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Growth and Yield Performance of Different Mustard Varieties Grown in Barind Tract Soils of Bangladesh

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Abstract

The present research was conducted to investigate the growth and yield performance of thirteen mustard varieties grown in Chapai Nawabganj district, Bangladesh. Thirteen mustard varieties, viz. “BINA Sarisha-4”, “BINA Sarisha-7”, “BINA Sarisha-9”, “BINA Sarisha-10”, “BARI Sarisha-14”, “BARI Sarisha-15”, “BARI Sarisha-16”, “BARI Sarisha-17”, “BARI Sarisha-18”, an “Indian tall” variety, “Indian short” variety, a Japanese variety “Sarisha” and a local variety were cultivated during “Rabi” (rainy) season 2021-2022. The preparation of land with recommended fertilizer doses, the experiment was arranged in a randomized complete block design consisting of three replications. All the growth, yield, and yield attributes significantly differed among the mustard varieties. In growth attributes, the highest value in plant height (149.97 cm), number of leaves per plant (16.77), leaf length (12.33 cm), number of branches per plant (11.40), and tap root length (22.53 cm) for “Indian tall” variety, “Indian short” variety , “BARI Sarisha-18”, “BINA Sarisha-7”, and “Japanese Sarisha”, respectively. In terms of yield and yield attributes, number of siliqua per plant (102.00), siliqua length (6.37 cm), number of grains per siliqua (39.50), grain yield per plot (576.33), 1000-seeds weight (3.75 g), biological yield (5.06 ton.ha^{-1}), and harvest index (35.23%) was highest in the “Indian tall” variety , “BARI Sarisha-14”, “BARI Sarisha-14”, “BINA Sarisha-9”, and “Indian short” variety , respectively. The maximum benefit cost ratio (BCR) was 2.21, observed in “BINA Sarisha-9”. Besides, BCR 1.71 and 1.66 were for “BARI Sarisha-14” and “Japanese Sarisha”, respectively. The findings of the study suggested that “BINA Sarisha-9”, “BARI Sarisha-14”, and “Japanese Sarisha” would be suitable for better productivity and recommended for cultivation in the medium highland of Chapai Nawabganj district of Bangladesh.

Keywords: barind tract, growth performance, mustard, rabi season, yield performance

Introduction

Mustard (*Brassica spp*.) is one the most vital oil seed crops next to soybean throughout the world (FAO, 2014). Among the oil seed crops grown in Bangladesh, mustard is considered as the principal oil seed crops which belongs to the genus *Brassica* of the family Cruciferae. Bangladesh is principally an agricultural country and produces good number of oil seed crops like mustard, sesame, groundnut, linseed, niger, safflower, sunflower, soybean, and castor. Mustard is the most important and popular crop which is mainly grown in the winter season in Bangladesh. Mustard oil is mainly used as cooking oil in the country.

There are 30 varieties of mustard in Bangladesh (DAE, 2022). Mustard is well adapted to all agro-climatic zones of the country and is grown in Rabi season (November-March). Mustard seeds have high energy, having 28–32% oil with relatively high protein content (28–36%) by weight, although these values can vary slightly between varieties, growing regions, and crop years. Mustard covers above 69.94% of the oil-cropped area and produces 38.80% of the total oil seed production in Bangladesh. The per capita consumption of edible oil in Bangladesh is 10-12 g per day. The internal production of edible oil only met less than one-third of the annual requirement (Mondal and Wahab, 2001). Asia produces 41.50% of mustard seed which occupies the first position in terms of percentage share of production followed by the USA (FAOSTAT, 2018). Oil seeds were cultivated in less than 2.20% of total arable land under the rice-based cultivation system in Bangladesh, where three-fourth of total cultivable land was engaged in rice production in 2015-16 (BBS, 2019).

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Mustard exhibits an increase in production from 1994 to 2018 except for a few fluctuations in the case of total production and area under cultivation (FAOSTAT, 2018). Mustard occupied more than 69.94% of the total cultivated area of oilseeds followed by sesame, groundnut, and soybean (BBS, 2019). In 2018, the cultivation area was 270023 ha and production of mustard was 311740 MT, which were relatively lower than the previous two years due to severe water logging condition after two spells of flooding. The scenario was far more than the cultivated area (210545 ha) and production (188880 MT) in 2007 (FAOSTAT, 2018; BBS, 2019). With the increase in population, the demand for edible oil and oil seeds is increasing trend (Alam, 2023). Based on area, mustard and rapeseed are in the first position, soybean is second, third is coconut and fourth, fifth, sixth are groundnut, sesame, linseed, sunflower has the lowest cultivated area. The total cultivated area of oil seeds is 1234969.71 (acre) and the production rate was 995543.71 (MT) in 2021.

