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Research Article

Morphological performance of local upland rice accessions from West Bangka for germplasm conservation

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ABSTRACT

The genetic diversity of upland rice in West Bangka plays a crucial role in food security and germplasm conservation. This study aimed to identify the morphological characteristics of upland rice accessions from West Bangka. The research involved identifying seven local rice accessions from West Bangka and was conducted from March to July 2024. This study employed survey methods and field observations using Purposive Random Sampling based on type or accession, and data analysis was carried out through experimental methods. Data collection involved observing the morphology of the upland rice plants qualitatively and quantitatively. Data analyses were performed using variability tests. Local upland rice accessions in West Bangka Regency showed morphological diversity as indicated by the value of the broad variability in leaf width, leaf blade length, seed width, and seed thickness, while other traits showed narrow variability. The wide morphological diversity in certain characters showed that local accessions of upland rice in the West Bangka Regency had good genetic potential for utilization in plant breeding programs.

Keywords: genetic resources; morphology; biodiversity conservation; agronomy; genetic variation

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INTRODUCTION

West Bangka Regency is known for its diversity of local rice accessions. Seven local rice accessions have not been identified and characterized, namely Jawa, Balok Merah, Pulut Hitam, Pulut Emas, Mukot, Padi Ungu, and Mayang Hutan. Local rice production data in West Bangka are not available yet, but general rice production data in West Bangka in 2023 decreased to 1,957 tons from 2,153 tons in 2022 (BPS-BABEL, 2023). Local rice in this area has grown for years, showing strong adaptation to the local environment and culture. The diversity of local rice cultivars in West Bangka is high, and detailed information on their characteristics is incomplete; therefore, further identification and characterization are needed as a source of germplasm.

Indonesia, the fourth largest rice producer in the world, has a variety of local rice varieties with unique physical properties that make it the main staple food for its population (Utami et al., 2019). Rice production in Indonesia is influenced by various factors, one of which is the use of high-quality seeds from new superior varieties that contribute to approximately 56% of the total national rice production (Mardiharini et al., 2023). Rice is widely distributed in Indonesia, where approximately 45 varieties of paddy rice and 150 varieties of upland rice are usually cultivated throughout Indonesia (Suranto et al., 2018).

Approximately 80% of the total global rice production originates from rice cultivation in Asia, which is estimated to have originated in South and Southeast Asia. The process of natural selection and human domestication over thousands of years has resulted in rich genetic diversity in rice, reflected in the more than 140,000 local varieties (landraces) and rice varieties that exist today (Hadianto et al., 2020). Local rice varieties are often adapted to specific ecological conditions, providing them with better resistance to local environmental challenges such as drought or pests (Coffie et al., 2024).

Exploration activities are an integral part of efforts to maintain the sustainability of genetic resources, especially in the context of saving germplasms. Exploration refers to efforts to search for, collect, and study certain local varieties in certain areas to protect them from extinction (Sembiring et al., 2021). The genetic diversity of local rice, especially in indigenous areas and underdeveloped regions, such as Southeast Asia, is essential for maintaining optimal yields, improving quality, and preventing disease and pest attacks (Hour et al., 2020). This study aimed to explore and evaluate morphological characteristics and relationships in local accessions of upland rice in the West Bangka Regency. This will provide important information for the conservation, breeding, and utilization of local rice genetic resources in the region.

MATERIALS AND METHODS

This research was conducted in four locations in the West Bangka Regency: Kelapa, Tebing, Beruas, and Tuik Village, Kelapa District. The location selection was based on the location of the germplasm from March to July 2024. The tools used in this study were agricultural tools, stationery, meters, cellphone cameras, scissors, ropes, analytical scales, buckets, RHS color charts, rulers, soil pH meters, and plastic. The main materials used in this study were the local rice accessions.

In this study, we employed an initial survey and field observations. The sampling technique used was purposive random sampling (intentional), with criteria based on the type or accession of rice (Firmansyah & Dede, 2022). An initial survey was conducted to identify the population of rice accessions in the West Bangka Regency. The research locations were selected in four villages that had rice ready for planting, namely Kelapa, Tebing, Beruas, and Tuik Village in Kelapa District, West Bangka Regency. The selection of this location is based on the criteria for villages that have different rice accessions. In this survey, seven types of local rice accessions were found, including Jawa, Balok Merah, Pulut Hitam, Pulut Mas, Mukot, Ungu, and Mayang Hutan. These local rice accessions were found in four villages in Kelapa District: Jawa, Mukot, and Pulut Hitam were found in Kelapa Village; Mayang Hutan accession was found in Tebing Village; Ungu and Balok Merah rice accessions were found in Beruas Village; and Pulut Emas accession was found in Tuik Village. This study was conducted by collecting samples from each garden of 30 plants so that the total sample used in this study was 210 plants.

