ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2521-5051 (Print)
ISSN: 2521-506X (Online)
CODEN: ASMCCQ

Acta Scientifica Malaysia (ASM)

DOI: http://doi.org/10.26480/asm.02.2024.62.66

RESEARCH ARTICLE

# RESPONSE OF SULPHUR AND PHOSPHORUS ON YIELD AND YIELD ATTRIBUTES OF MUSTARD IN OLD BRAHMAPUTRA FLOODPLAIN AREA OF BANGLADESH

**Md. Khairul Islam[a], Md. Parvez Anwar[a], Md. Rashedur Rahman[a*], Md. Rasheduzzaman[b]**

*[a]Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2200, Bangladesh*
*[b]Agricultural Economics Division, Bangladesh Agricultural Research Institute (BARI), Bangladesh*
**Corresponding Author Email: rashedagron@bau.edu.bd*



**ARTICLE DETAILS**

***Article History:***

Received 23 September 2024
Revised 18 October 2024
Accepted 04 November 2024
Available online 07 November 2024

**ABSTRACT**

The study was performed at the research field of the Department of Agronomy, Bangladesh Agricultural University, Mymensingh during November, 2020 to February, 2021 to assess the effect of Sulphur and Phosphorus on yield and yield attributes of mustard variety viz. BARI Sharisha-18 (canola type). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The study reported that Sulphur significantly influenced the number of pods plant$^{-1}$, number of seeds pod$^{-1}$, 1000 seeds weight, biological yield, harvest index, seed yield, stover yield, and extracted oil. On the other hand, Phosphorus showed significant influence on plant height, number of seeds pod$^{-1}$, seed yield, and extracted oil. Interestingly, the interaction effect of Sulphur and Phosphorus showed significant effect on every parameter of this study. The individual application of 15 and 35 kg ha$^{-1}$Sulphur and 35 kg ha$^{-1}$Phosphorus showed better response on yield and yield attributes of Mustard. The interaction effect of $P_2 \times S_1$ which is 35 kg ha$^{-1}$Phosphorus and 15 kg ha$^{-1}$Sulphur reported the highly effective on yield, yield attributes, and financial profitability of Mustard.

**KEYWORDS**

Mustard; Yield; Yield attributes; Sulphur; Phosphorus; Oil content

## 1. INTRODUCTION

The world's most significant oilseed crop, after soybean and palm, is mustard (*Brassica spp.*). It is widely grown in Bangladesh, comprises 60% of the entire land used for oil seed cultivation (Sarkar et al., 2020). In 2022-23, a total of 0.54 million metric tonnes of mustard seed were produced, grown on roughly 0.38 million hectares of land. Compared to previous year, the area is increased by 13.67 % in 2022-23 (BBS, 2022). Therefore, the production area is increasing nowadays amid to high yielding varieties and proper intercultural operations (i.e. fertilizer and water management). On the other hand, Mustard is useful for addressing the calorie demands of the people in this country due to its high energy content and edible oil qualities. The per capita per day recommended requirement of edible oil is 6 grams for a diet of 2700 kcal (Islam et al., 2021). Considering this, mustard contains 40-45 % edible oil and 20-25 % protein. Furthermore, mustard has high energy content (approximately 9 kcal g$^{-1}$) and high vitamin content (fat soluble vitamins A, D, E, and K) (Sharif et al., 2017). It is also crucial for enhancing the flavor of some foods. Therefore, there is a huge potentiality of this crop in Bangladesh. Additionally, it is a crucial raw element for industrial products like lubricants, paints, varnishes, hair oils, soaps, and textile auxiliaries. Oil cakes (contains 40% protein) and meals are used as animal feeds and manure for soil.

In the last five years, Bangladesh's per capita consumption of edible oil has climbed by 20%, to reach 18.4 kgs in 2020. Currently, 30.3 lakh tonnes of oils and fats are consumed annually; 92% of this amount is imported. In the 2019–20 fiscal year, Bangladesh imported 27.73 lakh tonnes of edible oil, fats, and oil seed at a cost of $2.12 billion (BBS, 2022). As a result, importing edible oils costs a significant sum of foreign currency each year. However, mustard farming has been moved to marginal lands with low productivity since it must compete with other food grain crops. The demand for edible oil is rising daily in tandem with the population's increasing rate of growth. Therefore, it is well acknowledged that in order to meet demand, edible oil output needs to be significantly increased. Lack of knowledge about appropriate dose of fertilizer application in mustard is one of the prime issues in this country. The optimization of farm income, the production of affordable, high-quality products, and the enhancement of the environment, all depend on the proper application of nutrients. Based on diagnostic techniques, the amount of fertilizer to be applied should be determined. Any fertilizer suggestion should take the product's value into account in addition to the cost of fertilizer and application (Saweda et al., 2017). The fertility status of Bangladesh soil is most uneven, and it varies considerably even between two adjacent plots. Fertilization of farm plots through soil analysis might be an effective way to achieve maximum yield goal with economic benefit, to maintain soil fertility, and to avoid environmental pollution. However, most of the Bangladesh's farmers are less educated and not aware of balanced fertilizer dose. Often, they use imbalanced fertilizer doses. Sometimes they totally ignore the application of Sulphur and Phosphorus fertilizers. The yield and oil content of the seed are impacted by the fact that many of them apply fertilizer at levels that are either lower or higher than those advised for mustard. However, there aren't enough studies or data available regarding farmers' unbalanced usage of fertilizers.

