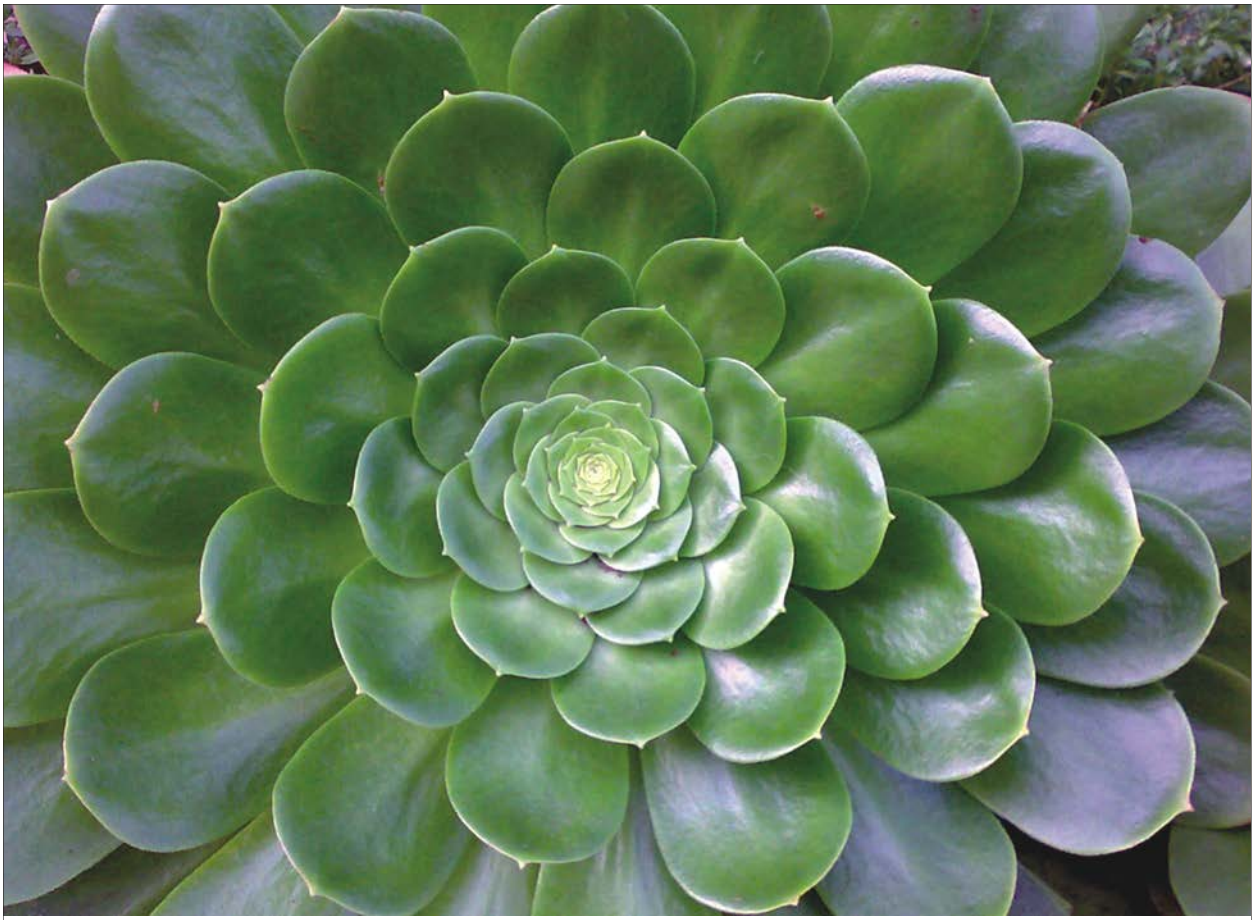

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# Research Article
# Assessment of Genetic Variability of Some Exotic Hybrid Varieties of Rice (*Oryza sativa* L.) in Bangladesh

