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# Response of different level of Sulphur and FYM on soil properties and yield of mustard. (*Brassica juncea L.*) (var. Varuna T-59)

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**Abstract**

An A field experiment was conducted during the Rabi season 2024–25 at the Central Research Farm, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj. The experimental soil was sandy loam in texture, comprising 65.32% sand, 19.08% silt, and 15.60% clay. The study was laid out in a Randomized Block Design (RBD) with three levels of sulphur (0, 50, and 100 kg $ha^{-1}$) and FYM (0, 50, and 100 kg $ha^{-1}$) to evaluate their effects on soil properties, crop growth, and yield. Results revealed that the treatment combination $T_9$ [IC 100% + SC 100% + FYM 100%] outperformed all other treatments. Significant improvements were observed in soil properties, including bulk density, porosity, pH, EC (dS $m^{-1}$), organic carbon (%), available nitrogen (60–90 kg $ha^{-1}$), available phosphorus (60 kg $ha^{-1}$), available potassium (40 kg $ha^{-1}$), and sulphur (mg $kg^{-1}$). Growth parameters and seed yield were also significantly enhanced with increasing levels of FYM and sulphur. Economically, $T_9$ recorded the highest gross return (Rs. 1,89,125), net return (Rs. 1,22,675), and benefit-cost ratio (1.85). These findings suggest that integrated application of FYM and sulphur at 100% levels is effective in improving soil fertility, crop growth, yield, and profitability.

**Keywords:** Soil properties, mustard, sulphur, FYM, etc.

## Introduction

Mustard plants belong to the genus *Brassica* in the family Brassicaceae. The *Brassica* group of crops is the third most important oilseed crop in India after soybean and groundnut, contributing nearly 20–25% of the country's total oilseed production (ICAR, 2009). Mustard seeds are used as a spice, for mustard oil extraction, and the edible leaves are consumed as mustard greens.

In India, various oilseed *Brassica* species are primarily cultivated in the Northern plains, with the highest area under cultivation in Rajasthan, followed by Uttar Pradesh, Madhya Pradesh, Haryana, Gujarat, West Bengal, Assam, Bihar, Punjab, Himachal Pradesh, and Jammu & Kashmir. Rajasthan, Uttar Pradesh, and Madhya Pradesh together account for 77% of the total rapeseed–mustard area. Rapeseed–mustard contributes approximately 30% of India's edible oils and accounts for 21% of the total area under oilseeds (CMIE, 2002).

Mustard seeds are nutritionally rich, containing minerals such as calcium, manganese, copper, iron, selenium, zinc, and vitamins A, B, and C, along with proteins. One hundred grams of mustard seed provides 508 kcal energy, 28.09 g carbohydrates, 26.08 g proteins, 26.08 g total fat, and 12.2 g dietary fiber (USDA, 2014). The seeds are small, round, 1–2 mm in diameter, and range in color from yellowish-white to black. Major species include black mustard (*Brassica nigra*), brown Indian mustard (*B. juncea*), and white mustard (*B. hirta/sinapis alba*).

Mustard oil contains high levels of sulphur compounds, making adequate sulphur nutrition crucial for oil synthesis. Among cruciferous crops, mustard seeds have the highest sulphur content (1–1.7%), and sulphur uptake is typically about one-third of nitrogen uptake (Bharose *et al.*, 2010) [2].

Application of farmyard manure (FYM) improves soil physical, chemical, and biological properties, enhancing soil nutrient supply capacity and sustainability (Ould *et al.*, 2010). FYM increases cation exchange capacity, maintains micronutrient availability through chelation, and improves microbial activity, supplying both macro- and micronutrients essential for crop growth (Sipai et al., 2015) [5].

Oilseed crops, particularly mustard, respond well to sulphur application, which is synergistic with nitrogen. Sulphur plays a key role in seed development and quality, forming amino acids such as cysteine, cystine, and methionine, which are essential components of plant proteins. Brassica species have the highest sulphur requirement due to the presence of sulphur-rich glucosinolates (Bharose et al., 2010) [2].

