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MORPHOLOGICAL CHARACTERIZATION OF AROMATIC LADRACES

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ABSTRACT

An experiment was conducted to characterize and to screen out in morphological variation of aromatic landraces at two locations of Rangpur region during the *Aman* season in 2022-23. Twenty aromatic landraces along with one known check were used at two locations i.e. BINA sub-station farm, Rangpur and farmer's field at Rangpur. The ALR genotypes are irradiated materials from BINA, Mymensingh and the BBRM genotypes including a check developed by Bangobondhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur. Three local genotypes were also used as local germplasm. The genotype ALR-6 had taller (164.10 cm) and BBRM-2 produced the highest number of total tiller hill^{-1} (20.9) than other genotypes while BBRM-7 took the highest days for maturity (146.50 days). However, the genotype ALR-3 produced higher number of filled grains panicle^{-1} (188.0) but the highest number of effective tillers hill^{-1} (15.2) and longest panicle length (25.9 cm) were obtained from the genotype Local-L which contributed the highest grain yield (6.5 t ha^{-1}). Between two locations, the highest significant response regarding the number of effective tillers hill^{-1} (11.95) and filled grains panicle^{-1} (153.1) and had the longer (143.2 days) maturity period. Interactions between genotypes and locations, BBRM-7 at farmers' plot required the highest days for maturity (149.0 days). However, ALR-3 at farmers' field produced the highest number of filled grains panicle^{-1} (190.6) but the Local-L had highly significant for getting the higher number of effective tillers hill^{-1} (17.0) and longest panicle (26.5 cm) length. As a result, aromatic rice cultivation in farmer's field is comparatively favorable to sub-station farm, Rangpur.

Key words: Morphological, variation, aromatic landraces.

Introduction

Rice (*Oryza sativa* L.) is a vital cereal crop and a primary food source for more than one-third of world's population (Sarkar *et al*., 2017) which supplying more than half of the daily calories and proteins for the half of world's population. Agriculture is the mainstay of economy in terms of contribution to GDP (14.23%) and employs around 40.60% of total labor force as well as improvement of livelihood of majority people in Bangladesh due to developing country and predominantly an agrarian country (Islam, 2021b; BBS, 2024). Over 95% people depend on rice for their daily diets and it engages over 85% of the total agricultural labor force in Bangladesh (Islam, 2021a). The Bangladesh ranks 3rd in area and 4th in production for rice while the annual production of rice is 39.10 million MT from 28.75 million acres of land during 2022-23 in Bangladesh (BBS, 2024). Golam *et al*. (2011) reported that the low yield is a common phenomenon of aromatic rice and consequently rice breeders are trying to develop the agronomic characters to gain a better grain yield. Aromatic rice's have also more demand both in internal and external trade markets due to the price of aromatic fine rice is much higher than other rice (Islam, 2008). Aromatic rice constitutes a small but special group of rice which is considered best in quality and now becoming more popular in Middle-east, Europe and the United States. Especially, Basmati (aromatic fine rice) has extremely high demand in the world and it occupies a unique place in the world rice market (Islam, 2008). Aromatic fine rice is generally used to prepare many dishes such as polau, paish, firny, birany, jarda etc. which are served on special occasions. So, aromatic rice is the most highly valued rice commodity in Bangladesh agricultural trade markets having small grain and pleasant aroma with soft texture upon cooking (Masud *et al*., 2023). However, the price of fine rice, especially the aromatic rice is 2-3 times higher than that of non-aromatic rice (Masud *et al*., 2023). So, therefore, the production of aromatic rice in our country is becoming popular due to its high prices and export potentiality (Ahmed, 2014). Though its yield is low, but it requires less input compared to non-aromatic rice. Masud *et al* (2023) also reported that the research works on local aromatic rice genotypes is limited in Bangladesh in relation to their yield and grain quality characteristics. Although the geographical, climatic and ethnic conditions of Bangladesh are favorable for year-round rice cultivation but historically the aromatic rice has been growing in transplanted *Aman* season due to climatic reasons and the *T. aman* season produces the grain yield (Islam *et al*., 2015). However, aromatic fine rice such as Kalizira, Katharibog, Chiniatab, BR 34 and BR 38 are the most high valued rice commodity in Bangladesh Agricultural Trade Market, having small grain and pleasant aroma but no effort has been made yet by the researchers to develop aromatic fine rice through agronomic manipulation with suitable cultivars for highly adaptable. In Bangladesh, BINA, BRRI, IRRI and diverse seed organizations has been presented high yielding rice varieties and it acquires positive documentation in rice production for the particular three distinct growing seasons (Haque and Biswas, 2011). Recently, BSMRAU, Salna, Gazipur developed some aromatic lines and BINA Sub-station Rangpur also irradiated some aromatic landraces for trial to adopt under different locations in Bangladesh. So, the present study was conducted to identify the suitable aromatic rice genotype(s) based on higher grain yield, earliness and adaptability with the studied regional condition in Bangladesh.

