ha).

$$\text{Protein content (\%)} = \text{Seed nitrogen content (\%)} \times \text{Jones Factor}$$

$$\text{Protein yield(kg/ ha)} = \frac{\text{Seed Yield (kg/ha)} \times \text{Protein content (\%)}}{100}$$

Economics: The cost of cultivation was calculated by considering the following inputs: machinery charges, seeds, fertilizers, plant protection, wage costs, and other expenses. Data were collected for each input, and their respective costs were recorded. Seed yield was valued based on the Minimum Support Price (MSP) set by the Government of India for the respective years, while stalks were sold at the prevailing local price. The gross returns were determined by adding the income from both seed and stalk sales. Net returns (₹/ha) were calculated by subtracting the cost of cultivation (₹/ha) from the gross returns (₹/ha) and expressed in rupees per hectare. The benefit-cost ratio was calculated by dividing the gross returns of each treatment by its respective cost of cultivation.

$$\text{Gross returns (₹/ha)} = \text{Returns from sell of seed (₹/ha)} + \text{Returns from sell of stover (₹/ha)}$$

$$\text{Net returns (₹/ha)} = \text{Gross returns (₹/ha)} - \text{Cost of cultivation (₹/ha)}$$

$$\text{BCR} = \frac{\text{Gross returns (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

Statistical analysis: The experiment was laid out in a Randomized Block Design with 11 treatments and 3 replications. Data were statistically analyzed using ANOVA, and treatment means were compared using the Least Significant Difference (LSD) test at 5% significance, as described by Gomez and Gomez (1984)^[9].

Results and Discussion

Yield attributes: The results indicate that application of sulphur along with recommended NPK significantly improved yield-

attributing of mustard such as siliquae per plant, seeds per siliqua, and test weight compared to the control (T₁). The lowest values were recorded in T₁ (300 siliquae/plant, 10.00 seeds/siliqua, 4.90 g test weight), showing the negative impact of sulphur omission. Among treatments, T₁₀ (bentonite sulphur @30 kg/ha) recorded the highest values for all three traits 354 siliquae/plant, 11.80 seeds/siliqua, and 5.10 g test weight followed closely by T₉ (ammonium sulphate @30 kg/ha) and T₁₁ (SSP @30 kg/ha). The LSD values at 5% significance level for siliquae/plant, seeds/siliqua, and test weight confirm that the differences among higher sulphur doses (especially 30 kg/ha) and sources are statistically significant over the control and lower dose treatments. In general, sulphur sources at 30 kg/ha performed better than at 15 kg/ha, indicating that higher sulphur availability enhanced reproductive growth and seed development (Pachauri *et al.*, 2012; Rathore *et al.*, 2015; Mishra *et al.*, 2023)^[19, 21, 15]. Bentonite sulphur showed maximum benefit likely due to its sustained release pattern (Muscolo *et al.*, 2017; Ramesh *et al.*, 2025)^[18, 20], while ammonium sulphate and SSP also proved effective due to their readily available sulphate forms and additional nutrient synergy (N and P, respectively) (Rathore *et al.*, 2015)^[21].

Yield: The results clearly show that sulphur application along with recommended NPK significantly enhanced seed yield, stover yield, and harvest index in mustard. The control treatment (T₁) recorded the lowest seed yield (15.00 q/ha), stover yield (31.88 q/ha), and harvest index (32.00%), reflecting the adverse effect of sulphur deficiency on overall crop performance. All sulphur-treated plots showed noticeable improvements, with increasing trends as sulphur dose increased from 15 to 30 kg/ha. Among all treatments, T₁₀ (bentonite sulphur @30 kg/ha) recorded the highest seed yield (17.70 q/ha), stover yield (35.94 q/ha), and harvest index (33.00%), followed closely by T₉ (ammonium sulphate @30 kg/ha) and T₁₁ (SSP @30 kg/ha). Treatments with 30 kg/ha sulphur consistently outperformed those with 15 kg/ha, regardless of source, suggesting that mustard has a higher sulphur requirement for optimal productivity. Bentonite sulphur likely performed best due to its slow and sustained release pattern, ensuring season-long sulphur availability (Muscolo *et al.*, 2017; Ramesh *et al.*, 2025)^[18, 20], while ammonium sulphate provided quick release of sulphate and also contributed nitrogen, supporting growth. SSP, with both phosphorus and sulphur, also showed positive effects (Rathore *et al.*, 2015)^[21].

