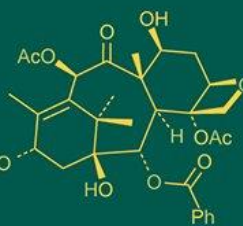
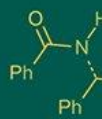


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**Hari Shankar Singh**  
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

**Sarvesh Kumar**  
Professor, Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

**VK Tripathi**  
Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

**Anil Kumar Singh**  
Associate Professor, Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

**Akhilesh Mishra**  
Professor, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

**Naushad Khan**  
Professor, Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

**Anurag**  
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

**Dharmendra Bahadur Singh**  
Ph.D. Scholar, Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

**Corresponding Author:**  
**Hari Shankar Singh**  
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

## Effect of phosphorus, sulphur and PSB on growth, yield and yield attributes of mustard (*Brassica juncea* L.). in central plain zone of U.P.

**Hari Shankar Singh, Sarvesh Kumar, VK Tripathi, Anil Kumar Singh, Akhilesh Mishra, Naushad Khan, Anurag and Dharmendra Bahadur Singh**

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### Abstract

Field experiments were conducted to studies the effect of phosphorus, sulphur and PSB on growth, yield and yield attributes of mustard during rabi season of 2024-25 and 2025-26 at student's instructional farm, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur under Central Plain Zone of Uttar Pradesh. The experiment consists of 13 treatments combinations in randomized block design and 3 replications with phosphorus, sulphur and PSB. Among the treatments, T<sub>13</sub> (100% RDF + 25%) + PSB + 50 kg S ha<sup>-1</sup> consistently produced maximum and T<sub>1</sub> (control) are minimum growth and yield characters, the pooled data presented the maximum and minimum plant height 187.48-164.49 cm at harvest, number of branches plant<sup>-1</sup> 31.87-21.04 and No. leaves plant<sup>-1</sup> 3.40-1.40, microbial biomass 37.77-50.22 g C, dry matter accumulation 60.10-31.26 g plant<sup>-1</sup>, plant population 14.36-11.18 and improved yield-attributing characters the same treatment also recorded the maximum and minimum data, no. of siliqua plant<sup>-1</sup> 285.87-247.64, siliqua length 4.91-3.28 cm, no. of seed siliqua<sup>-1</sup> plant 12.87-9.85, 1000 seed weight in 4.82-3.63 g respectively.

**Keywords:** Mustard (*Brassica juncea* L.), phosphorus, sulphur, PSB, growth, yield attributes

### 1. Introduction

Mustard (*Brassica juncea* L.), one of the most important oil-seed crops globally, is extensively cultivated for its high oil content and valuable by products such as stover, which is used as fodder and organic manure. As a key contributor to edible oil production in countries like India, China, and Canada, mustard faces growing pressure to improve yields to meet growing global demands. However, achieving high yields consistently is a complex challenge, influenced by numerous agronomic factors, including nutrient management and achieved high yield. Among the critical nutrients for oilseeds like mustard phosphorus, sulphur and PSB play essential roles in growth development and yield. Understanding low phosphorus, sulphur and PSB affect mustard crop performance is crucial for optimizing production in a sustainable manner.

Phosphorus (P) is the second major essential nutrient element for crop growth and good quality yield. The most obvious effect of P is on the plant root system. The requirement of P in nodulating legumes is higher compared to non-nodulating crops as it plays a significant role in nodule formation and fixation of atmospheric nitrogen. Due to the important role played by P in the physiological processes of plants, application of P to soil deficient in this nutrient leads to increase groundnut yield.

Sulphur (S) is a vital secondary macronutrient required for oilseed crops. It plays a critical role in various plant physiological and biochemical processes, including protein synthesis, chlorophyll formation, and nitrogen assimilation. In mustard, sulphur is essential for synthesizing glucosinolates, compounds that contribute to both the crop's flavour and its defence against pests. Sulphur deficiency in soil is becoming increasingly widespread due to intensive cropping, higher crop yields, and the use of sulphur-free fertilizers. This deficiency can result in stunted growth, delayed flowering, and significant yield reductions. Adequate sulphur application can enhance mustard yield by improving seed oil content, seed size, and overall plant Vigor.

