International Journal on Advanced Science Engineering Information Technology

Vol.13 (2023) No. 5
ISSN: 2088-5334

# Broad Level of Diversity and Low Level of Kinship Local Rice Genotypes

Chairil Ezward [a], Irfan Suliansyah [b,*], Nalwida Rozen [b], Indra Dwipa [b]

[a] *Agricultural Science Doctoral Program, Faculty of Agriculture, Andalas University, Padang, West Sumatera, 25175, Indonesia*
[b] *Department of Agrotechnology, Faculty of Agriculture, Andalas University, Padang, West Sumatera, 25175, Indonesia*
*Corresponding author: *irfansuliansyah@agr.unand.ac.id*

***Abstract*— Characterization of genetic resources will provide added value in enriching gene diversity. As many as 24 local rice genotypes have been found in Kuantan Singingi Regency. However, the specific problem of this study is that the level of diversity and kinship is unknown. This study aims to determine the level of kinship and diversity of 24 local rice genotypes from the Kuantan Singingi Regency. This study used an experimental method in which to assess the level of diversity and kinship, planting and observation (identification) of the characteristics of rice plant organs had to be carried out using the International Rice Research Institute (IRRI) translated edition of the Standard Evaluation System (SES) guide in 2003. Observational data, then processed using Ms. software. Excel and (NTSYS-pc) version 2.11 to get a kinship tree or dendrogram. The results showed that the criteria for wide and narrow levels of diversity. At the same time, the degree of kinship ranges from 0.49-0.90. Only the PL17 (pulut benai rice from Kinali Village) and PL22 (gondok rice from Market Inuman Village) genotypes had a high consanguinity coefficient of 0.90 (90%). The degree of consanguinity of other genotypes is low. The lower the level of kinship, the potential to be used for developing rice plant breeding in the future. Further research is hoped to identify the resistance properties of 24 local rice genotypes from Kuantan Singingi Regency to biotic and abiotic stresses.**

***Keywords*— Local; rice; genotypes; SES; IRRI.**

*Manuscript received 15 Feb. 2023; revised 7 May 2023; accepted 11 Aug. 2023. Date of publication 31 Oct. 2023.*


## I. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple foods in most parts of the world [1]. Rice is an essential commodity because rice is the staple food of Indonesian society [2]. Food security policy is a strategy to achieve food security in Indonesia [3]. The stagnation experienced by the yield of Indonesian rice varieties today [4]. This is caused by changes in the frequency and intensity of extreme climates and the difficulty of controlling plant pests [5]. Indonesia is a tropical country with enormous potential and is the second-largest country in terms of biodiversity [6]. Diversity can be obtained from plant breeding activities. Starting from exploration, characterization, and breeding to releasing new superior varieties [7].

Kuantan Singingi Regency is in Riau Province, Indonesia. Several paddy fields in this area have altitudes between 32 meters and 61.56 meters above sea level [8]. This area has technically irrigated and rainfed rice fields [9]. However, it is more dominated by rainfed rice fields. Rice cultivation in this area often experiences environmental stress, both abiotic and biotic. Some areas are only stressed by drought, but they are also stressed by drought and flooding. Then there are deep rice fields (lubuk) and rice fields with new openings. Besides that, the local community and farmers have their tastes in consuming rice. Because of this, 26 local rice genotypes were obtained in exploration activities [10], but two genotypes did not grow, remaining 24 genotypes. The study's results [8] showed that several local rice genotypes resisted the brown planthopper pest.

Farmers have planted this genotype for generations for a long time. Naturally, these genotypes have experienced adaptation and evolution to adjust their growth to the local environment where genotypic diversity can be found. However, it is necessary to know the actual morphological characters of this local rice genotype with accurate data.

Several previous researchers have researched the characterization of local rice genotypes. For example, [4] found the degree of kinship in the local Deli Serdang upland rice genotype of 32.12% through description. The study's results [6] found good diversity in North Sumatra upland red rice cultivars through characterization. The results of

Suliansyah's research in 2018 found a kinship rate of 70 percent in the West Sumatran brown rice genotype through characterization.

The results of the characterization of each region have local genotypes that have the potential to be developed for the better. Characterization is vital because each germplasm will show different characteristics according to the environment. The availability of unique genotypes will significantly impact the effectiveness and acceleration of plant breeding programs in producing superior varieties that have economic value [7]. This research hopes to know the level of diversity and kinship of local rice genotypes in the Kuantan Singingi Regency.

## II. Materials and Method

### A. *The Study Area*

The research began with exploring local rice genotypes in Kuantan Singingi Regency, Riau Province, Indonesia. It is located between 0°00 - 1°00 south latitude and 101°02 - 101°55 east longitude. The exploration sites were selected using a purposive sampling method. Information from farmers, community leaders and agricultural services became the basis for selecting research sites. So that the exploration was obtained as many as 26 genotypes from 6 sub-districts, namely Kuantan Hilir, Pangean, Inuman, Gunung Toar, Kuantan Mudik, and Peboun Hulu (Fig. 1). Grain samples were collected at various altitudes from 28.95 meters to 61.56 meters of sea level. Characterization activities were ex-situ at the wirehouse of the Faculty of Agriculture, Andalas University, Padang, from February 2021 to October 2021.

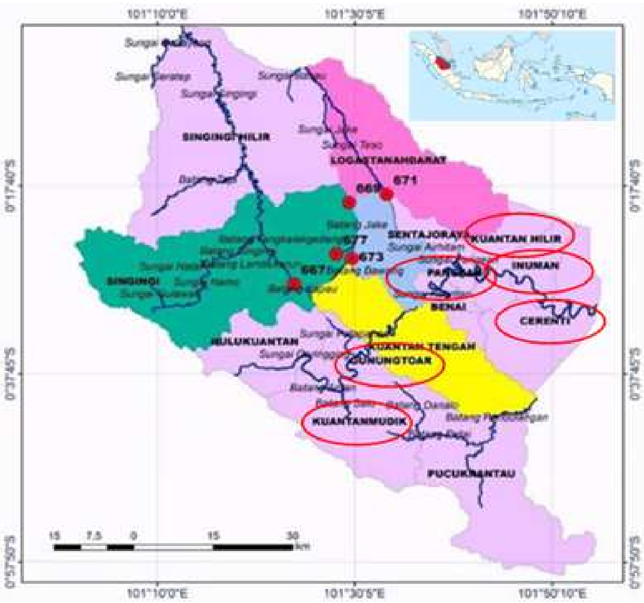



Fig. 1 Local Rice Genotype Sampling Locations in Kuantan Singingi Regency, Riau Province, Indonesia.

### B. *Procedure of Experiments*

An undesigned experimental method was used in this study, involving 24 local rice genotypes are : Padi sironda putih (PL01), Padi saronda merah (PL02), Padi pandan wangi (PL03), Pulut hitam (PL04), Padi ronda putiah (PL05), Padi singgaro merah (PL06), Padi kuning umur panjang (PL07), Padi ros (PL08), Padi samo putiah (PL09), Padi limbayang (PL10), Pulut karate (PL11), Padi sokan umur panjang (PL12), Pulut benai peboun hulu (PL13), Padi singgam putih (PL14), Padi singgam kuriak (PL15), Pulut kari (PL16), Pulut benai kinali (PL17), Padi kuning (PL18), Padi putih (PL19), Pulut lupo ka laki (PL20), Padi kuning (PL21), Padi gondok (PL22), Padi saronda kuning (PL23), and Padi katiok putih (PL24).