## Materials and Methods

The present study was conducted during the Rabi season of 2024–25 at the Soil Science Research Farm, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Naini Agricultural Institute, Prayagraj. Agroclimatically, the region lies in the subtropical belt of southeastern Uttar Pradesh, characterized by extremely hot summers, fairly cold winters, and an average annual rainfall of around 1100 mm. Temperatures during the season ranged from 4–5°C in winter to 46–48°C in summer, with relative humidity varying between 20–94%. The experiment was laid out in a Randomized Block Design (RBD) with three levels of sulphur (0, 50, and 100 kg ha$^{-1}$) and three levels of farmyard manure (FYM; 0, 50, and 100 kg ha$^{-1}$), and all treatments were replicated three times. The treatment combinations included IC 100% + SC 0% + F1C 0%, IC 100% + SC 50% + F1C 0%, IC 100% + SC 100% + F1C 0%, IC 100% + SC 0% + F2C 50%, IC 100% + SC 50% + F2C 50%, IC 100% + SC 100% + F2C 50%, IC 100% + SC 50% + F3C 100%, and IC 100% + SC 100% + F3C 100%. During the experiment, growth and yield parameters of mustard were recorded. The sources of inorganic nutrients included urea (for nitrogen), single super phosphate (SSP) for phosphorus, muriate of potash (MOP) for potassium, micronutrients, and Rhizobium inoculant, while FYM served as the organic nutrient source.

## Results and Discussions

The results presented in Table 1 indicate that plant growth parameters, including plant height, number of leaves, number of branches, and the days to first flowering, improved significantly with increasing levels of sulphur and FYM. The maximum plant height (128.48 cm), number of leaves per plant (25.80), and number of branches per plant (14.69) were recorded in $T_9$ [IC 100% + SC 100% + F3C 100%], whereas the maximum days to first flower (28.35 days) were observed in the control ($T_0$), with the minimum recorded in T9. Similarly, yield attributes such as number of seeds per siliqua (10.02), 1000-seed weight (6.03 g), seed yield (19.13 q ha$^{-1}$), and stover yield (33.15 q ha$^{-1}$) were highest in $T_9$, with the lowest values observed in the control. The superior performance in $T_9$ can be attributed to the synergistic effect of FYM and sulphur, which enhanced plant growth, branch development, siliqua formation, and ultimately yield. These results align with the findings of Tomar et al. (2007) [6], Bharose et al. (2010) [2], and Parmar et al. (2018) [3], who reported positive effects of sulphur and organic amendments on growth and yield of oilseed crops.

The effect of sulphur and FYM on soil physico-chemical properties is presented in Table 2. The maximum soil bulk density at 0–15 cm and 15–30 cm depths was recorded in the control ($T_0$), while the minimum was observed in treatments with higher FYM and sulphur application, particularly $T_6$ and $T_7$. Conversely, soil porosity and water holding capacity increased with FYM and sulphur levels, reaching the highest values in $T_9$ at both soil depths. Soil particle density was reduced under $T_9$ compared to $T_0$, indicating improved soil structure.

Soil chemical properties also responded positively to FYM and sulphur application. The highest soil organic carbon (0.51% at 0–15 cm and 0.50% at 15–30 cm), available nitrogen (258.87 kg ha$^{-1}$), available phosphorus (31.45 kg ha$^{-1}$), available potassium (220.26 kg ha$^{-1}$), and available sulphur (16.53 kg ha$^{-1}$) were recorded in $T_9$, while the lowest values were found in $T_0$. Soil pH slightly decreased with FYM and sulphur application, whereas electrical conductivity (EC) increased moderately in $T_9$. The improvement in soil organic carbon and nutrient availability is attributed to the combined effect of FYM as a source of organic matter and essential nutrients, along with sulphur application, which enhanced nutrient uptake by the crop. These observations are consistent with the findings of Alam et al. (2014) and Singh et al. (2004) [1, 4].

Overall, the results indicate that integrated application of FYM and sulphur at 100% levels significantly enhanced both growth, yield attributes, and soil fertility, demonstrating the importance of balanced nutrient management in mustard cultivation.