The major reasons for the low yield of mustard in Bangladesh are lack of high-yielding variety, appropriate population density and inadequate knowledge of sowing time, sowing methods and proper management practices (Mamun et al., 2014). There is a great scope for increasing the yield of mustard by selecting appropriate high-yielding varieties, soil topography, and weather condition with improved management practices (Bhuiyan et al., 2008). To consider the above context, the present study focuses on the selection of mustard varieties suitable for cultivation in the barind tract with an examination of growth and yield parameters.

Materials and Methods

Mustard Varieties and Study Area

Thirteen released varieties of mustard namely “BINA Sarisha-4”, “BINA Sarisha-7”, “BINA Sarisha-9”, “BINA Sarisha-10”, “BARI Sarisha-14”, “BARI Sarisha-15”, “BARI Sarisha-16”, “BARI Sarisha-17”, “BARI Sarisha-18”, “Indian tall” variety, “Indian short” variety, “Japanese Sarisha” and local variety, were studied in this experiment. The seeds of thirteen varieties were shown in Figure 1.

The experimental field of the present study was selected at the main campus of EXIM Bank Agricultural

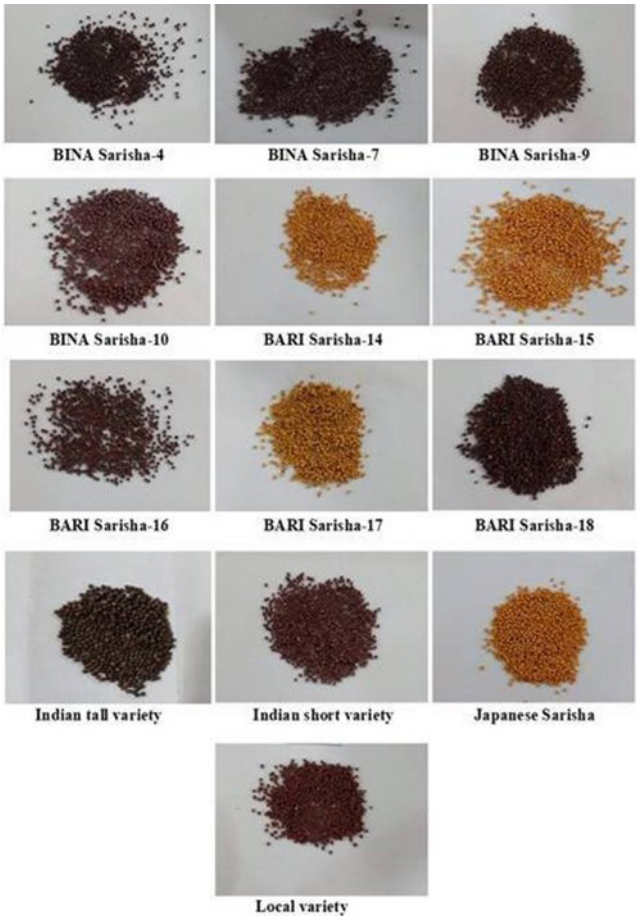

Figure 1. Seeds of the thirteen varieties of mustard tested in the study.

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University Bangladesh (EBAUB), located at Jhilim 3, Amnura Chapai Nawabganj District, Bangladesh.

Meteorological Parameters of the Experimental Site

Generally, Chapai Nawabganj is dominated by tropical wet and dry climate. The dry weather with moderate rainfalls were the predominant climatic features of the study site shown in Table 1.

External Features of Barind Tract Soil

The study was conducted in a medium highland soil under the agricultural zone (AEZ 26- high barind tract). The drainage condition of the studied soil was pretty good. The general characteristics of brind tract soils were shown in Table 2.

Land Preparation

The land was first ploughed with a power tiller on 16 November 2021. Ploughed soil was brought into desirable tilt condition by three operations of ploughing. The stubbles of the previous crops and weeds were removed. The land preparation was completed on 19 November 2021. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water. The experiment was laid out in a randomized complete block design with three replications. The size of a plot was 1.83 m × 1.83 m where 13 varieties were cultivated, thus the total numbers of experimental plots were 39.

The proper doses of fertilizers were applied according to the fertilizer recommendation guide 2012. The urea, DAP, Mop, gypsum, $ZnSO_4$, and boric acid at 194.22, 164.34,89.064, 112.05, 7.47 and 7.47 $kg.ha^{-1}$ fertilizers were applied, respectively. One-third of the whole amount of urea, and the full amount of DAP, Mop, gypsum, $ZnSO_4$ and boric acid were applied at the time of final land preparation. The remaining urea was applied as top dressing; in two equal installments, 25 days after the emergence of seedlings and just before the flowering stage.

