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Morphological characteristics of local rice in Deli Serdang District, North Sumatra, Indonesia

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Abstract. *Chaniago N, Suliansyah I, Chaniago I, Rozen N. 2022. Morphological characteristics of local rice in Deli Serdang District, North Sumatra, Indonesia. Biodiversitas 23: 883-894.* The preservation of local rice is essential to preventing genetic drain. In Deli Serdang District, North Sumatra, Indonesia, local rice is in great abundance. A total of 23 Deli Serdang local rice were collected and studied from coastal to highland areas. This study aims to determine the morphological characteristics of 23 local rice genotypes of Deli Serdang and to obtain superior characters to be developed into superior local varieties. A completely randomized design with three replicates was used in this study. Morphological characteristics of 23 local rice genotypes obtained various characters. The culm length was short to very long; culm diameter was thin to thick; the leaf-blade length was long to very long; leaf-blade width was intermediate to broad; culm number was low to high. The auricle, ligule, and collar were almost completely whitish, except for Sijambi yellowish-green and green, 2-cleft acute ligule shape. The harvest age was medium to deep. The grains were white, straw, gold, brown, brown spots, brown lines, and black. The pericarps were white, light brown, red, and black. Most of the organs indicated broad genetic variability having the opportunity to be developed into superior local varieties. All local rice was scattered into five groups based on morphological markers with a similarity of 32.12%.

Keywords: Caryopsis, diversity, genotype, grain, variability

Abbreviations: AC: auricle color; AL: awn length; CC: collar color; CD: culm diameter; CH: culm habit; CL: culm length; CN: culm number; FL: flag leaf length; FW: flag leaf width; FA: flowering age; GC: grain color; GL: grain length; GT: grain thickness; GW: grain width; HA: harvest age; LL: leaf blade length; LW: leaf blade width; LC: ligule color; LS: ligule shape; PL: panicle length; PC: pericarp color; PL: pericarp length; PS: pericarp shape; PT: pericarp thickness; PW: pericarp width; WG the weight of 1000 grains of grain; WP: the weight of 1000 grains of pericarp

INTRODUCTION

Rice is the main staple food for the majority of the population in Asia (Huang et al. 2012). The yield potential of modern rice varieties has stagnated. Many factors hinder the increase in rice production, which are the lack of sufficient investment to improve varieties with high yield potential, superior grain quality, and strong environmental adaptability (Amiri et al. 2011; Sadimantara et al. 2014). It is important to improve rice varieties with high yield potential under adverse and normal conditions to overcome these challenges.

Availability of diversity of genetic resources is an important factor in varietal improvement. It can be obtained through the exploration of local rice (Kuswantoro 2017). There are two main sub-species of rice, Indica, and Japonica. Most of the planted area for the Indica sub-species is in South China, Southeast Asia, and South Asia, while the Japonica sub-species are in East Asian China (Huang et al. 2012; Zhao et al. 2011). Indonesian local rice is classified as a sub-species of tropical rice, known as Javanica; there are more than 8000 varieties. The sub-species Javanica was originally only found in Java and Bali (Siwi and Harahap 1977). Each region has typical local rice, cultivated hereditary, so it adapts well on land with a variety of abiotic environmental stress such as drought, shade, and usually has a fragrant aroma and fluffier taste (Nurhasanah and Sunaryo 2015; Setyowati et al. 2018; Sitaresmi et al. 2013). The characterization of local rice in several regions in Indonesia has been carried out by previous researchers. For example, Masniawati et al. (2013), characterized ten local rice from North Toraja, South Sulawesi. Rusdiansyah and Intara (2015), have characterized 26 local rice from East Kalimantan. Furthermore, Suliansyah et al. (2018), have characterized 31 local rice from West Sumatra, and Setyowati et al. (2018), characterizing six local rice from Aceh. There were 23 local rice genotypes found from the exploration in Deli Serdang, 14 of them were cultivated on dry land, and some were cultivated under the shade of banana plants (Chaniago et al. 2020). Therefore, it is important to characterize those genotypes to obtain characters that have the potential to become superior local varieties.

The low management and sustainable use of local rice have resulted in a genetic drain. This is indicated by the low availability of local rice and the limited number of farmers cultivating it. This condition in the long term can lead to a decrease and an extinction. This can be seen from the low harvested area and local rice production. Based on data from BPS-Deli Serdang (2019), the local rice harvested area (2018) is only 2698 ha (0.8%) of the total rice harvested area of 86705,80 ha, and its production is only 3331,31 tons (0,7%) of the total production of 504539,55 tons. The existence of local rice needs to be preserved by utilizing and managing it wisely so that the quantity and quality of its diversity are maintained, and the sustainability of the supply can be improved. The early-stage in conserving plant genetic resources is exploration, collection, characterization, and selection (Nurhasanah et al. 2017; Rusdiansyah and Intara 2015; Suliansyah et al. 2018). Characterization is an activity to identify important or specific characteristics possessed by plants so that they can easily and quickly discriminate between phenotypes of plant species. The description of the plant will be useful in the selection of elders in the plant breeding program (Miswarti et al. 2014). Morphological and agronomic characterization with high yield targets, superior grain quality, and strong environmental adaptability are activities that are often carried out by plant breeding (Sujiprihati and Syukur 2012; Emon and Ahammed 2020).

This study aims to determine the morphological characteristics of 23 local rice genotypes of Deli Serdang and obtain superior characteristic such as high yield, superior grain quality, and strong environmental adaptability to be developed into superior local varieties.

