https://github.com/Sadi170538/Final_Project_Sadi_Robiul.git

Characterization of Local Rice Landraces at Greater Faridpur Region in Bangladesh for useful gene pool

Introduction

Rice (*Oryza sativa* L.) is an important staple crop for about 50% of the global population (Garris et al. 2005; Ram Kumar et al. 2010). Predominantly cultivated in South, East, and Southeast Asia, Tropical Latin America, and the West Indies, rice is a significant crop in these regions. Rice plays a vital role in both dietary and cultural practices in those regions (Khush et al.1997). Rice (*Oryza sativa* L.) comes from the family Gramineae, and the subfamily *Oryzoidea* comprises two main types, namely indica and japonica, in Asia (Mohapatra et al. 2022). Indica type is mainly grown in tropical and subtropical regions, including Bangladesh and India. Japonica type is cultivated in temperate climates like those found in China and Japan (Yang et al. 2014). Rice's genetic variety and climate-adaptive qualities make it a resilient food crop worldwide (Seck et al. 2012).

Bangladesh has a rich and wide genetic wealth of rice cultivars. About 75% of agricultural land is used for rice cultivation in Bangladesh (Nourollah et al. 2016). According to BBS (2016), the country's Gross Domestic Product (GDP) of about 17% comes from rice. From the beginning of agriculture, rice was cultivated by farmers using manually selected seeds, referred to as landraces. These landraces, which are traditional varieties adapted over generations to local conditions. These landraces still hold an essential place in Bangladesh's agriculture due to their high genetic variability and adaptability (Sathya et al. 2013). There are a lot of landraces of rice available in the major rice-growing regions of Bangladesh (Akter et al. 2016). Local rice landraces in Bangladesh have been passed down through generations and are prevalent across many regions. It reflects the country's rich heritage of rice diversity (Kamruzzaman et al. 2017; Deb et al. 2021). International Rice Research Institute's (IRRI) gene bank contains more than 8000 traditional rice varieties collected from Bangladesh (Hossain et al. 2013).

The local landraces of rice varieties in Bangladesh face numerous challenges such as low yield, long duration, and lodging issues. But they hold significant value in future crop improvement and serve as a valuable genetic source for breeding purposes (Das et al. 2024). Landraces have been used as sources of resistance to pests, abiotic stresses, and disease resistance for future crop improvement (Ashraf & Lokanadan et al. 2017).

Exploring diversity in the landrace, collection, and morphological characterization is very important for identifying new genes and further improving the germplasm. Exploring and characterizing the diversity of these traditional varieties is paramount for sustainable crop improvement. The morphological characterization of rice landraces is a critical step in identifying genotypes with valuable traits for gene banks. The process of morphological characterization involves evaluating various physical and agronomic traits such as plant height, grain shape, tiller number, flowering time, and drought tolerance. Through these evaluations, researchers can determine the distinctness, uniformity, and stability of genotypes. These characters also facilitate the selection of potential parent plants for breeding (Thomson et al. 2007). In a hybridization program, germplasm with unique traits can act as a good parent (Ahmed et al. 2016; Islam et al. 2017).

For this purpose, a further study was conducted to characterize local landraces for their distinctness and uniformity. Various types of landraces of rice are available in the major rice-growing regions of Faridpur (Yesmin et al. 2014), and hence, their characterization and establishment of uniformity are essential to consider them as variety. More than their registration as a variety, a better-performing local type may be used in crop improvement programs as a genetic resource. So, this study looked at the agro-morphological traits of 11 different types of rice from the Faridpur region in Bangladesh to find out how genetically different they are.

Materials and methods

Experimental site

During the Aman season in 2020, 2021, and 2022 the experiment was carried out at the research farm of the Bangladesh Institute of Nuclear Agriculture (BINA), Gopalganj, Dhaka Bangladesh Geographically, the region is situated at 89.76 °E longitude and 23.11 °N latitude, and it has a subtropical climate. The experimental site's soil had a clay loam texture.