Seed Sowing, Intercultural Operations and Harvesting

Seeds were sown on 19 December 2021 by following the broadcasting method. For uniform distribution of seeds, a small amount of ash was mixed with the seeds during broadcasting. Irrigations were done three times during the study period. The first irrigation was given in the field on 22 November 2021 at 4 days after sowing through the irrigation channel. The second irrigation was given at the stage of maximum flowering 35 days after sowing (DAS), on 22 December 2021. The final irrigation was given at the stage of seed formation (55 DAS), on 15

Table 1. Monthly recorded average high temperature, average low temperature, rainfall, relative humidity of experimental site during the experimental period.

Month	Average high temperature (°C)	Average low temperature (°C)	Humidity (%)	Rainfall (mm)
November	29.2	19.3	58	2
December	26.1	15.7	51	4
January	25.7	13.9	49	3
February	25.7	17.0	40	3
March	29.9	21.8	32	3

Source: www.weather-atlas.com

Table 2. Characteristics of brind tract soil.

Particulars	Soil Properties
Land type	Medium high land
Topography	Fairly level
Flood level	Above flood level
Soil color	Dark grey
Drainage	Moderately well-drained
Soil texture	Silty clay loam
Infiltration Rate	Moderate
Porosity	48%
pH	6.78

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January 2022. Different intercultural operations such as weeding, thinning, mulching, insect and disease management were practiced in the experimental field for successful plant growth and development. Harvesting was done at full maturity when 80% of the siliqua turned yellowish in color. Harvesting was done in the morning to avoid shattering.

Sampling and Data Collection

Twenty sample plants were selected randomly avoid the border plants and marked in each plot. Data on the growth parameters (plant height, number of leaves per plant, leaf length, number of branches per plant and tap root length) and yield parameters (number of siliquas per plant, siliqua length, number of grains per siliqua, grain yield, 1000 seeds weight, biological yield and harvest index) were collected, calculated and recorded carefully.

Plant height was measured in centimeters from the ground level to tip of the longest stem at 60 DAS and mean value was calculated. The number of leaves per plant was counted from 20 randomly selected plants at 60 DAS and their average was taken as the value of leaves number per plant. Ten leaves of each 20 plants of each plot were used to measure length (cm). The number of branches per plant was counted from 10 randomly selected plants from each plot at harvest and their average was taken as the number of total branches per plant. Length of tap root recorded from selected plants at the time of harvesting.

The number of siliquas per plant was measured from 20 plants of a plot. Siliqua length was measured to the 10 random siliquas from 20 sample plants and recorded to their average length. The number of grains per siliqua from 10 random siliqua of 20 sample plants were recorded with average number. Grain yield (g) measured from each plot (1.83 m × 1.83 m). The 1000 seeds were taken from 10 sample plants of each plot when the moisture was 8-13%. Biological yield and harvest index was calculated with methods of Thakur et al. (2021).

Statistical Analysis

The collected data were compiled and statistically analyzed following analysis of variance (one-way ANOVA) using the SPSS computer package program. Means were compared by using the Duncan's New Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984). The ratio of total return to the total cost per hectare was used to calculate the BCR by cost benefit analysis (CBA) method (Begum et al., 2018).

Results

Growth Parameters

The variable performance of mustard was recorded due to different parameters in 13 varieties. Significantly, the tallest plant was observed (149.97 cm) in the "Indian tall" variety, number of leaves per plant (16.77) in the "Indian tall" variety and (16.30) in "Indian short" variety , leaf length (12.33 cm) in "BARI Sarisha-18", number of branches (11.40) in "BINA Sarisha-7" and tap root length (22.53 cm) in "BARI Sarisha-17" and (22.53) in "Japanese Sarisha" were noted (Table 3). The immediate lesser from higher value were recorded on plant height (140.63 cm) in the "Indian tall" variety , number of leaves per plant (14.13) in "BARI Sarisha-16" and (14.7) in "BINA Sarisha-7", leaf length (10.78) in "BINA Sarisha-7", (10.25 cm) in "BARI Sarisha-18" and (10.12 cm) in "Indian short" variety, number of branches (8.00) in "BARI Sarisha-16", (7.93) in "Indian tall" variety and (7.87) in local variety, tap root length (16.00 cm) in "BARI Sarisha-14" (Table 3).

The shortest plant (80.57 cm) was found in the local variety, number of leaves per plant (6.90) in the local variety, (6.90) in "BINA Sarisha-9", (6.57) "BINA Sarisha-4", leaf length (4.78 cm) in local variety, number of branches (3.93) in "Indian short" variety, root length (6.80 cm) in "BARI Sarisha-15", (7.57 cm) in local variety, (7.93 cm) in "BINA Sarisha-4" (Table 3).