The research implementation consisted of land preparation, seed preparation, and planting. The seeds were planted in pots measuring 50 cm (height) x 35 cm (diameter) containing a mixture of soil and chicken manure at a ratio of 2: 1 [v/v]. Each pot was planted with one seed. When the plants were 7 to 10 days after planting, fertilizer was applied with the composition of 75 kg $ha^{-1}$ Urea, 100 kg $ha^{-1}$ SP-36, and 50 kg $ha^{-1}$ KCl. Then when the plants were 21 days after planting, they were fertilized with 150 kg $ha^{-1}$ Urea. Furthermore, when the plants were 42 days after planting, they were given 75 kg $ha^{-1}$ of Urea and 50 kg $ha^{-1}$ of KCl. The carried-out maintenance for rice plants is water condition checking in the pots, thinning, weeding, controlling pests and plant diseases, and harvesting.

Observations of plant morphology are carried out using a guide Standard Evaluation System for Rice (SES) translated edition by International Rice Research Institute (IRRI) in 2003. The observed parameters were morphological characters. Culm characters consist of the culm angle, the diameter of the basal internode, and the culm internode color. Leaf characters consist of flag leaf length, leaf length, leaf width, leaf angle, flag leaf angle, ligule length, leaf blade pubescence, collar color, auricles color, ligule color, ligule shape, leaf midrib color, and leaf blade color. Flower characteristics consist of the color of the stigma and the apiculus. Panicle characteristics include length, emergence, type, secondary branching, and panicle axis. The grain characteristics consist of lemma and palea color, lemma and palea pubescence, sterile lemma size, grain length, grain width, grain color, awn length, awning type, and awn color.

Furthermore, observing the agronomic characteristics consisted of number of tillers, number of productive tillers, number of grains per panicle, panicle treatability, spikelet sterility, plant emergence age, panicle emergence age, flowering age, harvesting period, seedlings height, plant height, grain thickness, 100-grain weight, and grain weight per clump.

### C. *Statistical Analysis*

The data on the variability level from rice genotype observations were divided into qualitative and quantitative characters. The data of these characters are then tabulated and analyzed descriptively. Data was analyzed by determining average, variance, and standard deviation values.

The formula calculates the average value:

$$\bar{X} = \frac{\sum X}{\sum(n)} \quad (1)$$

Information:

$\bar{X}$ = the average of each observation data

$X$ = number of observation values

$n$ = amount of data

The average value is used in presenting data to determine the character variability value by calculating the variance. The formula calculates the variance value:

Sample range:

$$\sigma^2 = \frac{\sum(Xi - \bar{X})}{n-1} \quad (2)$$

Population range:

$$\sigma^2 = \frac{\sum(Xi - \bar{X})}{n} \quad (3)$$

Information:

$\sigma^2$ = character variability (Variety)

$\bar{X}$ = the average of each observation data character

$Xi$ = the value of the i-observation.

$n$ = total number of data

The sample variance is used when calculating the variance value in the observation sample. The population variance is used when calculating the entire planted population. The standard deviation value can be used to determine the status of the character variability. The formula is:

$$SD = \sqrt{\sigma^2} \quad (4)$$

Information:

SD = Standard Deviation

$\sigma^2$ = Variety

Level of diversity:

Area if $\sigma^2 \geq 2$ x SD Narrow if $\sigma^2 \leq 2$ x SD

*D. Clusters Analysis*

Cluster analysis is used to determine kinship or similarity. The characters included in the kinship analysis are data from observations of qualitative characters in stems, leaves, panicles, flowers, and grain. Observational data were processed using Ms Excel and NTSYS-pc version 2.11. The results are presented in the form dendrogram, which can assist in grouping based on observed characters, which is comprehensive and narrow diversity.

## III. RESULTS AND DISCUSSION

### *A. Identification of Morphological Characters*

*1) Culm Characters*

Culm characters identified include the culm angle, the diameter of the basal internode, and the culm internode color (Table 1 in supplementary file). The culm angle is the position of the culm relative to the plant's perpendicular line. The culm angle of the 24 local rice genotypes has a wide diversity because it has various values (the lowest to the highest value ranging from 25° up to 55°). The culm angle of 24 local rice genotypes is classified according to three criteria, namely erect (<30°), intermediate (30° - 45°), and open (45° - 60°) (Fig. 2). The culm angle has a vital role because it can affect the determination of rice plant spacing and yield.

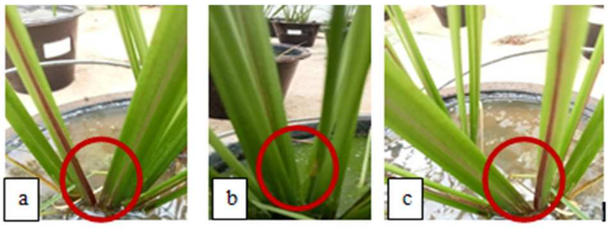



Fig. 2 Visualization of culm angles. (a) intermediate, (b) erect, and (c) open.

In the observation of the diameter of the basal internode, three criteria were obtained, namely large (> 8cm), intermediate (6-8 mm), and small diameter. The diversity degree in the basal internode diameter of 24 local rice genotypes is relatively narrow because the variation value is small. The culm internode color of the 24 local rice genotypes was found in three criteria, namely purple lines, purple, and green (Fig. 3). One of the variations that can be seen visually is color because it is part of a qualitative characteristic that is not influenced by the environment.

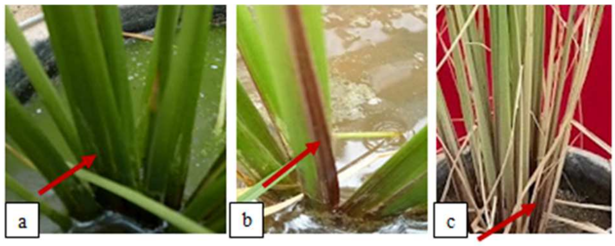



Fig. 3 Visualization of culm internode colour. (a) green, (b) purple lines, and (c) purple.

Stems can be used to circulate air and compounds in the body. Stem diameter and color can be influenced by heredity and the local environment. [12]. A new superior variety of rice stem lengths of 80-120 cm [13]. The stems must be sturdy so that the plants do not fall over easily and do not lose yield.

*2) Leaf Characters*

Leaf character data can be seen in Table 2 and Table 3 of supplementary data. The length of the flag leaf of the 24 rice genotypes had a high diversity between the genotypes. The population diversity degree in the flag leaf length of the 24 rice genotypes is wide. The criteria of flag leaf length consist of short (21-40 cm) and intermediate (41-60 cm). In observing leaf length, two criteria were obtained: intermediate (41-60 cm) and long (61-80 cm). The requirements for leaf width consist of intermediary (1-2 cm) and broad (>2 cm). The population diversity degree of the leaf width is relatively narrow, meaning that the leaf width of the 24 genotypes can be said to be almost uniform.

The angle of the leaves affects the reception of sunlight in photosynthesis. In observing leaf angles, all genotypes were categorized as erect (<45°). The flag leaf angle is formed between the panicle and the flag leaf. PL02 genotype has the smallest flag leaf angle average (20.25°), while the highest was obtained in PL05 (35.50°). The tongue of the leaf is called the ligule. The PL21 genotype had the highest average ligule length (3.2 cm), while the PL20 genotype had the lowest (1.6 cm). The ligule length between genotypes has a narrow or almost uniform variation which can be seen from the slight variation in the average value obtained.

The color of the ligule in this study was classified according to two criteria, namely white and purple lines (Fig. 4). The only genotype with purple line ligule was PL10. In contrast, the other 23 genotypes were white ligules. The ligule must be observed at the beginning of its growth because it usually dries after the plant enters the booting phase. In following the ligule shape, the results were obtained for all genotypes belonging to the 2-cleft criteria. The 2-cleft shape of the ligule is a triangle with split ends (Fig. 5).