Crop materials

A total of 11 local rice germplasm (Laldigha, Lokhsmidigha, Jabra, Modhudigha, Najirshail, Bandorjhata, Sishumaty, Rangadigha, Debmoni, Kachkalam, and Bidigha) of Faridpur region were selected and collected locally. Pre-germinated seeds were sown in the seed bed.

Experimental design and setting of the experiment

Three replications of the experiment were carried out using the randomized complete block design (RCBD). One seedling per hill, 25-day-old seedlings from each entry were transplanted into a 2×4-m2 plot with spacing between rows and plants of 25 cm and 20 cm, respectively.

Intercultural operations

At a rate of 60:20:40:10 kg N, P, K, and S per acre, fertilizer was applied. At the end of the land preparation process, a total amount of TSP, MP, and gypsum were applied. Three split applications of urea were made at 15, 30, and 45 days (DAT) following transplantation. When necessary, cross-cultural operations and pest control procedures were carried out.

Result

Statistical Analysis of Phenotypic Traits of Rice Landraces

An analysis of variance (ANOVA) was conducted to determine the variability among 11 rice landraces from the Faridpur region based on eight agronomic traits: plant height (cm), effective tiller/plant, panicle length (cm), filled grain/panicle, unfilled grain/panicle, 1000 seed weight (g), grain yield (t/ha), and straw yield (t/ha). The ANOVA results for the phenotypic traits are summarized in Table 1. Grain yield (t/ha) was the only trait that showed a significant difference among the landraces ($F_{10,22}=4.733$, $p=0.0011$). For the remaining traits, no significant differences were observed ($p > 0.05$). Tukey's HSD test for grain yield revealed significant pairwise differences among specific landraces (Table 2).

Table 1: ANOVA Summary for Agronomic Traits of Rice Landraces

Trait	Degrees of Freedom	F-Value	p-Value	Interpretation
Plant height (cm)	10, 22	1.325	0.278	Not significant
Effective tiller/plant	10, 22	1.400	0.244	Not significant
Panicle length (cm)	10, 22	1.086	0.413	Not significant
Filled grain/panicle	10, 22	0.517	0.860	Not significant
Unfilled grain/panicle	10, 22	0.553	0.834	Not significant
1000 seed weight (g)	10, 22	0.467	0.894	Not significant
Grain yield (t/ha)	10, 22	4.733	0.0011**	Significant

*Significant at $p<0.01$

Table 2: Tukey HSD Post-hoc Test Results for Grain Yield (t/ha)

Pairwise Comparison	Difference	Lower CI	Upper CI	Adjusted p-value	Significance
Kachkalam vs. Jabra	-2.793	-5.272	-0.314	0.019	*
Laldigha vs. Kachkalam	2.983	0.504	5.462	0.010	**
Najirshail vs. Kachkalam	2.883	0.404	5.362	0.014	*
Sishumaty vs. Kachkalam	2.780	0.301	5.259	0.020	*

The significant difference observed in grain yield among the rice landraces indicates genetic variability in this trait. Landraces such as *Kachkalam*, *Najirshail*, *Laldigha*, and *Sishumaty* exhibited distinct performance in grain yield. These findings highlight the potential for selecting high-yielding landraces for breeding programs or local agricultural practices in the Faridpur region. For traits such as plant height, panicle length, and 1000 seed weight, the absence of significant differences suggests a shared phenotypic expression across the tested landraces, possibly due to similar environmental adaptation or genetic homogeneity in these traits.