Yield Parameters

Different 13 mustard varieties experimented exert significant impact on yield parameters i.e. number of siliquas per plant, siliqua length, number of grains per siliqua, grain yield, 1000 seeds weight, biological yield and harvest index (Table 4). The number of siliquae was found highest in the "Indian tall" variety (102.00 per plant) and the lowest number of siliquae was 44.70 per plant in "BARI Sarisha-10". "BARI Sarisha-14" and "BARI Sarisha-15" had the highest siliqua length that was 6.37 and 6.20 cm, respectively. On the other hand, the lowest siliqua length (3.50 cm) was observed in local variety. The number of grains per siliqua (39.50 per siliqua) was highest in "BARI Sarisha-14", while it was lowest in the "Indian short" variety (9.23 per siliqua). The highest grain yield was 576.33 g per plot, observed in "BINA Sarisha-9" and it was the lowest in both "BARI Sarisha-18" (126.57 g per plot and the "Indian tall" variety (118.93 g per plot). The "Indian short" variety had the highest 1000 seeds weight (3.75 g) and "BARI Sarisha-18" had the lowest 1000 seeds weight (2.41 g) (Table 4).

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"BARI Sarisha-17", "Indian short" variety, "BINA Sarisha-9", "BARI Sarisha-17", local variety and "BINA Sarisha-4" showed the highest value in biological yield in the range of 4.02-5.06 ton. ha^{-1}. The lowest value was shown in the "Indian tall" variety (3.21 ton.ha^{-1}). The harvest indexes 35.23%, 35.22% and 34.25% were height that was observed in "BARI Sarisha-16", "Indian short" variety and "BINA Sarisha-9", respectively. The index was lowest in "BINA Sarisha-7" (17.92%) (Table 4).

Duration of Seed Emergence, First Flowering Day and Duration of Harvesting

The rapid seedlings emergence within 6 days was noticed in "BARI Sarisha-14" and "BARI Sarisha-15" mustards. The duration of seedlings emergence was maximum (11.0 days) in "BINA Sarisha-9" (Figure 2). The earliest flowering was found in local variety at 23 DAS while the late flowering was observed (44.0 DAS) in "BARI Sharisha-18". The harvesting time was

Table 3. Growth parameters, including plant height, leaf number per plant, number of leaf length, tap root length, branch number per plant of thirteen mustard varieties

Variety	Plant height (cm) ($\bar{x}$±SD)	Leaf number per plant ($\bar{x}$±SD)	Leaf length (cm) ($\bar{x}$±SD)	Branch number per plant ($\bar{x}$±SD)	Taproot length (cm) ($\bar{x}$±SD)
"BINA Sarisha-4"	85.13 ± 0.61j	6.57 ± 0.81e	7.85 ± 0.88d	5.40± 0.79cd	7.93 ± 0.40e
"BINA Sarisha-7"	124.63 ± 0.55e	14.07 ± 0.38e	10.78 ± 0.36b	11.40 ± 1.08a	13.77 ± 0.93c
"BINA Sarisha-9"	92.13 ± 0.71h	6.90 ± 0.70de	4.89 ± 0.21g	5.23 ± 0.57d	12.37 ± 0.51d
"BINA Sarisha-10"	86.87 ± 0.81ij	7.27 ± 0.57d	7.85 ± 0.69d	6.60 ± 0.36c	14.57 ± 1.37c
"BARI Sarisha-14"	87.10 ± 0.66i	7.97 ± 0.60d	8.18 ± 0.94d	6.27 ± 0.55c	16.00 ± 0.36b
"BARI Sarisha-15"	95.70 ± 0.96g	7.93 ± 0.60d	6.80 ±1.01de	5.30 ± 0.50d	6.80 ± 0.20e
"BARI Sarisha-16"	140.63 ± 0.85b	14.13 ± 0.64b	9.63 ± 0.56bc	8.00 ± 0.46b	13.37 ± 0.55c
"BARI Sarisha-17"	103.03 ± 0.45f	10.00 ± 0.53c	6.41 ± 0.47f	4.90 ± 0.36d	22.53 ± 0.64a
"BARI Sarisha-18"	127.67 ± 0.91d	8.83 ± 0.49c	12.33 ± 0.64a	5.87 ± 0.50c	12.93 ± 0.42d
"Indian tall" variety	149.97 ± 1.34a	16.30 ± 0.76a	10.25 ± 0.24b	7.93 ± 0.40b	13.10 ± 0.20cd
"Indian short" variety	130.57 ± 0.85c	16.77 ± 0.76a	10.12 ± 0.24b	3.93 ± 0.61de	12.57 ± 1.00d
"Japanese Sarisha"	104.03 ± 1.38f	8.40 ± 0.95cd	6.97 ± 0.59d	4.90 ± 0.36d	22.53 ± 0.64a
Local variety	80.57 ± 0.51k	6.90 ± 0.70e	4.78 ± 0.39gh	7.87 ± 0.76b	7.57 ± 0.38e

