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Investigating the Impact of Variety on the Growth and Yield of Mustard (*Brassica* sp.)

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ABSTRACT

The pivotal role that Mustard plays as a consumable and revenue-generating crop in Bangladesh is the primary concern of this study, particularly examining the impacts of several mustard varieties on the crop's development and productivity. The research was executed in the agricultural field of Karimpur, Bagharpara, Jashore, during the *Rabi* season spanning from October 2013 to March 2014 to ascertain the impact of different mustard varieties on the growth and yield of the crop. Seven varieties (V_1 = Tori-7, V_2 = BARI Sarisha-9, V_3 = BARI Sarisha-11, V_4 = BARI Sarisha-13, V_5 = BARI Sarisha-14, V_6 = BARI Sarisha-15, and V_7 = BARI Sarisha-16) of rapeseed-mustard were selected for the experiment, and various parameters related to growth and yield were measured. The seven treatments were accommodated in a Randomized Complete Block Design (RCBD) and replicated thrice. The outcomes showed notable differences among the varieties in terms of growth attributes and yield-contributing characteristics including plant height, number of leaves, number of pods, seed per pod, pod length, number of seeds per pod, 1000 seeds weight, and days to flowering and maturity. BARI Sharisha-11 (V_3) emerged as the most suitable variety for cultivation, demonstrating the highest seed yield (2320.00kg/ha), the highest plant height (110.00 cm), the highest number of pods (110.00), and the maximum weight of 1000 seeds (3.80 g). To maximize mustard yields, the study highlights the significance of varietal selection and efficient management techniques. The practical implications of these findings for farmers, policymakers, and researchers present a viable avenue to enhance the productivity and sustainability of mustard cultivation in Bangladesh and elsewhere.

Introduction

Mustard (*Brassica* sp.) is not only commercial but also a consumable crop. Rapeseed mustard, referred to as mustard throughout Bangladesh, is a cold-season, temperature-responsive, and photoperiod-sensitive crop (Sharif et al. 2016). It falls within the *Brassica* sp. genus, belonging to the Brassicaceae family (Cruciferae). Mustard has been grown worldwide for centuries. Mustard holds the third position among the major oilseed crops globally, following palm oil and soybeans in rank (FAO 2019). Bangladesh is predominantly an agrarian nation, cultivating a substantial variety of oilseed crops such as mustard, sesame, soybean, castor, groundnut, linseed, and more. Mustard is Bangladesh's primary dietary oilseed resource. It is a prominent Rabi oilseed crop and a vital component of

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Bangladesh's oilseed agriculture. It serves as a significant contributor to vegetable oil production in this region, with 328,604 hectares under cultivation and a production of 451,947 tons in the fiscal year 2021–2022 (BBS 2022). Over 69.94% of Bangladesh's oil-cropped land is covered by mustard, which also provides 38.80% of the country's oilseed output (Lietzow 2021). In terms of area and output, mustard ranks first among the oilseed crops in Bangladesh. Worldwide, the production of rapeseed oils reached 24,408 thousand tons, and Bangladesh played a role by contributing 126 thousand tons to the overall output (FAO 2019).

Mustard serves as a vital ingredient in various industries, contributing to soap, paint, varnish, hair oil, lubricant, textile, and pharmaceutical manufacturing. Its therapeutic properties have led to widespread use in culinary arts as a cooking component and condiment. In Bangladesh, each person uses 10–12 grams of edible oil per day. Furthermore, oilseed cakes that remain after extracting the oil have a variety of useful applications. These include using it as a plant conditioner, as cattle feed, and as a compost additive. Minerals, nitrogenous compounds, and protein are abundant in these oilseed cakes (Singh et al. 2022).