MATERIALS AND METHODS

Study area

The study began with local rice exploration in Deli Serdang District, North Sumatra Province, Indonesia at 2◦570-3◦160 N, 98◦330-99◦270 E. The exploration location was selected using the purposive sampling method (Sugiono 2013). The location was selected based on information from the Deli Serdang's Agriculture Office, community leaders, farmers, and rural village heads. The exploration results found 23 rice genotypes in the form of grain samples, from 13 sub-districts which is in Percut Sei Tuan, Galang, Tanjung Morawa, Namo Rambe, Batang Kuis, Beringin, Pagar Merbau, Sibolangit, Kutalimbaru, Biru-biru, Sinembah Tanjung Muda (STM) Hilir, Sinembah Tanjung Muda (STM) Hulu and Gunung Meriah (Chaniago et al. 2020). It was collected at various elevations ranging from 1 m to 1088 m asl. Furthermore, the grain samples were characterized ex-situ in the screen house of the Faculty of Agriculture, Islamic University of North Sumatra, Medan, with an elevation of ± 25 m above sea level, from October 2019 to March 2020.

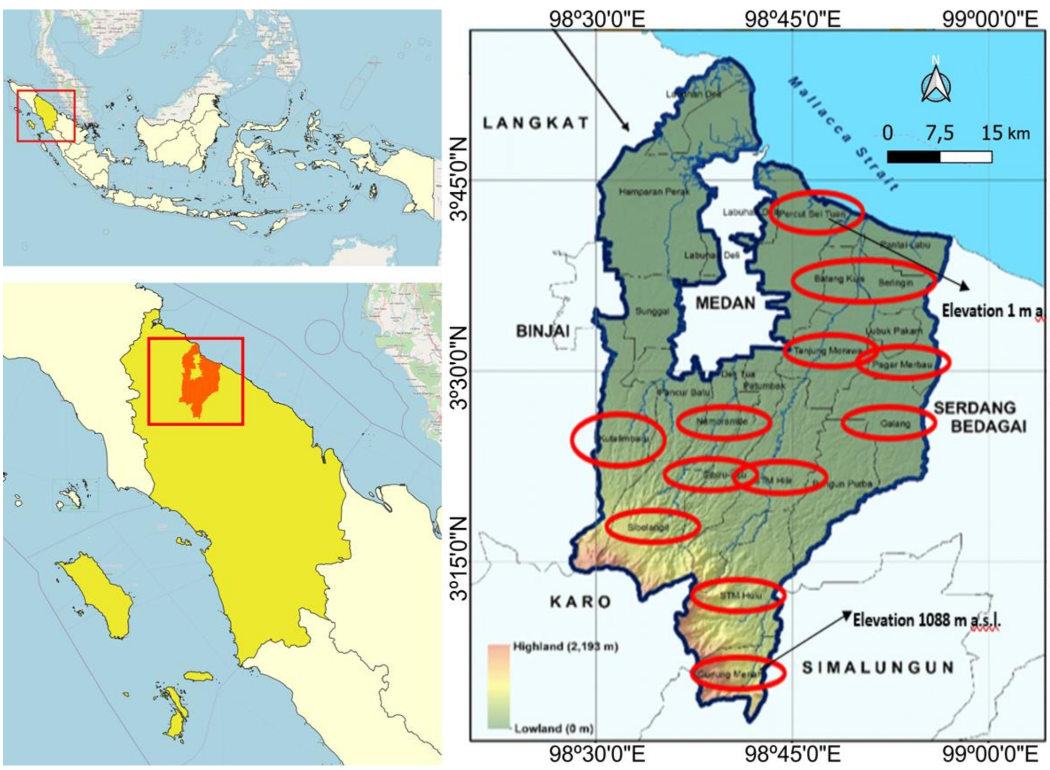


Figure 1. Location of exploration and collection of local rice in Deli Serdang District, North Sumatra Province, Indonesia

Procedures

The experiment was in the form of a non-factorial Completely Randomized Design, involving 23 local rice genotypes with three replicates. The rice seeds are planted in polybags with the size 50×40 cm, containing a planting medium of a mixture of topsoil and cow manure in a ratio (4: 1; w/w). One seed was planted in each polybag, and each genotype had nine plants samples. Fertilizer used were NPK (16-16-16) 2 g/polybag, Urea 1.5 g/polybag, KCl 0.75 g/polybag and ZA 0.75 g/polybag.

Observation of plant morphology during the vegetative and reproductive growth phases, and grain and rice for both quantitative and qualitative characters, was conducted in line with Bioversity International, IRRI and WARDA (2007).

Quantitative morphological characteristics

For all quantitative descriptors, it is recommended to use actual measurements. Coded scores for *Oryza sativa* are provided as an alternative where resources are insufficient to take the actual measurements. Observations of quantitative characters in the vegetative and reproductive growth phases consist of culm length (CL), the average record of the five actual measurements to the nearest cm that is measured from ground level to the panicle base after flowering. Culm diameter (CD) is the average record of three representative plants during flowering or at a late reproductive stage that measured from the outer diameter of the basal portion of the main culm. Leaf-blade length (LL) and Leaf-blade width (LW) is the average to nearest cm of five representative plants at an early reproductive stage that was measured from the penultimate leaf (i.e., highest leaf below the flag leaf) on the main culm. LL was measured from the ligule to the blade's tip and LW was measured from the widest portion of the penultimate leaf on the main culm. Flag leaf length (FL) and Flag leaf width (FW) were the averages to nearest cm of five representative plants after seven days of anthesis that measured from the ligule to the blade's tip, and measured from the widest portion of the flag leaf. Culm number (CN) was recorded as the total number of grain-bearing tillers on five plants after anthesis to near maturity. Flowering age (FA) was recorded as the date when 75% has emerged panicles. Harvest age (HA) was recorded as the date when plants hit maturity which 80% of the grains on the panicles are fully ripened. Panicle length (PL) was the average length of the main axis panicle from five representative plants after seven days of anthesis or upon full panicle exertion that measured from the panicle base to the tip.