Note: $\bar{x}$: Mean value; SD: Standard deviation; in a column, means followed by a similar letter(s) were not significantly different whereas, means followed by dissimilar letter(s) were significantly different.

Table 4. Yield and yield attributes of thirteen mustard varieties.

Variety	Number of siliqua per plant ($\bar{x}$±SD)	Siliqua length (cm) ($\bar{x}$±SD)	Number of grains per siliqua ($\bar{x}$±SD)	Grain yield (g) per plot ($\bar{x}$±SD)	1000 seeds weight (g) ($\bar{x}$±SD)	Biological yield (ton.ha^{-1}) ($\bar{x}$±SD)	Harvest Index (%) ($\bar{x}$±SD)
"BINA Sarisha-4"	56.57 ± 0.51h	4.40 ±0.26bc	15.03 ± 0.45g	486.67 ± 22.48b	3.42 ± 0.06b	4.02 ± 0.06 a	29.72 ± 1.24b
"BINA Sarisha-7"	80.27 ± 1.22c	5.27 ± 0.50b	11.70 ± 0.75h	209.07 ± 11.43e	2.39 ± 0.07d	3.46 ± 0.04 c	17.92 ± 0.86e
"BINA Sarisha-9"	98.53 ± 1.14b	3.73 ± 0.31c	32.70 ± 0.95c	576.33 ± 3.21a	3.45 ± 0.08b	4.89 ± 0.04 a	34.25 ± 0.51a
"BINA Sarisha-10"	44.70 ± 0.66i	5.36 ± 0.27b	17.03 ± 0.49f	383.33 ± 13.23ce	3.45 ± 0.03b	3.56 ± 0.02 b	25.16 ± 0.96cd
"BARI Sarisha-14"	66.05 ± 0.98f	6.37 ± 0.49a	39.50 ± 1.50a	421.00 ± 7.64bc	3.21 ± 0.09b	3.49 ± 0.05bc	23.68 ± 1.12d
"BARI Sarisha-15"	72.47 ± 0.71e	6.20 ± 0.20a	21.87 ± 0.47e	419.33 ± 43.89c	2.69 ± 0.08c	3.72 ± 0.15b	28.11 ± 2.04c
"BARI Sarisha-16"	77.53 ± 0.78d	5.33 ± 0.31b	18.17 ± 0.61f	349.33 ± 5.03d	2.63 ± 0.25c	5.06 ± 0.06a	35.23 ± 0.30a
"BARI Sarisha-17"	64.17 ± 0.47g	4.97 ± 0.67b	36.53 ± 1.33b	365.67 ± 25.03cd	2.62 ± 0.06c	4.19 ± 0.09a	31.61 ± 1.39b
"BARI Sarisha-18"	97.50 ± 1.05b	5.23 ± 0.21b	26.30 ± 0.46d	126.57 ± 7.67f	2.41 ± 0.07cd	3.87 ± 0.06ab	28.49 ± 0.77bc
"Indian tall" variety	102.00 ± 0.68a	4.80 ± 0.20b	17.43 ± 0.81f	118.93 ± 1.01f	3.43 ± 0.25b	3.21 ± 0.12d	32.16 ± 0.02b
"Indian short" variety	65.87 ± 0.86f	4.77 ± 0.45b	9.23 ± 0.55i	325.67 ± 5.13d	3.75 ± 0.06a	4.90 ± 0.09a	35.22 ± 0.30a
"Japanese Sarisha"	64.17 ± 0.47g	4.97 ± 0.67b	36.53 ± 1.33b	407.67 ± 58.53c	3.35 ± 0.11b	3.57 ± 0.16b	28.04 ± 3.43c
local variety	66.47 ± 1.29f	3.50 ± 0.20cd	12.97 ± 0.65h	332.33 ± 11.02d	2.54 ± 0.12c	4.18 ± 0.08a	29.98 ± 0.68b

Note: $\bar{x}$: Mean value; SD: standard deviation; values followed by the same letters (s) in a column were not significantly different.