Observations included 34 morphological characteristics, including plant height, leaf length, number of tillers, and stem color. These observations were based on IBPGR-IRRI (1980) rice descriptor guidelines.

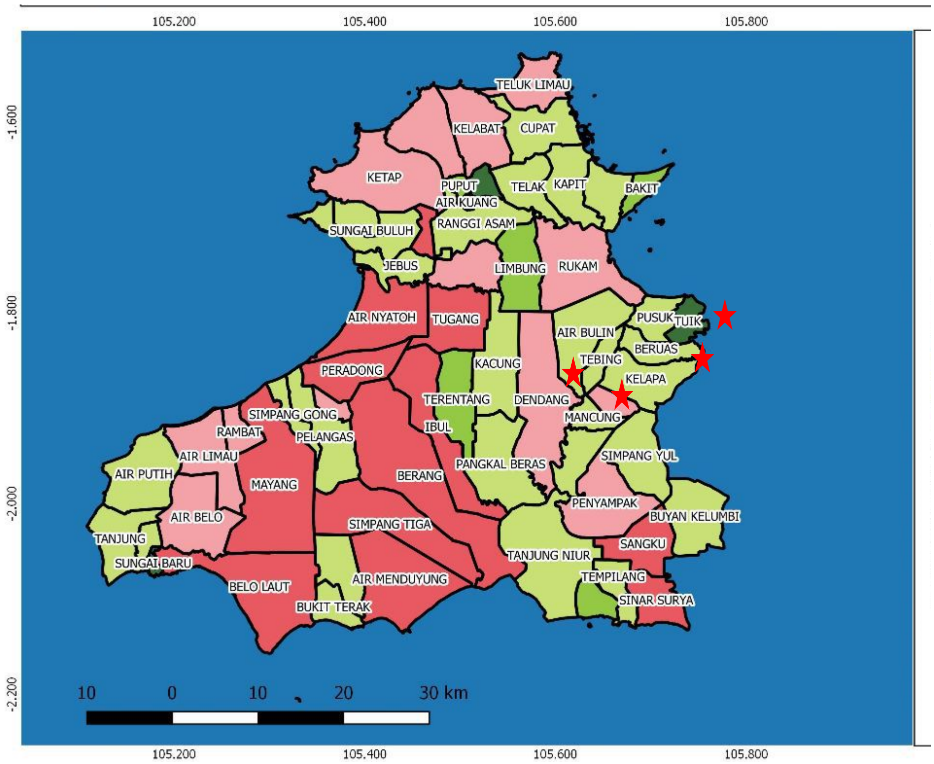

Figure 1. Map of research locations in Kelapa District (*)

The analysis of genetic performance data in this study was divided into two types of data tests: qualitative and quantitative data. Qualitative data were analyzed descriptively and were presented in the form of tables and figures. Quantitative data analysis included variability testing to determine uniformity. Kinship analysis evaluates relatedness between individuals or groups based on genetic, morphological, or behavioral characteristics. Plant characterization data were tabulated in Excel and analyzed using NTSys to obtain similarity values, genetic distances, and dendrograms. Cluster analysis based on data similarity produced a dendrogram showing the level of similarity in percentages based on the coefficient. The variability value was calculated by determining the genetic, environmental, and phenotypic variations. The second step was to calculate the standard error of phenotypic variation and genetic variation. The variability value was calculated using a mid-square analysis of variance. The next step was to estimate the value of genetic, environmental, and phenotypic variance using the following formula:

$$\sigma_g^2 = \frac{MSG - MSE}{r}$$

$$\sigma_p^2 = \sigma_g^2 + \sigma_e^2$$

$$\sigma_e^2 = MSE$$

σ_g^2 is the genetic variance, σ_e^2 is the environmental variance, σ_p^2 is the phenotypic variance, MSG is the mean square of genotype, MSE is the mean square error, and r is the number of replications.