Materials and methods

An experiment was conducted to assess the morphological characters of some aromatic landraces at two different locations of Rangpur during the *T. aman* during in 2022-23. Twenty one aromatic landraces/genotypes *viz.* ALR-1, ALR-2, ALR-3, ALR-4, ALR-5, ALR-6, BBRM-1, BBRM-2, BBRM-3, BBRM-4, BBRM-5, BBRM-6, BBRM-7, BBRM-8, BBRM-9, BBRM-10, BBRM-11 (Check), BBRM-12, Local-S, Local-L and Local-M were used as breeding materials as level factor A for the present study. Two locations i.e. research field of Bangladesh Institute of Nuclear Agriculture (BINA) and Farmers' field in Rangpur district were also selected as level factor B. All the selected ALR genotypes were collected from the BINA sub-station, Rangpur which were irradiated materials through BINA, Mymensingh and the BBRM genotypes included a check (BBRM-11) genotypes were also collected and developed by Bangobondhu Sheikh Mujubur Rahman Agricultural University (BSMRAU), Salna, Gazipur. Another three local genotypes were also used as local germplasm collected from the different northern districts. The experiment was laid out in two factors with five replications. The size of unit plot was 4.0 × 2.5 m (10 m^2) where block to block and plot to plot distance was 0.75 m and 0.5 m, respectively. The land was prepared thoroughly by tilling single time with a power tiller and subsequently ploughing four times with country plough followed by laddering on 22 June, 2023. All weeds, stubbles and crop residues were removed from the fields to obtain desirable puddling condition. After that the land was prepared plot and block wise as per layout of the experiment. The plots were fertilized followed by fertilizer recommendation guide BARC 2012. The seedlings were uprooted from the seedling nursery without causing much mechanical injury to the roots and immediately transplanted in the well prepared puddled field on 10 July 2023 at the rate of two seedlings $hill^{-1}$ maintaining row-row and hill-hill distance of 20cm and 15cm, respectively. Weeding, gap filling, irrigation, plant protection measures etc. were done properly depending upon the requirements. Data on plant height, days to maturity, number of total and effective tillers, panicle length, number of filled grains and grain yield were recorded. At maturity (when 90% of the seeds became golden yellow in color), all plots were harvested manually from the ground level to take grain yield. At first five hills were randomly selected from each plot for recording necessary data. Then the harvested crop of each plot were separately bundled, properly tagged and then brought to the threshing floor. The harvested crops were threshed manually. The grains were cleaned and dried to a moisture content of 14%. Final grain yield was recorded in tha^{-1}. Recorded data were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done with the help of MSTATC computer package programme. The mean differences among the treatments, locations and tested genotypes were evaluated with Duncan's Multiple Range Test (DMRT).

Results and Discussions

Plant height: The plant height was significantly influenced due to the effect of genotypes but there was no significant difference due to the effect of locations and interaction effect of genotypes and locations (Tables 1- 3). Results revealed that the genotype ALR-6 had taller (164.10 cm) than that of other genotypes while

BBRM-6 had shortest (Table 1). It ranged from 116.9 (Farmers' field) to 117.40 cm (BINA farm, Rangpur) due to locations and 90.20 (BBRM-6 × research field of BINA) to 165.60 cm (ALR-6 × Farmers' field) (Table 2). Plant height is a vertical spatial distribution of plant. The variation in plant height was found might be due to inherent genotypic characters or the well adaptability of the genotype ALR-6 to the environment and also the variation in photosynthetic activity, variation in utilizing capability of macro and micro nutrients from the soil and other physiological functions. Similarly, Masud *et al*. (2023) ; Islam *et al*. (2013); Uddin *et al*. (2011) and many other scientist were also conclude their research with some local aromatic rice genotypes where all of them were found significant variation in plant height due to genotypic effect.