Further, mustard is responsive to Sulphur and Phosphorusin comparison to other crops (Chaurasiya et al., 2019; Rakesh and Banki, 2016; Singh and Thenua, 2016; Singh et al., 2015). Sulphur and Phosphorus are essential for the growth and development of all crops especially for Oleiferous Brassica crops (Aulakh et al., 1980). The secret to apply nutrients in a balanced way for increased yields and better-quality products is Sulphur. Generally speaking, 97% of Bangladesh's soils lack sufficient amounts of

| Quick Response Code | Access this article online | |
|---|---|---|
| | Website: www.actascientificamalaysia.com | DOI: 10.26480/asm.02.2024.62.66 |

Cite The Article: Md. Khairul Islam, Md. Parvez Anwar, Md. Rashedur Rahman, Md. Rasheduzzaman (2024). Response of Sulphur and Phosphorus on Yield and Yield Attributes of Mustard in Old Brahmaputra Floodplain Area of Bangladesh. *Acta Scientifica Malaysia, 8(2): 62-66.*

phosphorus and Sulphur. This shortage is getting worse presently because of the widespread use of fertilizers devoid of Sulphur and phosphorus as well as the intensive crop production (Islam and Rahman, 2021). Thus, in Bangladesh, higher yield per unit area of land is essential to raise total production. Using improved cultivars and implementing better field-level fertilizer management techniques can help accomplish this.

However, there is a limited literature are available about the effect of Sulphur and Phosphorus on the physiological, biological, and economic aspects of rapeseed mustard in Bangladesh. Therefore, the present study aims to assess the effect of Sulphur and Phosphorus on the yield contributing characters, yield, and oil content of Mustard (BARI Sharisha-18) (canola type). Furthermore, this study also determines the suitable dose of Sulphur and Phosphorus for the increased yield, and oil content of mustard variety (BARI Sharisha-18) in Bangladesh.

## 2. Materials and Methods

### 2.1 Description of experimental site

The study was carried out from November 15, 2020 to February 24, 2021 during the Rabi season at the Agronomy research field of Bangladesh Agricultural University, Mymensingh. Geographically, the experimental field was located at 24° 75″ N latitude and 90° 50″ E longitudes in the southwest part of old Brahmaputra River at an elevation of 18 meter above the sea level. This site belongs to the non-calcareous dark grey floodplain soil under old Brahmaputra Floodplain AEZ-9. The experimental field was a medium high land with well drained silt loam textured having a $p^H$ value of 6.5. From early February through November, there was a moderately cold air temperature, and during the remaining months, there was a high air temperature. Throughout the research period, the average air temperature ranged from 16.46°C to 24.24°C. The average relative humidity was 74.18% to 83.71% and the total sunshine ranged between 132.9 to 203.9 hours month$^{-1}$ from November to February.

### 2.2 Characteristics of the Test Variety

The mustard variety namely, BARI Sharisha-18 (canola type), developed by Bangladesh Agricultural Research Institute, Joydebpur, Gazipur was used in the present experiment. Among these varieties, BARI Sharisha-18 (canola type) produces high yield and have high nutritional value. It is the first variety of "canola type" characteristics in Bangladesh. The BARI developed this variety in 2018 by selecting Australian BN-1404 line. The plant height is comparatively low (88-126 cm). This variety contain 1.06 percent erucic acid compared to others cultivated varieties in Bangladesh (contains 35-40 % erucic acid). It is a short duration plant and its life duration is 95-100 days. This variety produces 2.0-2.5 tha$^{-1}$(500-600 kg./acre) yield if proper intercultural management is practiced and this mustard seeds contain 40-42% oil. Therefore, this variety may have the potential of commercial cultivation considering its nutritional values. In response to nutritious value, BARI Sharisha-18 (canola type) variety could play an important role in commercial cultivation. It could provide the advantages of sustainable agriculture in Bangladesh.