**Table 1:** Response of Sulphur and FYM on soil Physio-chemical properties of Mustard var. Varuna T-59

| | Treatments | Plant height (cm) | No. of leaves | No. of branches | First flower | No. seeds /siliquae | 1000 seed weight (g) | Seed yield (q ha$^{-1}$) | Stover yield (q ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| $T_0$ | Absolute Control | 91.23 | 18.32 | 11.8 | 33.33 | 7.78 | 4.81 | 14.85 | 26.63 |
| $T_1$ | [$I_C$ @100% + $S_C$ @0% + $F_{1C}$ @0%] | 95.37 | 19.15 | 12.91 | 32.45 | 7.95 | 4.97 | 15.18 | 27.13 |
| $T_2$ | [$I_C$ @ 100% + Sc@50% + $F_{1C}$@ 0%] | 101.94 | 20.47 | 13.02 | 31.86 | 8.12 | 5.36 | 15.39 | 28.65 |
| $T_3$ | [$I_C$@ 100% + Sc@100% + $F_{1C}$ @0%] | 117.43 | 23.58 | 13.26 | 30.96 | 8.16 | 5.22 | 15.75 | 28.41 |
| $T_4$ | [$I_C$@ 100% + $S_C$@ 0% + $F_{2C}$@ 50%] | 111.35 | 22.36 | 13.45 | 30.73 | 8.22 | 5.16 | 16.02 | 28.79 |
| T5 | [$I_C$@ 100% + Sc@50% + $F_{2C}$@ 50%] | 104.68 | 21.02 | 13.69 | 29.06 | 8.52 | 5.24 | 16.27 | 28.24 |
| $T_6$ | [$I_C$ @100% + Sc@100% + $F_{2C}$ @50%] | 112.45 | 22.58 | 13.83 | 30.16 | 8.61 | 5.33 | 16.44 | 29.05 |
| $T_7$ | [$I_C$@ 100% + Sc@0% + $F_{3C}$ @100%] | 122.96 | 24.69 | 13.8 | 29.59 | 9.03 | 5.69 | 17.24 | 30.27 |
| $T_8$ | [$I_C$@ 100% + Sc@50% + $F_{3C}$@ 100%] | 121.86 | 24.47 | 14.22 | 29.02 | 9.39 | 5.95 | 17.93 | 31.32 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_9$ [$I_C$@100% +Sc@100% + $F_{3C}$@100%] | 128.48 | 25.8 | 14.69 | 28.35 | 10.02 | 6.03 | 19.13 | 33.15 |
| F- test | S | S | S | S | S | S | S | S |
| S. Ed. (±) | 1.1 | 0.68 | 0.89 | 0.628 | 0.325 | 0.293 | 0.926 | 0.649 |
| C. D. (P = 0.05) | 2.179 | 1.347 | 1.771 | 1.297 | 0.671 | 0.606 | 1.911 | 1.34 |

**Table 2:** Response of Sulphur and FYM on soil Physio-chemical properties of Mustard

| | Treatments | Bulk density ($Mg\ m^{-3}$) | | Particle density ($Mg\ m^{-3}$) | | Pore space (%) | | Water holding capacity (%) | | pH w/v (1:2.5) | | EC ($dS\ m^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 – 15 cm | 15 –30 cm | 0 – 15 cm | 15 – 30 cm | 0 – 15 cm | 15 – 30 cm | 0 – 15 cm | 15 – 30 cm | 0 – 15 cm | 15 – 30 cm | 0 – 15 cm | 15 – 30 cm |
| $T_0$ | Absolute Control | 1.35 | 1.36 | 2.57 | 2.61 | 40.6 | 38.95 | 30.48 | 31.15 | 7.29 | 7.31 | 0.29 | 0.26 |
| $T_1$ | [$I_C$@100%+$S_C$@0% + $F_{1C}$@ 0%] | 1.3 | 1.35 | 2.49 | 2.53 | 40.99 | 39.54 | 32.6 | 33.07 | 7.23 | 7.24 | 0.31 | 0.28 |
| $T_2$ | [$I_C$@100%+Sc@50%+$F_{1C}$@ 0%] | 1.29 | 1.32 | 2.48 | 2.5 | 42 | 40.55 | 34.18 | 35.76 | 7.17 | 7.2 | 0.33 | 0.3 |
| $T_3$ | [$I_C$@100%+Sc@100%+$F_{1C}$@ 0%] | 1.28 | 1.33 | 2.51 | 2.54 | 42.42 | 40.97 | 35.26 | 36.04 | 7.12 | 7.14 | 0.37 | 0.34 |
| $T_4$ | [$I_C$@100%+$S_C$@0%+$F_{2C}$@ 50%] | 1.31 | 1.34 | 2.53 | 2.55 | 43.88 | 42.43 | 35.92 | 36.61 | 7.07 | 7.1 | 0.38 | 0.35 |
| T5 | [$I_C$@100%+Sc@50%+$F_{2C}$@50%] | 1.28 | 1.33 | 2.47 | 2.5 | 44.22 | 42.77 | 36.22 | 37.3 | 7.02 | 7.04 | 0.38 | 0.35 |
| $T_6$ | [$I_C$@100%+Sc@100%+$F_{2C}$@50%] | 1.17 | 1.23 | 2.52 | 2.48 | 44.61 | 43.16 | 36.09 | 37.84 | 6.96 | 7 | 0.39 | 0.36 |
| $T_7$ | [$I_C$@100%+Sc@0%+$F_{3C}$@100%] | 1.19 | 1.2 | 2.5 | 2.52 | 45.6 | 44.15 | 37.15 | 38.51 | 6.91 | 6.94 | 0.43 | 0.42 |
| $T_8$ | [$I_C$@100%+Sc@50%+$F_{3C}$@100%] | 1.2 | 1.21 | 2.4 | 2.42 | 47.58 | 46.13 | 38.01 | 39.16 | 6.86 | 6.9 | 0.43 | 0.42 |
| $T_9$ | [$I_C$@100%+Sc@100%+$F_{3C}$@100%] | 1.21 | 1.19 | 2.35 | 2.36 | 48.87 | 47.42 | 38.96 | 40.17 | 6.82 | 6.86 | 0.45 | 0.43 |
| | F-Test | NS | NS | NS | NS | S | S | S | S | NS | NS | NS | NS |
| | S.Ed. (±) | - | - | - | - | 0.62 | 0.48 | 0.68 | 0.55 | - | - | - | - |
| | C.D. at 0.5% | - | - | - | - | 1.32 | 0.99 | 2.06 | 1.65 | - | - | - | - |