Quantitative characters of grain and caryopsis were measured after harvest. Grain, a mature grain of rice, consists of a caryopsis enclosed within a lemma and palea. Caryopsis, the fruit of grasses consisting of a single seed with the seed coat fused to a thin dry pericarp. In rice, the caryopsis/pericarp is ordinarily called brown rice. The structure remains after dehulling the grain and before milling. Those were measured, including grain length (GL) and pericarp length (PL), were measured as the distance from the base of the lowermost glume to the tip (apiculus) of the fertile lemma or palea, whichever is longer. On awned cultivars, measure to a point comparable to the tip of the apiculus (exclude the awn). Grain width (GW) and pericarp width (PW), measured as the distance across the fertile lemma and palea at the widest point than grain and pericarp thickness. Awn length (AL), the average length of ten representative spikelets and the longest of a fibrous bristle present in some cultivars that formed as an extension of the midrib of the lemma at maturity stage. Grain thickness (GT) and pericarp thickness (PT) were measured with a digital caliper, an average of 10 representative grains after harvest. The weight of 1000 grains of grain (WG) and 1000 grains of the pericarp (WP), the average weight of 1000 random well-developed whole grains sample of each ten representative grains that dried to 13% moisture content and weighed on a precision balance.

Quantitative descriptors of Bioversity International, IRRI and WARDA (2007): Culm length (CL) : (1) very short <50 cm, (2) very short to short 51-70 cm, (3) short 71-90 cm, (4) short to intermediate 91-105 cm, (5) intermediate 106-120 cm, (6) intermediate to long 121-140 cm, (7) long 141-155cm, (8) long to very long 156-180 cm (9) very long >180 cm. Culm diameter (CD): (1) thin <5 mm and (2) thick ≥5 mm. Leaf-blade length (LL): (1) very short < 21 c m, (3) short ~30 cm, (5) intermediate ~50 cm, (7) long ~70 cm and (9) very long ≥80 cm. Leaf-blade width (LW) : (3) narrow <1 cm, (5) intermediate 1cm, (7) broad >2 cm. Flag leaf length (FL) : (1) very short <21 cm, (3) short ~30 cm, (5) intermediate ~50 cm, (7) long ~70 cm, (9) very long ≥80 cm. Flag leaf width (FW) : (3) narrow <1 cm, (5) intermediate 1 cm, (7) broad >2 cm. Culm number (CN): (3) low <10 culms; (5) intermediate ~15 culms; (7) high>20 culms. Panicle length (PL): (1) very short <11 cm; (3) short ~15 cm); (5) intermediate ~25 cm; (7) long ~35 cm; (9) very long ≥40 cm. Awn length (AL): (0) None (awn less), (1) Very short <5 mm, 3) Short ~8 mm, (5) Intermediate ~15 mm, (7) Long ~30 mm, (9) Very long >40 mm

Qualitative morphological characteristics

All qualitative characters observed were measured using coded scores. The descriptor is scored using a 1-9 scale. The character will be described as 0 if it is not expressed. Observations of qualitative characters in the vegetative phase include auricle color (AC), ligule color (LC), collar color (CC), ligule shape (LS)**,** measured late vegetative and culm habit (CH) measured late vegetative to after flowering, with the estimated average angle of inclination of the base of the main culm from vertical. Qualitative characters of grain and caryopsis were measured after harvest, including grain color (GC), pericarp color (PC) and pericarp shape (PS).

Qualitative descriptors of Bioversity International, IRRI and WARDA (2007): Auricle color (AC): Absent (0), Whitish (011), Yellowish green (062), Purple (080), Light purple (081), Purple lines (084). Ligule color (LC): Absent (0), Whitish (011), Yellowish-green (062), Purple (080), Light purple (081) and Purple lines (084). Collar color (CC): Absent (0), Green (060), Light green (061), Purple (080), Purple lines (084). Culm habit (CH): Erect <15° (1), Semi-erect ~20° (3), Open ~40° (5), Spreading >60-80° (7), Procumbent (9). Grain color (GC): (10) White, (20) Straw, (42) Gold and gold furrows, (52) Brown (tawny), (53) Brown spots, (54) Brown furrows, (80) Purple, (82) Reddish to light purple, (90) Purple spots, (91) Purple furrows, (100) Black. Pericarp color (PC): (10) White, (51) Light brown, (55) Speckled brown, (50) Brown, (70) Red, (88) Variable purple, (80) Purple. Pericarp shape (PS): (1) Round, (2) Semi-round, (3) Half spindle-shaped, (4) Spindle-shaped, (5) Long spindle-shaped.

Statistical analysis

The data were subjected to analysis of variant, standard deviation, coefficient of variation, variability and cluster analysis was carried out using Minitab version 14® program (Matchik dan Sumertajaya 2013). Variability is categorized as broad if the coefficient of variation is greater or equal to twice the standard deviation of the genotype (CVg $\geq 2\ \sigma\ _{\sigma}{}^{2}g$). At the same time, variability is narrow if the coefficient of variation is smaller or equal to twice the standard deviation of the genotype (CVg<2 $\sigma\ _{\sigma}{}^{2}g$) (Pinaria et al. 1995).

RESULTS AND DISCUSSION

Quantitative and qualitative morphological characteristics of vegetative and reproductive phases

The results of statistical analysis of the characters CD, LW, FL, FW, CN, PL, AC, LC, CC, LS and CH obtained heterogeneous characteristics with broad variability, but the characters CL, LL, FA, and HA obtained heterogeneous characteristics with narrow variability (Tables 1, 2 and 3).

This variability has function as a measuring tool to determine the homogeneity and heterogeneity of the characteristics displayed by plants. Variability is one of the benchmarks frequently used by plant breeders to assess the actual appearance of the observed plants (Nur et al. 2013). Genetic variability is a measure of the tendency of individual genetic characteristics in a population to vary from one another. This can be seen from the diversity of morphological characteristics of 23 local rice genotypes of Deli Serdang, in the vegetative and reproductive phases. This diversity is due to the rice genotypes obtained from various elevations ranging from 2.3 m to 1088 m asl. The diversity of a plant's appearance in a population can be caused by the population's genetic structure, the environment, and genetic x environmental interactions (Suryanugraha 2017).

The CL ranges 90.67-173.33 cm. The longest culm was in Sialus (173.33 cm) and the shortest was in Gemuruh (90.67 cm). Based on Bioversity International, IRRI and WARDA (2007), the CL of the 23 genotypes measured was recorded 56% were classified as short to intermediate (91-105 cm); 13% were intermediate (106-120 cm); 9% were intermediate to long (121-140 cm); 9% were long (141-155 cm); 13% were long to very long (156-180 cm) (Table 1 and Figure 2).