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## Abstract
**Background and Objective:** The hybrid rice varieties are recommended for commercial cultivation in their individual countries but in the present study, researchers were tried to find out the genotypic ability of some exotic varieties in Bangladesh climatic condition. An experiment was carried out to investigate the genotypic ability of 17 exotic hybrid rice varieties by assessing morpho-physiological and yield attributing traits grown in Mymensingh, Bangladesh. **Materials and Methods:** The Randomized Complete Block Design (RCBD) was followed in the experiment with 3 replications of each treatment. Data were collected randomly from 5 selected plants per plot and the following parameters were recorded during the course of the experiment such as plant height, number of effective tiller, panicle length, days to maturity, unfilled grain, filled grain, grain length, grain width, date of 50% flowering, 1000 seed weight and yield per hectare. Then, one way analysis of variance (ANOVA) were done with the help of computer software package MSTAT-C program. **Results:** The divergence among the genotypes for all traits studied was found highly significant at 5%. level. The mean values for plant height ranged from 89.6-109.5 cm, number of effective tillers per plant from 6.12-11.32, panicle length from 17.43-25.18 cm, 1000-seed weight from 19.89-34.62 g and grain yield from 6.67-10.85 t ha$^{-1}$. Higher grain yield (10.85 t ha$^{-1}$) was harvested from cultivar HS-916 closely followed by the genotype HSD-651 (10.06 t ha$^{-1}$) and HS-100 (9.83 t ha$^{-1}$).Grain yield was significantly (at 5% level) and positively correlated with days to flowering, days to maturity, panicle length, filled grains per panicle and 1000 grain weight. The results further revealed that genotypes with medium plant height and maturity produced the highest number of tillers and ultimately gave maximum yield. **Conclusion:** After assessing all the characters, the hybrid variety HS-916 produced the highest grain yield along with HSD-651 and HS-100, those may be recommended for cultivation in Bangladesh climatic condition for higher yield.

Key words: Genetic variability, morphological features, hybrid rice, exotic varieties, yield traits

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food crop in Bangladesh and its productivity is highly valuable for fulfilling the demand of food security. Rice production has to be increased to supply adequate rice for an ever-growing population of rice-consuming countries. Due to the ever-decreasing trend of rice cultivation area, increasing yield production per unit land area is the only way to achieve sufficient rice production[1,2]. Hybrid rice has a yielding advantage of about 15-20% over the best commercial rice cultivars more with the application of almost same amount of agricultural inputs[3]. In the year 1974, Chinese scientists successfully transferred the male sterility gene from wild rice to create the cytoplasmic genetic male-sterile (CMS) line and hybrid combination[4]. In large scale hybrid rice cultivation, after China, Vietanam started in 1992 followed by India, Bangladesh, Myanmar and Philippines. However, the actual hybrid rice development technology in Bangladesh were started in 1993 by identified few elite maintainer lines. Julfiquar *et al.*[5] explained that $F_1$ seed production of rice were more in boro season rather than tamam season.

Several breeding strategies have been employed for increasing the yield potential of rice and those among the available strategies; hybrid rice offers an immediate opportunity to break the yield respite set[6-9]. In the last decades, much emphasis is given for the cultivation of hybrid varieties of rice. Hybrid rice technology has proved to be one of the most feasible and readily adoptable approaches to break the lower yield potentiality, as they yield comparatively more than the best of the improved or high yielding varieties. Being convinced of the potential of hybrid rice technology in enhancing the production, Bangladesh adopted this technique and has released nearly more than a dozon hybrid variety of rice for more cultivation. In the meantime, the new seed policy of the Bangladesh Government encouraged the private sector to participate in the rice seed market. Due to the limitation of public research system in Bangladesh for hybrid rice production, the government has taken initiatives to encourage the private companies to import hybrid rice seeds from abroad and try them with farmers. Some private seed companies imported hybrid rice and evaluated them through on-farm trials in different locations of Bangladesh during Boro season[5,10].