The grouping of criteria for genetic variability and phenotypic variability values was as follows (Wahdah et al., 2017):

Genetic variability

$\sigma_g^2 \geq 2\ \sigma_{\sigma_g^2}$ = Wide

$\sigma_g^2 < 2\ \sigma_{\sigma_g^2}$ = Narrow

Phenotypic variability

$\sigma_p^2 \geq 2\ \sigma_p^2$ = Wide

$\sigma_p^2 < 2\ \sigma_p^2$ = Narrow

Heritability measures the proportion of phenotypic variation in a character that can be attributed to genetic variation. It provides an estimate of the genetic contribution to the observed variation in a population. The formula for calculating heritability (h^2) in percentage is as follows:

$$h^2 = \frac{\sigma_g^2}{\sigma_p^2} \times 100\%$$

RESULTS AND DISCUSSION

The results of the rice germplasm exploration in Kelapa District, West Bangka Regency, revealed seven rice accessions with different qualitative and quantitative characteristics. Additional information (passport data), such as the area of origin and harvest age for the rice germplasm in West Bangka Regency, can be seen in Table 1.

Table 1. Passport data for local accessions of upland rice in West Bangka Regency.

Accession	Location of origin	Age of flowering (DAP)	Age of harvest (DAP)
Balok Merah	Beruas, Bangka Barat	77e	113g
Ungu	Beruas, Bangka Barat	80c	120f
Jawa	Kelapa, Bangka Barat	86b	129b
Pulut Hitam	Kelapa, Bangka Barat	78d	127c
Mukot	Kelapa, Bangka Barat	78d	124e
Pulut Emas	Tuik, Bangka Barat	88a	126d
Mayang Hutan	Tebing, Bangka Barat	69f	132a
LSD (0.05)		1.02	6.78
CV (%)		1.47	1.51

Note: Values in the same column with the same letter were not significantly different based on the LSD test at the 0.05 level; CV: coefficient of variation.

The flowering age of local upland rice in West Bangka Regency ranges from 69-88 days after planting (DAP), and the harvest age ranges from 113-132 DAP. The most important agronomic characteristics of rice plants are flowering and harvest age. These two characteristics indicate how long the rice plant needs to reach a certain growth stage. The local upland rice accession in West Bangka Regency, which had the fastest flowering age, was the Mayang Hutan accession, with a flowering period of 69 DAP and the longest harvest age of 132 DAP compared to other accessions. The upland rice accession with the fastest harvest age was the Ungu accession, with a harvest period of 120 DAP and a flowering age of 80 DAP. Flowering age is an important factor in estimating harvest age. The harvest age of rice plants depends on the flowering phase, which begins when the rice enters the booting stage and continues until the emergence of the panicle or flower (Rahim et al., 2017). Variations in flowering age can indicate differences in response to environmental factors such as day length, temperature, and water availability. Different grain-filling and ripening periods for each accession can also affect variations in harvest age (Yulianti et al., 2021).

The genetic diversity of local rice is a valuable resource for plant breeding and food security. The preservation of local rice germplasms is very important in facing future food security challenges. One of the efforts was to characterize local rice accessions from various regions. The results of the qualitative characterization of the seven local accessions of upland rice in the West Bangka Regency are presented in Table 2.

Table 2. Qualitative leaf characteristics of 7 local accessions upland rice in West Bangka Regency.

Accession	Leaf color	Ligule color	Leaf tongue shape	Leaf ear color	Leaf surface
Balok Merah	Dark green	White	2-cleft	White	Hairy
Ungu	Dark green	Purple	2-cleft	Purple lines	Hairy
Jawa	Dark green	White	2-cleft	White	Medium
Pulut Hitam	Dark green	Purple	2-cleft	Purple lines	Hairy
Mukot	Dark green	White	2-cleft	White	Medium
Pulut Emas	Dark green	White	2-cleft	White	Medium
Mayang Hutan	Dark green	White	2-cleft	White	Hairy

Local West Bangka rice has two leaf tongue color categories: white and purple. The white leaf tongue color was found in the accessions Balok Merah, Jawa, Mukot, Pulut Emas, and Mayang Hutan. Purple leaf tongue color was found in the Ungu and Pulut Hitam accessions. Overall, the leaf tongue shape found in local upland rice accessions in West Bangka had a 2-cleft leaf tongue shape. The leaf ear color in West Bangka rice accessions was found in two categories: white and purple stripes. The white leaf ear color was found in the accessions Balok Merah, Jawa, Mukot, Pulut Emas, and Mayang Hutan. Purple striped leaf ear color was observed in the Ungu and Pulut Hitam accessions. The appearance of leaf tongue color, leaf tongue shape, and leaf ear color are shown in Figure 1.