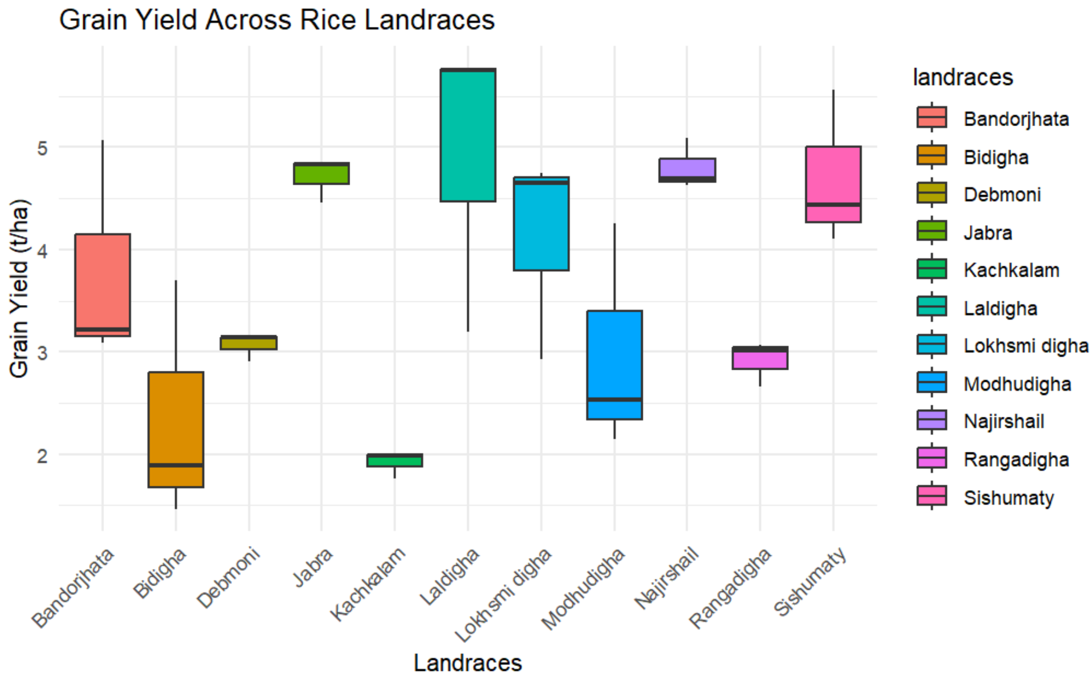

Figure 1: Range of Grain Yield Across Rice Landraces

This boxplot in Figure 1 displays the grain yield (in tons per hectare, t/ha) across 11 different rice landraces. Each landrace is represented by a distinct color and the corresponding yield values are shown as box-and-whisker plots. *Laldisigha* and *Lokhsmi digha* demonstrate the highest median yields, reaching or exceeding 4 t/ha. *Sishumaty* also has a high median yield, with a relatively narrow IQR indicating consistent performance. *Kachkalam* and *Rangadigha* have the lowest median yields, falling below 2 t/ha. These landraces also show less variability, suggesting consistently lower yields. *Bandorjhata* and *Bidigha* display median yields around 3–4 t/ha, with moderate variability. Certain landraces, such as *Modhudigha* and *Debmoni,* have extreme values that may indicate outlier data points or specific conditions leading to unusually high or low yields.