Phosphate solubilizing microorganisms are disturbed well in several ecosystems. Which have consistent capacity to solubilize insoluble phosphorus such a rock phosphate, tricalcium phosphate, aluminium phosphate, iron phosphate, etc. These bacteria secrete non-volatile organic acids such as butyric tartaric. Aspartic. Glutamic, lactic, Citric, oxalic glycolic, malic, fumaric and  $\alpha$ -ketobutyric acids. They also produce an enzyme phosphatase, which enhance the processes of solubilization of insoluble phosphate. There is a lack of information pertaining to effect of P, S and PSB on the yield and macro nutrients uptake by mustard. Performance of mustard under irrigated condition in Chittorgarh, Rajasthan.

The combined use of phosphorus, sulphur, and phosphate solubilizing bacteria (PSB) helps mustard plants grow more vigorously by improving root establishment and overall plant development. PSB enhances the availability of phosphorus in the soil, while sulphur supports important physiological processes and oil formation. Together, these nutrients improve nutrient absorption and utilization by the crop. As a result, mustard plants produce higher yields and better-quality seeds with improved oil content.

## 2. Materials and Methods

The experiment was conducted at the Students Instructional Farm (SIF) of CSAUA&T, Kanpur, Uttar Pradesh, situated at 25°18' N latitude, 83°03' E longitude and at an altitude of 80.71 meters above mean sea level. The site has a subtropical climate, characterized by hot summers and cool winters. During the crop growing periods of 2024-25 and 2025-26, the total rainfall recorded was 15.75 mm. The objective of the study the effect of phosphorus, sulphur and phosphate-solubilizing bacteria (PSB) on growth, yield and yield attributes of mustard (*Brassica juncea* L.). The experiment was designed as a Randomized Block Design (RBD) with three replications. The experimental soil was sandy loam in texture, slightly alkaline in reaction pH 7.93, normal with respect to salinity EC 0.35 dSm<sup>-1</sup>, low in organic carbon 0.35%, available nitrogen 197.42 kg ha<sup>-1</sup> and sulphur 15.69 mg kg<sup>-1</sup> and medium in available phosphorus 12.20 kg ha<sup>-1</sup> and potassium 264.68 kg ha<sup>-1</sup>. The experiment consisting of phosphorus (100% + 25% P<sub>2</sub>O<sub>5</sub>) and (100%-25% P<sub>2</sub>O<sub>5</sub>) and sulphur (40 and 50 kg S ha<sup>-1</sup>) and phosphate solubilizing bacteria (PSB) inoculation (control and inoculation with PSB). During both the years, required quantity of phosphorus and sulphur as per their levels were

applied through DAP and Gypsum, respectively. The crop fertilized with recommended dose of nitrogen i.e.60 kg N ha<sup>-1</sup>. Half dose of nitrogen was applied urea at 30 days after sowing. Varuna (T-59) cultivar was sown manually using a seed rate of 5 kg ha<sup>-1</sup> on 15 October, 2024 and 17 October, 2025 at row spacing of 45 cm plant to plant 10 cm row to row. All the agronomy practices were followed as per recommendation. After harvesting of mustard, the seed and straw samples were collected and analysed for N, P, K and S contents using the standard procedures given. The uptakes of above nutrients were calculated by multiplying their content with corresponding values of yield. To assess the fertility status of soil samples (0-15 cm depth) from each plot after harvest of mustard crop for both the years were collated with the help of auger and analysed for available N, P, K and S status in soil employing suitable methods.