Table 1. Quantitative morphological characteristic of Deli Serdang, North Sumatra, Indonesia local rice at vegetative phases

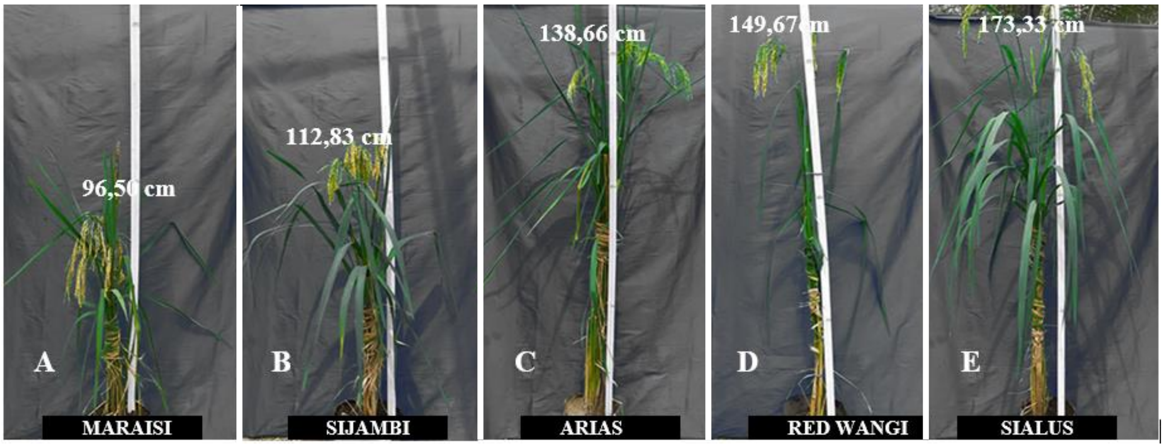
Local name	Genotype code	CL (cm)	CD (mm)	LL (cm)	LW (cm)	FL (cm)	FW (cm)
Kuku Balam	G 01	110.50	4.76	85.8	2.18	44.00	1.73
Siudang	G 02	90.80	4.04	83.8	1.68	36.50	1.66
Sigantang	G 03	95.33	7.20	82.0	1.66	36.67	1.88
Sibelacan	G 04	93.17	5.74	95.8	1.80	35.67	1.83
Gemuruh	G 05	90.67	7.22	84.0	1.58	46.50	1.93
Sipingkol	G 06	93.67	6.54	91.2	1.54	43.50	1.75
Red Sigambiri	G 07	93.00	4.85	73.5	1.78	47.33	2.00
Pandan Wangi	G 08	94.50	6.04	77.6	1.68	46.50	2.05
Black Rice	G 09	98.40	6.18	82.6	1.48	43.50	2.15
Sipirok	G 10	92.83	5.40	71.0	1.70	38.16	1.85
Red Wangi	G 11	149.67	6.70	81.4	1.92	45.00	2.00
Serang	G 12	104.00	6.12	77.0	1.72	51.16	2.18
White Ramos	G 13	162.50	8.30	108.6	2.18	70.50	2.43
Red Ramos	G 14	93.66	5.00	89.8	1.68	44.33	2.40
Arias	G 15	138.66	6.38	110.0	2.28	48.00	2.40
Maraisi	G 16	96.50	6.50	90.4	2.02	43.83	2.10
White Sigambiri	G 17	154.16	7.72	107.2	2.18	54.83	2.60
Sijambi	G 18	112.83	7.50	94.6	2.10	46.16	2.73
Tambur Kersik	G 19	156.33	7.60	103.6	2.44	45.66	2.50
Sialus	G 20	173.33	7.72	100.0	2.22	56.33	2.70
Silayur	G 21	123.16	5.80	78.2	1.68	37.83	2.01
Sirabut	G 22	94.83	5.58	75.6	1.66	49.60	2.01
Sigimbal	G 23	107.50	6.74	102.6	1.74	52.83	1.91
Variance		339.50	1.21	141.13	0.08	59.86	0.10
Standard deviation		18.43	1.10	11.88	0.27	7.73	0.32
Coefficient of Variation		13.92	17.43	13.35	14.64	16.69	14.88
Variability		Narrow	Broad	Narrow	Broad	Broad	Broad

Table 2. Quantitative morphological characteristic of Deli Serdang, North Sumatra, Indonesia local rice at reproductive phases

Local name	Genotype code	CN (culm)	FA (day)	HA (day)	PL (cm)
Kuku Balam	G 01	10.50	105	160	27.64
Siudang	G 02	9.83	106	161	28.98
Sigantang	G 03	9.33	76	130	26.75
Sibelacan	G 04	12.50	76	131	28.16
Gemuruh	G 05	7.67	75	130	31.30
Sipingkol	G 06	8.83	74	128	23.78
Red Sigambiri	G 07	5.50	83	138	28.75
Pandan Wangi	G 08	9.67	74	129	33.80
Black Rice	G 09	8.33	71	126	26.80
Sipirok	G 10	9.00	79	134	24.76
Red Wangi	G 11	7.00	73	135	30.00
Serang	G 12	15.33	72	127	27.06
White Ramos	G 13	12.66	90	145	35.26
Red Ramos	G 14	23.50	105	160	27.66
Arias	G 15	9.50	102	157	29.88
Maraisi	G 16	16.33	79	134	30.73
White Sigambiri	G 17	12.50	90	145	39.84
Sijambi	G 18	7.33	97	152	25.14
Tambur Kersik	G 19	7.16	103	158	31.56
Sialus	G 20	9.16	101	156	32.88
Silayur	G 21	15.83	76	131	25.70
Sirabut	G 22	20.16	75	130	29.86
Sigimbal	G 23	12.50	121	176	28.84
Variance		19.60	216.81	212.31	1.26
Standard deviation		4.43	14.72	14.57	1.12
Coefficient of Variation		39.14	16.91	10.24	12.55
Variability		Broad	Narrow	Narrow	Broad