### 2.3 Experimental Design, Treatments, and Land Preparation

The study adopted two factors i.e. Sulphur and Phosphorus and four treatments of each one. The four treatments of Sulphur were 0 kg S ha$^{-1}$ ($S_0$); 15 kg S ha$^{-1}$ ($S_1$); 25 kg S ha$^{-1}$ ($S_2$); and 35 kg S ha$^{-1}$ ($S_3$). Again, the four treatments of Phosphorus were 0 kg P ha$^{-1}$ ($P_0$); 25 kg P ha$^{-1}$($P_1$); 35 kg P ha$^{-1}$ ($P_2$) and 45 kg P ha$^{-1}$ ($P_3$). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There was a total of 48 plots for the experiment. The size of unit plot was 4 m × 2.5 m. Distance between plot to plot was 50.0 cm and the distance between replication to replication was 1.0 m. The row to row and plant to plant distances within a row were 30.0 cm and 15.0 cm, respectively. The experimental plot was opened on November 1, 2020, and on November 15, 2020, it was prepared for seeding by power tilling three times, then plowing with a country plough and laddering. The land's corner was leveled, and the larger clods that were visible were pounded into tiny fragments. The field was free of any weeds or stubble. Each experimental plot received fertilization at the appropriate rates determined by the treatments at the time of the last land preparation. Four levels of Triple super phosphate (Sulphur) and Gypsum (Phosphorus) as treatment were applied by mixing with urea and Muriate of Potash (MoP) as their recommended dose. The total amount of Urea and Muriate of Potash applied@ 220, 80 kg ha$^{-1}$, respectively. Urea was applied in two equal splits. Half applied at final land preparation and rest amount of urea applied in the flowering time.

### 2.4 Intercultural Operations, Harvesting, Processing, Sampling, and Data Analysis

The seed was collected from Bangladesh Agricultural Research Institute and sown in plots on November 15, 2020, manually in line in each plot uniformly maintaining the fixed spacing. After sowing, the seeds were covered with the loose soil by hand. All the intercultural operations were performed effectively. Thinning was done twice at 15 and 35 days after sowing (DAS) and it was done by uprooting of seedlings from the plots where plant population was thick. A light irrigation was given on 25 DAS. At the time of flowering irrigation was not needed due to presence of enough moisture in the soil. Weeds were controlled twice manually at 18 and 34 DAS. Insecticide viz. dursbun (chloropyrophos) 20EC was applied to control cut warm (*Agrotisipsilon*). Mustard plants were harvested from each plot with sickle at fully matured (i.e. when 95% siliqua became brown) on February 24, 2021. The harvested plants were kept for five days in the field and then brought to the threshing floor for threshing. Finally, the threshing was done and grain was collected. Before harvesting randomly selected five sample plants were uprooted from each unit plot to collect data on different vegetative and yield contributive characters. The data were recorded during the harvesting time on the basis of following parameters: Plant height (cm); Number of branches plant$^{-1}$; Number of siliqua plant$^{-1}$; Number of seeds siliqua$^{-1}$; 1000-seed weight (g); Seed yield (t ha$^{-1}$); Stover yield (t ha$^{-1}$); Biological yield (t ha$^{-1}$); Harvest index (%); Extracted oil (ml kg$^{-1}$ seed); and Percent oil extract. Among those, the biological yield was calculated using the following equation.

Biological yield = Seed yield (t ha$^{-1}$) + Stover yield (t ha$^{-1}$).

Furthermore, the harvest index was calculated by dividing the actual yield of seed bythe biological yield of the crop and expressed by following formula.

$$\text{Harvest index (\%)} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

Finally, a statistical analysis was performed on the gathered data on several criteria to determine the degree of relevance using MSTAT-C package program. The mean differences were compared by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Finally, an economic analysis was performed considering the cost of different inputs and gross returns at local charges. The following formulas were used to compute the benefit cost ratio, net return, and gross return.

Gross return = Amount of production × Price

Gross return = Gross return − Total cost of Production

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return}}{\text{Cost of Production}}$$

## 3. Results and Discussion

### 3.1 Effect of Sulphur, Phosphorus and their interaction on growth, yield and yield contributing characters of mustard

The effect of treatments on growth, yield, yield attributes, and oil content are presented in the following sections. The effect of different Sulphur level of treatment on BARI Sharisha-18 is presented in Table 1. Furthermore, Table 2 showed the effects of different Phosphorus level of treatment on BARI Sharisha-18. Moreover, the interaction effect of Sulphur and Phosphorus is presented in Table 3.

#### *3.1.1 Plant height*

Firstly, the level of Sulphur had no significant effect on plant height. But the level of Phosphorus had significant effect on it at 5% level and found the tallest plant (104.98 cm) was recorded from the application of 45 kg P ha$^{-1}$followed by 25 kg P ha$^{-1}$ (104.89 cm) (Table 2). Therefore, the study informs that the usage of Phosphorus could improve the plant height. Singh et al. (2018) observed that application of phosphorus increased plant height significantly up to 25 kg $P_2O_5$ ha$^{-1}$. Further, the plant height was significantly influenced by the interaction effect of Sulphur and Phosphorus level at 5% level (Table 3) and produced the tallest plant (108.93 cm) from the interaction between 25 kg P ha$^{-1}$ and 15 kg S ha$^{-1}$(P2×S1) compared with other interactions. The results are in aligned with the report of (Singh et al., 2018).

#### *3.1.2 Number of branches plant$^{-1}$*

The study found that there is no significant effect of Sulphur and Phosphorus on the number of branches plant$^{-1}$ individually. However, the

interaction effect showed that the number of branches plant$^{-1}$ was significantly influenced by the interaction of Sulphur and Phosphorus at 5% level (Table 3) and the highest number of branches plant$^{-1}$ (6.60) was recorded from the interaction between 25 kg P ha$^{-1}$ with 0 kg S ha$^{-1}$(Table 3). A study in 2010 observed that the combined application of Phosphorus and Sulphur @ 60 kg P ha$^{-1}$ and 30 kg S ha$^{-1}$ produced the maximum number of primary branches plant$^{-1}$ rather than the control plot (Mishra et al., 2010).