Table 3: Effect of different doses and sources of sulphur on yield attributes and yield mustard

Treatments	Siliquae/Plant	Seeds/Siliqua	Test weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest Index (%)
T ₁	300.00	10.00	4.90	15.00	31.88	32.00
T ₂	336.00	11.20	5.04	16.80	35.37	32.20
T ₃	333.00	11.10	4.99	16.65	35.22	32.10
T ₄	342.00	11.40	5.05	17.10	35.68	32.40
T ₅	342.60	11.42	5.06	17.13	35.58	32.50
T ₆	339.00	11.30	5.02	16.95	35.53	32.30
T ₇	348.00	11.60	5.07	17.40	35.65	32.80
T ₈	345.60	11.52	5.05	17.28	35.56	32.70
T ₉	351.00	11.70	5.08	17.55	35.63	33.00
T ₁₀	354.00	11.80	5.10	17.70	35.94	33.00
T ₁₁	348.90	11.63	5.09	17.45	35.59	32.90
S.Em	10.56	0.39	0.15	0.55	1.56	0.22
LSD(p=0.05)	29.58	1.09	0.42	1.70	4.42	0.61

T₁: Recommended NPK with no sulphur application; T₂: Recommended NPK with sulphur through elemental sulphur @15 kg/ha; T₃: Recommended NPK with sulphur through gypsum 1 @5 kg/ha; T₄: Recommended NPK with sulphur through ammonium sulphate @15 kg/ha; T₅: Recommended NPK with sulphur through bentonite sulphur @15 kg/ha; T₆: Recommended NPK with sulphur through single super phosphate @15 kg/ha; T₇: Recommended NPK with sulphur through elemental sulphur @30 kg/ha; T₈: Recommended NPK with sulphur through gypsum @30 kg/ha; T₉: Recommended NPK with sulphur through ammonium sulphate @30 kg/ha; T₁₀: Recommended NPK with sulphur through bentonite sulphur @30 kg/ha; T₁₁: Recommended NPK with sulphur through single super phosphate @30 kg/ha.

Biochemical: The data show a clear and consistent positive effect of sulphur application on protein content, protein yield, oil content, and oil yield in mustard. The control treatment (T₁) had the lowest values across all parameters, with 17.77% protein, 266.26 kg/ha protein yield, 41.00% oil, and 615.32 kg/ha oil yield. The application of sulphur, regardless of source, led to significant increases in both protein and oil components (Chahal *et al.*, 2020; Heikal, *et al.*, 2022)^[5, 11], with improvements becoming more pronounced at the higher sulphur dose (30 kg/ha). Among all treatments, T₁₀ (bentonite sulphur @30 kg/ha) recorded the highest protein yield (326.52 kg/ha) and maximum oil yield (743.35 kg/ha) along with high protein (18.44%) and oil content (42.00%). This was closely followed by T₉ (ammonium sulphate @30 kg/ha) and T₁₁ (SSP @30 kg/ha). The increase in protein content and yield with sulphur is due to its critical role in amino acid synthesis and protein formation in oilseed crops (Bones and Rossiter, 1996)^[4]. Similarly, enhanced oil content and yield result from sulphur's involvement in fatty acid synthesis and oil metabolism (Dimree and Dwivedi, 1994)^[8]. Higher sulphur availability at 30 kg/ha, especially from

sustained-release sources like bentonite, ensured continuous nutrient supply throughout the growth stages, leading to improved seed quality.

Table 4: Effect of different doses and sources of sulphur on protein and oil yield of mustard

Treatments	Protein (%)	Protein yield (kg/ha)	Oil (%)	Oil yield (kg/ha)
T ₁	17.77	266.26	41.00	615.32
T ₂	18.06	303.95	41.20	692.51
T ₃	17.91	297.99	41.10	684.16
T ₄	18.35	314.14	41.30	706.15
T ₅	18.35	314.00	41.50	710.66
T ₆	18.21	308.10	41.20	697.93
T ₇	18.40	320.33	41.80	727.39
T ₈	18.41	318.44	41.70	720.89
T ₉	18.43	323.53	42.00	737.05
T ₁₀	18.44	326.52	42.00	743.35
T ₁₁	18.30	318.95	41.90	731.18
S.Em	0.23	13.63	0.23	31.52
LSD(p=0.05)	0.67	38.15	0.63	88.29

T₁: Recommended NPK with no sulphur application; T₂: Recommended NPK with sulphur through elemental sulphur @15 kg/ha; T₃: Recommended NPK with sulphur through gypsum 1 @5 kg/ha; T₄: Recommended NPK with sulphur through ammonium sulphate @15 kg/ha; T₅: Recommended NPK with sulphur through bentonite sulphur @15 kg/ha; T₆: Recommended NPK with sulphur through single super phosphate @15 kg/ha; T₇: Recommended NPK with sulphur through elemental sulphur @30 kg/ha; T₈: Recommended NPK with sulphur through gypsum @30 kg/ha; T₉: Recommended NPK with sulphur through ammonium sulphate @30 kg/ha; T₁₀: Recommended NPK with sulphur through bentonite sulphur @30 kg/ha; T₁₁: Recommended NPK with sulphur through single super phosphate @30 kg/ha.