Table 3. Qualitative morphological characteristic of Deli Serdang, North Sumatra, Indonesia local rice at vegetative phases

Local name	Genotype code	AC	Score*	LC	Score*	CC	Score*	CH	Score*
Kuku Balam	G 01	Whitish	(011)	Whitish	(011)	Green	(060)	Semi-erect	(3)
Siudang	G 02	Whitish	(011)	Whitish	(011)	Green	(060)	Open	(5)
Sigantang	G 03	Whitish	(011)	Whitish	(011)	Green	(060)	Erect	(1)
Sibelacan	G 04	Whitish	(011)	Whitish	(011)	Green	(060)	Open	(5)
Gemuruh	G 05	Whitish	(011)	Whitish	(011)	Green	(060)	Semi-erect	(3)
Sipingkol	G 06	Whitish	(011)	Whitish	(011)	Green	(060)	Open	(5)
Red Sigambiri	G 07	Whitish	(011)	Whitish	(011)	Green	(060)	Open	(5)
Pandan Wangi	G 08	Whitish	(011)	Whitish	(011)	Green	(060)	Open	(5)
Black Rice	G 09	Whitish	(011)	Whitish	(011)	Green	(060)	Open	(5)
Sipirok	G 10	Whitish	(011)	Whitish	(011)	Green	(060)	Semi-erect	(3)
Red Wangi	G 11	Whitish	(011)	Whitish	(011)	Green	(060)	Open	(5)
Serang	G 12	Whitish	(011)	Whitish	(011)	Green	(060)	Semi-erect	(3)
White Ramos	G 13	Whitish	(011)	Whitish	(011)	Green	(060)	Semi-erect	(3)
Red Ramos	G 14	Whitish	(011)	Whitish	(011)	Green	(060)	Erect	(1)
Arias	G 15	Whitish	(011)	Whitish	(011)	Green	(060)	Erect	(1)
Maraisi	G 16	Whitish	(011)	Whitish	(011)	Green	(060)	Erect	(1)
White Sigambiri	G 17	Whitish	(011)	Whitish	(011)	Green	(060)	Semi-erect	(3)
Sijambi	G 18	Yellow-green	(062)	Yellow-green	(062)	Light green	(061)	Erect	(1)
Tambur Kersik	G 19	Whitish	(011)	Whitish	(011)	Green	(060)	Erect	(1)
Sialus	G 20	Whitish	(011)	Whitish	(011)	Green	(060)	Erect	(1)
Silayur	G 21	Whitish	(011)	Whitish	(011)	Green	(060)	Semi-erect	(3)
Sirabut	G 22	Whitish	(011)	Whitish	(011)	Green	(060)	Open	(5)
Sigimbal	G 23	Whitish	(011)	Whitish	(011)	Green	(060)	Open	(5)
Variant			113.09		113.09		0.04		2.88
Standard deviation			10.63		10.63		0.21		1.69
Coefficient of Variation			80.46		80.46		0.35		53.45
Variability			Broad		Broad		Broad		Broad



A B C D E

Figure 2. The culm lengths classification of local rice in Deli Serdang, North Sumatra, Indonesia: A. Short to intermediate 91-105 cm; B. Intermediate 106-120 cm; C. Intermediate to long121-140 cm; D. Long 141-155cm; E. Long to very long 156-180 cm

The results of the measurement of CD as recorded ±83% were classified as thick (≥5 mm) and ±17% were as thin (<5 mm). The thickest local rice genotype was found in White Ramos (8.30 mm) and the thinnest was Siudang (4.04 mm). The length and diameter of the local rice culm were classified as short to intermediate and thick, thus indicating a figure of culm that was resistant to falling. The culm acts as a support for plants, as a channel for water, inorganic and organic compounds in the plant body. Plants that can take full advantage of sunlight, water, and nutrients, as indicated by their thick culm diameter, have high photosynthetic yields so that they can be utilized for generative growth (Hadi 2013). Generally, the culm length of rice that has been released as new superior varieties ranges from 80-120 cm (Jamil et al. 2018). A sturdy stem must support the high yield potential of rice plants. Otherwise, the plants will easily fall, especially in areas frequently hit by strong winds (Makarim and Suhartatik 2009).

Leaf characters such as LL, LW, FL, and FW are morphological traits that are closely related to plant productivity. Leaves are a source of assimilation which will be distributed to the organs of assimilating users, such as roots, stems, flowers, fruits and seeds. Long and broad leaves are indicators of a rice cultivar having high yield potential (Makarim and Suhartatik, 2009). The leaf is the organ that must be measured in breeding activities. The measured leaves tend to be long and broad. The LL recorded were 26% classified as long (~70 cm) and 74% as very long (≥80 cm). The longest leaf was in Arias (110 cm) and the shortest was in Sipirok (71 cm). The LW recorded were 65% classified as intermediate (~1cm) and 35% as broad (>2 cm), the broadest leaf was in Tambur Kersik (1,48 cm) and the narrowest was in Black Rice (2,28 cm). The FL recorded were 26% classified as short (~30 cm), 70% as intermediate (~50cm), and 4% as long (~70 cm), the longest flag leaf was White Ramos (70.50 cm) and the shortest was Sibelacan (35,67 cm). The FW recorded were 35% classified as intermediate ~1cm and 65% as broad (>2 cm), the broadest flag leaf was in Sijambi (1,66 cm) and the narrowest was in Siudang (2,73 cm). Broad leaves will tend to form a comprehensive plant canopy (Yoshida 1981); theoretically, the photosynthesis process will be higher when compared to a narrow plant canopy. At the same time, leaf size and the number of stomata are highly affected by height (Suranto et al. 2018). A broad plant canopy can absorb more solar radiation so that the rate of photosynthesis is higher. One of the devices that play an important role in photosynthesis is the chloroplast which contains chlorophyll, which plays a role in capturing sunlight. Broad leaves have many chloroplasts (Li et al. 2006).