Qualitative characteristics observed as supporting data were leaf color, ligule color, leaf tongue shape, leaf ear color, leaf surface texture, stem color, secondary panicle branches, grain color, rice skin color, and rice shape. Seven local upland rice accessions in West Bangka had the same overall characteristics, such as dark green leaf color, 2-cleft leaf tongue shape, green stem color, and straw yellow grain color. The color of the rice leaf tongue can be influenced by genetic variation between accessions. Genetic mutations that occur during the reproductive process can cause differences in leaf tongue color between accessions (Mulyaningsih & Indrayani, 2014).

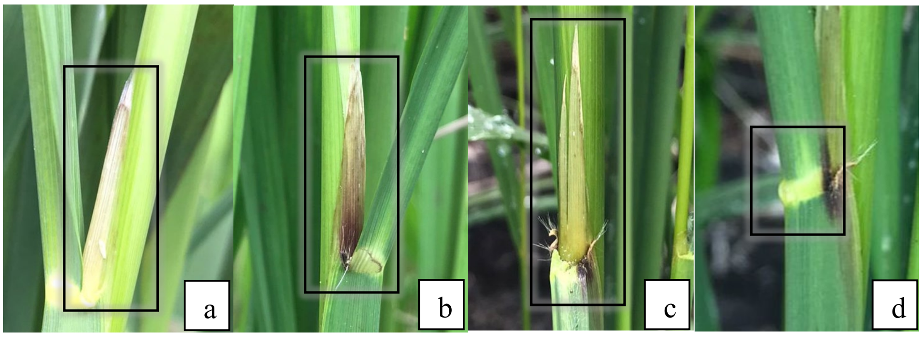

Figure 2. The appearance of several local accessions upland rice characters in West Bangka Regency (a) white leaf tongue color, (b) purple leaf tongue color, (c) 2-cleft leaf tongue shape, and (d) white leaf ear color.

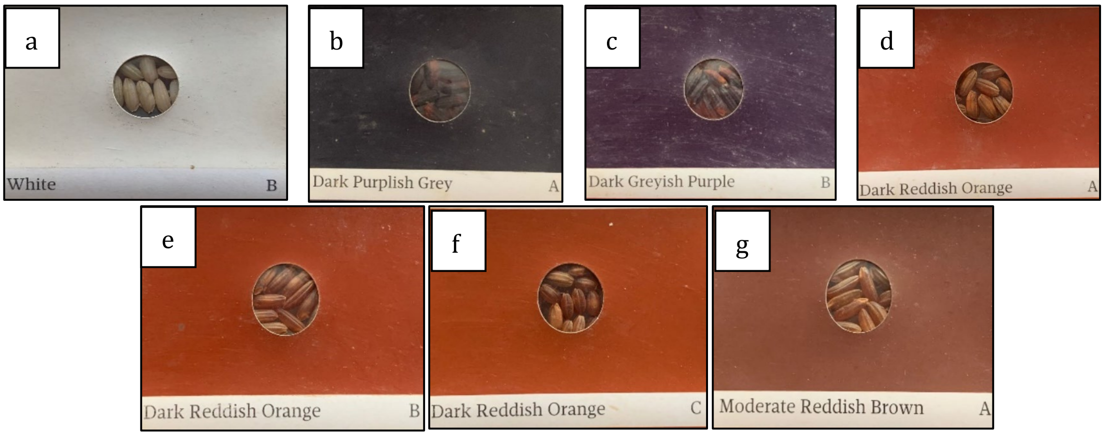

Figure 3. Grain color of rice from locally accessions upland rice in West Bangka Regency (a) Pulut Emas, (b) Pulut Hitam, (c) Ungu, (d) Balok Merah, (e) Jawa, (f) Mukot (g) Mayang Hutan.

Table 3. Qualitative stem, panicle, and grain characteristics of 7 local accessions upland rice in West Bangka Regency.