Economic: The cost of cultivation varied from ₹47,319/ha in T₆ (SSP @15 kg S/ha) to ₹53,832/ha in T₇ (Elemental sulphur @30 kg/ha) (Table 5). These differences are due to the nature and dosage of sulphur sources used. Gross return significantly increased with sulphur application compared to the control (T₁:

₹86,850/ha) (Table 5). The highest gross return was recorded in T₁₀ (₹1,02,483/ha), followed by T₉ (₹1,01,614/ha), T₁₁ (₹1,01,006/ha), and T₇ (₹1,00,746/ha). These treatments were significantly superior to T₁. Treatments T₂, T₃, T₄, T₅, T₆, and T₈ were statistically at par with each other and showed non-significant differences among themselves, but still had significantly higher returns than T₁. Net returns followed a similar trend, significantly improving with sulphur application. The highest net return was observed in T₁₀ (₹51,617/ha), which was significantly superior to T₁ (₹37,184/ha) (Table 5). Treatments T₆ (₹50,822/ha) and T₉ (₹48,574/ha) were at par with T₁₀. All sulphur-treated plots exhibited significantly higher net returns than the control, indicating the economic benefit of sulphur use in mustard cultivation. The B:C ratio improved from 1.75 in T₁ to 2.07 in T₆, which was significantly higher than the control (Table 5). T₁₀ (2.01) and T₁₁ (1.95) were at par with T₆ and significantly better than T₁. Treatments T₂, T₃, T₄, T₅, T₇, T₈, and T₉ also showed significant improvement over the control but were non-significantly different among themselves.

Table 5: Effect of different doses and sources of sulphur on economic of mustard

Treatments	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net returns (₹/ha)	Benefit to cost ratio	Added return (₹/ha)
T ₁	49666	86850	37184	1.75	0
T ₂	51549	97272	45723	1.89	10422
T ₃	50441	96403	45963	1.91	9554
T ₄	51153	99009	47856	1.94	12159
T ₅	51732	99182	47450	1.92	12333
T ₆	47319	98140	50822	2.07	11291
T ₇	53832	100746	46914	1.87	13896
T ₈	51616	100051	48436	1.94	13202
T ₉	53040	101614	48574	1.92	14765
T ₁₀	50866	102483	51617	2.01	15633
T ₁₁	51921	101006	49086	1.95	14157
S.Em	-	4350.23	4350.23	0.09	511.97
LSD(p=0.05)	-	12180.64	12180.65	0.22	1433.52

T₁: Recommended NPK with no sulphur application; T₂: Recommended NPK with sulphur through elemental sulphur @15 kg/ha; T₃: Recommended NPK with sulphur through gypsum 1 @5 kg/ha; T₄: Recommended NPK with sulphur through ammonium sulphate @15 kg/ha; T₅: Recommended NPK with sulphur through bentonite sulphur @15 kg/ha; T₆: Recommended NPK with sulphur through single super phosphate @15 kg/ha; T₇: Recommended NPK with sulphur through elemental sulphur @30 kg/ha; T₈: Recommended NPK with sulphur through gypsum @30 kg/ha; T₉: Recommended NPK with sulphur through ammonium sulphate @30 kg/ha; T₁₀: Recommended NPK with sulphur through bentonite sulphur @30 kg/ha; T₁₁: Recommended NPK with sulphur through single super phosphate @30 kg/ha.

Conclusion

In conclusion, the application of sulphur, particularly in the form of bentonite sulphur at 30 kg/ha, significantly improved the yield attributes, yields, and economic returns of Indian mustard. This treatment proved to be the most effective and economically viable option under the study conditions, making it a recommended practice for mustard cultivation.

References

- Ahmad A, Abdin MZ. Interactive effect of sulphur and nitrogen on the oil and protein contents and on the fatty acid profiles of oil in the seeds of rapeseed (*Brassica campestris* L.) and mustard (*Brassica juncea* L. Czern. and Coss.). J Agron Crop Sci. 2000;185(1):49-54.
- Ahmad G, Jan A, Arif M, Jan MT, Khattak RA. Influence of nitrogen and sulphur fertilization on quality of canola (*Brassica napus* L.) under rainfed conditions. J Zhejiang Univ Sci B. 2007;8(10):731-7. <https://doi.org/10.1631/jzus.2007.B0731>
- Aulakh MS. Crop responses to sulphur nutrition. In: Abrol Z, Ahmad A, editors. Sulphur in plants. Springer; 2003. p. 341-58. https://doi.org/10.1007/978-94-017-0303-0_15
- Bones AM, Rossiter JT. The myrosinase-glucosinolate system, its organization and biochemistry. Physiol Plant. 1996;97(1):194-208. <https://doi.org/10.1111/j.1399-3054.1996.tb00495.x>
- Chahal HS, Singh A, Malhi GS. Role of sulphur nutrition in oilseed crop production - A review. J Pharmacogn Phytochem. 2020;9(5):1515-20. <https://www.phytojournal.com/archives/2020/vol9issue5/PartV/9-5-237-294.pdf>
- Chandel RS, Sudhakar PC, Singh K. Response of sulphur nutrition in mustard - A review. Agric Rev. 2003;24(3):175-82.
- Dick WA, Kost D, Chen L. Availability of sulfur to crops from soil and other sources. In: Jez J, editor. Sulfur: A missing link between soils, crops, and nutrition. Vol. 50. ASA; 2008. p. 59-82. <https://doi.org/10.2134/aspectpub50.c4>
- Dimree S, Dwivedi KN. Response of sulphur and phosphorus on groundnut. J Oilseeds Res. 1994;11(2):193-5.
- Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: John Wiley &