### 3.1.3 Number of pods plant$^{-1}$

The number of pods plant$^{-1}$ was significantly influenced by different levels of Sulphur at 1% level. The maximum number of pods plant$^{-1}$ (67.58) was recorded from application of 15 kg S ha$^{-1}$ (Table 1). However, Phosphorus had no significant effect on the number of pods plant$^{-1}$ in this present study. Moreover, the number of pods plant$^{-1}$ was significantly influenced by the interaction effect of Sulphur and Phosphorus at 5% level (Table 3). Among different levels of interaction, the highest number of pods plant$^{-1}$ (72.33) was recorded from interaction between 35 kg P ha$^{-1}$ and 15 kg S ha$^{-1}$ compared with other interactions.

### 3.1.4 Number of seeds pod$^{-1}$

The number of seeds pod$^{-1}$ was significantly impacted by different levels of Sulphurat 5% level, and the highest number of seeds pod$^{-1}$ (2.44) was recorded from the treatment of 15 kg S ha$^{-1}$ followed by 0 kg S and 25 kg S ha$^{-1}$(Table 1). Similarly, the number of seeds pod$^{-1}$ was significantly influenced by Phosphorus at 5% level. The maximum number of seeds pod$^{-1}$ (2.46) was recorded from the application of 35 kg P ha$^{-1}$ where the minimum number of seeds pod$^{-1}$ (2.27) was found from the application of 0 kg P ha$^{-1}$ (Table 2). Research reported the same result that Phosphorus significantly increased the number of seeds pod$^{-1}$ (Singh and Thenua, 2016). Sulphur and Phosphorus interacted significantly in producing the number of seeds pod$^{-1}$at 5% level. The maximum number of seeds pod$^{-1}$ (2.57) was recorded from the application of 35 kg P ha$^{-1}$ and 15 kg S ha$^{-1}$ (Table 3).

### 3.1.5 1000 seeds weight

The weight of 1000 seeds was significantly influenced by different levels of Sulphurat 5% level.The result revealed that application of 15 kg S ha$^{-1}$ had highest 1000 seeds weight (4.569g) which was statistically higher than that of 25 kg S and 35 kg S ha$^{-1}$ (Table 1). Singh and Thenua, also reported that 1000 seeds weight was significantly increased with the application of 40 kg S ha$^{-1}$ (Singh and Thenua, 2016). However, the weight of 1000 seeds were not significantly influenced by the application of different levels of Phosphorus. Furthermore, the study also showed the effect of interaction and reported that the interaction of Sulphur and Phosphorus was significant in producing 1000 seeds weight at 5% level. The highest weight of 1000 seeds (4.64g) was recorded from the interaction from the application of 45 kg P ha$^{-1}$ with 15 kg S ha$^{-1}$ compared with other interactions (Table 3).

### 3.1.6 Biological yield

The study found that the effect of Sulphur level showed significant effect on biological yield at 5% level but not significant by Phosphorus level. Furthermore, the study reported that 35 kg S ha$^{-1}$ produced the highest (3.73 t ha$^{-1}$) biological yield which is significantly superior to all the levels of Sulphur treatments (Table 2). Moreover, the interaction of Sulphur and Phosphorus had a significant effect on biological yield at 5% level (Table 3). The highest biological yield (4.79 t ha$^{-1}$) was recorded from the combined application of 25 kg P ha$^{-1}$ and 35 kg S ha$^{-1}$.

### 3.1.7 Harvest index

It was observed that Sulphur had a significant effect on harvest index at 5% level. The highest harvest index (43.60%) was recorded from the treatment of 15 kg S ha$^{-1}$(Table 1). An experiment was conducted in 2018 and reported that harvest index was significantly influenced due to Sulphur levels on yield and yield contributing character at all stages (Singh et al., 2018). However, Phosphorus had no significant effect on harvest index. Furthermore, the interaction effect was significant on harvest index at 5% level and found that the maximum value of harvest index (45.89%) was found from interaction from 15 kg S ha$^{-1}$ with 25 kg P ha$^{-1}$ (Table3).