## 3. Result and Discussion

### 3.1 Plant height

Plant height of mustard increased progressively from 30 DAS to at harvest under all treatment combinations, indicating normal crop growth throughout the experimental period. Among the treatments, T<sub>13</sub> (100% RDF + 25% P) + PSB + 50 kg S ha<sup>-1</sup> consistently recorded the maximum plants, with pooled plant heights of 15.91, 84.54, 158.63, and 187.48 cm at 30 DAS, 60 DAS, 90 DAS, and at harvest respectively. The improved plant height under this treatment may be attributed to the combined application of phosphorus, sulphur, and PSB, which enhanced nutrient availability, promoted better root growth, and supported efficient physiological processes, leading to vigorous vegetative development. In contrast, the control treatment T<sub>1</sub> (control) produced the minimum plants height, recorded with pooled values of 14.38 cm, 64.90 cm, 125.23 cm, and 164.49 cm at the growth stages. The comparatively minimum plant height in the control was likely due to limited nutrient availability in the absence of phosphorus, sulphur, and PSB application. Overall, the results demonstrate that the integrated use of phosphorus, sulphur, and PSB effectively enhanced plant growth and contributed to greater plant height throughout the crop growth period. The combined application likely provided optimal nutrient availability, leading to improved plant growth and these interactions and their statistical significance are provided in Table no. 1.

**Table 1:** Plant height 30, 60 90 and at harvest

| Treatments      | 30 DAS  |         |        | 60 DAS  |         |        | 90 DAS  |         |        | At Harvest |         |        |
|-----------------|---------|---------|--------|---------|---------|--------|---------|---------|--------|------------|---------|--------|
|                 | 2024-25 | 2025-26 | Pooled | 2024-25 | 2025-26 | Pooled | 2024-25 | 2025-26 | Pooled | 2024-25    | 2025-26 | Pooled |
| T <sub>1</sub>  | 14.37   | 14.39   | 14.38  | 64.85   | 64.96   | 64.90  | 125.2   | 125.28  | 125.23 | 164.10     | 164.87  | 164.49 |
| T <sub>2</sub>  | 14.82   | 14.84   | 14.83  | 66.91   | 67.04   | 66.98  | 132.2   | 132.44  | 132.33 | 166.00     | 167.62  | 166.81 |
| T <sub>3</sub>  | 15.31   | 15.34   | 15.33  | 68.70   | 68.82   | 68.76  | 137.6   | 137.71  | 137.65 | 170.36     | 171.27  | 170.81 |
| T <sub>4</sub>  | 15.39   | 15.41   | 15.40  | 72.78   | 73.20   | 72.99  | 143.1   | 143.25  | 143.19 | 174.13     | 175.45  | 174.79 |
| T <sub>5</sub>  | 15.07   | 15.09   | 15.08  | 67.81   | 67.93   | 67.87  | 135.3   | 135.53  | 135.43 | 168.29     | 168.87  | 168.58 |
| T <sub>6</sub>  | 15.35   | 15.37   | 15.36  | 71.69   | 71.81   | 71.75  | 141.6   | 141.78  | 141.71 | 172.02     | 173.03  | 172.53 |
| T <sub>7</sub>  | 15.41   | 15.44   | 15.43  | 74.75   | 74.88   | 74.81  | 144.1   | 144.26  | 144.19 | 176.42     | 177.00  | 176.71 |
| T <sub>8</sub>  | 15.44   | 15.46   | 15.45  | 76.14   | 76.22   | 76.18  | 145.9   | 146.15  | 146.03 | 178.40     | 178.99  | 178.69 |
| T <sub>9</sub>  | 15.50   | 15.54   | 15.52  | 79.12   | 79.25   | 79.19  | 151.1   | 151.21  | 151.14 | 182.17     | 182.96  | 182.57 |
| T <sub>10</sub> | 15.71   | 15.73   | 15.72  | 83.80   | 83.92   | 83.86  | 156.2   | 156.37  | 156.31 | 185.27     | 186.26  | 185.77 |
| C.D             | 0.019   | 0.061   | 0.002  | 0.15    | 0.12    | 0.113  | 0.622   | 0.612   | 15.751 | 0.135      | 0.576   | NS     |
| SE(m)           | 0.006   | 0.021   | 0.001  | 0.051   | 0.041   | 0.038  | 0.212   | 0.208   | 5.364  | 0.046      | 0.196   | 6.517  |
| C.V.            | 0.072   | 0.234   | 0.008  | 0.119   | 0.095   | 0.09   | 0.255   | 0.251   | 6.447  | 0.045      | 0.192   | 6.397  |

