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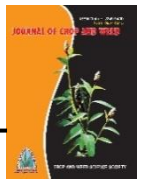

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# Assessment of Indian mustard varieties based on their phenological and yield attributing characteristics in Gangetic Plains of West Bengal

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**ABSTRACT**

*During rabi season of 2021-2022, a field experiment was undertaken at the District Seed Farm, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India. The experiment employed a Randomized Complete Block Design (RCBD) comprising seven treatments, each representing a different variety of Indian Mustard (Pusa Mustard 25, Pusa Mustard 26, Pusa Mustard 27, Pusa Mustard 28, Pusa Mustard 30, Pusa Mustard 31, and Pusa Vijay), with three replications. The experimental results unveiled significant differences among the varieties regarding phenology, yield-attributing characteristics and yield. Regarding phenology, it was observed that the duration required for flower initiation, 50% flowering, 100% flowering and maturity were the longest in Pusa Mustard 28, recording as 48 days, 56 days, 65 days and 109 days, respectively. Pusa Mustard 28 also showed the highest number of branches and siliqua per plant. Furthermore, Pusa Vijay produced the heaviest seeds, with a 1000-seed weight of 4.26 grams. Pusa Mustard 31 exhibited the highest number of seeds per siliqua (16.3), while Pusa Mustard 25 produced the longest siliqua with an average of 6.35 cm. With superior yield-attributing characteristics, Pusa Mustard 28 achieved the highest seed yield (1409 kg ha$^{-1}$). In the evaluation of phenology, yield and yield-attributing characteristics, Pusa Mustard 28 and Pusa Mustard 31 demonstrated notably superior performance among all the varieties.*

**Keywords:** Mustard, phenology, seed yield, silique and variety

Oilseed crops have occupied a crucial position in Indian agriculture for decades, constituting a significant component of human nutrition (Shah *et al.*, 2022). Among them, mustard stands out as superior to all other oilseeds in India. Rapeseed-mustard, belonging to the family Cruciferae (Brassicaceae), ranks as the third most important oilseed crop cultivated in this country (Chaudhary *et al.*, 2023). Mustard accounts for about 28.6% of India's overall edible oil production (Shekhawat *et al.*, 2012). The cultivation of this crop is of great importance to the Indian economy. Despite boasting the world's largest area dedicated to oilseed cultivation, India continues to import significant quantities of edible oils (Hegde and Sudhakara, 2011). Mustard cultivation is primarily concentrated in states such as Rajasthan, Uttar Pradesh, Haryana, and Madhya Pradesh. In India, eight different groups of rapeseed-mustard ~~groups~~ are primarily cultivated for edible oil production. Moreover, there is a growing trend of cultivating mustard in unconventional areas like West Bengal, Karnataka, Tamil Nadu, Andhra Pradesh and Assam.

Although West Bengal's diverse agro-ecological conditions are conducive to cultivating all nine oilseeds, the major oilseed crops grown in the state are rapeseed-mustard, sesame, groundnut, and sunflower. In West Bengal, rapeseed mustard accounts for 53% of the overall oilseed production (Dutta, 2014). It is cultivated in the state under sub-tropical climates as a cold-weather crop, either under irrigated or limited irrigated conditions (Ray *et al.*, 2015).

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Despite this, the state's contribution to national production is only 6.07% (Economic Review, 2015). The crop's productivity in the state, as 1066 kg $ha^{-1}$, is considerably lower compared to that of developed countries, primarily because of the cultivation of traditional varieties with limited yield potential (De *et al.*, 2014; Directorate of Agriculture, 2015). Enhanced productivity of Indian mustard can be attained through the adoption of appropriate agronomic management practices and improved genotypes. Improved agricultural practices such as employing superior cultivars, real-time sowing, appropriate sowing techniques, optimal nutrient and water management, strategic weed control and timely harvesting contribute significantly ~~to~~ in enhancing the productivity of this crop. The choice of varieties primarily depends on various factors including the time of sowing, cropping system, land conditions, pest management, water availability and prevailing climatic conditions.