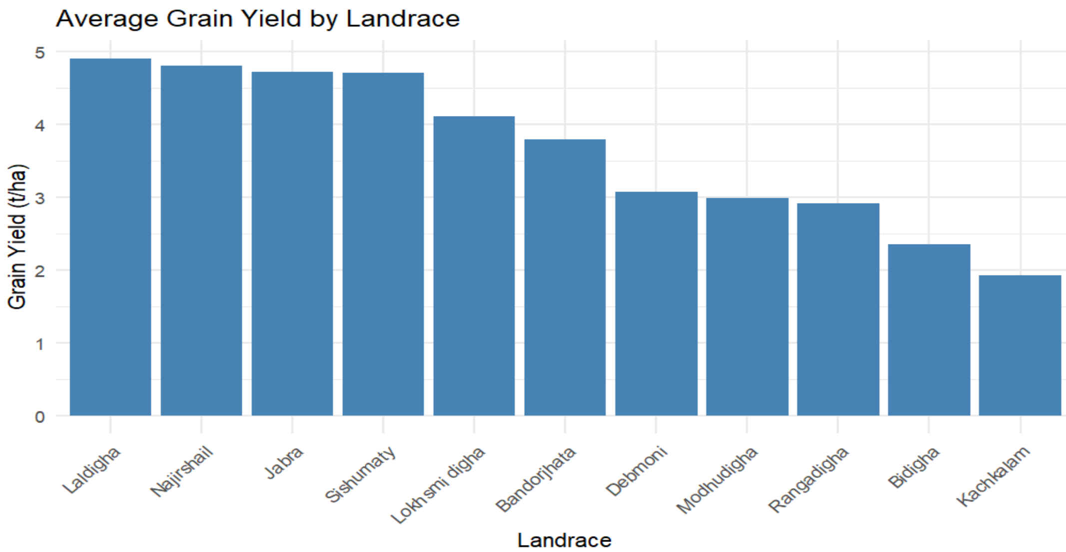

Figure 2: Average Grain Yield Across Rice Landraces

The average grain yield (t/ha) of 11 rice landraces was assessed, and the results are presented in Figure 2. Among the landraces, *Laldigha* exhibited the highest grain yield, averaging approximately 5 t/ha, followed closely by *Najirshail* and Jabra, both producing similar yields. In contrast, *Kachkalam* displayed the lowest average grain yield at approximately 2 t/ha. Other landraces, including *Bidigha*, *Rangadigha*, and *Modhudigha*, demonstrated moderate yields ranging between 2.5 and 3.5 t/ha.

The landraces *Sishumaty* and *Lokhsmi digha* also showed relatively high yields, slightly exceeding 4 t/ha. Intermediate performance was observed for landraces such as *Bandorjhata* and *Debmoni*, both averaging between 3.5 and 4 t/ha. The data highlights significant variability in grain yield among the studied rice landraces. The superior performance of *Laldigha*, *Najirshail*, and *Jabra* suggests their potential as high-yielding varieties, which could be advantageous for breeding programs or cultivation in regions with similar agro-climatic conditions. Conversely, the consistently lower performance of *Kachkalam* may indicate specific limitations, such as genetic potential, adaptability, or response to environmental stressors.

Correlation Analysis Among Agronomic Traits of Rice Landraces

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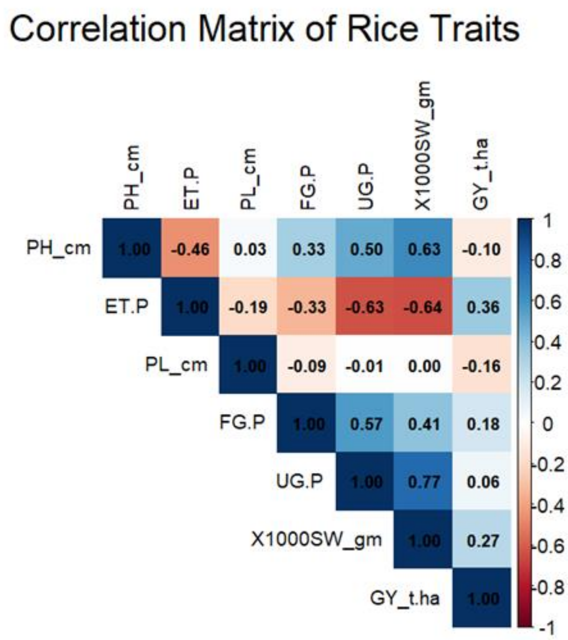

Figure 3: Correlation Analysis Among Agronomic Traits of Rice Landraces

Pearson correlation analysis was conducted to examine the relationships among various agronomic traits of 11 rice landraces including plant height (PH_cm), tillers per plant (ET.P), panicle length (PL_cm), filled grains per panicle (FG.P), unfilled grains per panicle (UG.P), 1000-seed weight (X1000SW_gm), and grain yield per hectare (GY_t.ha). It is shown in Figure 3