(a) (b) (c)

Fig. 4 Appearance of ligule colour (a) purple, (b) purple lines, and (c) white.

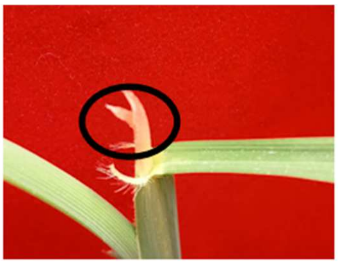


Fig. 5 The appearance of the 2-cleft type of ligule

The leaf midrib is the part of the leaf that wraps around the stem. Leaf midrib color can be a characteristic of a genotype. The results of leaf midrib color observations of 24 local rice genotypes were classified into purple lines and green criteria (Fig. 6). The genotype that had purple lines color was only one genotype, namely PL04. At the same time, the other 23 genotypes had green leaf midrib.

(a) (b)

Fig. 6 The appearance of leaf midrib color. (a) green and (b) purple lines.

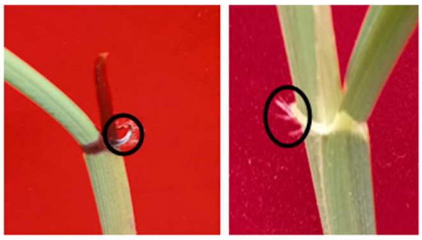
The finest hair on the leaf surface is one of the defense patterns of rice plants against pest attacks. Hairs in the leaf surface are called leaf blade pubescence, observed by rubbing fingers from the tip down to the base on the leaf surface. The presence of hairs on the blade surface is classified. In this study, we also observed it through a magnifying glass.

In this study, from 24 local rice genotypes, we found pubescent and intermediate criteria in leaf blade pubescent observations (Fig. 7). The hair's presence on the leaf surface of the observed rice genotypes did not cover the entire leaf surface. But the dominance of fine hair on some surfaces and a little on the edges.

(a) (b)

Fig. 7 The appearance of the leaf blade pubescence (a) intermediate and (b) pubescent criteria.

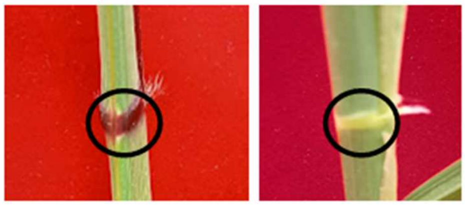
The ear of the leaf is called the auricle, while the neck of the leaf is called the collar. Auricle color can be a characteristic or morphology marker of a rice genotype. In 24 local rice genotypes, 23 have green auricles, and only one was purple (Fig. 8). PL04 is the only one with a purple auricle.



(a) (b)

Fig. 8 The appearance of auricle color. (a) purple and (b) green.

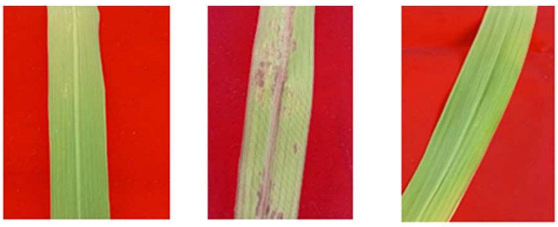
The collar color found in 24 local rice genotypes is light green and purple (Fig. 9). Twenty-three genotypes are light green, while the PL04 is the only one with a purple collar.



(a) (b)

Fig. 9 Appearance of collar color (a) purple (b) light green.

The results of observations on the leaf blade color of 24 local rice genotypes were classified into three criteria: purple on the edges, green, and dark green (Fig. 10). The genotype with a purple color on the edge is only the PL04 genotype. Leaves with a leaf blade with a purple color combination, usually, the basal sheath also has a purple color combination. Green leaf blade color was the most dominant, consisting of 21 genotypes. Meanwhile, the color of the dark green leaf blade was only found in the PL02 and PL20 genotypes.



(a) (b) (c)

Fig. 10 The appearance of leaf blade color. (a) dark green, (b) purple on the edges, and (c) green.

The organs of roots, stems, flowers, fruits and seeds are the user's assimilated organs. The source of assimilation is the leaf organ. This follows the opinion of Henry et al. [14], which states that plants have leaves that capture light energy through photosynthesis and produce photosynthates. Leaf length and width indicate rice cultivars with high yield potential. This follows the opinion of Su et al. [15] that plant production was influenced by leaf size, leaf area, nitrogen and potassium content. Nitrogen is one of the macronutrients that plants need in large quantities and impacts leaf growth and development. In Ponelo rice, nitrogen can stimulate growth above the ground, namely in the stems, gives green color to the leaves, and increases the size of the rice grains. This means that nitrogen fertilization in Ponelo rice functions to increase growth and increase production [16].

Munira *et al*. [17] also stated the same thing, the higher the dose of nitrogen fertilizer, the number of tillers of rice plants also increased. This is because rice plants that meet their nutrient needs have good growth and development, so the number of tillers can increase. Then in the research of Zhu *et al*. [18], it was found that efficient nitrogen doses affected roots in the form of higher root oxidation activity, greater root dry weight, longer roots, and more extensive root diameters. Another effect of efficient nitrogen administration is a higher leaf ratio and more productive tillers until the seed-filling stage. Then there was also an increase in the flag leaf's morphological and physiological properties, leaf thickness, leaf weight, and chlorophyll amount, which can lead to better photosynthetic performance.

Theoretically, photosynthesis will be higher in plants with broad crowns when compared to narrow plant crowns. At the same time, leaf size and the number of stomata is highly affected by plant height [19]. Yustiningsih [20] states that the distribution of chlorophyll is uneven in all plant cells, and concentrating only on chloroplasts can produce a practical filtering effect. Plants that grow in the shade and under the canopy will wrap chlorophyll by providing wider spacing in the stroma than plants exposed to direct light. The filtering effect will result in less total light absorption when compared to the total amount of chlorophyll. Light absorption can occur efficiently in the canopy area due to a limited balance of $CO_2$ absorption. The plant canopy is affected by excess light and drought, which will be related to the rate of $CO_2$ assimilation. This is similar to Sukhova *et al*. [21], who stated that light and dryness can affect stomata and the rate of $CO_2$ assimilation. Rohaeni and Yuliani [22] stated that the physiological properties of leaves have a positive relationship with assimilation content and ultimately have a relationship with rice yields. Morphological and physiological properties are related to plant resistance to pests and diseases.

*3) Flower Characters*

Characters in flowers are qualitative characters that are influenced by the genetics of the plant itself and are only slightly influenced by the environment. Therefore, the characters in flowers can be a particular identifier of a plant. In this study, the flower characters were observed directly by looking at the spikelet's using a magnifying glass. The results of monitoring the color of the stigma and the apiculus on 24 local rice genotypes can be seen in Table 4 in supplementary data.

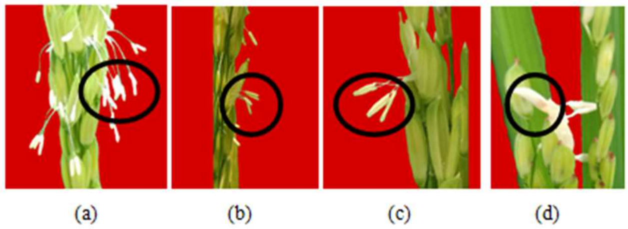



Fig. 11 The visualization of the stigma color. (a) white, (b) light green, (c) yellow, and (d) purple

Observation of the color of the stigma in 24 local rice genotypes is classified into four criteria consisting of purple, white, yellow, and light green (Fig. 11). Both white and yellow stigmas are found in 11 genotypes, respectively. The purple stigma is only found in the PL04 genotype. At the same time, the light green stigma is only present in PL05.