Nevertheless, the overall trend of rapeseed-mustard cultivation in west Bengal has been on the rise over the past five years, attributed to the adoption of new varieties with enhanced yield potential (Biswas *et al*., 2019). Given the existing gap between demand and supply of edible oil in this state, there remains substantial growth potential in this sector (Banerjee *et al*., 2017). Emphasizing this context, the current study was conducted in 2021-22 focused on Indian mustard varieties with the aim of identifying the most suitable variety for the Gangetic Plains of West Bengal based on phenological and yield attributing characteristics.

An experiment was carried out during the rabi season (November-March) of 2021-2022 at the District Seed Farm, Kalyani Simanta, affiliated with Bidhan Chandra Krishi Viswavidyalaya, situated in West Bengal, India (Latitude 22º58´ N and Longitude 88º32´ E). The study site's terrain is flat, with an altitude of 9.75 meters above mean sea level (AMSL) and falls under a sub-tropical climate. The average annual rainfall in the area is approximately 1400 mm, with 70-80% occurring during the monsoon season. During the crop growing period, temperature ranged between 6.1°C to 31.8°C, while relative humidity fluctuated between 52.2% and 92.12%. The land conditions were characterized as medium, well-drained, with sandy loam soil of moderate fertility and nearly neutral pH (7.2).

Seven distinct varieties of Indian mustard (Pusa Mustard 31, Pusa Mustard 25, Pusa Mustard 26, Pusa Mustard 27, Pusa Mustard 28, Pusa Mustard 30, and Pusa Vijay) underwent comprehensive evaluation for their phenological attributes and yield-related characteristics.

The experimental setup utilized a Randomized Complete Block Design (RCBD) with three replications and seven distinct varieties serving as treatments, thus leading to a total of 21 plots. Each plot covered an area of 4 meters by 3 meters, with a plant spacing of 30 centimeters by 10 centimeters. Standard agronomic practices were meticulously adhered to from land preparation to harvesting. The complete doses of nitrogen, phosphorus, and potassium amounting to 60 kg, 30 kg and 30 kg per hectare respectively, were applied during the final land preparation using Urea, SSP and MOP respectively. Seeds were sown in shallow furrows @4 kg per hectare. Two rounds of irrigation were administered, one after weeding and another during the siliqua formation stage. Oil extraction was done using petroleum benzene and the Soxhlet apparatus.

The data collected as previously outlined underwent statistical analysis using the analysis of variance (ANOVA) method appropriate for the Randomized Complete Block Design (RCBD) utilized in this study (Gomez and Gomez, 1984). The significance of various sources of variation was assessed using Fisher and Snedecor's F test with suitable degrees of freedom. To test 'F' statistics and compute the critical difference (C.D.) at a 5% significance level, the Fisher and Yates table (1963) was consulted. All the data were statistically analyzed by using all formulae in Microsoft Excel and then the results were cross checked by using OPSTAT software.

The entire life cycle of mustard can be grouped into two developmental phases viz., vegetative and reproductive. Experimental results showed progress in crop development (ontogeny) differs from variety to variety and the crop has taken a minimum of 43 days and a maximum of 48 days to reach the first flowering in different varieties (Table 1). Varieties showed a notable disparity in reaching the flowering stage. Pusa Mustard 28 and Pusa Mustard 30 required the longest duration (48 days) to reach flowering, statistically comparable to Pusa Mustard 31, which took 47 days to reach the same stage. These findings align with those reported by Goyal *et al.* (2018). Days to reach 50% flowering significantly varied among the seven varieties considered here. The varieties took 49 to 56 days to reach the 50% flowering stage (Table 1). Among the varieties, Pusa Mustard 28 and Pusa Mustard 30 took maximum days (56 days) to achieve 50% flowering followed by Pusa Mustard 27, the varieties Pusa Mustard 26 and Pusa Vijay achieved 50% flowering with a minimum duration of 49 days. Kumar *et al*. (2018) reported that mustard varieties took 46 to 50 days to reach the 50% flowering stage. Indian mustard varieties reached 100% flowering within 9-11 days after

50% flowering. Among all tested varieties, Pusa Mustard 28 took more time (65 days) to achieve full blooming followed by Pusa Mustard 30 (64 days), which remained at par with Pusa Mustard 28 (Table 1). Kumar *et al*. (2018) reported that mustard varieties have taken 55 to 62 days to reach 100% flowering stage. The time taken by different varieties of mustard to achieve maturity varied from 103 to 109 days. Pusa Mustard 28 took the maximum time followed by Pusa Mustard 30, these two have remained at par (Table 1). Conversely, the duration was shortest for Pusa Vijay, being comparable to Pusa Mustard 25 and Pusa Mustard 26.