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shorted in local variety at 70 days of seed showing. The below 100 days of harvesting noted below in "BARI Sarisha-14", "BARI Sarisha-17" and "BARI Sarisha-15" at 78, 84 and 92 days, respectively. Among 13 varieties, the late variety was "BINA Sarisha-4" where the harvesting duration was 118 days (Figure 2).

Benefit Cost Ratio (BCR)

The total variable fixed cost of mustard production was calculated 45,930, and 22,500 taka per ha, respectively. The total cost of cultivation of mustard was estimated to be 68,430 per ha. Of the total cost, 67.2% was variable cost and 32.8% was fixed cost (Table 5).

Discussion

Plant height of the studies varieties are significantly different, and at harvest the highest value observed in "Indian tall" variety, and it was lowest in *local variety.* Variation of plant height had occurred due to the genetic makeup of the varieties and under a given set of environments. Sarker et al. (2021) and Akhter (2005) reported significant variation in plant height among mustard varieties. Similar variation in the plant height among rapeseed/mustard varieties was also reported by many studies (Ahmed and Kashem, 2017; Roy, 2007; Hossain et al., 1996). In contrast, Yeasmin et al. (2014) disagreed with this finding who reported that varietal effect was insignificant on plant height.

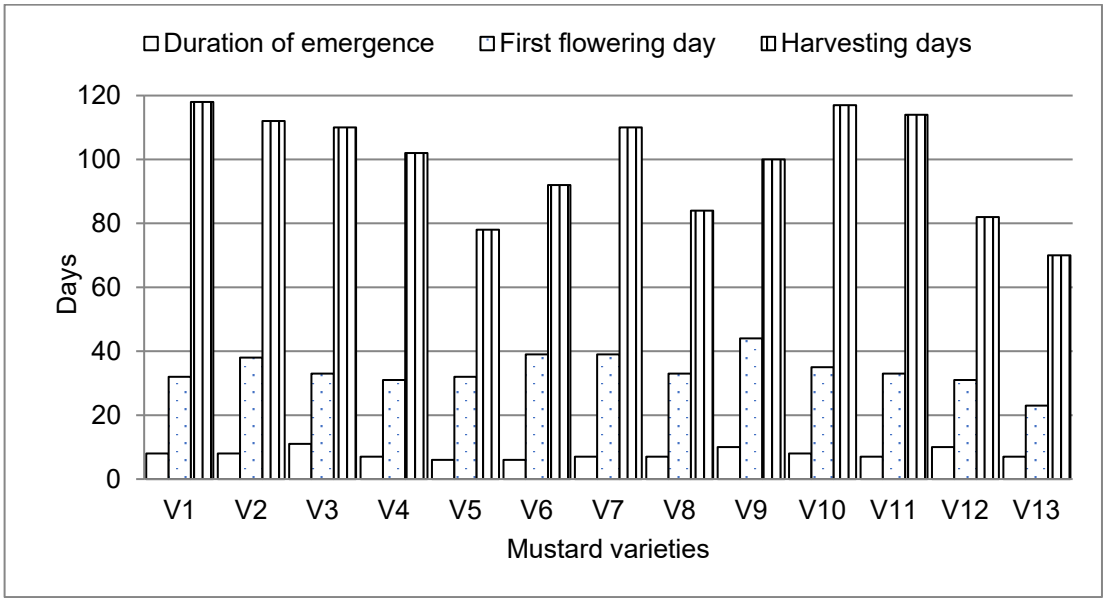

Figure 2. Time of emergence, first flowering day and harvesting days of thirteen varieties, V1: "BINA Sarisha-4", V2: "BINA Sarisha-7", V3: "BINA Sarisha-9", V4: "BINA Sarisha-10", V5: "BARI Sarisha-14", V6: "BARI Sarisha-15", V7: "BARI Sarisha-16", V8: "BARI Sarisha-17", V9: "BARI Sarisha-18", V10: "Indian tall" variety , V11: "Indian short" variety , V12:"Japanese Sarisha", V13: local variety

The highest yield was found at 1723.22 kg.ha^{-1} in "BINA Sarisha-9" and lowest was found in "BARI Sarisha-18" (378.43 kg.ha^{-1}) (Table 6). The gross return and net return were 150781.75 taka and 82351.75 taka for "BINA Sarisha-9", respectively. The benefit-cost ratio was highest (2.20) in "BINA Sarisha-9" among 13 mustard varieties cultivated (Table 6). The BCR value above 1.00 was noticed in ten varieties and it was below 1.00; "BINA Sarisha-7" had 0.73 and "BARI Sarisha-18" had 0.44 as shown in Table 6.