Observation of the apiculus color of 24 local rice genotypes obtained various colors, including red, purple, brown (tawny), and white (Fig. 12). The genotype with red apiculus color is PL16. The purple apiculus was only found in the PL04 genotype. There are three genotypes of brown (tawny) apiculus, which are PL13, PL17, and PL22. The most common apiculus colour was white in 19 genotypes.

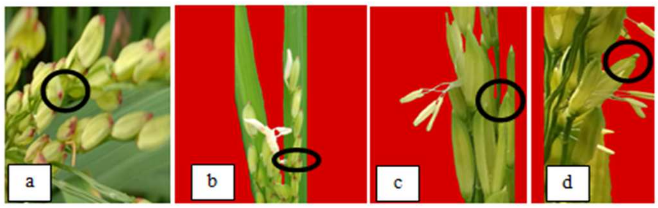



Fig. 12 The visualization of the apiculus color. (a) red, (b) purple, (c) white, and (d) brown (tawny)

Qualitative characters can be observed visually in individual plants. With the existence of qualitative characters, we can easily select the variations that occur in the phenotype of individual plants. Qualitative characters are traits that can be distinguished strictly or discretely without overlapping because a single gene control them, so they are easily grouped and usually expressed in categories. Qualitative traits are characters that are not, or little influenced by environmental factors and are controlled by simple genes that are more easily inherited.

*4) Panicle Characters*

Identification of panicle characters includes panicle length, panicle emergence, panicle type, secondary branching of panicle, and panicle axis (shown in Table 5 in supplementary data). Panicle length was observed from the tip to the neck of the panicle. Two criteria for panicle length were obtained for 24 local rice genotypes, namely intermediate (21-30 cm) and short (<20 cm). The degree of diversity in panicle length is relatively narrow and can be seen from the slight variation in the average panicle length value in the rice plant population. Long panicles are expected to increase plant production because they have more branch capacity, so the grain produced will also increase.

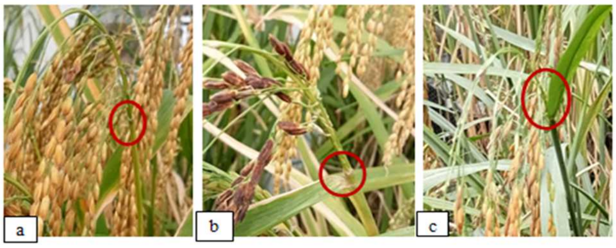



Fig. 13 The appearance of a panicle emerges. (a) all panicles and neck emerge out, (b) all panicles emerge out, and the panicle's neck in the middle, and (c) panicles only emerge up to the panicles' neck

Panicle formation occurs at the tip of the growing point of the culm. Only one primary branch emerges from the panicle base, and secondary branches will appear from this primary branch. Three criteria were obtained based on observations of panicle emerges on 24 local rice genotypes. These criteria were all panicles and necks emerge out, all panicles emerge out, and necks in the middle. Panicles only emerge up to the panicle's neck (Fig. 13). Factors influencing panicle formation are genes, environment, and disease.

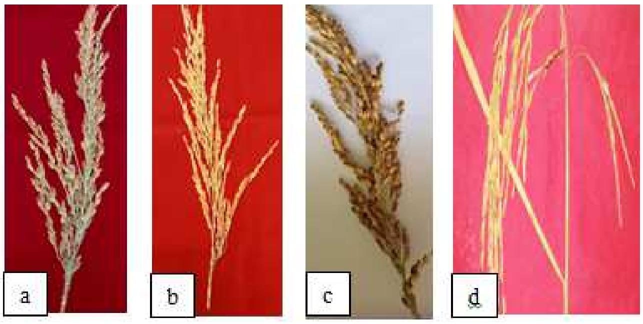



Fig. 14 The appearance of a panicle type. (a) criteria between compact and intermediate, (b) intermediate, (c) compact, and (d) open.

Observation of panicle types in 24 local rice genotypes consisted of various criteria (Fig. 14). The panicle type between compact and intermediate is a closed branch, and the main branch angle is not open. The 12 genotypes from 24 local rice have panicle types between compact and intermediate. The intermediate type is the slightly closed branches, and the main branch angles are slightly open. The open type is the non-closing branches, and the main branch angles are open. The desired panicle type in rice plants is intermediate because it can maximize yields. If the panicles are too closed, grain development will be disrupted, and if the panicles are too open, birds will easily eat the grains.


Fig. 15 The appearance of secondary branching of the panicle. (a) clustered, (b) light, and (c) heavy

The secondary branching of the panicle observed was divided into three criteria: light, heavy, and clustered (Fig. 15). Of the 24 local rice genotypes, the light types were found the most.

The panicle axis was observed when the rice plant entered the milky phase until maturity. All local rice genotypes have a panicle axis that is classified as droopy. The grain weight in each panicle will affect the panicle axis. Drooping panicles are affected by the number and weight of the grains.

*5) Grain Characters*

Observation of grain character includes lemma and palea color, lemma and palea pubescence, sterile lemma length, sterile lemma color, grain length, grain width, grain color, awning type, and awn color (Table 6 and Table 7 in supplementary data).

In 24 local rice genotypes, five color variations of lemma and palea were obtained. The colors are straw yellow and tawny, with brown spots on straw yellow, gold and gold furrows on a straw yellow background, and brown furrows on straw yellow (Fig. 16).

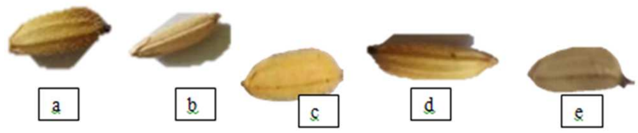



Fig. 16 The appearance of lemma and palea color. (a) brown (tawny), (b) straw yellow, (c) gold and gold furrows on straw yellow background, (d) brown spots on straw yellow, (e) brown furrows on straw yellow.

The presence of pubescence on the grain of 24 local rice genotypes belongs to three types: hairs on the upper portion, short hairs, and long hairs (velvety). Then the sterile lemma colors of those rice genotypes also consist of purple, gold, and straw yellow (Fig. 17).

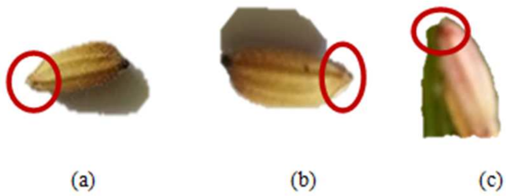



Fig. 17 The appearance of sterile lemma colour. (a) straw yellow, (b) gold, and (c) purple.

The sterile lemma is small, so measurements are made using a vernier caliper. There were three criteria for the length of the sterile lemma observed, namely long (>2.5 mm), horizontal (1.6-2.5 mm), and medium (<1.5 mm). At the same time, the measurement of grain length obtained two criteria, namely very long (> 7.5 mm) and long (6.61-7.50 mm). The degree of diversity in grain length is relatively narrow because the rice plant population has an average value that varies slightly or is almost uniform. The grain width of 24 local rice genotypes showed uniform criteria belonging to the width criterion (>2 mm). The PL22 genotype had the widest grain with an average of 2.93 mm, while the PL11 genotype had the smallest with an average of 2.22 mm. Long and wide grains are expected to increase rice production and quality. However, grain that is too long and is accompanied by a drying process that does not pay attention to the moisture content of the grain will cause the rice to break, thereby reducing the quality of the rice.

Grain color is observed after the plant enters the ripening or harvesting phase. The grain color criteria obtained for 24 local rice genotypes were purple, straw yellow, and brown (tawny) (Fig. 18). Purple grain is only observed in genotype PL04. Meanwhile, straw yellow grain was found in 11 genotypes. The brown (tawny) grain is the most widely observed because it belongs to 12 genotypes.