### 3.2 Number of branches plant<sup>-1</sup> and no. of leaves plant<sup>-1</sup>

The combined application of phosphorus, sulphur, and phosphate-solubilizing bacteria (PSB) significantly improved branch development in mustard. T<sub>13</sub> (100% RDF + 25% additional P + PSB + 50 kg S ha<sup>-1</sup>) recorded the highest number of branches plant<sup>-1</sup> and no. of leaves plant<sup>-1</sup>, with pooled values of 17.84-12.12 at 60 DAS, 31.84-15.84 at 90 DAS, and 31.87-3.40 at harvest. In contrast, the control (T<sub>1</sub>) produced the lowest values of 12.95-9.95, 21.01-13.00, and 21.04-1.10 branches plant<sup>-1</sup>, respectively they provided in table no. 2. The improvement in branches and leaves may be attributed to enhanced phosphorus availability, improved sulphur nutrition, and increased microbial activity, which together promoted better vegetative growth and plant Vigor. These findings are consistent with earlier reports by Sharma *et al.* (2019) [2], Kumar *et al.* (2021) [1], and Singh *et al.* (2022) [3].

### 3.3 Dry Matter Accumulation, Plant Population and microbial biomass

The combined application of phosphorus, sulphur, and phosphate-solubilizing bacteria (PSB) had a significant effect on dry matter accumulation and plant population and microbial biomass of mustard during both years of experimentation and in the pooled data analysis. Among all the treatments, T<sub>13</sub> (100% RDF + 25% P + PSB + 50 kg S ha<sup>-1</sup>) recorded the maximum dry matter accumulation, with

59.77 g plant<sup>-1</sup> in the 2024-2025, 60.42 g plant<sup>-1</sup> in the 2025-2026, and a pooled mean of 60.10 g plant<sup>-1</sup>. The minimum dry matter accumulation was observed under the control T<sub>1</sub> (control), which recorded 31.20, 31.31, and 31.26 g plant<sup>-1</sup>, respectively. Similarly, the maximum plant population was obtained in T<sub>13</sub> (14.34, 14.37, and 14.36 plants) and the minimum was recorded under the T<sub>1</sub> (control) (11.17, 11.19 and 11.18 plants), respectively they provided in table no. 3. The enhancement in dry matter production and plant stand under T<sub>13</sub> may be attributed to the balanced supply of phosphorus, sulphur along with PSB inoculation, which enhanced nutrient availability, promoted root growth, and improved photosynthetic activity, ultimately resulting in greater biomass production. Similar findings have been reported by Singh *et al.* (2018) [7], Kumar *et al.* (2020) [5], and Meena *et al.* (2021) [1], who observed that integrated nutrient management significantly enhanced growth and biomass accumulation in mustard. In contrast, microbial biomass recorded the maximum values under the control treatment (T<sub>1</sub>), which registered 49.87, 50.57, and 50.22 during the 2024-2025, 2025-2026 and pooled mean, respectively. The minimum microbial biomass was observed under T<sub>13</sub>, with corresponding values of 37.39, 38.16, and 37.77. This response differs from the findings of earlier studies, where integrated application of fertilizers and biofertilizers generally increased soil microbial biomass (Vance *et al.*, 1987; Ghosh *et al.*, 2019).