The achievement of high yield of rice mainly initiate from the affords in breeding new genotype with adoptive traits to yield production and improvement of management and grain quality characters are also reported to play an important role in genetic divergence[11,12]. Rather than yield quality character, few morphological traits viz. plant height, number of panicle per plant, number of effective tillers, 1000-grain weight, panicle length also contribute the genetic variability[3,13,14]. Presently, in Bangladesh government and private research organizations have been trying to introduce some hybrid varieties of rice from China, India and Philippines for the improvement of rice production. A lot of research information on specific rice variety is available, but there is little or no documented research report on comparative study of morphological and yield attributing characters of exotic hybrid rice varieties in Bangladesh. Therefore, this experiment was undertaken to evaluate the performance of exotic hybrid varieties by assessing their morphological and yield characteristics adapted with Bangladeshi environment.

## MATERIALS AND METHODS

The experiment was carried out at the farmer's field in Muktagacha, Mymensingh, Bangladesh during December 2015-May 2016 to evaluate the morpho-physiological attributes and yield performance of 17 exotic hybrid varieties of rice along with a local variety. The climate and soil of the selected plot was under subtropical climate having heavy rainfall during April-September (Kharif Season) and scanty rainfall during October-March (Rabi Season), high land type, well drained and non-calcareous grey floodplain fertile soils. Seventeen exotic hybrid genotypes of rice were used as experimental materials along with the local variety Heera-2 as control. Among these, seven i.e., AS-100, APH-8181, RXEL-15, RXML-18, RXML-19, RXEL-20 and RXEL-21 were collected from India and ten genotypes viz.HB-5, HS-12, HS-87, HS-100, HS-547, HS-688, HS-851, HS-916, HSD-651 and HR-891were collected from China.

Thirty five days old single seedling was transplanted per hill for each genotype in Randomized Complete Block Design (RCBD) with three replications. Space within and between rows were 20 and 25 cm, respectively and each plot size was $3\times2$ m = 6 $m^2$. The fertilizer dose of 280-150-130-70-10 kg $ha^{-1}$ was applied in the form of Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP), gypsum and zinc sulphate, respectively. Total fertilizers except urea were applied before the final land preparation. Urea was applied in three installments at 15, 30 and 45 Days After Transplanting (DAT). Appropriate control measures were taken for pest and disease when necessary.

Data were collected randomly from 5 selected plants per plot. Data on the following parameters were recorded during the course of the experiment such as plant height, number of effective tiller, panicle length, days to maturity, unfilled grain, filled grain, grain length, grain width, date of 50% flowering, 1000 seed weight and yield per hectare. Plant samples were separated into straw (including rachis) and grain and the panicle number was counted to determine panicles per meter square. Spikelets and all unfilled spikelets were taken to count the number of spikelets. Spikelets per panicle, spikelet filling percentage and grain weight were calculated. Grain yield was determined from the harvested plants for each plot and adjusted to the yield per hectare.

**Statistical analysis:** The collected data were then analyzed statistically with the help of computer software package MSTAT-C program using the one way analysis of variance (ANOVA). The mean differences among the treatments were compared by Duncan's Multiple Range Test (DMRT) at 5% level of significant[15].

## RESULTS AND DISCUSSION

**Days to 50% flowering:** There were highly significant ($p\leq 0.05$) differences for days to 50% flowering among the rice genotypes. With regarding this, both HS-87 and HS-688 combinedly seemed to be the first and HS-547 produced the second earliest flowering, respectively (Table 1). The cultivar RXML-19 completed 50% flowering in 125.5 days and was significantly late among all genotypes. Sarker *et al.*[16] stated that medium maturing genotypes produced better yield as compared to late genotypes.