**Table 1:** Effect of Sulphur level on growth, yield and yield contributing characters of mustard

| Sulphur levels | Plant height (cm) | No. of branches plant$^{-1}$ | No. of pods plant$^{-1}$ | No. of seeds pod$^{-1}$ | 1000 seeds weight (g) | Biological yield (t ha$^{-1}$) | Harvest index (%) | Seed yield (t ha$^{-1}$) | Stover yield (t ha$^{-1}$) | Extracted oil (ml kg$^{-1}$ seed) | Percent oil extracted |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_0$ | 102.25 | 6.17 | 53.28b | 2.42a | 4.13ab | 2.16b | 41.28ab | 0.89b | 1.27b | 313.33b | 31.05 |
| $S_1$ | 105.26 | 6.17 | **67.58a** | **2.44a** | **4.56a** | 2.32b | **43.60a** | 1.01a | 1.31b | 360.42ab | 30.89 |
| $S_2$ | 99.43 | 5.75 | 55.03b | 2.20b | 4.09b | 2.12b | 41,12ab | 0.87b | 1.24b | 309.58b | 29.74 |
| $S_3$ | 101.24 | 5.77 | 60.28ab | 2.34ab | 4.31ab | **3.73a** | 35.14b | **1.02a** | **2.71a** | **371.67a** | **32.41** |
| S$\bar{x}$ | 1.22 | 0.12 | 3.21 | 0.05 | 0.11 | 0.39 | 3.27 | 0.04 | 0.36 | 15.94 | 0.55 |
| Level of sig. | NS | NS | ** | * | * | * | * | ** | * | * | NS |
| CV (%) | 7.64 | 15.07 | 15.95 | 9.90 | 12.74 | 9.79 | 19.85 | 11.06 | 12.78 | 19.39 | 11.28 |

Means with the same letters or without letters within the same column do not differ significantly.

** = Significant at 1% level of probability. *= Significant at 5% level of probability, NS = Not significant

$S_0$ = 0 kg ha$^{-1}$, $S_1$ = 15 kg ha$^{-1}$, $S_2$ = 25 kg ha$^{-1}$, $S_3$ = 35 kg ha$^{-1}$

**Table 2:** Effect of Phosphorus level on growth, yield and yield contributing characters of mustard

| Phosphorus levels | Plant height (cm) | No. of branches plant$^{-1}$ | No. of pods plant$^{-1}$ | No. of seeds pod$^{-1}$ | 1000 seeds weight (g) | Biological yield (t ha$^{-1}$) | Harvest index (%) | Seed yield (t ha$^{-1}$) | Stover yield (t ha$^{-1}$) | Extracted oil (ml kg$^{-1}$ seed) | Percent oil extracted |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_0$ | 96.37b | 6.15 | 61.10 | 2.27b | 4.26 | 2.25 | 38.66 | 0.86b | 1.39 | 290.00b | 29.77 |
| $P_1$ | 104.89a | 6.13 | 57.40 | 2.38ab | 4.34 | 2.85 | 40.16 | 0.97a | 1.88 | 348.33ab | 32.05 |
| $P_2$ | 101.95ab | 5.72 | 55.20 | **2.46a** | 4.28 | 2.89 | 41.43 | **1.01a** | 1.88 | **377.50a** | 31.69 |
| $P_3$ | **104.98a** | 5.85 | 62.48 | 2.29ab | 4.20 | 2.35 | 40.97 | 0.95ab | 1.39 | 339.17ab | 30.58 |
| S$\bar{x}$ | 2.02 | 0.11 | 1.67 | 0.04 | 0.03 | 0.17 | 3.27 | 0.03 | 0.14 | 18.19 | 0.52 |
| Level of sig. | * | NS | NS | * | NS | NS | NS | * | NS | * | NS |
| CV (%) | 7.64 | 15.07 | 15.95 | 9.90 | 12.74 | 9.79 | 19.85 | 11.06 | 12.78 | 19.39 | 11.28 |

Means with the same letters or without letter within the same column do not differ significantly.

*= Significant at 5% level of probability, NS = Not significant

$P_0$ = 0 kg ha$^{-1}$, $P_1$= 25 kg ha$^{-1}$, $P_2$ = 35 kg ha$^{-1}$, $P_3$ = 45 kg ha$^{-1}$