The findings regarding yield-attributing characteristics revealed significant variation in the number of branches per plant across different varieties. Among the seven Indian mustard varieties, Pusa Mustard 28 exhibited the highest number of branches, averaging 5.46 per plant, followed by Pusa Mustard 30 and Pusa Mustard 27 (Table 2). The number of siliqua per plant showed significant variation as a result of the different varieties tested. Among the seven varieties examined, Pusa Mustard 28 yielded the highest number of siliqua per plant (367.37), followed by Pusa Mustard 30 (269.9) and Pusa Mustard 27 (198.27) (Table 2). Tripathi *et al.* (2021) observed that the number of siliqua per plant was significantly depended on the varieties tested. Additionally, the length of the siliqua varied significantly among the different varieties. Pusa Mustard 25 produced the longest siliqua, measuring 6.35 cm (Table 2), which was 0.25, 0.57, 0.80, 1.06, 1.47 and 2.71 cm longer than those of Pusa Vijay, Pusa Mustard 28, Pusa Mustard 30, Pusa Mustard 27, Pusa Mustard 26, and Pusa Mustard 31 respectively. According to Barma *et al.* (2021), average length of siliqua is the unique character of mustard varieties, ranging from 4.1 cm to 5.21 cm. Pusa Mustard 31 exhibited the highest number of seeds per siliqua, with an average of 16.3 seeds. Additionally, Pusa Vijay had the highest 1000-seed weight, measuring 4.62 grams (Table 2).

For a grower, achieving a high seed yield is of paramount importance. Varieties exhibited a notable difference in seed yield, ranging from 1097 kg $ha^{-1}$ to 1409 kg $ha^{-1}$. Pusa Mustard 28 emerged as the top performer, yielding the highest seed yield of 1409 kg $ha^{-1}$ (Table 3). In their study, Kumar *et al.* (2016) noted a substantial disparity in seed yield among ten mustard varieties. This variation in seed yield can be attributed to differences in all yield-related characteristics across the varieties. Some factors, such as the number of branches and siliqua per plant, demonstrated a positive correlation with seed yield; while others, like the length of siliqua, seeds containing in siliqua and test weight, did not exhibit a linear relationship with seed yield. In certain instances, it was observed that varieties producing the longest siliqua did not necessarily yield the highest seed yield. This was also evident for seeds per siliqua and 1000-seed weight. The correlation between the number of branches per plant and the seed yield of various Indian mustard varieties (Figure 1) exhibited a linear relationship. This indicates that as the number of branches per plant increases in Indian mustard, there is a corresponding rise in seed yield of the crop. The regression coefficient value of 0.892 indicated a strong correlation between the two parameters, suggesting that 89.2% of seed yield production could be predicted through the number of branches per plant. Conversely, the relationship between the siliqua number and seed yield of different Indian mustard varieties (Figure 2) demonstrated that a second-degree polynomial equation provided the best fit to the data. The figure illustrated that as the number of siliqua per plant in Indian mustard increased, so did the seed yield of the crop. With a regression coefficient value of 0.746, it can be inferred that the two parameters were highly correlated, indicating that 74.6% of the variation in seed yield was influenced by the variation in the number of siliqua per plant.

Although there was significant variation in seed production among the varieties, there was no notable difference in stover yield. Among the seven Indian mustard varieties tested, Pusa Vijay was found to produce the highest amount of stover at 4755 kg $ha^{-1}$ compared to the others (Table 3). In their study, Kumar *et al.* (2018) noted that Pusa Vijay, among the three Indian mustard varieties tested, yielded the highest stover at 6400 kg $ha^{-1}$. The Harvest Index serves as a significant indicator for assessing the allocation of dry matter towards the economic product of a crop. The experiment revealed a notable discrepancy in the Harvest Index among the varieties. Pusa Mustard 28 exhibited the highest Harvest Index as 28.09, attributed to its superior seed yield compared to the others (Table 3). Among the seven varieties of Indian mustard, significant differences were observed in terms of oil content. Pusa Mustard 31 exhibited the highest oil content of seed among the seven tested varieties, reaching 42% (Table 4). According to Sharif *et al.* (2017), variations in oil content among different mustard varieties are attributed to biological and environmental factors, soil composition, and crop management practices. The oil yield of mustard is influenced by both oil content and seed yield. Pusa Mustard 31 demonstrated superiority in oil yield, yielding 546 kg $ha^{-1}$ (Table 4). Banga *et al.* (2007) also noted significant differences in the oil yield of Indian mustard attributable to varietal effects.