Accession	Stem color	Secondary branching of panicles	Color of grain	Rice bran color	Rice shape
Balok Merah	Green	Light	Straw yellow	Red	Medium
Ungu	Green	Light	Straw yellow	Purple	Slender
Jawa	Green	Heavy	Straw yellow	Red	Slender
Pulut Hitam	Green	Heavy	Straw yellow	Purple	Slender
Mukot	Green	Light	Straw yellow	Red	Medium
Pulut Emas	Green	Light	Straw yellow	White	Slender
Mayang Hutan	Green	Light	Straw yellow	Red	Slender

The secondary panicle branches of local accession upland rice in West Bangka Regency, based on the research results, showed panicle variations. Accessions Balok Merah, Ungu, Mukot, Pulut Emas, and Mayang Hutan showed few secondary panicle branches, while accessions Jawa and Pulut Hitam had many secondary panicle branches. The secondary panicle branches can be influenced by the genetic variance between rice accessions. Genetic mutations that occur during the reproductive process can cause differences in the secondary panicle branches between accessions (Parida et al., 2022).

Based on observations made on the character of the color of the rice husk on local accession upland rice in the West Bangka Regency, it showed color variations. The results of observations of the Balok Merah, Jawa, Mukot, and Mayang Hutan accessions showed that the color of the rice husk was red. The results for the Ungu and Pulut Hitam rice accessions showed that the color of the rice husk was purple, whereas the Pulut Emas accession showed that the color of the rice husk was white. The genetic composition of the color of each rice accession has a genetic composition that regulates the biosynthesis and accumulation of anthocyanins in the rice husk (Dwiatmini & Afza, 2018). The high anthocyanin content can cause the pigment in rice grains to become dark. This content is usually found in black rice because of its unique color and high antioxidant content.

Qualitative characters in the shape of rice exhibited a variety of shapes. Accessions Ungu, Jawa, Pulut Hitam, Pulut Emas, and Mayang Hutan showed a slender shape of rice, while accessions Balok Merah and Mukot showed a medium shape of rice. The assessment of rice shape has four size criteria: slender (> 3.0 mm), medium (2.1-3.0 mm), oval (1.1-2.0 mm), and round (<1.1). The main component that affects the shape of rice in each accession is the gene (Kamsiati et al., 2018). Each rice accession has a different gene arrangement that regulates the shape and proportions of the length, width, and thickness of rice grains (Hanas et al., 2017).

The local rice accessions from West Bangka had diverse quantitative traits. The diversity of traits measured quantitatively was the main difference between the rice accessions. The quantitative characteristics of the local rice accessions from West Bangka are presented in Table 4.

Table 4. Quantitative characteristics of 7 local accessions of upland rice in West Bangka Regency.

Character	Balok Merah	Ungu	Jawa	Pulut Hitam	Mukot	Pulut Emas	Mayang Hutan	CV	LSD
Plant height (cm)	152.23a	165.37a	144.89c	138.75d	145.04c	150.43a	154.87b	1.77	4.75
Stem diameter (mm)	5.33b	4.93b	3.32c	7.06a	3.31c	7.10a	7.42a	4.60	0.44
Leaf length (cm)	57.82cd	62.91ab	56.54cd	63.93a	55.25d	59.83bc	63.86a	3.38	3.61
Leaf width (cm)	1.93cd	1.85de	2.01bc	1.87de	2.14a	1.80e	2.05ab	3.51	0.12
Leaf tongue length (cm)	1.88c	2.09b	1.84c	1.88c	1.59d	1.70cd	2.59a	5.26	0.18
Panicle length (cm)	23.92c	33.63a	34.13a	30.05b	35.08a	34.63a	28.55b	5.45	3.04
Number of tillers	12.57c	15.43b	19.13a	19.47a	15.30b	15.10b	15.57b	3.62	1.03
Seed length (mm)	7.05d	8.46c	8.46c	8.47c	6.42e	8.86a	8.68b	1.62	0.22
Seed width (mm)	3.03a	2.45d	2.48d	2.75c	2.73c	2.91b	2.50d	2.49	0.11
Seed thickness (mm)	1.75a	1.52cd	1.47d	1.58bc	1.55cd	1.82a	1.66b	3.01	8.69
Grain length (mm)	4.99c	6.26b	6.07b	6.29b	3.35d	6.86a	6.93a	2.70	0.27
Grain width (mm)	2.73a	1.48d	2.09c	1.35d	1.39d	2.31b	2.30b	3.91	0.13
1,000 grains weight (g)	29.57c	21.33e	31.10a	30.30b	21.23e	28.07d	30.77ab	0.98	0.48
Plant yield 5 m^2 (kg)	5.50	7.10	6.20	6.10	5.30	7.20	6.70	2.31	2.59

Note: Values in the same row with the same letter were not significantly different based on the LSD test at 0.05 level; CV: coefficient of variation.