The results of the measurement of the number of tillers were only 9% high (>20 culms), 57% classified as low (<10 culms), and 34% moderate (~15 culms). The least numbers of culms shown were in Red Sigambiri with 6 culms, and the maximum was 24 culms found in Red Ramos (Table 2). The ability of Red Ramos and Sirabut to form high the culm of grain-bearing tillers (>20 culms) is an important character that can be used as a source of genetic material in developing high yielding varieties. According to Tampoma et al. (2017), absorption of solar radiation and distribution of maximum assimilation occurred when the number of tillers formed was around 10-19 tillers/clump. The maximum assimilation process at the tiller formation can be used for flowering and seed filling. The total number of grain-bearing tillers will determine the final yield.

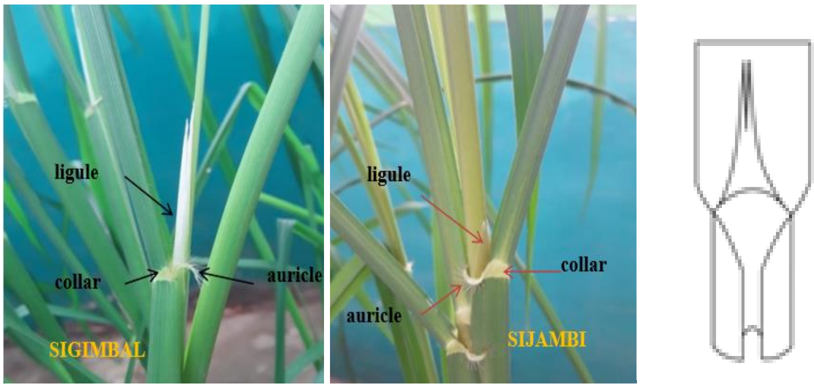
There is low diversity in the characteristics of FA and HA of 23 local rice genotypes, for FA ranging from 71-121 days after planting and HA ranging from 127-176 days after planting (Table 2). The classification of rice harvesting age is grouped into three, namely deep-age plants if harvest age is >151 days after planting, medium 125-150 days after planting, and early 105-124 days after planting (Akmal et al. 2011; Jamil et al. 2018). The result of observations of the harvest age of 23 local rice recorded that 65% were classified as medium and 35% deep. There were no genotypes of rice that were classified as early harvest age. In line with the results of studies Rohaeni (2015) and Rahmah (2018), local rice's harvesting age is classified as medium to deep. However, three genotypes need to be considered to be used as a source of genetic material in the development of high-yielding local rice varieties with near-early harvesting ages, namely Pandan Wangi, Black Rice, and Serang, because their harvest ages range from 126-129 days after planting. An early harvest age is one of the characteristics favored by farmers, especially by local agroecological conditions (Ghimire et al. 2015).

Most of the PL was classified as intermediate (91%) and the rest (9%) was long. The longest panicle is White Sigambiri, followed by White Ramos. Improvement of panicle architecture and grain yield of rice PL is needed because it was an important asset. The panicle architectural aspect that is usually measured is panicle length. This character is related to the number and density of grains, determines the number of grains per panicle, and relates to yield (Liu et al. 2016).

The results of observations of the auricle color and ligule color on 23 local rice genotypes obtained that all of them were whitish, except the Sijambi genotype was yellowish-green. The collar color of all genotypes was green, except the Sijambi genotype, which was light green (Table 3 and Figure 3). All local rice genotypes ligule shaped 2-cleft acute (Figure 3). Local rice from Indonesia has the same ligula shape, is 2-cleft (Rohaeni and Yuliani 2019; Rusdiansyah and Intara, 2015). As for CH, the average estimation angle of inclination of the base of the main culm from vertical, 31% were classified as upright (<15°), 30% semi-upright (~20°), and 39% open (~40°) (Figure 4). CH regulates the genotype for responsiveness of nitrogen and light interception. Optimizing the crop canopy structure can improve canopy photosynthetic productivity and crop yield potential. Erect culm (< 30°) allows to intercept light within the canopy and avoid self-shading effect between individual plants. The habit of culm that grows upright to semi-erect is more productive than growing open (Tafere and Irie 2019). Of the 23 genotypes of local Deli Serdang rice, several genotypes have open culm habits, such as Sirabut and Sigimbal. Both of these genotypes were explored from highlands or hills with an elevation of 753 m to 1088 m asl, so these genotypes were more suitable for cultivation in slightly shaded habitats and can be cultivated as an intercrop among plantation crops. Most of the local rice genotypes have erect to semi-erect culm habit, making them suitable for cultivation in open habitats.

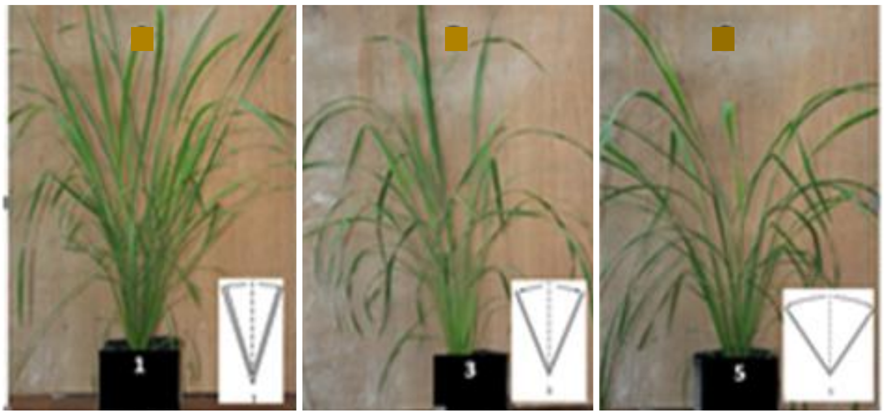
Quantitative and qualitative morphology characteristics of grain and caryopsis

Actual measurements data of the quantitative characters of grain and caryopsis/pericarp of 23 local rice genotypes include GL, GW, GT, AL, WG, PL, PW, PT, and WP. Statistical analysis results showed broad variability, as seen in Tables 4 and 5. The observation data of qualitative characters include GC, PC, and PS. Statistical analysis results showed broad variability (Table 6).