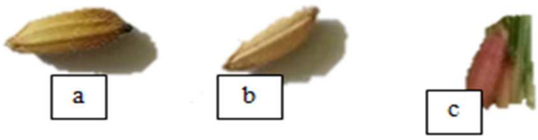



Fig. 18 The appearance of grain color. (a) brown (tawny), (b) straw yellow, and (c) purple

The tip of the grain or the tail of the grain is known as the awn. Awn variations found in 24 local rice genotypes are awnless (6 genotypes), short and partly awned (4 genotypes), short and fully awned (5 genotypes), long and partly awned (7 genotypes), and also long and fully awned (2 genotypes). Each of the observed local rice genotypes had a different awn color (shown in Fig. 19). 6 out of 24 genotypes did not have awns. There are three criteria for awn colors, which are gold (7 genotypes), purple (1 genotype), and brown (tawny) (10 genotypes). The purple awn is only found in PL04.

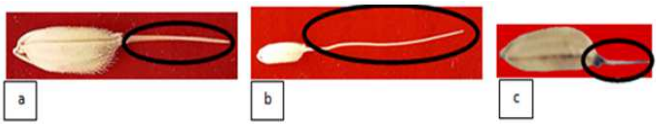



Fig. 19 The appearance of awn color. (a) brown (tawny), (b) gold, and (c) purple.

Genetic factors affect the color and shape of rice. It will be classified as a long grain if it is three times the grain [23]. Several factors cause the color difference. Among them are differences in alleles related to pigment properties in lemma palea or caryopsis grains. Then genetically, through the stages of aleurone regulation, endospermic color, and starch composition in the endosperm [24]. Anthocyanin phenolic bioactive compounds contained in rice are influenced by environmental factors [25]. Taste, shape, color, vitamins, essential fatty acids, and fiber content in rice determine consumer taste [26]. Based on these characteristics, local rice has the potential to be developed into local superior varieties [4].

### *B. Agronomic Characters*

#### *1) Plant Age and Plant Height Characters*

Observation of plant age characters includes plant emergence age, panicle emergence age, flowering age, and harvest age (shown in Table 8 in supplementary data). The age of plant emergence was observed from the first day the seeds were sown in beds with a uniform depth until the seeds grew past the soil surface. Of the 24 local rice genotypes, the genotypes that grew the fastest after sowing were PL01 and PL02 (average of 4.5 days). At the same time, the PL13 and PL20 genotypes had a longer time than the genotypes (an average of 5.75 days). The average growth after sowing between genotypes was 4.78 days—the level of diversity between genotypes for characters of emerging age after sowing was classified as uniform.

The age of panicle emergence was observed from when the seed was sowed until the first time the plant raised its panicle. The results showed that the average age of panicle emergence among the 24 local rice genotypes was 114.44 days. The genotype with the fastest panicle emergence was the PL18 genotype (average of 94.5 days), and the longest was the PL24 genotype (average of 129.75 days).

The age of flowering among the 24 local rice genotypes varies, which are divided into early flowering (<100 days), intermediate (100-125 days), and deep (>125 days). The average flowering age between genotypes is 115.44 days. The genotype with the shortest flowering time was PL18 (average 95.5 days). The PL11 genotype had the longest flowering age (average of 134 days). Environmental conditions influence the flowering age of rice plants during the flowering process or the generative phase. Environmental factors influencing whether the flowers appear quickly are temperature, solar radiation, humidity, and season. Sunny days is great for plants because the sunlight intensity received by plants is high. Whereas in humid conditions, it can cause the leaves to turn yellow due to the use of little light and will affect the flowering process.

The classification of plant harvest age is divided into three, which are depth (> 151 days after planting), intermediate (125-150 days after planting), and early (105-124 days after planting) [13]. The harvesting age for 24 local rice genotypes was divided into intermediate and depth. Intermediate harvesting ages were found in the genotypes PL13 (average 143 days) and PL19 (average 145 days). Then the other 22 genotypes belong to the depth harvest age. The shortest harvesting age was found in the PL13 genotype, which was an average of 143 days. Meanwhile, the PL11 genotype found the longest harvesting age, an average of 173.25 days. There are no rice genotypes belonging to the early harvest age. From these results, the characteristics of harvesting age among genotypes vary. In line with the results of Rahmah's research [27], the age of harvesting local rice is classified as intermediate to deep age. Farmers like shorter rice harvest periods [28].

The age at which the panicles appear and the age at which flowering occurs the fastest does not impact the age at which the harvest will be fast. However, the plant's vegetative growth phase affects the harvest age. The duration of the reproductive and ripening phases was not affected by rice varieties or environmental influences.

During the vegetative growth phase, tillers increase rapidly, plants grow taller, and leaves grow regularly. The vegetative growth phase is divided into the fast and slow vegetative phases. The fast vegetative phase is characterized by the rapid growth of rice plants, such as stem growth and the maximum number of tillers, usually achieved in the sixth or seventh week after planting. The slow vegetative phase begins with maximum tillering until the panicles (primordia) emerge. The duration of the vegetative phase is different for each genotype. For the reproductive and maturation phases are usually relatively constant. The reproductive stage is also marked by a decrease in the number of tillers, the appearance of the flag leaf, and the plant entering the booting phase.

Identification of plant height characters includes seedling height and plant height. Observations on the height of plant seeds found various results. The genotype with the highest seedling height was PL08 (average 31.87 cm). At the same time, the PL21 genotype had the shortest seedling height (average 16.37 cm). The average seedling height in the population is 24.52 cm.

Plant height was measured from the base of the stem to the longest leaf. The plant heights of 24 local rice were categorized according to three criteria, namely tall (>130 cm), medium (110-130 cm), and short (<110 cm). PL18 genotype (average 106.75 cm) had the lowest plant height. At the same time, the genotype with the highest plant height was PL08 (average 160.25 cm). The character of plant height has a wide diversity, meaning that the plant height in rice plant populations varies. Selection can be made if the level of variety of a plant population is said to change.

Plant height is a hereditary trait; the influence of environmental conditions also causes the difference in height of genotypes. Farmers usually consider plant height because it can affect plant yield. Tall plants are more at risk of overturning than low plants.

*2) Number of Tillers and Grain Characters*

Each rice plant has a different number of tillers and the ability to form tillers. Tillers' number and ability to create 24 local rice genotypes are shown in Table 9 in supplementary data. The 24 local rice genotypes observed belonged to the criteria for a very high number of tillers (>25). The highest number of tillers was in the PL03 genotype (average 87.5 tillers), while the lowest was in the PL21 genotype (38 tillers on average). The character of tillers number has a wide diversity degree, meaning that the population of planted rice plants has varying tillers for each genotype.

The tillering stage occurs during the vegetative phase. This phase starts from the beginning of plant growth until the plant reaches the maximum number of tillers. If the maximum number of tillers has been reached, there will be no more increase but will decrease. Furthermore, some of the full numbers of tillers formed will die or cannot produce panicles, called ineffective tillers. On the other hand, tillers that produce panicles are called productive tillers. Other factors affecting tillers include spacing, planting season, and fertilizer. Of the 24 local rice genotypes observed, almost all of the genotypes belong to a very high number of productive tillers (>25 tillers). Only two genotypes are included in the good criteria (20-25 tillers).

The highest number of productive tillers was found in the PL18 genotype (average 76 tillers). Then the smallest number is found in genotype PL11 (average 21 tillers). The character of productive tillers is diverse because of the various values obtained. The number of tillers is an indicator of superior rice plants among farmers. Productive tillers are tillers that can produce panicles and can fill the panicles into the pithy grain. The more the number of productive tillers, the higher the productivity of rice plants.