**Table 3:** Interaction effect of Phosphorus and Sulphur levels on yield contributing characters and yield of mustard

| Phosphorus levels × Sulphur levels | Plant height (cm) | No. of branches plant$^{-1}$ | No. of pods plant$^{-1}$ | No. of seeds pod$^{-1}$ | 1000 seeds weight (g) | Biological yield (t ha$^{-1}$) | Harvest index (%) | Seed yield (t ha$^{-1}$) | Stover yield (t ha$^{-1}$) | Extracted oil (ml kg$^{-1}$ seed) | Percent oil extracted |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_0 \times S_0$ | 99.77ab | 5.87ab | 49.20c | 2.39ab | 4.34ab | 2.01c | 43,94ab | 0.88b-e | 1.13b | 290.00bc | 29.26ab |
| $P_0 \times S_1$ | 97.63ab | **6.73a** | 70.80ab | 2.38ab | 4.51ab | 2.23a-c | 39.08ab | 0.87c-e | 1.36ab | 311.67bc | 32.60ab |
| $P_0 \times S_2$ | 95.30b | 5.53ab | 54.00a-c | 2.13b | 3.80ab | 2.07c | 35.86ab | 0.75e | 1.32ab | 238.33c | 28.28ab |
| $P_0 \times S_3$ | 92.77b | 6.47ab | 70.40ab | 2.17b | 4.40ab | 2.68a-c | 35.81ab | 0.94a-d | 1.74ab | 320.00bc | 28.95ab |
| $P_1 \times S_0$ | 105.60ab | 6.60a | 53,00bc | 2.43ab | 4.18ab | 2.28a-c | 39,32ab | 0.89a-e | 1.38ab | 333.33bc | 30.30ab |
| $P_1 \times S_1$ | 105.67ab | 5.93ab | 60.27a-c | 2.44ab | 4.43ab | 2.28a-c | 45.89ab | 1.04ab | 1.23ab | 343.33a-c | 32.16ab |
| $P_1 \times S_2$ | 105.20ab | 6.13ab | 60.53a-c | 2.23ab | 4.29ab | 2.05c | 43.27ab | 0.89a-e | 1.17b | 323.33bc | 32.74ab |
| $P_1 \times S_3$ | 103.10ab | 5.87ab | 55.80a-c | 2.41ab | 4.48ab | **4.79a** | 32.24b | 1.05ab | **3.74a** | 393.33ab | 32.97ab |
| $P_2 \times S_0$ | 104.67ab | 6.33ab | 52.93bc | 2.48ab | 4.34ab | 2.24a-c | 42.15ab | 0.94a-d | 1.30ab | 336.67bc | 32.19ab |
| $P_2 \times S_1$ | **108.93a** | 5.67ab | 66.93a-c | **2.57a** | **4.66a** | 2.32a-c | **45.92a** | **1.06a** | 1.26ab | **463.33a** | 32.46ab |
| $P_2 \times S_2$ | 93.93b | 5.87ab | 50.47c | 2.34ab | 4.06ab | 2.30a-c | 43.02ab | 0.99a-d | 1.31ab | 336.67bc | 27.05b |
| $P_2 \times S_3$ | 100.27ab | 5.00b | 50.47c | 2.47ab | 4.08ab | 4.67ab | 34.61ab | 1.04a-c | 3.64ab | 373.33ab | **35.03a** |
| $P_3 \times S_0$ | 98.97ab | 5.87ab | 58.00a-c | 2.45ab | 3.68b | 2.10bc | 39.70ab | 0.83de | 1.27ab | 293.33bc | 32.43ab |
| $P_3 \times S_1$ | 108.80a | 6.33ab | **72.33a** | 2.29ab | 4.64a | 2.45a-c | 43.55ab | 1.05ab | 1.40ab | 323.33bc | 26.34b |
| $P_3 \times S_2$ | 103.30ab | 5.47ab | 55.13a-c | 2.12b | 4.20ab | 2.04c | 42.49ab | 0.86de | 1.18b | 340.00bc | 30.87ab |
| $P_3 \times S_3$ | 108.83a | 5.73ab | 64.47a-c | 2.31ab | 4.29ab | 2.78a-c | 38.09ab | 1.06a | 1.72ab | 400.00ab | 32.67ab |
| $S\bar{x}$ | 1.32 | 0.11 | 1.95 | 0.03 | 0.07 | 0.22 | 3.27 | 0.02 | 0.20 | 12.84 | 0.61 |
| Level of significance | * | * | * | * | * | * | * | * | * | * | * |
| CV (%) | 7.64 | 15.07 | 15.95 | 9.90 | 12.74 | 9.79 | 19.85 | 11.06 | 12.78 | 19.39 | 11.28 |

Means with the same letters within the same column do not differ significantly.

*= Significant at 5% level of probability

$S_0$ = 0 kg ha$^{-1}$, $S_1$ = 15 kg ha$^{-1}$, $S_2$ = 25 kg ha$^{-1}$, $S_3$ = 35 kg ha$^{-1}$

$P_0$ = 0 kg ha$^{-1}$, $P_1$= 25 kg ha$^{-1}$, $P_2$ = 35 kg ha$^{-1}$, $P_3$ = 45 kg ha$^{-1}$

### *3.1.8 Seed yield*

Seed yield of mustard was significantly influenced by Sulphur level at 1% level. Statistically the highest seed yield (1.02 t ha$^{-1}$) was recorded from the treatment of 35 kg S ha$^{-1}$ (Table 1). Observed that the highest seed yield was recorded at 45 Kg S ha$^{-1}$ (Yadav and Dhanai, 2018). Similarly, Phosphorus level had significant effect on mustard seed yield at 5% level. The maximum seed yield (1.01 t ha$^{-1}$) was obtained from the application of 35 kg Pha$^{-1}$. Similar findings were found by Singh and Thenua, 2016. They reported that the application of Phosphorus significantly increases the seed yield of mustard. Further, the interaction of Sulphur and Phosphorus had significant effect on mustard seed yield at 5% level. Statistically the maximum yield (1.06 t ha$^{-1}$) was recorded from the application of 35 kg P ha$^{-1}$ with 15 kg S ha$^{-1}$(Table 3).