However, over the last few decades, Bangladesh has faced a significant shortage of consumable oil. Locally produced oilseeds meet only 10% of the country's edible oil requirements. The remainder is imported as crude oil or as oilseeds (USDA 2022). There is a significant potential to reduce the import of oil seeds by cultivating high-yielding varieties of mustard, thereby increasing production. The insufficient mustard production in our country can be attributed to the absence of productive varieties, the improper population density, the inadequate knowledge about the ideal planting time, the inadequate implementation of management strategies, and so on (Zhou et al. 2020). By choosing suitable cultivars with high yield potential and effectively managing soil topography, weather conditions, and agricultural practices, it is possible to significantly enhance mustard yields (Rahman et al. 2022). Due to the delayed harvest of high-yielding T. *Aman* rice and the growing cultivation of *Boro* rice, the mustard farming area in Bangladesh has experienced a decrease, causing 104 thousand hectares to be lost and 68 thousand tons of mustard and rapeseed to be produced over the past decade (BBS 2006). In Bangladesh, T. *Aman-Fallow-Boro* is the major cropping pattern, and after the harvest of T. Aman, most of the land remains fallow. Mustard is a short-duration crop that can be introduced into the existing cropping pattern to make better use of the fallow land and increase the cropping intensity. The causes of low yield are attributed to cultivating traditional varieties with low yield potential from farmers' sources, susceptibility to diseases and pests, long duration, and so on. The varieties of mustard and rapeseed differed greatly in terms of yield-contributing traits, seed production, and other aspects apart from altering seedling development (Das et al. 2020). Besides local varieties, different agricultural organizations such as the Bangladesh Institute of Nuclear Agriculture (BINA) and the Bangladesh Agriculture Research Institute (BARI) developed several short-duration, improved mustard varieties. After the harvest of T. Aman, there is scope to cultivate short-duration, high-yield mustard varieties using residual soil moisture by replacing the conventional 'Tori' with improved varieties. There is not enough research in Bangladesh about how different kinds of mustard plants affect their growth and how much they produce. Most studies have not looked closely at how each type of mustard influences how well it grows and the amount we can harvest. This gap in research makes it hard to figure out the best ways to grow each variety of mustard. Different varieties of mustard exhibit significant variations in growth patterns and yield when cultivated under the same environmental and management conditions in Bangladesh. By identifying and cultivating high-yielding, short-duration varieties, mustard production can be increased, making better use of fallow land after the harvest of T. Aman rice, thereby contributing to reducing the country's dependency on imported edible oils. This research aims to examine how different mustard plant varieties influence growth patterns and yield, understand the growth pattern, and identify the most suitable variety. It seeks to bridge existing research gaps and offer modified cultivation strategies for diverse mustard varieties, providing practical recommendations to enhance farmers' yields.

Materials and methods

The study was executed in the agricultural fields of Karimpur, Bagharpara, Jamdia, Jashore, and Bangladesh between October 2013 and March 2014, which is known as the *Rabi* season. The experimental site featured a sub-tropical climate, and the well-drained, medium-high land had a soil pH of 7.17. The trial season saw a lowest air temperature of 13.8 ^{0}C in January and a high of 37.7 ^{0}C in April. The land preparation involved plowing, cross-plow, and laddering, followed by uniform fertilization with recommended doses. The plots were bounded by waterways for drainage and irrigation. The seeds of different mustard varieties were sown on 10th November 2013. A week before seeding, the last bit of land preparation was completed. In the experiment, a randomized complete block design (RCBD) was employed in three replications. Each plot measured 3 m by 2 m and had row spacing of 30 cm, intra-plot spacing of 50 cm, and intra-block spacing of 1 m. Seven varieties of mustard were selected to serve as treatments: Tori-7 is represented by V_1, BARI Sarisha-9 by V_2, BARI Sarisha-11 by V_3, BARI Sarisha-13 by V_4, BARI Sarisha-14 by V_5, BARI Sarisha-15 by V_6, and BARI Sarisha-16 by V_7 (Table 1). The seeds were sown two to three centimeters below the surface of the earth, and then they were immediately given a mild irrigation. Intercultural methods such as trimming, watering, weeding, and protecting the plant were applied as needed. Five mustard plants were randomly opted per treatment within each plot and subsequently marked for monitoring. The harvesting was started on 2 March and completed by 23 March 2014. Observations were meticulously recorded throughout various developmental stages, encompassing both growth components and yield-related factors, culminating in comprehensive harvest data. The MSTAT-C package application was used to assemble and statistically analyze the data that had been collected on a variety of factors. The F variance test was used to do an analysis of variance for all parameters after mean values for each treatment were determined. According to (Gomez and Gomez's 1984) description, Duncan's Multiple Range Test (DMRT) was used to determine the relevance of differences between treatment means at the 5% and 1% levels of probability.