If the number of tillers reaches 10-19 tillers/clump, the process of photosynthesis and assimilation is at its maximum. According to Tampoma *et al.* [29], plant yield is affected by grain filling, flowering phase and assimilation. Determining grain character numbers includes the number of grains per panicle, panicle treatability, spikelet sterility, grain thickness, 100-grain weight, and grain weight in clumps (Table 9 and Table 10 in supplementary data). Observations on the number of grains per panicle showed variation among the 24 observed genotypes. Based on the results of the number of grains per panicle, three criteria were obtained, namely small (> 100-grains), intermediate (100-250 grains), and high (> 250 grains). The genotype had the smallest number of grains per panicle was the PL20 genotype (average 84.75 grains). At the same time, the highest number was in the PL02 genotype (average 308.50 grains). The remaining genotypes are at intermediate criteria.

The number of grains per panicle is determined by the number of productive tillers and the earlier flowering age, where pollination will be successful and produce lots of whole grain. Grain filling occurs through the accumulation of starch (carbohydrates) transported to the grain sourced from photosynthetic products and stored assimilation resources in the stem and leaf tissues starting from the flowering phase.

Panicle testability is one of the components to be considered. Easy grain shattered facilitates the easy threshing process at harvest. Harvesting rice with easy destroyed can be faster than rice with complex broken, but it can also cause yield losses during transportation. In this study, panicle treatability was observed during the ripening phase of rice plants by gently grasping and pulling the panicles by hand and then calculating the percentage of the shattered grain amount. Based on the observation, it was found that the entire observed genotypes were classified as easy (51-100%).

Spikelet sterility is the inability of flowers to produce grains. The spikelet sterility is observed by calculating the percentage of grain that is not ripe or empty grain per panicle. Of the 24 local rice genotypes observed, almost all were classified as fertile (<50%). There were only two genotypes classified as partially sterile (>50%), namely genotype PL07 (average 66.75%) and PL13 (average 60.5%). The genotype with the lowest sterility level was PL09 (average 6%).

The lower the level of sterility, the better because more pithy grain is produced than empty grain. More or less empty grain will affect the amount of plant productivity. The occurrence of bare grain is caused by the influence of wind on the heading phase and seed development. Other factors are fatigue, lack of light intensity, and dry leaves. These things result in reduced and disturbed starch in the grains of rice.

Grain thickness measurement is carried out using a caliper to make it more accurate. The population diversity of grain thickness characters is narrow or uniform. The genotype with the highest grain thickness was the PL22 genotype, with an average value of 2.02 mm. The lowest is found in genotype PL20 (average 1.63 mm).

The weight of 100 grains for each genotype is different. There are three criteria which are light (<2 grams), intermediate (2-2.5 grams), and heavy (>2.5 grams). Light bars were found in the genotypes PL12 (average 1.95 gram), PL15 (moderate 1.9 gram), PL13 (average 1.75 gram), and PL14 (average 1.7 gram). The PL04 genotype (3 grams on average) is the only one in the heavy criteria. The other 19 genotypes were classified as intermediate. The weight of 100 grains is one observed variable closely related to production yields, and plant needs in a unit area. The higher the weight of 100 grains, the more yield will be obtained, and vice versa.

Grain weight per clump on 24 local rice genotypes was classified into two, namely intermediate (25-50 grams) and heavy (> 50 grams). Intermediate criteria were only found in two genotypes: the PL13 genotype (38.65-gram average) and PL20 (37.25-gram average). The rest is classified as heavy criteria. The heaviest weight was found in the PL01 genotype, with an average of 170.15 grams.

In the parameters of grain thickness and weight of 100 grains, there was a narrow level of diversity between genotypes. While the parameters of the number of grains per panicle, the grain fall-off ability, sterility of grain, and grain weight per clump showed a wide diversity degree between genotypes. The narrow level of diversity means that in one parameter observed, the variation between genotypes tends to be small or uniform. If, in one observation parameter, there is a high variation between genotypes, it means that the level of diversity is comprehensive.

### *C. Kinship Analysis*

Kinship analysis between genotypes was carried out to determine the degree of similarity based on the observed qualitative characters. Qualitative characters are controlled by a single gene, not influenced by the environment. Meanwhile, quantitative characters can generally be affected by the environment and controlled by many genes.

The qualitative characters from 24 local rice genotypes which are used to construct the dendrogram include the culm internode color, blade pubescence, collar color, auricles color, ligule color, ligule shape, leaf midrib color, leaf blade color, stigma color, apiculus color, panicle emergence, panicle type, secondary branching of the panicle, panicle axis, lemma and palea color, lemma and palea pubescence, sterile lemma color, grain color, awning type, and awn color.

The 24 local rice genotypes from Kuantan Singingi Regency had similarity levels ranging from 0.49-0.90. Based on the dendrogram construction (Fig. 20), the diversity is classified into 10 clusters. The majority of observed genotypes were classified into cluster IV.

Cluster IV consists of eight genotypes including PL07, PL09, PL16, PL17, PL18, PL19, PL22, and PL024. Furthermore, cluster I became the class with the second most genotypes consisting of seven. The seven genotypes are PL01, PL03, PL05, PL12, PL14, PL15 and PL21. Cluster III and Cluster V both consist of 2 genotypes. In cluster III, there are PL06 and PL11; in cluster V, there are PL19 and PL23. Clusters that only consist of one genotype are clusters II (PL08), VI (PL10), VII (PL02), VIII (PL20), IX (PL13), and X (PL04).

The closeness of kinship relations can be seen by the number of characters they have in common. Genotypes with many character similarities have a more significant similarity coefficient, so the kinship relationship is closer and vice versa. The smaller the similarity coefficient value (closer to 0), the more distant the kinship is. At the same time, the PL04 genotype has the furthest kinship coefficient value with the other 23 genotypes, which is 0.49.

Observing qualitative characters in stems, leaves, flowers, and grain is expected to find characters that distinguish one genotype from another, which can later become their characteristics. Based on observed qualitative characters, it is apparent to distinguish the PL04 genotype, which differs from the other genotypes. These characters were culm internode color, collar color, auricle color, ligule color, leaf midrib color, leaf blade color, stigma color, apiculus color, grain color, and awn color.

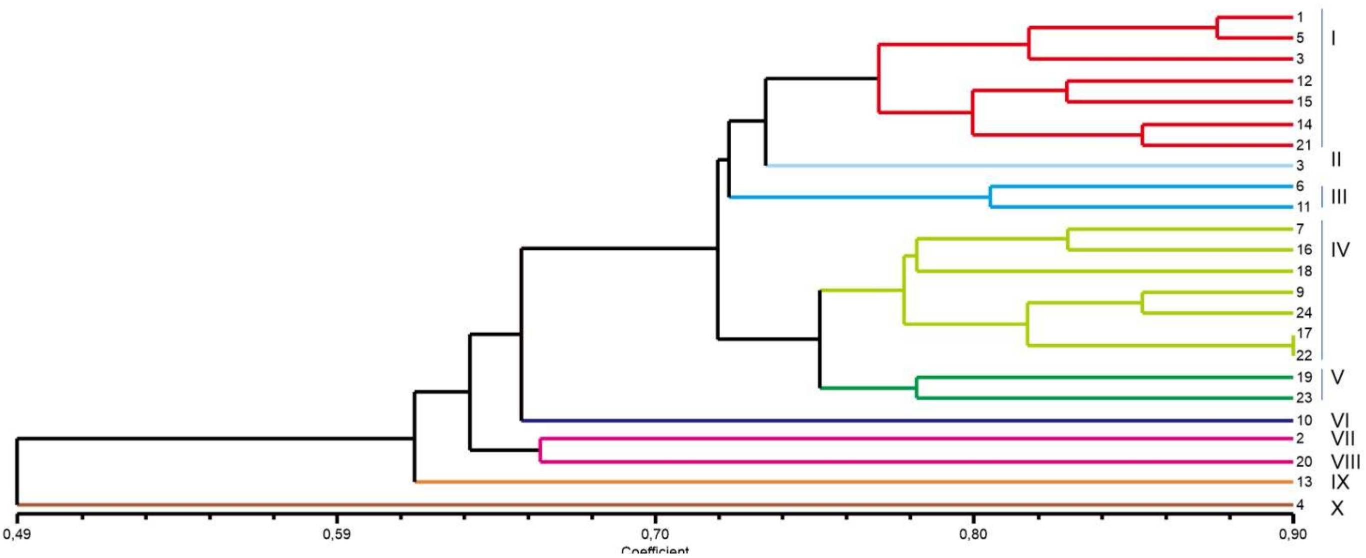



Fig. 20 The dendrogram of the relationship of 24 local rice genotypes in Kuantan Singingi Regency