The plant height of all tested local upland rice accessions in West Bangka fell into the tall category. The Ungu rice accession had the highest plant height (165.37 cm), whereas the accession with the lowest plant height was the Pulut Hitam accession (138.75 cm). Differences in genetic composition are one of the factors causing variation in plant appearance, especially in terms of plant height. Genetic factors play a major role in determining the plant height. In addition, environmental conditions also have an influence. Supportive growing environments can enhance plant growth and production (Yulina et al., 2021). The results of this study showed that the stem diameter varied among the accessions. The largest stem diameter was found in the Mayang Hutan accession (7.42 mm), while the smallest diameter was found in the Mukot accession (3.31 mm). This difference in stem diameter is caused by environmental factors and the genetic characteristics of each accession (Purwansyah et al., 2021). Larger stems produce stronger plants that can withstand strong winds, and plants with larger stems can also produce more rice because stronger plants can support larger panicles (Simamora et al., 2023).

Leaf components, such as leaf length and width, also showed performance among accessions and good photosynthetic potential. The balance between leaf size and plant height must be considered to prevent etiolation or excessive shading (Afdila et al., 2021). The ratio of the length and width of the grains affects the quality of the rice grains. Grains with a larger ratio of length to width have larger and better grains, which has an impact on the quality of the rice produced (Ellya et al., 2020). The 1000-grain weight can indicate the overall crop yield potential, making it an important yield component. Dry matter in grains produced from assimilates from the photosynthesis process during grain filling affects the high and low 1000-grain weight (Supriatna et al., 2023).

The number of tillers in all the local West Bangka accession dryland rice produced was partly in the small category and partly in the medium category. The average number of tillers in rice plants ranges from 12.57 to 19.47 stems/plant. Each action produces a different number of offspring, which are influenced by the genetic factors of each accession (Mustikarini et al., 2020). The number of offspring will be optimal if the plant has superior genetic characteristics and is supported by environmental conditions that are suitable or supportive of plant growth and development (Oktavianty et al., 2023). The yield of rice plants in 5 m^2 showed that the Pulut Emas accession had the highest yield compared to other accessions (7.20 kg or equivalent to 11.5 tons/ha), while the lowest yield was obtained by the Mukot accession (5.30 kg or equivalent to 9.7 tons/ha). According to Mustikarini et al. (2016), the high and low yields of rice production can be influenced by genetic factors, where rice seeds that are small in size will produce low weight.

The dendrogram was based on quantitative and qualitative characteristics, which were observed in seven local accessions of upland rice in West Bangka Regency and classified into three clusters (Figure 4).

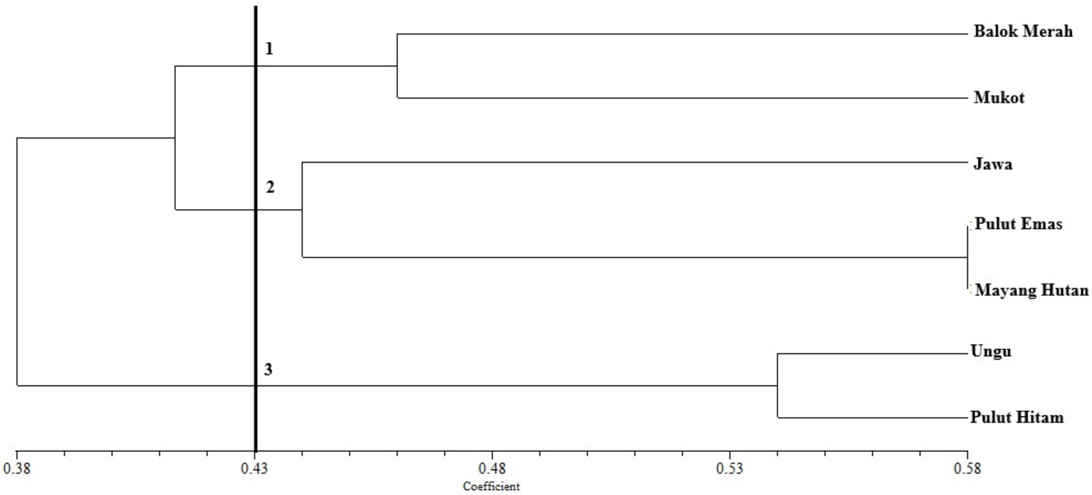

Figure 4. Dendrogram of seven local accessions of upland rice in West Bangka Regency based on qualitative and quantitative morphological characters.