**Table 2:** Number of branches plant<sup>-1</sup> and no. of leaves plant<sup>-1</sup>

| Treatments      | No. of branches plant <sup>-1</sup> |         |        |         |         |        |            |         |        | No. of leaves plant <sup>-1</sup> |         |        |         |         |        |            |         |        |
|-----------------|-------------------------------------|---------|--------|---------|---------|--------|------------|---------|--------|-----------------------------------|---------|--------|---------|---------|--------|------------|---------|--------|
|                 | 60 DAS                              |         |        | 90 DAS  |         |        | At harvest |         |        | 60 DAS                            |         |        | 90 DAS  |         |        | At harvest |         |        |
|                 | 2024-25                             | 2025-26 | Pooled | 2024-25 | 2025-26 | Pooled | 2024-25    | 2025-26 | Pooled | 2024-25                           | 2025-26 | Pooled | 2024-25 | 2025-26 | Pooled | 2024-25    | 2025-26 | Pooled |
| T <sub>1</sub>  | 12.85                               | 13.05   | 12.95  | 20.96   | 21.06   | 21.01  | 20.98      | 21.10   | 21.04  | 9.93                              | 9.97    | 9.95   | 12.85   | 13.14   | 13.00  | 1.08       | 1.11    | 1.10   |
| T <sub>2</sub>  | 14.26                               | 14.46   | 14.36  | 22.95   | 23.07   | 23.01  | 22.97      | 23.11   | 23.04  | 10.74                             | 10.77   | 10.75  | 14.10   | 14.12   | 14.11  | 2.47       | 2.49    | 2.48   |
| T <sub>3</sub>  | 14.97                               | 15.16   | 15.06  | 25.32   | 25.46   | 25.39  | 25.32      | 25.50   | 25.41  | 10.85                             | 10.87   | 10.86  | 14.52   | 14.55   | 14.54  | 2.73       | 2.75    | 2.74   |
| T <sub>4</sub>  | 15.36                               | 15.57   | 15.47  | 27.01   | 27.14   | 27.08  | 27.04      | 27.17   | 27.11  | 11.13                             | 11.14   | 11.13  | 14.70   | 14.72   | 14.71  | 2.89       | 2.93    | 2.91   |
| T <sub>5</sub>  | 14.56                               | 14.76   | 14.66  | 24.26   | 24.39   | 24.32  | 24.28      | 24.42   | 24.35  | 10.81                             | 10.83   | 10.82  | 14.35   | 14.37   | 14.36  | 2.61       | 2.63    | 2.62   |
| T <sub>6</sub>  | 15.25                               | 15.44   | 15.35  | 26.22   | 26.35   | 26.29  | 26.26      | 26.39   | 26.33  | 10.99                             | 11.03   | 11.01  | 14.63   | 14.65   | 14.64  | 2.79       | 2.81    | 2.80   |
| T <sub>7</sub>  | 15.44                               | 15.64   | 15.54  | 27.21   | 27.34   | 27.28  | 27.26      | 27.36   | 27.31  | 11.21                             | 11.23   | 11.22  | 14.82   | 14.84   | 14.83  | 2.99       | 3.02    | 3.00   |
| T <sub>8</sub>  | 15.53                               | 15.73   | 15.63  | 27.40   | 27.54   | 27.47  | 27.42      | 27.56   | 27.49  | 11.30                             | 11.33   | 11.32  | 15.10   | 15.11   | 15.10  | 3.03       | 3.05    | 3.04   |
| T <sub>9</sub>  | 16.44                               | 16.62   | 16.53  | 29.00   | 29.12   | 29.06  | 29.03      | 29.15   | 29.09  | 11.50                             | 11.53   | 11.52  | 15.37   | 15.40   | 15.39  | 3.14       | 3.16    | 3.15   |
| T <sub>10</sub> | 17.43                               | 17.62   | 17.52  | 31.19   | 31.30   | 31.25  | 31.22      | 31.34   | 31.28  | 11.72                             | 11.76   | 11.74  | 15.74   | 15.76   | 15.75  | 3.27       | 3.30    | 3.28   |
| T <sub>11</sub> | 16.23                               | 16.43   | 16.33  | 27.92   | 28.01   | 27.96  | 27.94      | 28.04   | 27.99  | 11.39                             | 11.42   | 11.41  | 15.18   | 15.21   | 15.19  | 3.09       | 3.10    | 3.09   |
| T <sub>12</sub> | 17.03                               | 17.22   | 17.13  | 30.09   | 30.22   | 30.16  | 30.12      | 30.25   | 30.19  | 11.60                             | 11.63   | 11.62  | 15.57   | 15.60   | 15.59  | 3.17       | 3.20    | 3.18   |
| T <sub>13</sub> | 17.72                               | 17.96   | 17.84  | 31.77   | 31.91   | 31.84  | 31.80      | 31.95   | 31.87  | 12.10                             | 12.14   | 12.12  | 15.75   | 15.92   | 15.84  | 3.38       | 3.42    | 3.40   |
| C.D             | 0.021                               | 0.009   | 1.731  | 0.056   | 0.058   | 3.026  | 0.056      | 0.05    | 3.013  | 0.015                             | 0.048   | N/A    | 0.021   | 0.005   | N/A    | 0.011      | 0.011   | 0.311  |
| SE(m)           | 0.007                               | 0.003   | 0.59   | 0.019   | 0.02    | 1.031  | 0.019      | 0.017   | 1.026  | 0.005                             | 0.016   | 0.418  | 0.007   | 0.002   | 0.549  | 0.004      | 0.005   | 0.106  |
| C.V.            | 0.081                               | 0.033   | 6.498  | 0.122   | 0.127   | 6.59   | 0.123      | 0.109   | 6.555  | 0.079                             | 0.256   | 6.472  | 0.083   | 0.019   | 6.408  | 0.233      | 0.225   | 6.504  |