Positive Correlations:

- Plant Height (PH*)* exhibited a strong positive correlation with 1000-seed weight (r = 0.63) and unfilled grains per panicle (r = 0.50), indicating that taller plants tend to produce heavier seeds and more unfilled grains. Filled Grains per Panicle *(FG.P)* showed a moderate positive correlation with unfilled grains per panicle (r = 0.57) and 1000-seed weight (r = 0.41). This suggests that while more filled grains are associated with higher seed weight, there is also an increase in unfilled grains. Unfilled Grains per Panicle *(UG.P)* demonstrated the highest positive correlation with 1000-seed weight (r = 0.77), implying a strong genetic or physiological link between these traits.

Negative Correlations:

- Tillers per Plant (ET. P) showed negative correlations with most traits, particularly 1000-seed weight (r = -0.64) and unfilled grains per panicle (r = -0.63), suggesting that plants with more tillers may produce lighter seeds and fewer unfilled grains. Grain Yield (GY_t.ha) had weak to moderate negative correlations with traits like plant height (r = -0.10), tillers per plant (r = -0.16), and panicle length (r = -0.16), indicating that higher grain yield may not necessarily correlate with these structural traits.

Genetic Dissimilarity Among Rice Landraces in the Faridpur Region

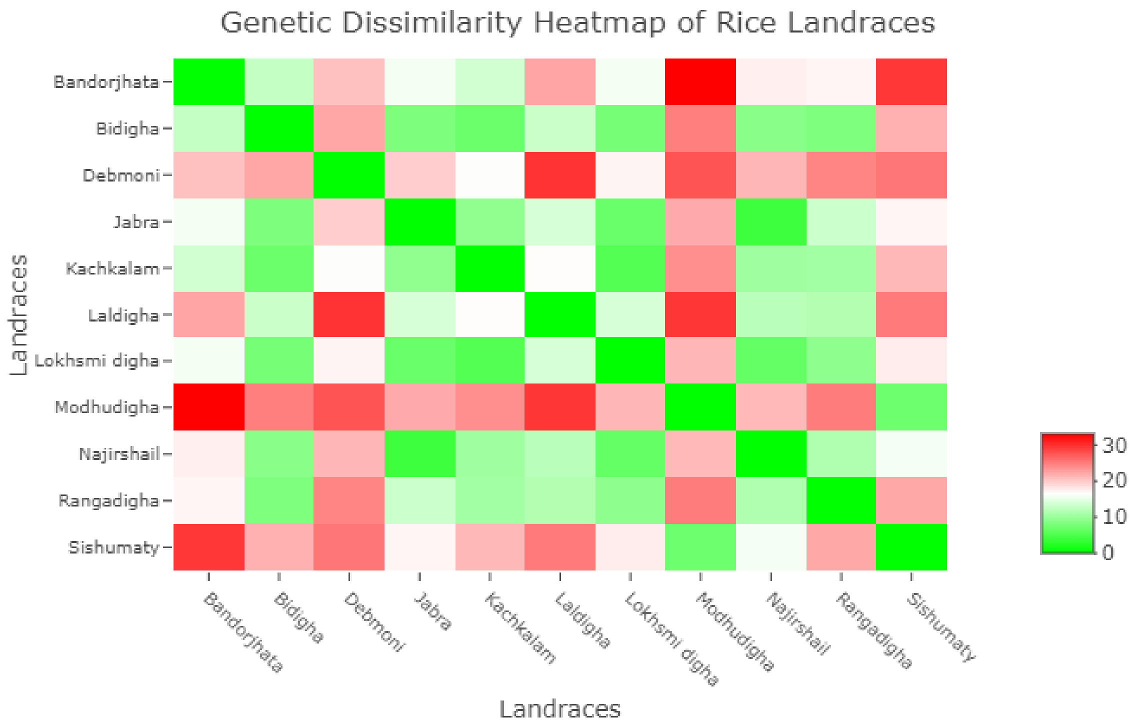

Figure 4: Heat map of Genetic Dissimilarity Among Rice Landraces

The genetic diversity of 11 rice landraces from the Faridpur region was analyzed using a genetic dissimilarity matrix, visualized as a heatmap (Figure 4). The heatmap illustrates pairwise dissimilarity values, where colors range from green (low dissimilarity) to red (high dissimilarity).