A B C

Figure 3. A. Ligule color and auricle color (whitish), collar color (green); B. Ligule color and auricle color (yellow-green), collar color (light green); C. Ligule shape, namely 2-cleft acute



A B C

Figure 4. Culm habit (CH) of Deli Serdang, North Sumatra, Indonesia local rice: A. Erect <15° (score 1); B. Semi-erect ~20° (score 3); and C. Open ~40° (score 5)

Table 4. Quantitative morphological characteristic of Deli Serdang, North Sumatra, Indonesia local rice at vegetative phases

Local name	Genotype code	GL (mm)	GW (mm)	GT (mm)	WG (g)	AL (mm)
Kuku Balam	G 01	8.68	2.22	1.45	19.54	8
Siudang	G 02	8.62	2.14	1.54	19.24	2
Sigantang	G 03	8.54	2.17	1.61	23.01	4
Sibelacan	G 04	8.47	2.45	1.63	26.19	20
Gemuruh	G 05	8.36	2.47	1.58	26.30	15
Sipingkol	G 06	8.45	2.71	1.72	28.05	0
Red Sigambiri	G 07	7.05	3.29	1.92	26.25	0
Pandan Wangi	G 08	8.25	2.95	1.46	25.86	11
Black Rice	G 09	9.03	2.46	1.53	24.22	0
Sipirok	G 10	8.83	2.93	2.01	26.43	28
Red Wangi	G 11	8.93	2.11	1.47	21.35	0
Serang	G 12	9.35	2.18	1.61	24.31	17
White Ramos	G 13	9.10	2.35	1.70	26.67	3
Red Ramos	G 14	8.92	2.35	1.55	21.53	8
Arias	G 15	7.55	2.59	1.65	20.03	0
Maraisi	G 16	8.98	2.52	1.72	25.47	2
White Sigambiri	G 17	7.53	2.57	1.60	20.28	0
Sijambi	G 18	7.20	3.30	1.73	24.59	0
Tambur Kersik	G 19	8.35	2.55	1.54	21.50	0
Sialus	G 20	8.10	2.39	1.61	24.23	0
Silayur	G 21	9.13	2.48	1.80	24.97	2
Sirabut	G 22	9.47	2.65	2.11	27.65	13
Sigimbal	G 23	7.32	2.31	1.48	17.93	0
Variant		0.49	0.11	0.03	8.75	62.91
Standard Deviation		0.69	0.33	0.17	2.96	7.93
Coefficient of Variation		8.25	13.03	10.43	12.47	137.16
Variability		Broad	Broad	Broad	Broad	Broad

Table 5. Quantitative morphological characteristic of grain and caryopsis of Deli Serdang, North Sumatra, Indonesia local rice

Local name	Genotype code	PL (mm)	PW (mm)	PT (mm)	WP (g)
Kuku Balam	G 01	6.30	1.80	1.43	15.43
Siudang	G 02	6.15	1.78	1.44	15.68
Sigantang	G 03	7.54	2.32	1.78	23.01
Sibelacan	G 04	6.61	2.13	1.63	20.35
Gemuruh	G 05	6.23	2.12	1.56	19.27
Sipingkol	G 06	6.72	2.00	1.54	22.02
Red Sigambiri	G 07	5.03	2.77	1.86	22.26
Pandan Wangi	G 08	5.49	2.43	1.58	19.68
Black Rice	G 09	6.64	2.24	1.45	19.08
Sipirok	G 10	6.13	2.42	1.72	22.02
Red wangi	G 11	6.91	1.7	1.41	15.67
Serang	G 12	6.77	1.95	1.60	18.97
White Ramos	G 13	6.93	2.09	1.65	22.01
Red Ramos	G 14	6.40	1.99	1.51	17.25
Arias	G 15	6.61	2.13	1.62	18.25
Maraisi	G 16	6.23	2.31	1.64	21.05
White Sigambiri	G 17	5.60	2.24	1.57	18.06
Sijambi	G 18	5.88	2.96	1.84	21.61
Tambur Kersik	G 19	5.95	2.17	1.63	18.81
Sialus	G 20	6.19	2.19	1.60	17.66
Silayur	G 21	6.48	2.08	1.59	19.75
Sirabut	G 22	6.68	2.39	1.70	23.43
Sigimbal	G 23	5.46	1.84	1.49	14.85
Variant		0.32	0.09	0.02	7.62
Standard Deviation		0.57	0.30	0.12	2.54
Coefficient of Variation		8.97	13.73	7.62	13.11
Variability		Broad	Broad	Broad	Broad

Table 6. Qualitative morphological characteristic of grain and caryopsis of Deli Serdang, North Sumatra, Indonesia local rice