Table 1. Effect of genotype on growth and yield of aromatic rice

Genotype	Plant height (cm)	Days to maturity	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Grain yield (t ha^{-1})
ALR-1	137.3 d	141.0 g-i	16.80 cd	12.60 c-e	23.92 de	158.0 f	5.755 e
ALR-2	133.8 e	143.5 c-e	16.70 cd	12.50 c-e	24.18 c-e	164.5 de	5.365 h
ALR-3	112.3 h	145.0 a-c	13.00 efg	8.900 hi	20.36 i	188.0 a	5.000 i
ALR-4	149.3 b	140.4 hi	13.60 ef	8.500 i	23.50 de	161.5 d-f	4.060 m
ALR-5	131.2 e	140.0 h-j	14.60 de	11.30 e-g	23.10 ef	178.3 b	4.694 k
ALR-6	164.1 a	142.5 e-g	17.60 bc	12.20 c-f	20.57 hi	179.9 b	5.530 g
BBRM-1	143.6 c	139.5 ij	17.80 bc	11.10 e-g	17.60 j	124.2 l	4.045 m
BBRM-2	108.9 h	146.0 ab	20.90 a	11.30 e-g	21.66 gh	125.9 kl	4.130 l
BBRM-3	103.6 i	139.5 ij	13.70 ef	10.80 e-g	20.94 g-i	130.5 jk	5.910 d
BBRM-4	111.1 h	144.5 b-d	16.20 cd	10.40 f-h	24.35 b-e	137.5 hi	5.686 f
BBRM-5	110.1 h	143.0 d-f	16.60 cd	14.80 ab	25.56 ab	172.3 c	6.500 a
BBRM-6	90.30 k	145.5 ab	19.30 ab	13.80 a-c	19.70 i	122.9 l	4.185 l
BBRM-7	95.30 j	146.5 a	16.70 cd	13.30 b-d	24.06 de	105.4 m	5.580 g
BBRM-8	119.7 g	142.5 e-g	12.30 fg	9.900 g-i	25.45 a-c	164.9 de	5.055 i
BBRM-9	111.4 h	144.5 b-d	14.60 de	11.50 d-g	22.17 fg	176.2 bc	6.075 c
BBRM-10	95.10 j	141.0 g-i	19.70 ab	13.90 a-c	24.59 a-d	149.5 g	5.787 e
BBRM-11, Check	108.9 h	141.5 f-h	15.20 de	11.20 e-g	24.72 a-d	159.7 ef	6.217 b
BBRM-12	93.80 j	136.5 k	14.70 de	11.10 e-g	25.55 ab	149.6 g	5.582 g
Local-S	123.8 f	138.5 j	11.20 g	9.500 g-i	21.85 gh	141.5 h	4.825 j
Local-L	93.90 j	138.5 j	18.30 bc	15.20 a	25.90 a	166.4 d	6.540 a
Local-M	122.6 fg	138.5 j	12.10 fg	10.90 e-g	16.54 j	135.3 ij	4.176 l
Level of sig.	**	**	**	**	**	**	**
$LSD_{(0.05)}$	3.347	1.622	2.03	1.685	1.184	5.099	0.068
CV (%)	3.24	1.3	14.56	16.38	5.91	3.8	1.5

Table 2. Effect of location on growth and yield of aromatic rice

Location	Plant height (cm)	Days to maturity	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Grain yield (t ha^{-1})
L_1 (BINA, Rangpur)	117.4	140.5 b	15.76	11.35 b	22.55	150.9 b	5.181 b
L_2 (Farmers' plot)	116.9	143.2 a	15.82	11.95 a	22.81	153.1 a	5.362 a
Level of sig.	ns	**	ns	*	ns	**	**
$LSD_{(0.05)}$	1.033	0.501	0.626	0.52	0.365	1.574	0.021
CV (%)	3.24	1.3	14.56	16.38	5.91	3.8	1.5