**Table 1: Different phenological phases (reproduction phase) of Indian Mustard varieties**

| Treatment (Variety) | Different phenological phases (Reproduction phase) (Day) | | | |
|---|---|---|---|---|
| | Days to flower initiation | Days to 50% flowering | Days to 100% flowering | Days to maturity |
| Pusa Mustard 25 | 45 | 51 | 60 | 104 |
| Pusa Mustard 26 | 44 | 49 | 60 | 104 |
| Pusa Mustard 27 | 46 | 54 | 63 | 107 |
| Pusa Mustard 28 | 48 | 56 | 65 | 109 |
| Pusa Mustard 30 | 48 | 56 | 64 | 108 |
| Pusa Mustard 31 | 47 | 53 | 62 | 107 |
| Pusa Vijay | 43 | 49 | 58 | 103 |
| **SEm (±)** | 0.54 | 0.55 | 0.43 | 0.50 |
| **CD (0.05)** | 1.68 | 1.70 | 1.34 | 1.55 |

**Table 2: Yield attributes of Indian Mustard varieties grown during *Rabi* 2021-2022**

| Treatment (Variety) | Yield attributes | | | | |
|---|---|---|---|---|---|
| | Number of branches/plant | Number of siliqua/plant | Length of Siliqua (cm) | Number of seeds/siliqua | 1000-seed weight (g) |
| Pusa Mustard 25 | 4.30 | 167.67 | 6.35 | 16.06 | 3.50 |
| Pusa Mustard 26 | 4.76 | 194.1 | 4.98 | 15.60 | 3.60 |
| Pusa Mustard 27 | 5.23 | 198.27 | 5.39 | 15.23 | 2.53 |
| Pusa Mustard 28 | 5.46 | 367.37 | 5.88 | 14.86 | 3.00 |
| Pusa Mustard 30 | 5.30 | 269.9 | 5.65 | 13.16 | 3.86 |
| Pusa Mustard 31 | 4.93 | 195.9 | 3.86 | 16.30 | 2.56 |
| Pusa Vijay | 4.26 | 166.2 | 6.20 | 15.96 | 4.26 |
| **SEm (±)** | 0.08 | 1.76 | 0.02 | 0.08 | 0.04 |
| **CD (0.05)** | 0.25 | 5.48 | 0.08 | 0.27 | 0.14 |

**Table 3: Seed yield, Stover yield, and Harvest Index of Indian Mustard varieties grownduring *Rabi* 2021-2022**

| Treatment(Variety) | Seed yield (kg ha$^{-1}$) | Stover yield (kg ha$^{-1}$) | Harvest Index(%) |
|---|---|---|---|
| Pusa Mustard 25 | 1199 | 3969 | 23.20 |
| Pusa Mustard 26 | 1246 | 4003 | 23.73 |
| Pusa Mustard 27 | 1320 | 3407 | 27.92 |
| Pusa Mustard 28 | 1409 | 3606 | 28.09 |
| Pusa Mustard 30 | 1325 | 4364 | 23.29 |
| Pusa Mustard 31 | 1300 | 4166 | 23.78 |
| Pusa Vijay | 1097 | 4755 | 18.74 |
| **SEm (±)** | 1.09 | 365.45 | 0.02 |
| **CD (0.05)** | 3.36 | NS | 0.07 |

**Table 4: Oil content and oil yield of different varieties of Indian mustard grown during *Rabi* 2021-2022**

| Treatment (Variety) | Oil content (%) | Oil yield (kg ha$^{-1}$) |
|---|---|---|
| Pusa Mustard 25 | 35.4 | 424.7 |
| Pusa Mustard 26 | 35.2 | 438.6 |
| Pusa Mustard 27 | 34.4 | 454.2 |
| Pusa Mustard 28 | 34.4 | 484.7 |
| Pusa Mustard 30 | 35.5 | 470.5 |
| Pusa Mustard 31 | 42 | 546.0 |
| Pusa Vijay | 33.2 | 364.2 |
| **SEm (±)** | 0.09 | 0.08 |
| **CD (0.05)** | 0.28 | 0.25 |