Table 1: Days to 50% flowering and days to maturity of hybrid rice genotypes

| Genotypes | Days to 50% flowering | Days to maturity |
|---|---|---|
| AS-100 | $127.75^{cd}$ | $140.12^{cd}$ |
| APH-8181 | $108.25^{e}$ | $137.25^{cde}$ |
| RXEL-15 | $114.50^{cd}$ | $138.50^{cd}$ |
| RXML-18 | $115.00^{cd}$ | $139.12^{cd}$ |
| RXML-19 | $125.50^{a}$ | $156.76^{a}$ |
| RXEL-20 | $114.35^{cd}$ | $134.50^{de}$ |
| RXEL-21 | $108.56^{e}$ | $132.48^{e}$ |
| HB-5 | $121.62^{bc}$ | $148.35^{bc}$ |
| HS-12 | $117.75^{bc}$ | $142.90^{cd}$ |
| HS-87 | $99.25^{g}$ | $128.75^{f}$ |
| HS-100 | $113.25^{cd}$ | $138.25^{cd}$ |
| HS-547 | $102.12^{ef}$ | $124.88^{fg}$ |
| HS-688 | $99.25^{g}$ | $121.50^{g}$ |
| HS-851 | $120.62^{bc}$ | $139.62^{cd}$ |
| HS-916 | $118.50^{bc}$ | $129.74^{f}$ |
| HSD-651 | $122.75^{abc}$ | $150.87^{bc}$ |
| HR-891 | $110.92^{de}$ | $140.40^{cd}$ |
| Heera-2 | $123.75^{ab}$ | $152.50^{ab}$ |
| CV (%) | 2.94 | 6.68 |

Values having same letter (s) in a column do not differ significantly at 5% level of significance as per DMRT

**Days to maturity:** Days to maturity showed same trend as was observed in case of days to flowering. The early heading lines matured early and late heading lines matured late. Genotypes HS-688 and HS-547 remained earlier in maturity (121.5 and 124.88 days) followed by HS-87 (128.75 days) (Table 1). The genotype RXML-19 took 156.76 days to maturity and was late as compared to all other genotypes followed by check variety Heera-2 (152.50 days). Variation in days to maturity in different genotypes has also been reported by Singh and Singh[17] and Ahmed *et al.*[18].

**Plant height (cm):** Plant height at different Days After Transplanting (DAT) was exhibited remarkable difference among the tested rice varieties. Plant height increased progressively with the advance of time. At 50 days after transplanting, the tallest plant was obtained from RXML-19 (72.60 cm) followed by HS-100 (71.80 cm) and Heera-2 (70.60 cm) while the shortest plant was obtained in HS-87 (57.80 cm). At reproductive phase, the highest plant height was achieved from RXML-19 (96.20 and 107.60 cm, respectively) and the shortest was recorded in HS-87 (74.70 and 85.90 cm, respectively). Rest of the genotypes showed intermediate status. At harvesting stage, maximum plant height was noted in genotype RXML-19 (109.5 cm) which was statistically similar to Heera-2 (108.6) and RXML-18 (106.7 cm) while HS-87 and HS-688 showed short stature with 89.6 and 91.8 cm, respectively (Fig. 1). This showed that plant height is positively correlated with length of panicle in rice. The variation in plant height was due to the genetic variability and variation in growth behavior. Sabouri *et al.*[19] recommended the plant height as an important trait for selection of high yielding rice plants. Akram *et al.*[20] and Osekita *et al.*[21] also found the significant result of plant height and the genotypes were obtained moderate plant height.

**Number of total and effective tillers per hill:** Significant variation (at 5% level) in total number of tillers ranging from 7.83-12.45 per hill was observed among the genotypes (Table 2). Higher number of tillers was produced by the genotype HS-916 with medium stature plants having high panicle length, number of effective tillers, 1000-seed weight and grain yield which was closely followed by HSD-651. The lowest number of tillers was produced by HS-547 which was statistically followed by RXEL-21. Yaqoob *et al.*[22] stated that the difference might be due to the variation in the genotype of the varieties. The research conducted by Srijan *et al.*[23] revealed that increased number of tillers per unit area was the single most important yield component associated with rice