In a column, figures having similar and no letter(s) do not differed significantly at $p \le 0.05$, whereas figures with dissimilar letter(s) differed significantly as per DMRT; $^{**}p \le 0.01$

Table 3. Interaction effect of genotype and location on growth and yield of aromatic rice

Genotype	Location	Plant height (cm)	Days to maturity	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Grain yield (t ha^{-1})
ALR-1	L_1	136.80	139.0 ij	15.80	12.00 c-k	23.50 c-g	160.2 g-i	5.380 no
	L_2	137.80	143.0 e-g	17.80	13.20 c-g	24.34 b-e	155.8 i-k	6.130 ef
ALR-2	L_1	135.20	140.0 h-j	16.60	13.20 c-g	23.56 c-g	162.4 f-i	5.470 l-n
	L_2	132.40	147.0 a-c	16.80	11.80 d-l	24.80 a-d	166.6 fg	5.260 p
ALR-3	L_1	112.80	142.0 f-h	13.60	9.000 l-o	21.00 i-l	185.4 ab	4.930 r
	L_2	111.80	148.0 ab	12.40	8.800 m-o	19.72 k-m	190.6 a	5.070 q
ALR-4	L_1	148.00	137.8 jk	13.20	8.400 o	23.00 d-h	161.8 f-i	4.130 w
	L_2	150.60	143.0 e-g	14.00	8.600 no	24.00 b-g	161.2 f-i	3.990 x
ALR-5	L_1	133.40	138.0 jk	14.60	11.20 e-n	24.00 b-g	176.2 c-e	4.472 t
	L_2	129.00	142.0 f-h	14.60	11.40 e-n	22.20 f-j	180.4 bc	4.916 r
ALR-6	L_1	162.60	140.0 h-j	17.40	12.60 c-i	20.30 j-m	182.4 bc	5.560 kl
	L_2	165.60	145.0 c-e	17.80	11.80 d-l	20.84 i-m	177.4 b-d	5.500 k-m
BBRM-1	L_1	144.60	141.0 g-i	17.80	10.00 h-o	19.10 l-n	128.6 o-r	4.110 w
	L_2	142.60	138.0 jk	17.80	12.20 c-k	16.10 op	119.8 t	3.980 x
BBRM-2	L_1	110.20	144.0 d-f	19.40	11.80 d-l	21.10 h-k	123.8 r-t	3.990 x
	L_2	107.60	148.0 ab	22.40	10.80 f-o	22.22 f-j	128.0 p-s	4.270 v
BBRM-3	L_1	106.20	141.0 g-i	13.40	10.00 h-o	21.28 h-k	128.0 p-s	5.710 hi
	L_2	101.00	138.0 jk	14.00	11.60 d-m	20.60 i-m	133.0 n-q	6.110 f
BBRM-4	L_1	112.00	142.0 f-h	16.60	10.40 g-o	24.20 b-f	139.0 mn	5.780 h
	L_2	110.20	147.0 a-c	15.80	10.40 g-o	24.50 a-e	136.0 m-p	5.592 jk
BBRM-5	L_1	111.40	141.0 ghi	17.40	16.80 ab	25.12 a-c	169.6 d-f	6.420 c
	L_2	108.80	145.0 c-e	15.80	12.80 c-h	26.00 ab	175.0 c-e	6.580 b
BBRM-6	L_1	90.20	143.0 e-g	19.80	12.80 c-h	19.00 mn	120.2 st	4.390 tu
	L_2	90.40	148.0 ab	18.80	14.80 a-c	20.40 j-m	125.6 q-t	3.980 x
BBRM-7	L_1	94.20	144.0 d-f	16.60	12.60 c-i	23.32 c-g	101.4 v	5.490 k-m
	L_2	96.40	149.0 a	16.80	14.00 c-e	24.80 a-d	109.4 u	5.670 ij
BBRM-8	L_1	118.80	142.0 f-h	11.60	10.20 g-o	25.80 ab	163.8 f-i	4.790 s
	L_2	120.60	143.0 e-g	13.00	9.600 j-o	25.10 a-c	166.0 f-h	5.320 op
BBRM-9	L_1	111.20	143.0 e-g	14.40	9.800 i-o	22.10 g-j	169.4 d-f	6.250 d
	L_2	111.60	146.0 b-d	14.80	13.20 c-g	22.24 f-j	183.0 bc	5.900 g
BBRM-10	L_1	94.60	143.0 e-g	19.40	14.40 b-d	24.64 a-d	148.0 kl	5.392 m-o
	L_2	95.60	139.0 ij	20.00	13.40 c-f	24.54 a-e	151.0 jk	6.182 d-f
BBRM-11	L_1	109.20	142.0 f-h	15.00	10.80 f-o	24.70 a-d	158.0 h-j	5.984 g
(Check)	L_2	108.60	141.0 g-i	15.40	11.60 d-m	24.74 a-d	161.4 f-	6.450 c
BBRM-12	L_1	94.00	135.0 l	15.40	11.00 f-o	25.80 ab	149.6 kl	5.474 l-n
	L_2	93.60	138.0 jk	14.00	11.20 e-n	25.30 a-c	149.6 kl	5.690 h-j
Local-S	L_1	124.20	136.0 kl	12.40	8.600 no	21.10 h-k	142.8 lm	4.860 rs
	L_2	123.40	141.0 g-i	10.00	10.40 g-o	22.60 e-i	140.2 mn	4.790 s
Local-L	L_1	92.40	138.0 jk	17.80	13.40 c-f	25.30 a-c	164.6 f-h	6.230 de
	L_2	95.40	139.0 ij	18.80	17.00 a	26.50 a	168.2 e-g	6.850 a
Local-M	L_1	123.40	138.0 jk	12.80	9.400 k-o	15.64 p	134.2 n-p	3.982 x
	L_2	121.80	139.0 ij	11.40	12.40 c-j	17.44 no	136.4 m-o	4.370 u
Level of sig.		ns	**	ns	*	**	**	**
$LSD_{(0.05)}$		4.73	2.29	2.87	2.38	1.68	7.21	0.10
CV (%)		3.24	1.30	14.56	16.38	5.91	3.80	1.50