1. **Clusters of Similarity:**

- Certain rice landraces exhibit lower genetic dissimilarity, evident from green-dominant cells. For instance, *Bandorjhata* and *Debmoni* show high similarity, indicating they may share closer genetic traits or common ancestry. *Lokhsmi digha* and *Laldigha* also demonstrate a relatively low level of genetic dissimilarity.

2. **High Genetic Dissimilarity:**

- Some landraces, such as *Modhudigha*, display high genetic dissimilarity with others, as indicated by prominent red cells in the heatmap, particularly against *Kachkalam* and *Najirshail*. These differences suggest unique genetic traits or adaptations that distinguish them from other landraces.

3. **Intermediate Relationships:**

- Landraces such as *Jabra* and *Sishumaty* exhibit a mix of intermediate dissimilarity with most other landraces, reflecting a balanced genetic relationship that neither clusters strongly with nor diverges widely from other varieties.

The observed genetic dissimilarity patterns highlight substantial genetic diversity among the rice landraces studied. Such diversity is critical for breeding programs, as it provides a genetic reservoir for improving stress tolerance, yield, and other agronomic traits. Landraces like *Modhudigha* and *Kachkalam*, with higher genetic dissimilarity, may offer unique alleles for future genetic improvement.

Hierarchical Clustering of Rice Landraces

The dendrogram illustrates the genetic relationships among 11 rice landraces based on key agronomic traits. Hierarchical clustering was performed using the Euclidean distance method, and complete linkage was applied to group the landraces based on their genetic similarity.