- Sons; 1984.
10. Govahi M, Saffari M. Effect of potassium and sulphur fertilizers on yield and yield components and seed quality of spring canola (*Brassica napus*). *Agron J.* 2006;5:577-82.
 11. Heikal YM, El-Esawi MA, Galilah DA. Morpho-anatomical, biochemical and molecular genetic responses of canola (*Brassica napus* L.) to sulphur application. *Environ Exp Bot.* 2022;194:104739. <https://doi.org/10.1016/j.envexpbot.2022.104739>
 12. Jordan HV, Ensminger LE. The role of sulfur in soil fertility. *Adv Agron.* 1959;10:407-34. [https://doi.org/10.1016/S0065-2113\(08\)60124-2](https://doi.org/10.1016/S0065-2113(08)60124-2)
 13. Katyal JC, Sharma KL, Srinivas K. Sulphur in Indian agriculture. In: *Proc TSI/FAI/IFA Symp Sulphur Balanced Fertilisation. The Sulphur Institute & The Fertiliser Association of India*; 1997. p. KS-2/1-KS-2/12.
 14. Malhi SS, Gan Y, Raney JP. Yield, seed quality, and sulphur uptake of Brassica oilseed crops in response to sulphur fertilization. *Agron J.* 2007;99(2):570-7. <https://doi.org/10.2134/agronj2006.0150>
 15. Mishra AP, Pradhan PP, Dash AK, Panda N, Dash BP, Patel S. Role of Sulphur in cereals and oilseeds crops. *Ecol Environ Conserv.* 2023;29:S386-92.
 16. Misra SK. Effect of sulphur and potassium on yield, nutrient uptake and quality characteristics of mustard (*Brassica juncea* L.) in Kanpur. *J Indian Soc Soil Sci.* 2003;51:544-8.
 17. Mohiuddin M, Paul AK, Sutradhar GNC, Bhuiyan MSI, Zubair HM. Response of nitrogen and sulphur fertilizers on yield, yield components and protein content of oilseed mustard (*Brassica* spp.). *Int J Bioresour Stress Manag.* 2011;2(1):93-9.
 18. Muscolo A, Mallamaci C, Settineri G, Calamarà G. Increasing soil and crop productivity by using agricultural wastes pelletized with elemental sulfur and bentonite. *Agron J.* 2017;109(5):1900-10.
 19. Pachauri RK, Trivedi SK, Yogendra Kumar YK. Effect of sulphur levels on growth, yield and quality of Indian mustard genotypes and their economics. 2012.
 20. Ramesh K, Raghavan V. Biochar/bentonite composite beads for controlled nitrogen release and reduced environmental impact: From banana waste to sustainable food security. *Results Surf Interfaces.* 2025;19:100500.
 21. Rathore SS, Shekhawat K, Kandpal BK, Premi OP, Singh SP, Chand G. Sulphur management for increased productivity of Indian mustard: A review. *Ann Plant Soil Res.* 2015;17(1):1-12.
 22. SEA. All India mustard production 2024-25: Detailed report. Solvent Extractors' Association of India; 2025. <https://www.igrain.in/posts/all-india-mustard-production-2024-25-detailed-report>
 23. Tabatabai MA. Importance of sulphur in crop production. *Biogeochemistry.* 1984;1(1):45-62. <https://doi.org/10.1007/BF02181118>
 24. Tandon HLS. Sulphur in soils, crops and fertilisers - From research to practical application. New Delhi: Fertiliser Development and Consultation Organisation (FDCO); 2011.
 25. Tiwari PN, Gambhir PN, Rajan TS. Rapid and nondestructive determination of seed oil by pulsed nuclear magnetic resonance technique. *J Am Oil Chem Soc.* 1974;51(3):104-9. <https://doi.org/10.1007/BF02633510>
 26. Tkachuk R. Nitrogen-to-protein conversion factors for cereals and oilseed meals. *Cereal Chem.* 1969;46(5):419-23.