Table 1: A brief overview of the treatments

Treatments	A brief overview
Tory-7	Two domed pods, a height of 60-70 cm, major branch of two to three, and 10-12 seeds per pod. Fruit is somewhat thicker than average; seeds are spherical, and pale, weight of 2.6-2.7 grams, and are vulnerable to insect and disease assault.
BARI Sarisha -9	Short-lived, extending to a height of 80-95 cm. Has 4-6 main branches per plant, uniform, pale green leaves, and erect blooming blossoms on leaf axils. The flower is yellow, and each plant possesses 80-100 siliqua per plant, each having a pink-colored seed and weight of 2.5-3.0 grams.
BARI Sarisha-11	Height of 120-130 cm; three to five main stems; rough, light-green leaves with petioles, and yellow flowers blooming on axils, each plant produces between 75 and 150 pods, each of which has two chambers and contains 12 to 15 pink seed, the weight of 3.5-4.0grams much more than other Rai sarisha seeds.
BARI Sarisha-13	Height of 85-80 cm, 5-6 main branches, uniform, hairless leaves, spherical stem with no petiole, and yellow flowers that bloom in an inflorescence that is positioned downward on the bud. There are 65-75 pods per plant, each with two chambers, and 28-30 pink seeds, weight of 3.7-3.9 grams.
BARI Sarisha-14	Short-lived, growing to a height of 75-85 cm, with uniform, pale green leaves and 80-102 pods per plant, each of which can have two chambers that resemble four chambers. Each pod contains 22-26 pinkish-colored seeds and weight of 3.5- 3.8 grams.
BARI Sarisha-15	Short-lived with plant height of 90-100 cm, pods/plant 70-80, a pair of chambers in the pod, seed/pod of 20-22, more compact and taller pod compared to BARI Sarisha-14, yellow seeds, and a 1000-seed weight of 3.25-3.50 grams.
BARI Sarisha-16	Short-lived with plant height of 95-110 cm, pods/plant 80-90, a pair of chambers in the pod, seed/pod of 20-25, more compact and taller pod compared to BARI Sarisha-15, yellow seeds, and 1000-seed weight of 3.75-4.00 grams.

Source: Digital herbarium of crop plants (BSMRAU)

Result and Discussion

Plant height

Plant height was considerably impacted by variabilities at 30 and 50 days after sowing (DAS). Variety V_3 produced the tallest plants, which measured 89.00 cm and 110.00 cm at 30 and 50 DAS, respectively. These values were substantially different from all other treatments (Fig. 1). On the other hand, V_1 produced the shortest plants, with measures of 50.50 cm and 68.00 cm at 30 and 50 DAS, individually.

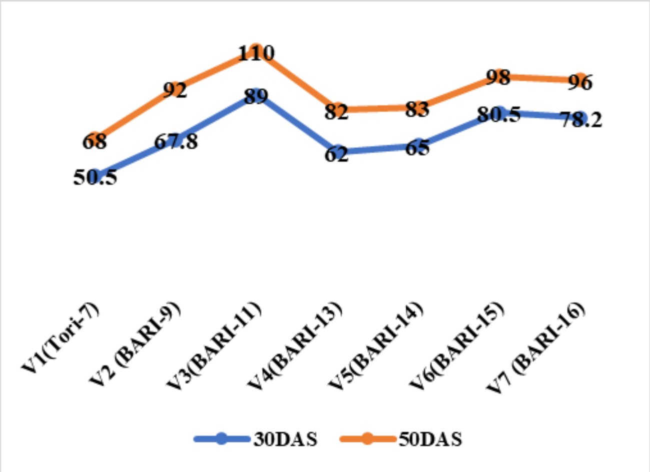

Fig. 1. Plant height of different Mustard varieties

These results contrasted sharply with those of other treatments (Fig. 1). Numerous scientists have also discovered similar variations in plant height across rapeseed/mustard types (Zakaria and Jahan 1997; Ahmed and Kashem 2017; Sarker et al. 2021; Begum et al. 2022).