**Table 3:** Dry Matter Accumulation, Plant Population and microbial biomass

| Treatments      | Dry Matter Accumulation |         |        | Plant Population |         |        | Microbial biomass |         |        |
|-----------------|-------------------------|---------|--------|------------------|---------|--------|-------------------|---------|--------|
|                 | 2024-25                 | 2025-26 | Pooled | 2024-25          | 2025-26 | Pooled | 2024-25           | 2025-26 | Pooled |
| T <sub>1</sub>  | 31.20                   | 31.31   | 31.26  | 11.17            | 11.19   | 11.18  | 49.87             | 50.57   | 50.22  |
| T <sub>2</sub>  | 37.28                   | 37.68   | 37.48  | 12.04            | 12.06   | 12.05  | 46.20             | 46.40   | 46.30  |
| T <sub>3</sub>  | 41.55                   | 41.90   | 41.72  | 12.94            | 12.96   | 12.95  | 47.39             | 47.62   | 47.51  |
| T <sub>4</sub>  | 45.90                   | 46.52   | 46.21  | 11.84            | 11.87   | 11.86  | 43.89             | 44.12   | 44.00  |
| T <sub>5</sub>  | 39.35                   | 40.25   | 39.80  | 12.18            | 12.21   | 12.19  | 46.90             | 47.53   | 47.21  |
| T <sub>6</sub>  | 43.54                   | 43.79   | 43.67  | 12.69            | 12.71   | 12.70  | 41.42             | 41.49   | 41.45  |
| T <sub>7</sub>  | 46.98                   | 47.53   | 47.25  | 13.12            | 13.15   | 13.14  | 46.63             | 46.76   | 46.69  |
| T <sub>8</sub>  | 49.30                   | 49.67   | 49.49  | 13.54            | 13.55   | 13.55  | 43.53             | 43.64   | 43.59  |
| T <sub>9</sub>  | 54.27                   | 54.71   | 54.49  | 12.43            | 12.46   | 12.45  | 42.43             | 42.54   | 42.48  |
| T <sub>10</sub> | 58.11                   | 58.43   | 58.27  | 14.02            | 14.05   | 14.03  | 40.26             | 40.36   | 40.31  |
| T <sub>11</sub> | 51.83                   | 52.49   | 52.16  | 11.28            | 11.30   | 11.29  | 43.01             | 43.12   | 43.07  |
| T <sub>12</sub> | 56.03                   | 56.54   | 56.28  | 13.88            | 13.90   | 13.89  | 38.96             | 39.45   | 39.20  |
| T <sub>13</sub> | 59.77                   | 60.42   | 60.10  | 14.34            | 14.37   | 14.36  | 37.39             | 38.16   | 37.77  |
| C.D             | 0.15                    | 0.157   | 5.439  | 0.013            | 0.555   | 1.402  | 0.101             | 0.053   | 4.625  |
| SE(m)           | 0.051                   | 0.053   | 1.852  | 0.004            | 0.019   | 0.478  | 0.034             | 0.018   | 1.575  |
| C.V.            | 0.187                   | 0.194   | 6.746  | 0.06             | 0.252   | 6.453  | 0.137             | 0.071   | 6.224  |