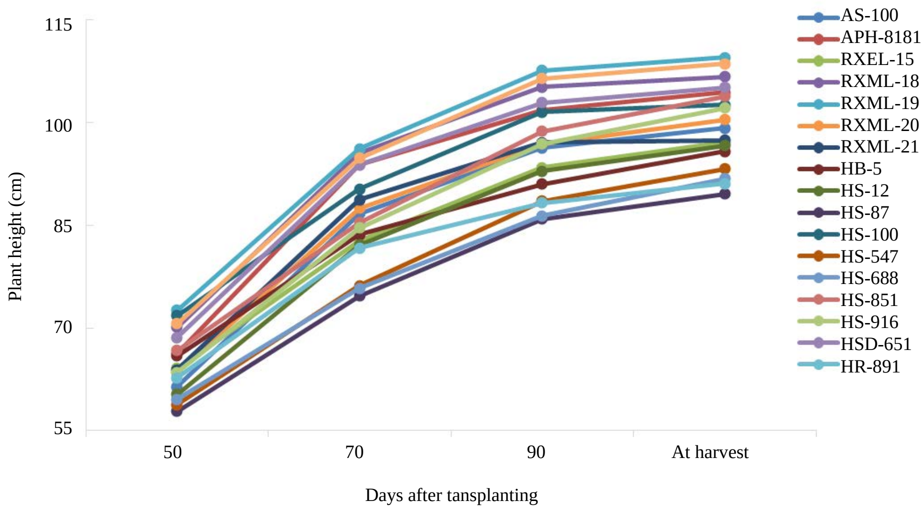


Fig. 1: Effect of different genotypes of hybrid rice on plant height at different Days After Transplanting (DAT)

Table 2: Yield and yield components of hybrid rice genotypes

| Genotypes | No. of total tillers per hill | No. of effective tillers per hill | Panicle length (cm) | 1000-seed weight (g) |
|---|---|---|---|---|
| aS-100 | 10.43$^{bc}$ | 8.42$^{bc}$ | 22.20$^{bc}$ | 27.64$^{cd}$ |
| aPH-8181 | 9.68$^{cd}$ | 7.83$^{cd}$ | 20.93$^{bcd}$ | 24.58$^{d}$ |
| RXEL-15 | 9.95$^{cd}$ | 8.20$^{bc}$ | 21.05$^{bc}$ | 21.96$^{ef}$ |
| RXML-18 | 10.30$^{bc}$ | 7.91$^{cd}$ | 23.07$^{ab}$ | 23.85$^{de}$ |
| RXML-19 | 8.68$^{cde}$ | 6.84$^{ef}$ | 24.12$^{ab}$ | 26.74$^{cd}$ |
| RXEL-20 | 9.81$^{cd}$ | 7.50$^{cd}$ | 22.04$^{bc}$ | 23.98$^{de}$ |
| RXEL-21 | 7.89$^{de}$ | 6.12$^{f}$ | 18.09$^{def}$ | 19.89$^{f}$ |
| HB-5 | 10.65$^{bc}$ | 8.97$^{b}$ | 21.58$^{bc}$ | 30.51$^{bc}$ |
| HS-12 | 9.37$^{cd}$ | 7.60$^{cd}$ | 19.04$^{bcd}$ | 32.50$^{b}$ |
| HS-87 | 10.14$^{bc}$ | 7.79$^{cd}$ | 20.78$^{bcd}$ | 26.73$^{cd}$ |
| HS-100 | 10.92$^{bc}$ | 8.92$^{bc}$ | 23.05$^{b}$ | 30.60$^{bc}$ |
| HS-547 | 7.83$^{de}$ | 6.64$^{ef}$ | 21.57$^{bc}$ | 23.57$^{de}$ |
| HS-688 | 8.75$^{cde}$ | 7.11$^{de}$ | 17.43$^{f}$ | 24.48$^{de}$ |
| HS-851 | 10.07$^{bc}$ | 8.30$^{bc}$ | 21.45$^{bc}$ | 28.91$^{bc}$ |
| HS-916 | 12.45$^{a}$ | 11.32$^{a}$ | 25.18$^{a}$ | 34.62$^{a}$ |
| HSD-651 | 11.96$^{ab}$ | 9.83$^{b}$ | 24.25$^{ab}$ | 32.83$^{ab}$ |
| HR-891 | 9.95$^{cd}$ | 8.33$^{bc}$ | 20.51$^{cd}$ | 27.23$^{cd}$ |
| Heera-2 | 9.63$^{cd}$ | 7.76$^{cd}$ | 23.55$^{b}$ | 25.76$^{d}$ |
| CV % | 5.827 | 4.73 | 4.13 | 2.96 |

Values having same letter (s) in a column do not differ significantly at 5% level of significance as per DMRT

yield and the number of spikelets per panicle and percentage of filled grains per panicle being of secondary and tertiary importance as yield components.