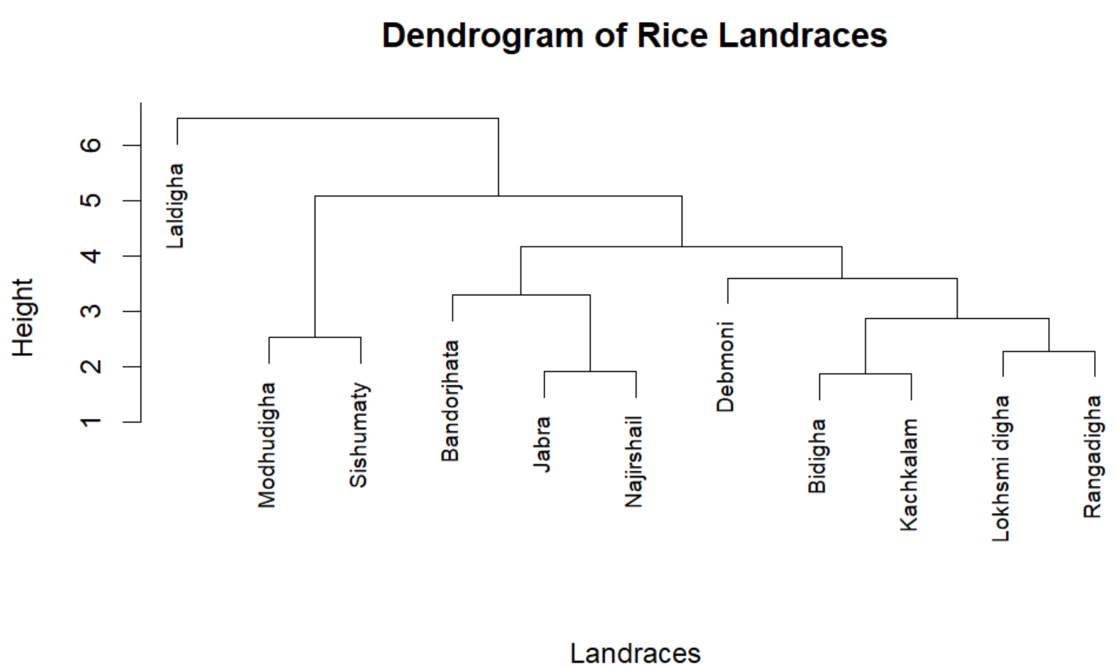

Figure 5: Dendrogram of Rice Landraces

The analysis grouped the landraces into distinct clusters are shown in Figure 5, revealing significant variation in genetic traits among them:

1. **Distinct Clustering of Laldigha**:

- *Laldigha* forms an independent cluster, suggesting it has the highest level of divergence compared to the other landraces. This result implies unique agronomic traits that set it apart from the remaining landraces.

2. **Close Genetic Similarity Among Subgroups**:

- *Modhudigha* and *Sishumaty* are grouped together, indicating a high degree of similarity in their measured traits. Similarly, *Bandorjhata* and Jabra form another subgroup, showing moderate levels of similarity.

3. **Genetic Relationships Within the Larger Cluster**:

- The larger cluster comprises *Bidigha, Debmoni, Kachkalam, Lokhsmi digha*, and *Rangadigha.* Within this group, *Bidigha and Debmoni* are closely related, forming a smaller subgroup. *Kachkalam, Lokhsmi digha, and Rangadigha* are grouped together, highlighting their similar genetic traits, though *Lokhsmi digha* and *Rangadigha* exhibit closer clustering than with *Kachkalam.*

4. **Intermediate Position of Najirshail**:

- *Najirshail* bridges the gap between the *Modhudigha-Sishumaty* cluster and the larger cluster, reflecting moderate genetic divergence from both groups.

Discussion

Focusing on agronomic traits, the results of this study demonstrate the genetic and phenotypic diversity between the 11 rice landraces of the Faridpur region. In contrast, grain yield was the only trait to show such a level of variability, with higher yielding landraces including Laldigha, Najirshail and Sishumaty. This implies that these landraces have better agronomic traits and can be good selections for future breeding programs, directed towards yield improvement. By contrast, landraces like Kachkalam consistently exhibited lower yields, which could be indicative of genetic constraints or environmental sensitivities.

Similarly limited variation in morphological attributes, such as plant stature, tiller number, and panicle length may suggest a common ancestry or adaptation under similar environmental conditions. Yet highly positive correlations of some traits, like the plant height and 1000-seed weight found in this study, suggest that trait associations should be considered in view of their phenotypic impact on agronomic performance.

Genetic variability was considerable between these landraces as confirmed using dissimilarity analysis, exemplified by landraces such as Modhudigha and Kachkalam. This genetic diversity creates a strong pool for improving stress tolerance and disease resistance. Yet clustering patterns also form distinct groups of genetically related landraces (Bandorjhata and Jabra), providing useful information for breeding programs aimed at similar characteristics.

These results are consistent with previous studies including Roy et al. (2004) revealing clustering among rice landraces based on agronomic traits.

Conclusion

The agronomic and genetic diversity of 11 rice landraces from the Faridpur region is highlighted in this study as a significant resource for sustainable crop improvement. Landraces Laldigha has higher yielding than other varieties in the germplasm collection, such as Jabra and Lokhsmi digha, have the potential to provide useful alleles for breeding programs in terms of genetic contributions. Among the cultivar Laldigha, Lokhsmi digha, and Jabra can be used for further breeding programs. These results highlight the significance of preserving indigenous rice landraces as a key part of Bangladesh's agricultural legacy and source of traits needed to meet future agricultural challenges.

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