Based on this research, there were seven local rice accessions: Balok Merah, Mukot, Java, Golden Pulut, Purple, Forest Mayang, and Black Pulut. The characteristics used to analyze the kinship relationship of local accession rice in West Bangka showed that there were differences between accessions, as many as 26 characters. Kinship relationships were based on quantitative and qualitative characteristics observed in seven locally accessed upland rice in West Bangka Regency and were classified into three clusters at the level of similarity at a coefficient of 0.43 or 43%. Accessions of the Pulut Emas and Mayang Forest had a close kinship relationship at a coefficient of 0.58 or 58% (Figure 4). The more differences in characters that are owned, the fewer similarities indicate that there is a kinship relationship between genotypes that are increasingly distant (Apriliani et al., 2024). Closer kinship relationships in rice plants are considered to show how wide the diversity is produced by several superior rice accessions tested. The more distant the relationship between genotypes is, the wider the diversity is (Nurmayanti et al., 2023).

The genetic variability of a population can be determined by evaluating several plant growth and yield traits. The results of quantitative character variability in local rice accessions from West Bangka are presented in Table 5.

Table 5. Variability of quantitative characters of local accessions upland rice in West Bangka Regency.

Character	Mean	σ_g^2	Criteria	σ_p^2	Criteria	σ_e^2	Heritability (%)
Plant height	150.22	310.25	Wide	331.64	Wide	21.40	93.55
Stem diameter	5.50	13.72	Wide	13.91	Wide	0.19	98.62
Leaf length	60.02	46.23	Wide	58.62	Wide	12.40	78.86
Leaf width	1.95	0.05	Narrow	0.07	Narrow	0.01	79.55
Leaf tongue length	1.94	0.45	Narrow	0.48	Narrow	0.03	93.46
Panicle length	31.42	67.92	Wide	76.73	Wide	8.81	88.51
Number of tillers	16.08	25.52	Wide	26.54	Wide	1.02	96.17
Seed length	7.62	3.89	Wide	3.94	Wide	0.05	98.80
Seed width	2.69	0.21	Narrow	0.23	Narrow	0.01	90.28
Seed thickness	1.62	0.06	Narrow	0.07	Narrow	0.01	90.02
Grain length	5.82	7.12	Wide	7.19	Wide	0.07	98.97
Grain width	1.95	1.32	Wide	1.34	Wide	0.02	98.69
1,000 grains weight	27.49	84.80	Wide	85.02	Wide	0.22	99.74
Age of flowering	80.86	249.64	Wide	249.64	Wide	0.00	100.00
Age of harvest	125.14	251.14	Wide	251.14	Wide	0.00	100.00
Plant yield	6.30	2.48	Wide	2.48	Wide	0.00	100.00

Note: Criteria on genotypic variability: $\sigma_g^2 \geq 2\sigma_g^2$ = wide, $\sigma_g^2 < 2\sigma_g^2$ = narrow; criteria on phenotypic variability: $\sigma_p^2 \geq 2\sigma_p^2$ = wide, $\sigma_p^2 < 2\sigma_p^2$ = narrow (Wahdah et al., 2017).

The genetic variability of a population can be determined by evaluating several plant growth traits and yield characteristics. Rice accessions in West Bangka Regency had both narrow and wide variability. Analysis of variability in local upland rice accessions showed that the most dominant criteria were narrow genotypic and phenotypic variability. The narrow criteria for several of these characteristics are estimated to be caused by higher phenotypic variance compared to genotypic variance (Zasari et al., 2023). The variability observed in quantitatively measured morphological characters is the result of interactions between genetic and environmental factors (Lestari et al., 2020). Wide criteria are found in the characters of leaf width, leaf ligule length, seed width, and seed thickness. Variability is a genetic parameter that indicates the level of diversity in a population. The higher the variability, the greater the chance of finding genes that correspond to desired characteristics (Mardiyah et al., 2022).

CONCLUSIONS

The varied morphological diversity showed the potential of local upland rice accessions in the West Bangka Regency to be used as a source of genetic material in plant breeding, taking into account heritability as a basis for selection to develop superior, more productive varieties.

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