In a column, figures having similar and no letter(s) do not differed significantly at $p \leq 0.05$, whereas figures with dissimilar letter(s) differed significantly as per DMRT; **$p \leq 0.01$

Days to maturity: Days to maturity showed significant response due to the effect of genotypes, locations and their interactions due to the effect of interactions. However, the genotype BBRM-7 required the highest days for maturity (146.50 days) but the least days for the maturity (135.01 days) was needed for the genotype BBRM-12 (Table 1). Between the locations, farmers' field took the highest days for maturity (143.20 days) as compared to that of the research field of BINA (140.50 days) (Table 2). However the least days for maturity (135.0 days) were required for the genotype BBRM-12 while it was grown under the research field of BINA, Rangpur (Table 3).

Number of total and effective tillers hill^{-1}: The number of total and effective tillers hill^{-1} also found significant variation among the genotypes where BBRM-2 produced the highest number of total tillers hill^{-1} (20.9) followed by BBRM-10 (19.7) and BBRM-6 (19.3) while Local-S showed the least performance regarding this traits (11.2). Similarly, Local-L showed the highest number of effective tillers hill^{-1} (15.2) followed by BBRM-5 (14.8), BBRM-10 (13.9) and BBRM-6 (1380) while ALR-4 obtained the lowest number of effective tillers hill^{-1} (8.5) (Table 1). However, the number of total tillers hill^{-1} did not showed any significant response between the locations while farmers' field produced the more number of effective tillers hill^{-1} (11.95) compared to that of the research field of BINA, Rangpur (11.35) (Table 2). In case of the effect of interactions, the number of total tillers hill^{-1} non significantly varied from 11.40 (Loca-M × farmers' field) to 22.40 (BBRM-2 × farmers' field) while the genotype Local-L grown at farmers' field produced significantly the highest number of effective tillers hill^{-1} (17.00) followed by BBRM-5 at the research field of BINA, Rangpur (16.80) while it was obtained lowest (8.40) with the genotype ALR-4 at research field of BINA, Rangpur (Table 3). Tiller production hill^{-1} especially effective or ear bearing tillers are directly related to the yield of rice, however, non-effective tillers production showed negative effect on yield. In the present study, both traits showed variation among the genotypes might be due to the variation in genetic make up of the genotypes, variation in adaptability with two locations, morphological and physiological functions of the genotypes under study.