Observing qualitative characters in stems, leaves, flowers, and grain is expected to find characters that distinguish one genotype from another, which can later become their particular characteristics. Based on observed qualitative characters, it is obvious to distinguish the PL04 genotype, which differs from the other genotypes. These characters were culm internode color, collar color, auricle color, ligule color, leaf midrib color, leaf blade color, stigma color, apiculus color, grain color, and awn color.

The PL04 genotype has purple culm internode color while the other 21 genotypes were green and 2 were purple lines. The collar color of PL04 is purple, while the different 23 genotypes are light green. The auricle color of PL04 is also purple, and the other 23 genotypes are green. The ligule color of the PL04 genotype is purple, while the other 22 are white and have one purple line. PL04 has purple lines on the leaf midrib, while the others are green. The leaf blade of the PL04 genotype is purple on the edges, while the other genotypes are green or dark green. In the stigma color characters, PL04 is the only one with a purple stigma; different genotypes are yellow, white, or light green. Then for apiculus color, PL04 also has purple apiculus while others are white or brown. The grain and the awn color of PL04 are also purple, while the others are straw yellow and brown in grain color and gold and brown in awn color character.

The PL24 genotype had the closest kinship coefficient to the PL17 and PL22, with a value of 0.85. Five qualitative characters distinguished PL24 from PL17 and PL22. The apiculus color of PL24 is white, then PL17 and PL22 are straw yellow. The PL24 has a white stigma; a yellow stigma is found in Pl17 and PL22. The panicles type of PL24 is compact, while Pl17 and PL22 are between intermediate and compact classes. The secondary branching of the panicle type of PL24 is light, but PL17 and PL22 are clustered. In the pubescence of lemma and palea character, PL24 has hairs on the upper portion criteria, while PL17 and PL22 had short hairs.

There is also a close similarity between the PL07 and PL16 genotypes, with a similarity coefficient 0.83. The qualitative characteristics that differentiate between the two are the culm internode color, panicle type, and lemma palea color. PL07 had green culm internode color while PL16 had purple lines. The panicle type of PL07 was intermediate and compact, while PL16 had a medium type. The lemma and palea color of PL07 had brown spots on the straw yellow, while PL16 was yellow straw.

A similarity value is obtained from the score of the binary number value. At the same time, the acquisition value of similarity is determined from the total value of the characters. So that the similarity value tends to a specific character, there may be differences in the characters being compared. Population uniformity can be seen from the distance between the genetics. It is more uniform when the distance is small and more diverse when it is significant.

The kinship relationship and genetic distance of local rice from the Kuantan Singingi Regency can provide an overview of the genetic diversity of local rice characters so that it can be used in breeding programs, primarily to obtain the right parental plants for the formation of new cultivars. Plant breeding programs such as crosses require information on genetic relationships to identify germplasm. According to Susila *et al.* [30], local rice is usually grown for generations so that it can cause high morphological similarity between genotypes.

## IV. Conclusion

The criteria for the level of wide and narrow diversity are known. At the same time, the degree of kinship ranges from 0.49-0.90. Only the PL17 and PL22 genotypes had a high consanguinity coefficient of 0.90 (90%). The other genotypes had low consanguinity. The lower the level of kinship, the potential to be used for developing rice plant breeding in the future.


## Acknowledgements

We thank Andalas University, the Head of the Doctoral Program in Agricultural Sciences of Andalas University, the Islamic University of Kuantan Singingi, and the Kuantan Singingi Regency Agriculture Office for permitting and coordinating the research. Thanks also go to all parties who have provided moral and material support in this study.


## References


[1] Z. M. Zuki, M. Y. Rafii, A. Ramli, Y. Oladosu, M. A. Latif, K. Sijam, M. R. Ismail, and H. M. Sarif, "Segregation analysis for bacterial leaf blight disease resistance genes in rice 'MR219' using SSR marker," *Chilean Journal of Agricultural Research*, vol. 80, no. 2, pp 227–233, 2020. doi: 10.4067/S0718-58392020000200227.

[2] G. N. A. S. Wirya, M. S. Andrayuga, I. P. Sudiarta, M. Shishido, and C. Hongo, "The existing method to assess the disease incidence of bacterial leaf blight and its effect to rice yield to support the Indonesian Agriculture Insurance," *SOCA: Jurnal Sosial, Ekonomi Pertanian*, vol. 15, no. 3, pp 641-655, 2021. doi: 10.24843/SOCA.2021.v15.i03.p19.

[3] S. Safrizal, L. Lisnawita, K. Lubis, F. J. M. Maathuis, and I. Safni, "Mapping bacterial leaf blight disease of rice (*Xanthomonas oryzae* pv *oryzae*) in North Sumatra," *IOP Conference Series: Earth and Environmental Science*, vol. 454, no. 1, pp 1-7, 2020. doi: 10.1088/1755-1315/454/1/012160.

[4] N. Chaniago, I. Suliansyah, I. Chaniago, and N Rozen, "Morphological characteristics of local rice in Deli Serdang District, North Sumatra, Indonesia," *Biodiversitas*, vol. 23, no. 2, pp 883–894, 2022. doi: 10.13057/biodiv/d230229.

[5] A. A. Santoso, R. Kartikawati, D. M. WP, E. Supraptomo, and M. Fikra, "Productivity of four rice varieties and pest diseases with the application of environment friendly agriculture technology in Jaken, Pati, Central Java," *Agric.* vol. 34, no. 1, pp 35–44, 2022. doi: 10.24246/agric.2022.v34.i1.p35-44.

[6] R. S. Budi, I. Suliansyah, Y. Yusniwati, and S. Sobrizal, "Characterization and rejuvenation of upland red rice in North Sumatra," *International Journal of Scientific and Technology research*, vol. 7, no. 2, pp 1–6, 2018.

[7] G. I. Prayoga, R. Ropalia, S. N. Aini, E. D. Mustikarini, and Y. Rosalin, "Diversity of black pepper plant (*Piper nigrum*) in Bangka Island (Indonesia) based on agro-morphological characters," *Biodiversitas*, vol. 21, no. 2, pp 652–660, 2020. doi: 10.13057/biodiv/d210230.

[8] C. Ezward, I. Suliansyah, N. Rozen, and I. Dwipa, "Identifikasi karakter vegetatif genotipe padi lokal Kabupaten Kuantan Singingi," *Menara Ilmu*, vol. 14, no. 02, pp 12–22, 2020. doi: 10.31869/mi.v14i2.1749.