### 3.4 Yield and attributes and yield

#### 3.4.1 No. of siliqua per plant, siliqua length, no. of seed per siliqua and 1000 test weight

The combined application of phosphorus, sulphur, and phosphate-solubilizing bacteria (PSB) significantly improved the yield attributes and seed yield of mustard during both years of experimentation as well as in the pooled analysis. Among all the treatments, T<sub>13</sub> (100% RDF + 25% phosphorus + PSB + 50 kg S ha<sup>-1</sup>) consistently recorded the highest values for all yield parameters. It produced the maximum and minimum, number of siliquae plant<sup>-1</sup> 283.6-245.7 and 288.1-249.6 and pooled mean 285.87-247.64, siliqua length 4.86-3.18 and 4.96-3.37 cm, pooled 4.91-3.28, number of seeds per siliqua 12.85-9.84, 12.89-9.87 and pooled mean 12.87-9.85, 1000-seed weight 4.8-3.6, 4.9-3.7 g and pooled mean 4.82-3.63 g, during the

2024-2025 and 2025-2026 and pooled mean respectively they provided in table no. 4, The improvement in yield attributes under T<sub>13</sub> may be attributed to the balanced and continuous supply of phosphorus and sulphur together with PSB inoculation, which enhanced phosphorus solubilization, nutrient uptake, root development, photosynthetic efficiency, and translocation of assimilates from source to sink. These favourable effects promoted better flowering, increased pod formation, improved seed setting, and enhanced seed filling, ultimately resulting in higher seed yield. The findings of the present study agree with those of Singh *et al.* (2018) [7], Kumar *et al.* (2020) [5], Meena *et al.* (2021) [1], and Meena and Singh (2022) [3], who also reported that integrated application of phosphorus, sulphur, and biofertilizers significantly improved yield components and productivity of Indian mustard.