The number of effective tillers also significantly differed (at 5% level) among the genotypes which ranged from 6.12-11.32 per hill (Table 2). The lines with more number of total tillers excelled in number of productive tillers per hill. Maximum productive tillers were produced by HS-916 which was similar to the genotype HSD-651. Cultivar KS-133, line HHZ-11-Y-11-Y3-DT1 HHZ9DT7-SAL2-DT1 and HHZ5-Y3-SAL3-DT1 remained statistically at par with one another. The plants with highest number of tillers usually produced the highest number of panicles and ultimately produce more grain yield. The number of productive tillers is significantly (5% level) and positively correlated with grain yield[20].

**Panicle length (cm):** The panicle length also differed significantly (at 5% level) in different genotypes of hybrid rice. Maximum panicle length (25.18 cm) was noted in HS-916 followed by HSD-651 (24.25 cm) and RXML-19 (24.12 cm) (Table 2). It was interestingly observed that genotypes showing medium plant height had also shown long panicles and other yield contributing characteristics. This might be ascribed due to positive association between plant height and panicle length. Chen *et al.*[24] also noted that to reduced panicle length of rice genotypes under moisture stress conditions. Xu *et al.*[25] observed that the reduced panicle in rice crop planted under moisture stress conditions.

**1000-seed weight (g):** The weight of grain plays an important role in enhancing the final yield of any crop commodity. Like other traits, 1000-grain weight also differed significantly (at 5% level) in different rice genotypes. Maximum seed weight was recorded in HS-916 (34.62 g) followed by HSD-651 (32.83 g). Both lines were significantly better than rest of the genotypes. The RXEL-21 genotype showed less grain weight (19.89 g) among all the genotypes (Table 2). Generally, as the number of plants increases, the number of panicles per unit area increases as well and the increase in the number of seeds per panicle resulted in a decrease in the weight of individual seeds. Singh *et al.*[11] suggested that selection for seed weight, number of panicles per plant and panicle length, plant height

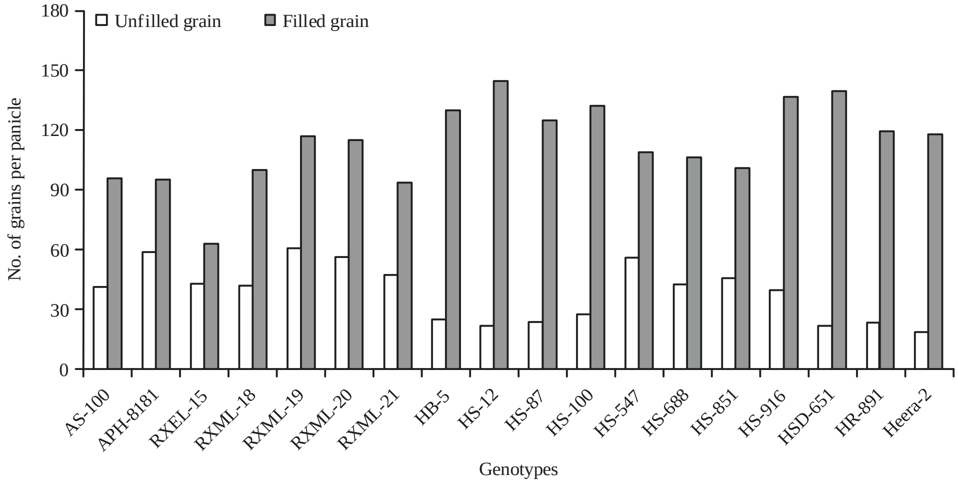


Fig. 2: Effect of different genotypes of hybrid rice on number of filled and unfilled grains per panicle