| | Treatments | Organic carbon (%) | | Av. N ($kg\ ha^{-1}$) | | Av. P ($kg\ ha^{1}$) | | Av. K ($kg\ ha^{-1}$) | | Av. S ($kg\ ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 – 15 cm | 15 – 30 cm | 0 – 15 cm | 15 – 30 cm | 0 – 15 cm | 15 – 30 cm | 0 – 15 cm | 15 – 30 cm | 0 – 15 cm | 15 – 30 cm |
| $T_0$ | Absolute Control | 0.4 | 0.38 | 244.15 | 240.22 | 20.25 | 19.32 | 185.24 | 181.56 | 7.125 | 6.66 |
| $T_1$ | [$I_C$@ 100% + $S_C$ @0% + $F_{1C}$@ 0%] | 0.41 | 0.39 | 245.06 | 243.64 | 22.93 | 20.9 | 193.42 | 190.8 | 9.96 | 8.76 |
| $T_2$ | [$I_C$@ 100% + Sc@50% + $F_{1C}$ @0%] | 0.42 | 0.4 | 246.65 | 244.32 | 23.21 | 21.28 | 196.59 | 193.52 | 10.12 | 8.99 |
| $T_3$ | [$I_C$@ 100% + Sc@100% + $F_{1C}$@ 0%] | 0.43 | 0.41 | 248.18 | 246.72 | 24.22 | 22.29 | 197.1 | 194.77 | 11.31 | 10.17 |
| $T_4$ | [$I_C$@ 100% + $S_C$ @0% + $F_{2C}$@ 50%] | 0.46 | 0.44 | 250.21 | 247.58 | 26.93 | 25.25 | 201.54 | 198.89 | 12.9 | 11.91 |
| T5 | [$I_C$ @100% + Sc@50% + $F_{2C}$ @50%] | 0.48 | 0.46 | 252.05 | 250.26 | 28.97 | 27.04 | 206.7 | 203.42 | 14.1 | 12.96 |
| $T_6$ | [$I_C$@100% + Sc@100% + $F_{2C}$ @50%] | 0.48 | 0.47 | 253.26 | 251.3 | 29.96 | 28.15 | 211.83 | 207.61 | 15.6 | 14.47 |
| $T_7$ | [$I_C$@100%+ Sc@0% + $F_{3C}$@ 100%] | 0.49 | 0.48 | 256.59 | 252.26 | 30.1 | 29.05 | 215.97 | 211.56 | 15.69 | 15.03 |
| $T_8$ | [$I_C$@100% + Sc@50% + $F_{3C}$ @100%] | 0.5 | 0.49 | 260.42 | 257.93 | 30.96 | 29.72 | 219.45 | 215.72 | 16.23 | 15.45 |
| $T_9$ | [$I_C$@100%+Sc@100% + $F_{3C}$ @100%] | 0.51 | 0.5 | 261.15 | 258.87 | 31.45 | 30.16 | 220.26 | 216.15 | 16.53 | 15.73 |
| | F-Test | NS | NS | S | S | S | S | S | S | S | S |
| | S.Ed. (±) | - | - | 2.18 | 1.8 | 1.1 | 0.68 | 1.75 | 1.41 | 1.01 | 0.59 |
| | C.D. at 0.5% | - | - | 4.42 | 3.62 | 2.23 | 1.4 | 3.28 | 1.85 | 2.12 | 1.24 |

**Conclusion:** The present study concluded that $T_9$ (IC 100% + SC 100% + F3C 100%) was the most effective treatment for improving soil health, crop productivity, and economic returns. Application of sulphur and FYM at this level significantly enhanced the physico-chemical properties of soil by reducing bulk density, particle density, and pH, while increasing pore space, water holding capacity, electrical conductivity, organic carbon, and the availability of nitrogen, phosphorus, and potassium. Therefore, the integrated use of FYM and sulphur at recommended levels can be considered a sustainable and economically viable practice for mustard cultivation.

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