No. of leaves per plant

The greatest number of leaves per plant was obtained in V_6 at 30 days after sowing (DAS) and was 22.50. This figure was statistically similar to V_2, V_2, V_5, and V_7. Conversely, the lowest number of leaves per plant 11.50 was noted in V_4, which was statistically comparable to V_1 and V_2. At 50 DAS, V_2 had the most leaves per plant (27.80), and this figure was statistically comparable to other treatments excluding V_4. When compared to the other treatments, V_4 (18.20) had the fewest leaves per plant, which was a notable difference (Table 2). The differences in leaf count among the types were consistent with (Sarker et al. 2021; Rahman et al. 2022).

No. of branches per plant

Regarding the number of branches produced at 30 and 60 days after sowing, no discernible differences were found amongst the chosen varieties (Table 2). There was no apparent distinction between the variations in the case of branch productions (Rahman et. al. 2022).

Table 2. Different growth attributes as influenced by different Mustard varieties

Treatments	No. of leaves per plant		No. of branches per plant	
	30 DAS	50 DAS	30 DAS	50 DAS
V_1 (Tori-7)	12.20^{bc}	20.20^{ab}	3.00	6.20
V_2 (BARI-9)	19.20^{a-c}	27.80^{a}	5.00	9.50
V_3(BARI-11)	20.00^{ab}	25.00^{ab}	4.90	8.70
V_4(BARI-13)	11.50^{c}	18.20^{b}	3.90	7.20
V_5(BARI-14)	21.00^{a}	26.70^{a}	4.50	6.90
V_6(BARI-15)	22.50^{a}	27.20^{a}	6.00	10.00
V_7 (BARI-16)	21.00^{a}	26.50^{a}	4.10	7.50
LS	**	*	NS	NS
CV (%)	17.08	11.78	40.04	32.27
LSD (5%)	7.75	7.19	4.48	6.44

At the 5% level of probability by LSD, means with the same letter or letters in a column do not differ a lot.

Number of pods/plant and seeds/pod

Varietal differences had a considerable influence on the number of pods per plant. As depicted in Fig. 2, variety V_3 exhibited the highest count of pod per plant, effective pod per plant, and non-effective pod per plant (110.00, 102.00, and 8.00, respectively). Conversely V_1 had the lowest count of pods per plant and effective pod per plant, although it recorded the minimum number of non-effective pods per plant (4.00). Notably, V_2 had the minimum non-effective pod per plant (4.00) statistically.

Regarding the number of seeds per pod and effective seeds per pod, V_4 demonstrated the highest values

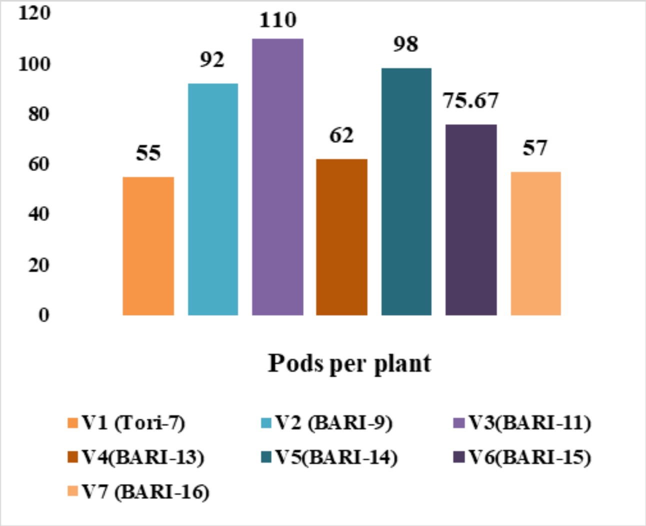

Fig. 2. Pods per plant of different Mustard varieties

(27.00 and 25.00, respectively). However, V_2 had the highest count of non-effective seeds per pod (6.50), a value statistically similar to those of other treatments (Fig. 3) except V_4.