Leaf numbers were significantly varied among the varieties at 60 DAS. At 60 DAS, significantly the highest number of leaves was recorded in "Indian short" variety and "Indian tall" variety. Sarker et al. (2021) also observed significant variation in number of leaves among eight mustard varieties at 40 DAS and 60 DAS.

The leaf length of mustard varieties was significantly different among the studied varieties. The leaf characteristics play a vital role in the seed yield of mustard. The leaf area index is one of the common leaf features that affect many species of mustard as reported by Cheema et al. (2001). Among the

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Table 5. Production cost of mustard cultivation in the studied areas.

Particulars	Total cost.ha^{-1} (taka)	Percentage (%) of total cost
A. Total variable cost	45930	67.2
Ploughing of land	6000	8.8
Labor cost	12000	17.5
Seed	1080	1.6
Fertilizers	10875	15.9
Pesticides, Vitamins & Hormone	9375	13.7
Irrigation	3600	5.3
Miscellaneous	3000	4.4
B. Total fixed cost (Taka) that was used for land rent	22500	32.8
C. Total cost (Taka) (A+B)	68430	100

Source: Cost benefit analysis method (Begum et al., 2011)

Table 6. Profitability of mustard cultivation (tk.ha^{-1})

Variety	Grain yield (kg.ha^{-1})	Price (taka.kg^{-1})	Gross return (main product) (taka)	Net return (taka)	BCR
“BINA Sarisha-4”	1455.12	87.5	127323.00	58893.00	1.86
“BINA Sarisha-7”	625.10	80.00	50008.00	-18422	0.73
“BINA Sarisha-9”	1723.22	87.5	150781.75	82351.75	2.20
“BINA Sarisha-10”	1146.16	82.5	94558.20	26128.20	1.38
“BARI Sarisha-14”	1258.78	92.5	116437.15	48007.15	1.70
“BARI Sarisha-15”	1253.80	92.5	115976.50	47546.50	1.69
“BARI Sarisha-16”	1044.50	80	83560.00	15130	1.22
“BARI Sarisha-17”	1093.33	92.5	101133.03	32703.03	1.48
“BARI Sarisha-18”	378.43	80	30274.40	-38155.6	0.44
“Indian tall” variety	1355.60	90	122004.00	53574.00	1.78
“Indian short” variety	973.73	90	87635.70	19205.70	1.28
“Japanese Sarisha”	1218.91	92.5	112749.18	44364.18	1.65
local variety	993.67	80	79493.60	11063.60	1.16

Source: CBA method (Begum et al., 2011).

varieties, the number of branches per plant differed significantly. Maximum number of branches was found from “BINA Sarisha-7”, second highest was “BARI Sarisha-16”, whereas minimum from “Indian short” variety. Choudhary et al. (2000) found significant differences in branches per plant among different mustard varieties.

Taproot length significantly exposed in the varieties experimented in the present study. Variation was found in the root length per seedling due to genetic makeup and the effect of spacing. Niraula and Timilsina (2020) examined the length of root differences in the mustard varieties. Jimba and Adedeji (2003) and South et al. (1990) reported that the effects of wider spacing in nurseries increase seedling biomass and root biomass.

Among the varieties, the number of siliquas per plant differed significantly. A maximum number of siliqua per plant was recorded in the “Indian tall” variety and the second highest was found in “BINA Sarisha-9” and “BARI Sarisha-18”, while the minimum was recorded from “BARI Sarisha-14”. The number of siliquas per plant is the result of the genetic makeup of the crop and environmental conditions (Sana et al., 2003). The findings of Akhter (2005), Roy (2007) and Mamun et al. (2014) are in conform to the results of this finding that the number of siliquas per plant of mustard was significantly affected by the varieties.

A significant variation in siliqua length was observed, and “BARI Sarisha-14” and “BARI Sarisha-15” had the highest siliqua length. Production of higher yield by different varieties might be due to the contribution

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of cumulative favourable effects of the crop characteristics, viz., number of branches per plants, silique per plant and seeds per siliqua (Helal et al., 2016). The contrast to the present study in siliqua length was declared in 5 different mustard varieties (Thakur et al., 2021).

Number of grains per siliqua was significantly influenced due to the varietal difference. The maximum number of grains per siliqua resulted in “BARI Sarisha-17” which was on parity with “BARI Sarisha-17”, whereas the minimum was recorded from the “Indian short” variety . Variation in the number of grain per siliqua among the varieties also reported by Sarker et. al (2021). Variation in seeds per siliqua among the varieties was in conform with Mamun et al., (2014), who found the highest seeds per siliqua in BARI Sarisha-13 and the lowest seeds per siliqua in “BARI Sarisha-16” and these results are in agreement with the findings of Gurjar and Chauhan (1997). But the results are in contradiction with Roy (2007) who found the highest seeds per siliqua in improved Tori-7 and the lowest number of seeds per siliqua in SAU Sarisha-1.