**Table 4:** No. of siliqua per plant, siliqua length, no. of seed per siliqua and 1000 test weight

| Treatments      | No. of siliqua per plant |         |        | Siliqua length |         |        | No. of seed per siliqua |         |        | 1000 test weight |         |        |
|-----------------|--------------------------|---------|--------|----------------|---------|--------|-------------------------|---------|--------|------------------|---------|--------|
|                 | 2024-25                  | 2025-26 | Pooled | 2024-25        | 2025-26 | Pooled | 2024-25                 | 2025-26 | Pooled | 2024-25          | 2025-26 | Pooled |
| T <sub>1</sub>  | 245.7                    | 249.6   | 247.64 | 3.18           | 3.37    | 3.28   | 9.84                    | 9.87    | 9.85   | 3.6              | 3.7     | 3.63   |
| T <sub>2</sub>  | 253.0                    | 257.0   | 254.97 | 3.57           | 3.67    | 3.62   | 10.65                   | 10.69   | 10.67  | 3.8              | 3.9     | 3.82   |
| T <sub>3</sub>  | 258.9                    | 263.0   | 260.98 | 3.77           | 3.87    | 3.82   | 11.32                   | 11.35   | 11.33  | 4.0              | 4.1     | 4.07   |
| T <sub>4</sub>  | 266.6                    | 270.8   | 268.70 | 3.97           | 4.07    | 4.02   | 11.82                   | 11.86   | 11.84  | 4.2              | 4.3     | 4.27   |
| T <sub>5</sub>  | 254.7                    | 258.7   | 256.68 | 3.67           | 3.77    | 3.72   | 11.00                   | 11.03   | 11.02  | 3.9              | 4.0     | 3.94   |
| T <sub>6</sub>  | 262.3                    | 266.5   | 264.41 | 3.87           | 3.97    | 3.92   | 11.59                   | 11.62   | 11.61  | 4.2              | 4.2     | 4.18   |
| T <sub>7</sub>  | 268.3                    | 272.5   | 270.42 | 4.07           | 4.17    | 4.12   | 12.02                   | 12.06   | 12.04  | 4.3              | 4.4     | 4.36   |
| T <sub>8</sub>  | 271.7                    | 276.0   | 273.85 | 4.07           | 4.27    | 4.17   | 12.21                   | 12.25   | 12.23  | 4.4              | 4.5     | 4.44   |
| T <sub>9</sub>  | 278.5                    | 282.9   | 280.72 | 4.47           | 4.57    | 4.52   | 12.47                   | 12.50   | 12.48  | 4.6              | 4.6     | 4.59   |
| T <sub>10</sub> | 281.9                    | 286.4   | 284.15 | 4.76           | 4.86    | 4.81   | 12.64                   | 12.68   | 12.66  | 4.7              | 4.8     | 4.72   |
| T <sub>11</sub> | 277.7                    | 282.1   | 279.86 | 4.37           | 4.47    | 4.42   | 12.37                   | 12.41   | 12.39  | 4.5              | 4.6     | 4.53   |
| T <sub>12</sub> | 279.4                    | 283.8   | 281.58 | 4.57           | 4.66    | 4.62   | 12.53                   | 12.56   | 12.55  | 4.6              | 4.7     | 4.66   |
| T <sub>13</sub> | 283.6                    | 288.1   | 285.87 | 4.86           | 4.96    | 4.91   | 12.85                   | 12.89   | 12.87  | 4.8              | 4.9     | 4.82   |
| C.D             | 0.281                    | 0.243   | 0.214  | 0.011          | 0.009   | 0.009  | 0.017                   | 0.012   | 0.018  | 0.056            | 0.053   | 0.006  |
| SE(m)           | 0.096                    | 0.083   | 0.073  | 0.004          | 0.003   | 0.003  | 0.006                   | 0.004   | 0.006  | 0.019            | 0.018   | 0.002  |
| C.V.            | 0.062                    | 0.053   | 0.047  | 0.165          | 0.129   | 0.122  | 0.086                   | 0.059   | 0.088  | 0.781            | 0.727   | 0.089  |

### 4. Conclusion

In conclusion, the present study demonstrated that the combined application of phosphorus, sulphur and phosphate-solubilizing bacteria (PSB) had a positive and significant effect on the growth, yield attributes, and yield of mustard (*Brassica juncea* L.) under Central Plain Zone of Uttar Pradesh. The best nutrient combination treatment T<sub>13</sub> (100% RDF + 25% phosphorus + PSB + 50 kg S ha<sup>-1</sup>) approach not only improved plant growth and biomass accumulation but also enhanced yield-contributing characters, resulting in higher seed, stover, and biological yields. The improved crop performance under this treatment may be attributed to enhanced nutrient availability, better root development, increased photosynthetic activity, and efficient translocation of assimilates to the developing seeds. Overall, the study suggests that the integrated application of 100% RDF + 25% phosphorus, PSB and 50 kg S ha<sup>-1</sup> is an effective nutrient management strategy for improving mustard productivity and nutrient use efficiency under the agro-climatic conditions of the Central Plain Zone of Uttar Pradesh. Adoption of this practice can contribute to higher and more sustainable mustard production while supporting long-term soil health.

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