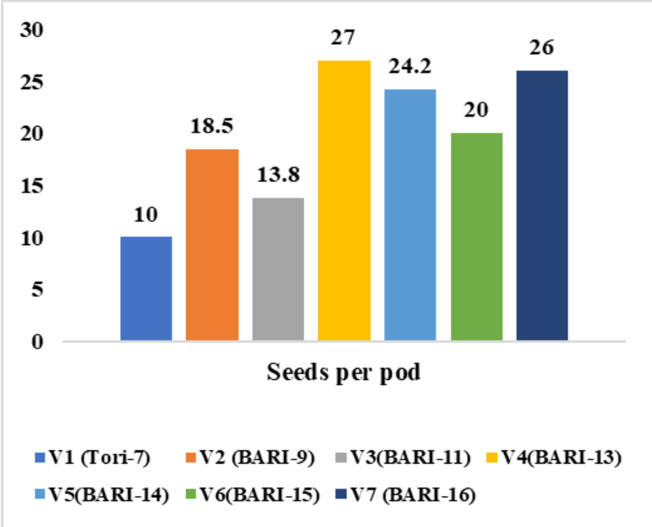

Fig. 3. Seeds per pod of different Mustard varieties

Table 3. No of pod per plant and seeds per pod of mustard as influenced by treatment variation

Treatments	No. of			
	Effective pod per plant	**Non-effective pod per plant**	**Effective seeds per pod**	**Non-effective seeds per pod**
V_1 (Tori-7)	48.00d	7.00ab	6.00d	4.00ab
V_2 (BARI-9)	88.00ab	4.00d	12.00cd	6.50a
V_3(BARI-11)	102.00a	8.00a	10.00cd	3.80ab
V_4(BARI-13)	55.50cd	6.50a-c	25.00a	2.00b
V_5(BARI-14)	92.50ab	5.50b-d	20.00ab	4.20ab
V_6(BARI-15)	70.17bc	6.00bc	16.00bc	4.00ab
V_7(BARI-16)	57.00cd	5.00cd	20.20ab	5.80ab
LS	**	**	**	**
CV (%)	13.42	11.50	18.82	31.98
LSD (5%)	23.90	1.72	7.32	3.45

At the 5% level of probability by LSD, means with the same letter or letters in a column do not differ a lot.

In contrast, statistically significant differences were seen between V_1 and other treatments in terms of the count of seeds per pod and effective seeds per pod (10.00 and 6.00, respectively). Notably, V_4 recorded the fewest count of non-effective seeds per pod. The genetic composition of the crop together with environmental factors determines the number of pod plants per plant (Sana et al. 2003). This conclusion showed the number of pods per plant of mustard was considerably impacted by varieties. This is consistent with the findings of Sarker et al. (2021), Mamun et al. (2014), (Akhter 2005).

According to Sarker et al. (2021), BARI Sarisha-14 generated the maximum number of seeds per pod (25.90), surpassing that of BARI Sarisha-13, whereas Tori-7 recorded the lowest number of seeds per pod (11.43). The variations in the seeds per pod of the different types were in line with the results of Mamun et al. (2014), who found that BARI Sarisha-16 had the lowest number of seeds per pod and BARI Sarisha-13 had the largest number of seeds.

Elements generating yield

Before harvesting, the mustard's pod length was measured at maturity. A substantial difference was seen between V_2 (5.80 cm) and V_1 (4.00 cm) for the greatest and lowest reported pod lengths, correspondingly, compared to other treatments (Fig. 4). The results of this study were parallel to those of Tripathi et al. (2021), who observed that the genetic structure of the several mustard varieties attributed to the notable variations in pod length diversity amongst them. The outcome of this research was in line with that of Biswas et al. (2019).