### *3.1.9 Stover yield*

Stover yield was significantly influenced by different levels of Sulphur at 5% level. The highest stover yield (2.71 t ha$^{-1}$) was recorded from the treatment of 35 kg S ha$^{-1}$. It is shown that stover yield increased with increase in the Sulphur level. The result was confirmed with the finding of Singh et al., 2018. However, stover yield was not significantly influenced by the application of different levels of Phosphorus. But the fact is that Phosphorus interaction with Sulphur showed significant results on stover yield at 5% level. The highest stover yield (3.74 t ha$^{-1}$) was recorded from the interaction between 25 kg P ha$^{-1}$ and 35 kg S ha$^{-1}$ (Table 3).

### *3.1.10 Extracted oil*

The study confirmed that the effect of Sulphur and Phosphorus on extracted oil was significant individually at 5% level. Further, the highest extracted oil (371.67 ml kg$^{-1}$ seed) was obtained from application of 35 kg S ha$^{-1}$(Table 1) and (377.50 ml kg$^{-1}$ seed) was recorded from the application of 35 kg P ha$^{-1}$ (Table 2). Moreover, the interaction effect of Sulphur and Phosphorus had significant effect on extracted oil at 5% level. The highest extracted oil (463.33 ml kg$^{-1}$ seed) was recorded from the interaction of 35 kg P ha$^{-1}$ with 15 kg S ha$^{-1}$ (Table 3).

### *3.1.11 Percent oil extracted*

The study found that the individual effect of Sulphur and Phosphorus on percent oil extracted was not significant. However, the interaction effect of Sulphur and Phosphorus had significant effect on percent oil extractedat 5% level. The highest percent oil extracted (35.03%) was recorded from the interaction of 35 kg P ha$^{-1}$ with 35 kg S ha$^{-1}$ (Table 3).

### *3.1.12 Financial analysis of Mustard*

The financial analysis of the response of different doses of Sulphur and Phosphorus is reported in Table 4. The results found that the highest BCR was found at the treatment of $P_2 \times S_1$. Therefore, in this scenario, it is possible to earn BDT. 1.58 by investing BDT. 1.00 in mustard production in Bangladesh. The result is aligned with (Sampa et al., 2020). Therefore, we could promote the utilization of mustard in the farmer's community for better profitability.

**Table 4:** Financial analysis of the response of Sulphur and Phosphorus on mustard

| Phosphorus levels × Sulphur levels | Gross Return (BDT) | Total Cost of Production (BDT) | Net Return (BDT) | Benefit Cost Ratio (BCR) |
|---|---|---|---|---|
| $P_0 \times S_0$ | 89130.00 | 66600.00 | 22530.00 | 1.34 |
| $P_0 \times S_1$ | 88360.00 | 67000.00 | 21360.00 | 1.32 |
| $P_0 \times S_2$ | 76320.00 | 67275.00 | 9045.00 | 1.13 |
| $P_0 \times S_3$ | 95740.00 | 67545.00 | 28195.00 | 1.42 |
| $P_1 \times S_0$ | 90380.00 | 67350.00 | 23030.00 | 1.34 |
| $P_1 \times S_1$ | 105230.00 | 67765.00 | 37465.00 | 1.55 |
| $P_1 \times S_2$ | 90170.00 | 68025.00 | 22145.00 | 1.33 |
| $P_1 \times S_3$ | 107040.00 | 68025.00 | 39015.00 | 1.57 |

| **Table 4:** Financial analysis of the response of Sulphur and Phosphorus on mustard | | | | |
|---|---|---|---|---|
| $P_2 \times S_0$ | 95300.00 | 67650.00 | 27650.00 | 1.41 |
| $P_2 \times S_1$ | 107260.00 | 68055.00 | 39205.00 | **1.58** |
| $P_2 \times S_2$ | 100310.00 | 68325.00 | 31985.00 | 1.47 |
| $P_2 \times S_3$ | 107640.00 | 68595.00 | 39045.00 | 1.57 |
| $P_3 \times S_0$ | 84270.00 | 67950.00 | 16320.00 | 1.24 |
| $P_3 \times S_1$ | 106400.00 | 68355.00 | 38045.00 | 1.56 |
| $P_3 \times S_2$ | 87180.00 | 68625.00 | 18555.00 | 1.27 |
| $P_3 \times S_3$ | 107720.00 | 68895.00 | 38825.00 | 1.56 |

Note: $S_0$ = 0 kg ha$^{-1}$, $S_1$ = 15 kg ha$^{-1}$, $S_2$ = 25 kg ha$^{-1}$, $S_3$ = 35 kg ha$^{-1}$

$P_0$ = 0 kg ha$^{-1}$, $P_1$= 25 kg ha$^{-1}$, $P_2$ = 35 kg ha$^{-1}$, $P_3$ = 45 kg ha$^{-1}$

## 4. Conclusion

The study highlighted that Sulphur significantly influenced the number of pods plant$^{-1}$ at 1% level and number of seeds pod$^{-1}$, 1000 seeds weight, biological yield, harvest index, seed yield, stover yield and extracted oil at 5% level of significance. On the other hand, Phosphorus showed significant influence on plant height, number of seeds pod$^{-1}$, seed yield and extracted oil at 5% level of significance. The interaction effect of Sulphur and Phosphorus showed significant effect on every parameter of this study. The individual application of 15 and 35 kg ha$^{-1}$Sulphur and 35 kg ha$^{-1}$ Phosphorus showed better response on yield and yield attributes of Mustard. The interaction effect of $P_2 \times S_1$ which is 35 kg ha$^{-1}$ Phosphorus and 15 kg ha$^{-1}$Sulphur reported the highly effective on yield, yield attributes, and financial profitability of mustard variety viz. BARI Sharisha-18 (canola type).