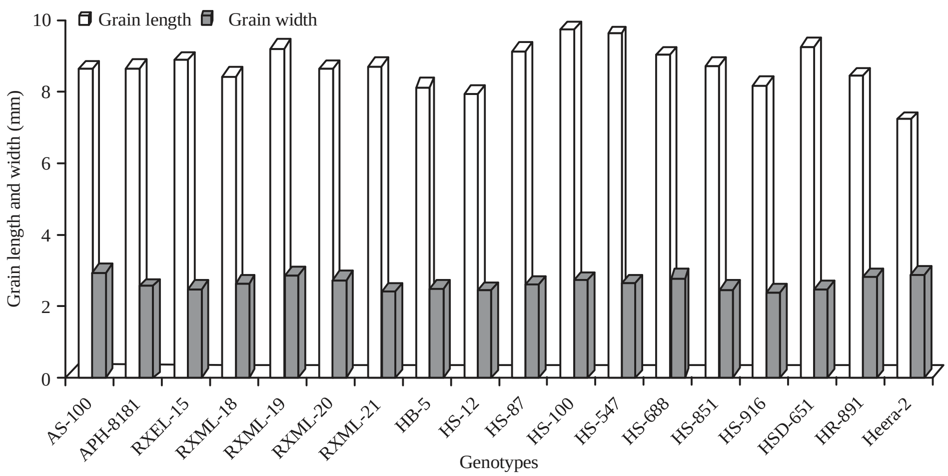


Fig. 3: Effect of different genotypes of hybrid rice on grain length and width

by using their phenotypic and/or genotypic direct effects as economic traits may serve as an effective selection criterion for using either optimum or base index.

**Number of filled and unfilled grain per panicle:** Both the number of filled and unfilled grain showed significant variation (at 5% level) among the hybrid rice genotypes (Fig. 2). Maximum number of filled grain per panicle was produced by the genotype HS-12 which was closely followed by HSD-651 with the lowest unfilled grain per panicle. The lowest number of filled grain was produced by RXEL-15. Similarly, a wide range of unfilled grain was produced ranging from 18.49-60.92 (Fig. 2). Maximum unfilled grain was noted in genotype RXML-19 which was closely followed by APH-8181, HS-547 and RXEL-20. The check variety Heera-2 comparatively produced the lowest unfilled grain followed by HS-12 and HSD-651. The results of Pachauri *et al.*[26] and Begum *et al.*[9] suggested considering grain per panicle by using their phenotypic and/or genotypic direct effects as economic trait for better varietal development.

**Grain length and width:** The grain length significantly differed (at 5% level) among the hybrid rice genotypes with check varieties. A wide range of grain length was observed ranging from 7.17-9.67 mm (Fig. 3). The longest grain length noted in genotype HS-100 which was statistically similar to HS-547 whereas the shortest grain was found in the check variety Heera-2 which was closely followed by HS-12. In grain width, all the hybrid rice genotypes along with check variety were also differed significantly (at 5% level). A wide range of grain dimensions was observed among the rice genotypes ranging from 2.32-2.91 mm (Fig. 3). The thickest grain was found in the