Analysis of variance revealed that grain yield among the varieties were differed significantly. “BINA Sarisha-9” resulted in the higher grain yield while the lower was obtained from the “Indian tall” variety. Higher seed yield was attributed by the yield components. Sarker et al. (2021) also revealed variation of grain yield among different mustard varieties. The results agreed with Zaman et al. (1991) who reported that seed yield of rape and mustard varied with different varieties. Yeasmin et al. (2014) also found a significant varietal effect on seed yield. These findings are in conformity with the findings of Zaman et al. (1991), Chakraborty et al. (1991) and Uddin et al. (1987) who reported that yields were different among the varieties. But the result was in contradiction with Roy (2007) who reported that seed yield of rapeseed and mustard was not significantly influenced by the variety.

There was a significant variation among the varieties in the weight of 1000 seeds. Weight of 1000 seeds was higher in the “Indian short” variety which was statistically at parity with “BARI Sarisha-14”, “Indian tall” variety , “Japanese Sarisha”, “BINA Sarisha-4”, “BINA Sarisha-9” and “BINA Sarisha-10”, while “BINA Sarisha-7”, “BARI Sarisha-15”, “BARI Sarisha-16”, “BARI Sarisha-17”, “BARI Sarisha-18”, and local variety produced the lowest 1000 seed weight. Mamun et al. (2014) observed that “BARI Sarisha-13” had the highest 1000 seed weight (4.00 g) whereas the lowest one (2.82 g) was found in SAU Sarisha-3. The 1000-seed weight is the stable part of yield, and it varied from variety to variety, which is also reported by Mondal and Wahab (2001).

The biological yield of different varieties of mustard varied significantly. Maximum biological yield was obtained from “Japanese Sarisha” and the minimum was obtained from “Indian tall” variety . Mamun et al. (2014) found similar results on biological yield due to varieties. But these results are in contradiction with the findings of Yeasmin et al. (2014) who found insignificant varietal effect on biological yield.

The harvest index differed significantly among the tested varieties. “BARI Sarisha-11” contributed the highest harvest index which was statistically at parity with the “Indian short” variety while the lowest was calculated from “BINA Sarisha-7”. Our findings of harvest index in “BARI Sarisha-14” were 23.68%, which is insignificant with the calculated result (26.00%) of Sarker et al. (2021). Roy (2007) reported a result, lowest harvest index in was found in Tori-7. Similar results were also observed by Islam et al. (1994) that harvest index varied significantly among the varieties. Yeasmin et al. (2014) found insignificant varietal effect on harvest index.

Cost and return are the two most important terms in economic research. To determine the profitability of a project, a farm must assess profit. Total cost (TC) is calculated using total variable and fixed expenses, with variable costs including land preparation, human labor, seed, fertilizer, pesticides, and water management. BCR, or the average return on each taka spent on production, is one of the most essential metrics for assessing a project’s viability and determining its profitability. The ratio of total return to the total cost per hectare was used to calculate the undiscounted BCR. In the present study, the highest BCR was calculated in “BINA Sarisha-9” (2.20) and it’s near BCR was determined in “BINA Sarisha-4” and the “Indian tall” variety. The CBA method was carried out in mustard crops (Begum et al., 2018). Sanzidur and Haque (2016) reported that mustard production is profitable at the farm level (BCR 1.34) with no adverse influence of farm size on yield and profitability. Rahman et al. (2022) reported BCR (1.8) on the “Indian tall” variety that was similar to present study, whereas Chanda et al. (2020) conducted a study to analyze the cost and return of mustard where the estimated BCR was 1.11.

Conclusion

The present research work was carried out to investigate the suitable as well as profitable mustard varieties available in the northwestern part of

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Bangladesh. The result of this study revealed that the growth, yield and yield attributes of mustard varied considerably among the 13 mustard varieties tested. The production of "BINA Sarisha-9", "BINA Sarisha-4", "BARI Sarisha-14", "BARI Sarisha-15", "Japanese Sarisha", and "BINA Sarisha-10" was profitable at the farm level, as indicated by the BCR over total cost being higher than unity. Considering the productivity, profitability and harvesting time, "BINA Sarisha-9" was found suitable for practicing the cropping pattern i.e., 'Transplanted Aman – "BINA Sarisha-9" – Fallow' as well as "BARI Sarisha-14" or "Japanese Sarisha" were recommended for practicing the cropping pattern 'Transplanted Aman – "BARI Sarisha-14" / "Japanese Sarisha" - Boro rice in the Barind tract of Bangladesh.

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