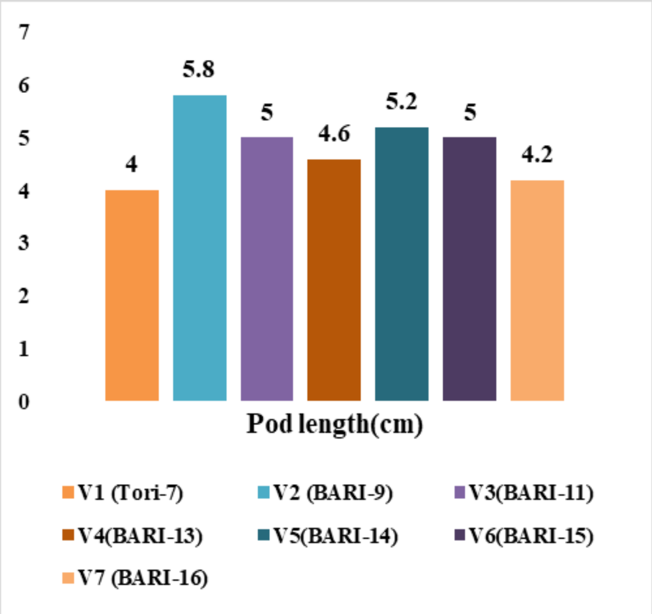

Fig. 4. Pod length (cm) of different Mustard varieties

The number of seeds produced by a plant is significantly impacted by varieties. By counting the seeds in each pod, the number of seeds per plant was determined. During the research, V_5 recorded the highest seed content per plant at 2372.00, while V_1 had the smallest amount per plant at 550.00. These results were considerably different from other treatments. Table 4 demonstrates that V_1 generated the lowest 1000 seed weight (2.60 g), which was statistically equivalent to other treatments except V_3. The number of seeds produced by a plant is significantly impacted by varieties. By counting the seeds in each V_4, and V_5, and V_3 produced the largest 1000 seed weight (3.80 g), which was statistically identical to all other treatments except V_1. This outcome harmonized with that of Mamun et al. (2014). Additionally, they noted that SAU Sarisha-3 had the lowest 1000 seed weight (2.82g), whereas BARI Sarisha-13 had the most seed weight (4.00g). The consistent portion of the production, measured in 1000 seeds, varies depending on the variety (Mashfiqur et al. 2022; Ahmed and Kashem 2017; Mondal and Wahab 2001).

Except for V_2, V_4, V_6, and V_7, the largest number of days needed for blooming and maturity were found in V_3 (51.33 and 105.20), and these values diverged considerably from the other treatments. V_5 had minimal flowering and maturity days of 35.80 and 76.00, respectively, which were statistically comparable to V_1, V_2, and V_5 (Table 4). Variability has an immense effect on maturity. The findings are displayed in Table 4. During the research time, BARI Sarisha-11 (105.20) had the most maturity days among all of the varieties, whereas BARI Sarisha-14 (76.00) had a shorter duration. The results reflected those of Aziz et al. (2011) and Mashfiqur et al. (2022).

Table 4. Elements generating yields of mustard varieties

Treatments	No. of seeds per plant	1000 seeds weight (g)	Days to flowering	Days to maturity
V_1 (Tori-7)	550.00c	2.60b	39.20bc	77.20cd
V_2 (BARI-9)	1702.00b	2.90ab	45.00a-c	82.50cd
V_3 (BARI-9)	1518.00b	3.80a	51.33a	105.20a
V_4(BARI-13)	1674.00b	3.60a	48.20ab	92.00b
V_5(BARI-14)	2372.00a	3.75a	35.80c	76.00d
V_6(BARI-15)	1520.00b	3.10ab	44.20a-c	81.00cd
V_7 (BARI-16)	1612.00b	3.00ab	46.00ab	84.00c
LS	**	*	**	**
CV (%)	10.09	15.12	8.46	3.10
LSD (5%)	9.45	0.87	9.33	6.59

At the 5% level of probability by LSD, means with the same letter or letters in a column do not differ a lot.

Yield

Variety has a substantial impact on seed production. Higher-yielding varieties may be owing to the contribution of cumulative beneficial consequences of crop features such as the number of branches per plant, pod per plant, and seeds per pod. The findings are shown in (Fig. 5). V_3 had the highest seed production (2320.00 kg/ha), which was statistically equivalent to V_4, and V_1 produced the lowest (950.00 kg/ha), which was statistically different from other treatments except V_2. Both Sarkar et al. (2021) and Yeasmin (2013) demonstrated a strong varietal influence on seed yield.