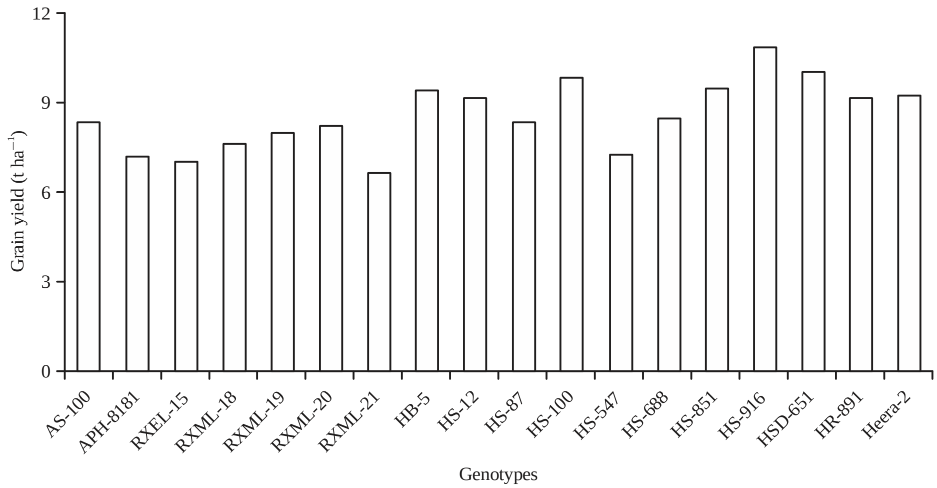


Fig. 4: Effect of different genotypes of hybrid rice on grain yield

genotype AS-100 which were closely followed by Heera-2 and RXML-19 while HS-916 produced the thinnest grain which was closely followed by RXEL-21 and HS-12. Mamun *et al.*[6] and Osekita *et al.*[21] found to have highest values of positive significant (at 5% level) correlations in grain length and width, this implies that grain length and width ratio can be simultaneously selected for improvement of the studied genotypes and that they can also be used concurrently in improving the genotypes studied.

**Grain yield (t ha$^{-1}$):** Being a quantitative trait, it is highly influenced by various biotic and abiotic elements. Yield is a dependent variable and is therefore interplay of various yield components. It depends upon genotypes, environment and their interaction. The grain yield of rice per plot was converted into yield per hectare and has been expressed in tons. The ANOVA results for grain yield revealed significant differences (at 5% level) among the hybrid rice genotypes. Higher grain yield (10.85 t ha$^{-1}$) was harvested from cultivar HS-916 closely followed by the genotype HSD-651 (10.06 t ha$^{-1}$) and HS-100 (9.83 t ha$^{-1}$). Similarly, the lowest grain yield was obtained in RXEL-21 (6.67 t ha$^{-1}$) which was closely similar to the yield of RXEL-15 (7.02 t ha$^{-1}$) (Fig. 4). Most of the tested hybrids seem to out yield their check counterpart, this might be attributed by their high number of effective tiller per plant, number of grains per panicle, panicle length and 1000-seed weight. The association of grain yield with above mentioned traits has been reported by various authors, number of panicle per hill[10], number of grains per panicles[8], percentage of filled grains per panicle[26] and 1000 grains per panicle[6,12]. Yaqoob *et al.*[22] reported that the genotypes, which produced higher number of effective tillers per hill and higher number of grains per panicle also showed higher grain yield in rice. Sarker *et al.*[16] also observed that different yield potentialities were observed in different studies might be due to variation in genotype, seasons and experimental setup.

## CONCLUSION

It is therefore concluded that exotic rice hybrids studied under Bangladesh conditions had shown significant variability in most of the yield components. The lines with early flowering were found early in maturity thereby showing positive association between these two traits. The grain yield was better in medium maturing lines coupled with medium panicle length and plant height. The hybrid variety HS-916 produced the highest grain yield followed by HSD-651 and HS-100 which was ranked 2nd and 3rd position, respectively among the exotic hybrids and local genotypes, excelled in effective tillers, panicle length, filled grains, 1000-grain weight, normal maturity period those ultimately correlated for the production of higher grain yield. Thus, the hybrid variety HS-916 along with HSD-651 and HS-100 may be recommended for cultivation in Bangladesh climatic condition for higher yield.

## SIGNIFICANCE STATEMENTS

The study discovers the possible way to find out the exotic hybrid rice cultivars and mechanisms how such plants adapt in new environment and give the quality yield that will beneficial for the farmers of Bangladesh to produce higher grain yield. This study will help the researcher to uncover the critical areas of hybrid rice production and identify promising cultivars that many researchers were not able to explore. Therefore, the present findings will also be the useful tools to the plant breeders for further rice research.

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