Panicle length (cm): The length of panicle also found significant variation due to the effect of genotype but non significant due to the effect of locations while their interactions had significant response to this trait. In case of the effect of genotypes, Local-L had the longest panicle (25.90 cm) followed by BBRM-5 (25.56 cm), BBRM-12 (25.55 cm), BBRM-8 (25.45 cm), check BBRM-11 (24.72) and BBRM-10 (24.59 cm) while Local-M and BBRM-1 were statistically identical for getting the shortest panicle (16.54 and 17.60 cm, respectively) (Table 1). In case of the effect of interactions, the genotype Local-L grown at the farmers' field of Rangpur showed the longest panicle (26.50 cm) followed by BBRM-8 grown at farmers' field and BBRM-12 grown at research field of BINA, Rangpur with similar panicle length (25.80 cm). On the other hand, the genotype Local-M grown at research field of BINA, Rangpur had the shortest panicle (15.64 cm) followed by BBRM-1 grown at farmers' field (16.10 cm) (Table 3). Length of panicle is also another most imperative character which evidently influenced the yields of crops. These result revealed that aromatic rice genotypes showed significant variation in respect of panicle length which might be due to the variation in their genotypic characteristics. This result is in agreement with the findings Hossaina *et al*. (2013) where they found wide variations among the cultivars regarding panicle length. Variation in panicle length due to genotypic differences of varieties which were also similar to Masud *et al*. (2023); Islam *et al*. (2013); Uddin *et al*. (2011) and more other researchers.

Number of filled grains panicle^{-1}: The genotype ALR-3 produced significantly the highest number of filled (188.0) grains panicle^{-1}. The genotype BBRM-7 recorded the lowest number of filled grains panicle^{-1} (105.40) (Table 1). Between the locations, filled grains panicle^{-1} was produced highest (153.10) from the farmers' field compared to research field of BINA, Rangpur (150.90) (Table 2). The number of field grains panicle^{-1} was also obtained highest (196.60) from the genotype ALR-3 grown at farmers' field followed by the same genotype grown at research field of BINA, Rangpur (185.40) while BBRM-7 grown at research field of BINA, Rangpur recorded the lowest number of filled grains panicle^{-1} (101.40). Filled grains panicle^{-1} is directly related to the grain yield which might be due to the more filled grains confirm the greater production. The variation in filled grains also found might be the genetic makeup of the genotypes.

Islam *et al*. (2013) also found similar observation with the present study whereas the filled grains panicle^{-1} had higher in Khaskani and the lowest in Raniselute might be due to the genetic makeup of the varieties.

Grain yield: A significant variation due to the effect of genotypes, locations and their interactions were also observed for grain yield where the genotype Local-L produced significantly the highest (6.5 t ha^{-1}) yield of grain while both BBRM-1 and ALR-4 recorded the statistically identical lowest yield of grain (4.05 t ha^{-1} and 4.1 t ha^{-1}) (Table 1). Between the locations, farmers' field also produced the highest grain yield (5.4 t ha^{-1}) as compared to the research field of BINA, Rangpur (5.2 t ha^{-1}) (Table 2). Interaction effect between the genotypes and locations also showed that the genotype Local-L grown at the farmer's field recorded the highest grain yield (6.85 t ha^{-1}) while BBRM-1 and BBRM-6 grown at farmers' field observed the same lowest grain yield (3.98 t ha^{-1}) which was also statistically identical to the genotype ALR-4 grown at farmers' field and the both genotypes BBRM-2 and Local-M grown at the research field of BINA, Rangpur (3.99 t ha^{-1}, 3.99 t ha^{-1} and 3.98 t ha^{-1}, respectively) (Table 3). The variation in grain yield was observed might be due to the genetic variation of the genotypes and also the variation in their adaptability with the studied region while such the similar observation was also reported by Masud *et al.* (2023). Similarly, Mannan *et al.* (2012) reported that the grain yield of Chinigura and Kalijira was almost highest might be due to attribute towards the highest number of effective tillers hill^{-1}, higher fertile grains panicle^{-1}, longest panicle length which findings was fully supported by the present findings.

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