## Conflicts of Interest

The authors of this research work declare that they have no potential conflict of personal or economic interest with other people or organization that could unduly influence this manuscript.

## Acknowledgement

The author would like to acknowledge the Department of Agronomy, Faculty of Agriculture, Bangladesh Agricultural University, Mymensing for allowing the research to be conducted in their facility.

## References

Aulakh, M.S., Pasricha, N.S.Sahota, N.S., 1980. Yield, nutrient concentration and quality of mustard crop as influenced by nitrogen and sulphur fertilizers. J. Agric. Sci. 94, Pp. 545-549.

BBS (Bangladesh Bureau of Statistics), 2022. Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Government of Bangladesh.

Chaurasiya, A., Patel, S., Singh, S., Singh, V., Singh, N., Singh, A., Correspondence, V., Singh, 2019. Effect of Nitrogen and Sulphur nutrition on interaction effect, quality parameters, nutrient content or uptake and economics of Indian mustard (Brassica juncea L.) in western UP.Int. J. Chem. Stud. 7(1), Pp. 787-791.

Gomez, K.A. and Gomez, A.A., 1984. Statistical Procedures for Agricultural Research.A Wiley Int. Sci. Pub.John Wiley and Sons, New York, Brisbane, Singapore. Pp. 139-240.

Islam, M.A. Rahman, S. M., 2021. Effect of sulphur containing fertilizer and poultry manure on the growth and yield of BARI Sarisha-15 in HSTU soil. Int. J. Agric. Med. Plants. 2(4), Pp. 1-9.

Islam, S., Rahman, M.H., Haque, M.R., Sarkar, M.M.A. Sultana, R., 2021. An economic study on sesame variety Binatil-3 in some selected areas of Bangladesh. IOSR J. Agric. Vet. Sci. 14 (1), Pp. 21-26. http://dx.doi.org/10.9790/2380-1401012126

Mishra, S.V., Maurya, D., Gupta, G., 2010. Effect of phosphorus and sulphur and their interaction on mustard crop. Asian Sci. 5(2), Pp. 79-84.

Rakesh, S., Banik, G.C., 2016. Effect of Sulphur levels and sources on growth, yield and quality of Mustard in Terai region of West Bengal. Ann. Plant Soil Res. 18(2), Pp. 152-155.

Sampa, A.Y, Sarker, F., Rahman, M.R., Begum, R., 2021.Profitability and Resource Use Efficiency of Mustard Cultivation. SAARC J. Agric. 18(2), Pp. 195–206. https://doi.org/10.3329/sja.v18i2.51119

Sarkar, M.M.A., Rahman, M.H., Haque, M.R., Islam, S., Sultana, R., 2020. An economic study of the oilseed Mustard variety Binasarisha-4 production in some selected areas of Bangladesh. Saudi J. Econ. Fin. 4(11), Pp. 506-512. http://doi.org/10.36348/sjef.2020.v04i11.001

Saweda, L., Omonona, B.T., Sanou, A., Ogunleye, W., 2017. Is increasing inorganic fertilizer use for maize production in SSA a profitable proposition? Evidence from Nigeria.Food Policy. 67, Pp. 41-51. https://doi.org/10.1016%2Fj.foodpol.2016.09.011

Sharif, R., Paul, R., Bhattacharjya, D., Ahmed, K., 2017. Physicochemical characters of oilseeds from selected mustard genotypes. J. Bangladesh Agric. Univ. 15, Pp. 27-40. http://dx.doi.org/10.3329/jbau.v15i1.33527

Singh, D.P., Upadhyay, P.K., Singh, M.P.,Ashutosh, S., 2018. Effect of phosphorus and sulphur level on growth, yield and oil content of mustard (Brassica juncea L.). Int. J. Agric. Sci. 14(2), Pp. 376-380. http://doi.org/10.15740/HAS/IJAS/14.2/376-380

Singh, S.B., Thenua, O.V.S., 2016. Effects of phosphorus and sulphur fertilization on yield and NPS uptake by Mustard (Bras sicajuncea L.).Progress. J. Int. J. 11 (1), Pp. 80-83.

Singh, U., Tomar, S.S., Rameshwar, Choudhary, S., 2015. Yield, nutrient uptake and economics of Indian mustard as influenced by varieties, sources and levels of Sulphur. Ann. Plant Soil Res. 17(3), Pp. 266-268.

Yadav, M.S., Dhanai, C.S., 2018. Effect of fertilizers on yield and yield attributing characters of mustard (Brassica juncea L. Czern, Coss). J.Pharmacogl. Phytochem. 7(2), Pp. 2300-2303.