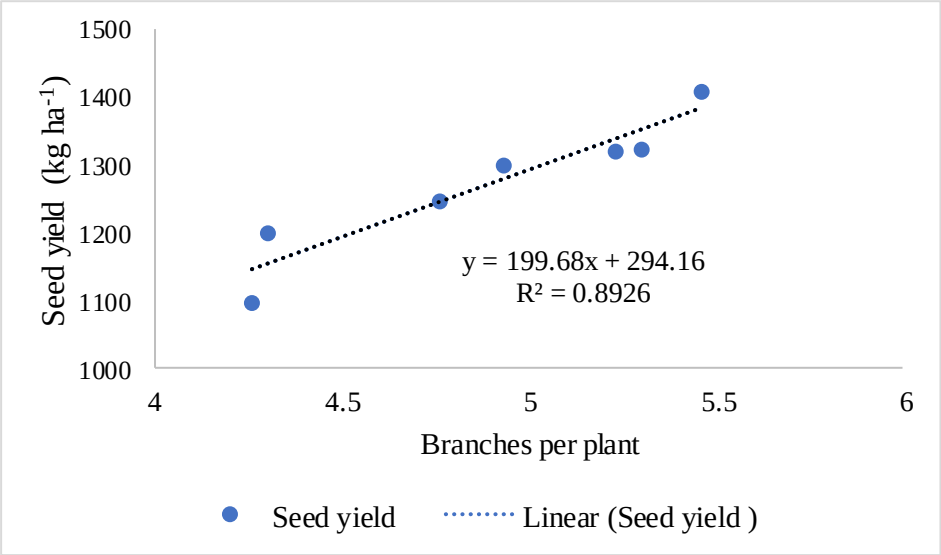


**Fig. 1: Impact of number of branches per plant on seed yield of different varieties of Indian mustard**

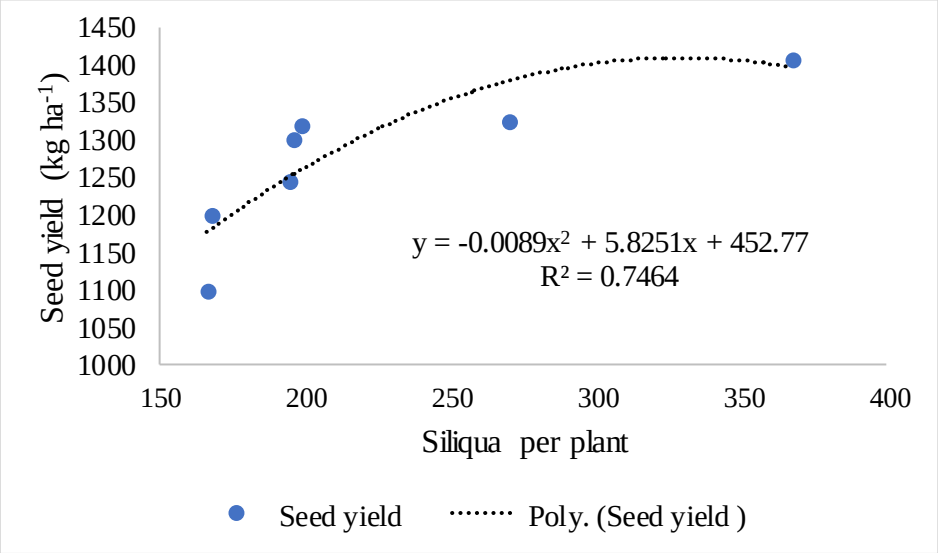


**Fig. 2: Impact of number of siliqua per plant on seed yield of different varieties of Indian mustard**

## CONCLUSION

After comparing various parameters such as yield attributes, yield, oil content and oil yield among the seven varieties of Indian mustard, it can be concluded that Pusa Mustard 28 and Pusa Mustard 31 exhibit promise in the *Gangetic* plains of West Bengal. Pusa Mustard 28 shows potential for total grain yield production, while Pusa Mustard 31 demonstrates superior oil yield.

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