[9] C. Ezward, I. Suliansyah, N. Rozen, and I. Dwipa, "Upaya pengembangan genotipe padi lokal Kabupaten Kuantan Singingi," *Jurnal Sains Agro*, vol. 4, no. 2, pp 1–11, 2019. doi: 10.36355/jsa.v4i2.284.

[10] C. Ezward, I. Suliansyah, N. Rozen, and I. Dwipa, "Genetic relationship of local rice from Kuantan Singingi District using Sequence Related Amplified Polymorphism ( SRAP ) markers," *JERAMI (Indonesian J. of Crop Science)*, vol. 4, no. 1, pp 1–8, 2021. doi: 10.25077/jijcs.4.1.1-8.2021.

[11] C. Ezward, I. Suliansyah, N. Rozen, and I. Dwipa, "Resistance of local rice genotypes against brown planthopper pest in Kuantan Singingi Regency," *Jurnal Agronomi Tanaman Tropika (JUATIKA)*, vol. 4, no. 1, pp 166 – 176, 2022. doi: 10.36378/juatika.v4i1.1809.

[12] B. E. Hadi, "Kajian morfologi tanaman padi beras merah di wilayah Surakarta," Bachelor thesis, Dept. of Agrotechnology, Agriculture Faculty, Universitas Sebelas Maret, Surakarta, Indonesia, 2013. https://digilib.uns.ac.id/dokumen/detail/29560/Kajian-Morfologi-Tanaman-Padi-Beras-Merah-Di-Wilayah-Surakarta.

[13] A. Jamil, S. Satoto, P. Sasmita, J. Baliadi, A. Guswara, and S. Suharma "Deskripsi varietas unggul baru padi (Inpari, Inpago, Inpara, Hipa)," Jakarta: Badan Litbang Pertanian, 2015.

[14] R. J. Henry, A. Furtado, and P. Rangan, "Pathways of Photosynthesis in Non-Leaf Tissues," *Biology*, vol. 9. no 438, pp 1-13, 2020. doi: 10.3390/biology9120438.

[15] Y. Su, M. Renz, B. Cui, X. Sun, Z. Ouyang, and X. Wang "Leaf morphological and nutrient traits of common woody plants change along the urban-rural gradient in Beijing, China," *Frontiers in Plant Science*, vol. 12, no. 682274, pp. 1-10, 2021. doi: 10.3389/fpls.2021.682274.

[16] R. Asmuliani, M. Darmawan, I. M. Sudiarta, and R. Megasari, "Pertumbuhan tanaman padi (*Oryza sativa* L.) varietas Ponelo pada berbagai dosis pupuk nitrogen dan jumlah benih per lubang tanam,"

*Perbal: Jurnal Pertanian Berkelanjutan,* vol. 9, no. 1, pp 10-17, 2021. doi: 10.30605/perbal.v9i1.1559.

[17] S. Munira, S. Sapdi, and H. Husni, “Pengaruh dosis pupuk nitrogen terhadap serangan hama penggerek batang padi putih (*Scirpophaga innotata* Walker),” *Jurnal Ilmiah Mahasiswa Pertanian*, vol. 7, no. 3, pp 596-605, 2022. doi: 10.17969/jimfp.v7i3.21350.

[18] K. Y. Zhu, J. Q. Yuan, Y. Shen, W. Y. Zhang, Y. J. Xu, Z. Q. Wang, and J. C. Yang, “Deciphering the morpho–physiological traits for high yield potential in nitrogen efficient varieties (NEVs): A japonica rice case study,” *Journal of Integrative Agriculture,* vol. 21, no. 4, pp 947–963, 2022. doi: 10.1016/S2095-3119(20)63600-0.

[19] S. Suranto, A. T. Syahidah, and E. Mahadjoeno, “Variation of morphology, anatomy and nutrition contents of local cultivar Mentik rice based on the altitudes at Ngawi District, East Java, Indonesia,” *Biodiversitas*, vol. 19, no. 2, pp 572–579, 2018. doi: 10.13057/biodiv/d190237.

[20] M. Yustiningsih, “Intensitas cahaya dan efisiensi fotosintesis pada tanaman naungan dan tanaman terpapar cahaya langsung,” *BIOEDU*, vol. 4, no. 2, pp 43-48, 2019. doi: 10.32938/jbe.v4i2.385.

[21] E. Sukhova, D. Ratnitsyna, E. Gromova and V. Sukhov, “Development of two-dimensional model of photosynthesis in plant leaves and analysis of induction of spatial heterogeneity of $CO_2$ assimilation rate under action of excess light and drought,” *Plants,* vol. 11, no. 3285, pp 1-20, 2022. doi: 10.3390/plants11233285.

[22] W. R. Rohaeni and D. Yuliani, “Keragaman morfologi daun padi lokal Indonesia dan korelasinya dengan ketahanan penyakit hawar daun bakteri,” *Jurnal Ilmu Pertanian Indonesia (JIPI),* vol. 24, no. 3, pp 258–266, 2019. doi: 10.18343/jipi.24.3.258.

[23] H. Afza, "Peran konservasi dan karakterisasi plasma nutfah padi beras merah dalam pemuliaan tanaman," *Jurnal Penelitian dan Pengembangan Pertanian*, vol. 35, no. 3, pp 143-153, 2016. doi: 10.21082/jp3.v35n3.2016.p143-153

[24] K. Kristamtini, T Taryono, P. Basunanda, and R. H. Murti, "Keragaman genetik kultivar padi beras hitam lokal berdasarkan penanda mikrosatelit," *Jurnal AgroBiogen*, vol. 10, no. 2, pp 69-76, 2014. doi: 10.21082/jbio.v10n2.2014.p69-76.

[25] K. Kristamtini, E. W. Wiranti, and S. Sutarno, “Variation of pigment and anthocyanin content of local black rice from Yogyakarta on two altitudes,” *Buletin Plasma Nutfah*, vol. 24, no. 2, pp 99-106, 2018. doi: 10.21082/blpn.v24n2.2018.p97-102.

[26] I. Suliansyah, Y. Yusniwati, and I. Dwipa, “Genetic diversity and association among West Sumatra brown rice genotype based on morphological and molecular markers,” *International Journal on Advanced Science, Engineering and Information Technology*, vol. 8, no. 2, pp 610–615, 2018. doi: 10.18517/ijaseit.8.2.1944.

[27] N. H. Rahmah, "Identifikasi karakter morfologis padi beras merah (Oryza sativa L.) di Kecamatan Lintong Nihuta Kabupaten Humbang Hasundutan Provinsi Sumatera Utara," Bachelor thesis, Dept. of Agrotechnology, Agriculture Faculty, Universitas Sumatera Utara, Medan, Indonesia, 2018. https://repositori.usu.ac.id/handle/123456789/13091

[28] R. Ghimire, W. C. Huang, and R. B. Shrestha, “Factors affecting adoption of improved rice varieties among rural farm households in Central Nepal,” *Rice Science*, vol. 22, no. 1, pp 35–43, 2015. doi: 10.1016/j.rsci.2015.05.006.

[29] W. P. Tampoma, T. Nurmala, and M. Rachmadi, "Pengaruh dosis silika terhadap karakter fisiologı dan hasil tanaman padi (*Oryza sativa* L.) kultivar lokal Poso (kultıvar 36-Super dan Tagolu),"*Jurnal Kultivasi*, vol. 16, no. 2, pp 320–325, 2017. doi: 10.24198/kultivasi.v16i2.12612.

[30] A. Susila, S. Rustini, E. Rohman, I. G. Cempaka, and V. E. Prasetya, "Kekerabatan kultivar padi lokal Jawa Tengah berdasarkan karakter agronomi dan morfologi," *Prosiding Seminar Nasional Sumber Daya Genetik Pertanian,* pp 80-89, 2015. http://repository.pertanian.go.id/handle/123456789/11969.