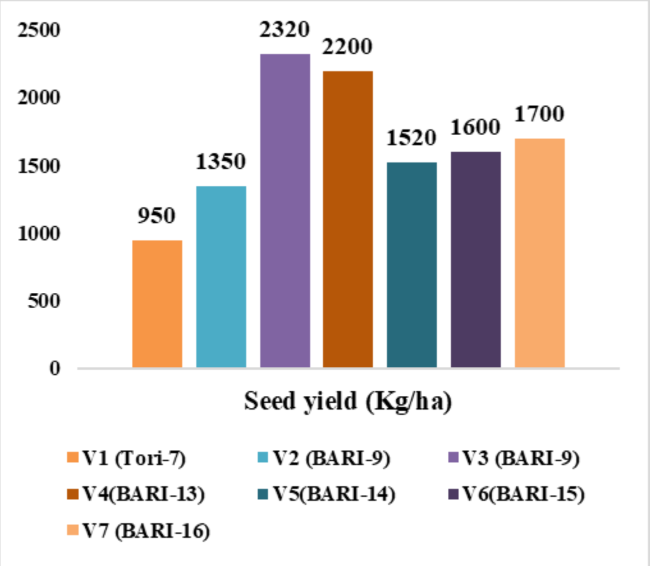

Fig. 5. Seed yield of different mustard varieties

The biggest number of pods per plant, the maximum seed weight, and the longest grain growth duration were the reasons stated by Aziz et al. (2011) for the highest yield (1740 kg/ha) for BARI Sarisha-11. Significant yield differences amongst mustard varieties were also found by Rahman et al. (2019). Zaman et al. (1991), Mondal and Wahab (2003), Rahman et al. (2022), and Begum et al. (2022) also concurred with these results.

As seed yields were pointed out, straw yield showed a similar pattern (Table 5). Increased straw yield can be linked to a higher accumulation of biomass, arising from an increased number of leaves, branches, and favorable yield attributes like more pods per plant and a greater number of seeds per pod. The oil content of the varieties was noticeably affected (Table 5). The highest oil content and oil yield (43.30% and 405.00 kg/ha) were observed in V_2, and these values were statistically indistinguishable from all other treatments, except for V_1. Conversely, V_1 exhibited the most minimal oil content and oil yield, measuring 33.20% and 206.40 kg/ha, respectively, both of which were found to be statistically distinct from all alternative treatments (Table 5). These findings align with Mashfiqur et al. (2022), who reported the highest oil content in BARI Sarisha-18 (43.40%) and the lowest in Tori-7 (41.37%). Additionally, Ali et al. (2013) noted oil variations ranging from 31.35 to 41.03 among five varieties. This observation is consistent with Mondal and Wahab (2001) results, highlighting significant variations in seed yield and other yield-related characteristics across different varieties. Because of their inherent capabilities, diverse types of mustard varieties may exhibit varying yield potentials and growth characteristics when subjected to different agroclimatic conditions.

Table 5. Yield of Different Mustard Varieties

Treatments	Straw yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)
V_1 (Tori-7)	1330.00d	33.20b	206.40b
V_2 (BARI-9)	2420.00bc	43.30a	405.00a
V_3 (BARI-11)	2830.00a	40.50ba	400.00a
V_4 (BARI-13)	2700.00ab	42.10a	380.00a
V_5 (BARI-14)	2100.00c	40.80a	398.00a
V_6 (BARI-15)	2130.00c	40.23a	360.00a
V_7 (BARI-16)	2750.00ab	41.20a	390.00a
LS	**	**	*
CV (%)	8.26	6.76	20.78
LSD (5%)	340.70	6.77	134.10

At the 5% level of probability by LSD, means with the same letter or letters in a column do not differ a lot.

Conclusion

The substantial impact that mustard varieties have on growth and yield indices is clarified by this research. The research highlighted significant varietal differences that were evident in plant height and leaf count and branches, pod and seed characteristics, maturity periods, and yield-contributing factors. BARI Sarisha-11 (V3) exhibited promising results with the highest seed yield, attributed to factors like the number of pods, the number of seeds in each pod, and the weight of 1000 seeds. The results emphasize the opportunity to improve mustard production by choosing high-yield varieties and managing key factors influencing growth and yield. These findings can guide farmers in optimizing cultivation strategies, leading to better mustard yields and benefiting both food security and economic development in Bangladesh and elsewhere.

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Authors’ contribution

Md. Mosleh Ud-Deen was involved in planning, designing, and supervising the research work. Girish Chandra Biswas carried out the experiment, collected data, and wrote the manuscript with support from Md. Mosleh Ud-Deen. Most. Moslema Haque and Most. Taslima Khatun helped with data analysis and processing. They also discussed the results and contributed to the final manuscript, ensuring clarity and coherence in presenting the research findings. Md. Kamrul Haque finalized the full manuscript.

Conflict of interest

The authors state that there isn’t any conflict of interest in the current paper’s publication.

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