Local name	Genotype code	GC	Score*	PC	Score*	PS	Score*
Kuku Balam	G 01	Gold	(42)	White	(10)	Spindle	(4)
Siudang	G 02	Brown	(52)	White	(10)	Spindle	(4)
Sigantang	G 03	Straw	(20)	White	(10)	Spindle	(4)
Sibelacan	G 04	Straw	(20)	Light brown	(51)	Long spindle	(5)
Gemuruh	G 05	Straw	(20)	White	(10)	Long spindle	(5)
Sipingkol	G 06	Brown	(52)	White	(10)	Long spindle	(5)
Red Sigambiri	G 07	Straw	(20)	Red	(70)	Semi round	(2)
Pandan Wangi	G 08	Straw	(20)	White	(10)	Semi round	(2)
Black Rice	G 09	Black	(100)	Purple	(80)	Long spindle	(5)
Sipirok	G 10	Brown furrows	(54)	White	(10)	Spindle	(4)
Red Wangi	G 11	White	(10)	Light brown	(51)	Long spindle	(5)
Serang	G 12	Straw	(20)	Red	(70)	Long spindle	(5)
White Ramos	G 13	Straw	(20)	White	(10)	Long spindle	(5)
Red Ramos	G 14	Straw	(20)	Light brown	(51)	Spindle	(4)
Arias	G 15	Brown	(52)	White	(10)	Semi-round	(2)
Maraisi	G 16	White	(10)	Light brown	(51)	Half spindle	(3)
White Sigambiri	G 17	Brown	(52)	White	(10)	Semi-round	(2)
Sijambi	G 18	Gold	(42)	White	(10)	Semi-round	(2)
Tambur Kersik	G 19	Brown spots	(53)	White	(10)	Spindle	(4)
Sialus	G 20	Gold	(42)	White	(10)	Spindle	(4)
Silayur	G 21	Straw	(20)	White	(10)	Long spindle	(5)
Sirabut	G 22	Straw	(20)	Red	(70)	Long spindle	(5)
Sigimbal	G 23	Brown	(52)	White	(10)	Half spindle	(3)
Variant		456.07		680.55		1.39	
Standard Deviation		21.36		26.09		1.18	
Coefficient of Variation		60.34		93.17		30.48	
Variability		Broad		Broad		Broad	

The GL ranges from 7.05-9.47 mm. The longest grain was found in the Sirabut and the shortest in the Red Sigambiri. The GW ranges from 2.11-3.30 mm, the broadest grain found in the Sijambi and the narrowest in the Red Wangi. If the length of the grain was more than three times the width, then it was classified as long (Afza 2017). The thinnest grain is found in the Kuku Balam (1.45 mm) and the thickest in the Sirabut (2.11 mm). The weight of 1000 grains of lightest was found in the Sigimbal (17.93 g) and heaviest in the Sipingkol (28.05 g). Not all local rice genotypes have awn at the end of grain, 13 genotypes have awn, and ten are awnless. AL varies from very short to long (2-28 mm). The longest awn was found in the Sipirok (28 mm), as seen in Table 4. The longest caryopsis/pericarp was found in the Sigantang (7.54 mm) and the shortest in the Red Sigambiri (5.03 mm). The narrowest pericarp was found in the Red Wangi (1.77 mm) and the widest in the Sijambi (2.96 mm). The thinnest pericarp was found in the Red Wangi (1.41 mm) and the thickest in the Sirabut (2.11 mm). The weight of 1000 grains of lightest was found in the Sigimbal (14.85 g) and heaviest in the Sirabut (23.43 g), as seen in Table 5. Aspects of the shape and appearance of rice consist of length and rice shape. According to Jamil et al. (2018), in general, the length of rice consists of: very long (>>7.5 mm), long (6.61-7.5 mm), medium (5.51-6.6 mm), and short (<5.5). The various sizes of rice from 23 characterized local rice genotypes can be used as a genetic source in plant breeding programs.

The GC of the 23 local rice genotypes was as follows: white (8.70%) straw (43.48%), gold and gold furrows (13.04%), brown (tawny) (17.38%), brown spots on green (8.70%), brown lines (4.35%), and black (4.35%). The PC was predominantly white (65.22%), light brown (17.39%), red (13.04%), and black (4.35%) as seen in Table 6 and Figure 4. The PL also varied; they were semi-round (21.74%), half spindle-shaped (8.70%), Spindle-shaped (30.43%), and long Spindle-shaped (39.13%). The shape and color of rice are a character caused by genetic factors. This rice color difference was due to differences in alleles related to the nature of the pigment in the lemma palea or caryopsis of the grain, and genetically through the regulation of aleurone and endospermic color, and starch composition in the endospermic (Kristamtini et al. 2014). Rice has a high bioactive compound, one of the phenolic compounds. Most of the phenolic compounds (anthocyanins) in rice are indicated by the dark color of rice. The environment strongly influences these bioactive compounds (Chakuton et al. 2012; Kristamtini et al. 2018). One of the characteristics that consumers pay attention to when choosing and buying rice is the shape and color. The long Spindle and colored forms of rice such as brown, red and black are one of the consumer choices to meet the nutritional needs of food because it contains high levels of vitamin B complex, essential fatty acids, fiber, and anthocyanin dyes which are very beneficial for health (Suliansyah et al. 2018). In this regard, several local rice genotypes observed, such as Black Rice, Red Wangi, Serang, Red Ramos, and Sirabut can be developed into superior local varieties.

Figure 5. Grains and Caryopsis 23 local rice genotypes of Deli Serdang, North Sumatra, Indonesia

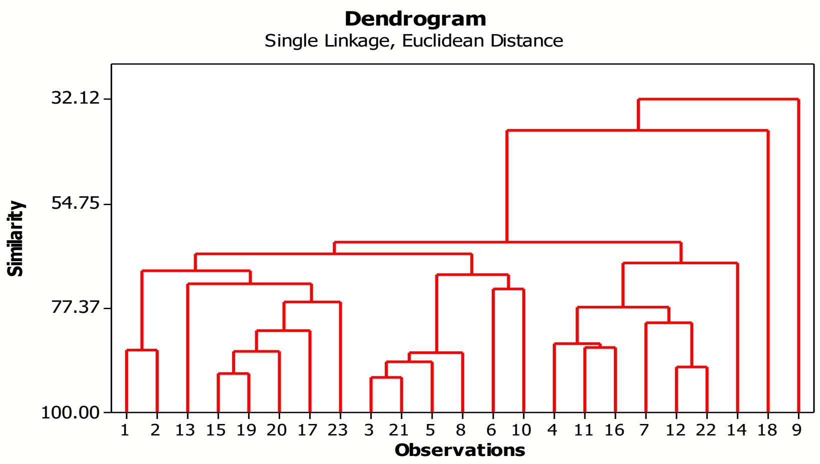


Figure 6. The kinship level of 23 local rice genotypes of Deli Serdang, North Sumatra, Indonesia

Cluster analysis 23 local rice genotype of Deli Serdang District

Cluster analysis aims to group members of the population (observations) into several classes, where members in each group are more homogeneous (similar). The similarity between 24 local rice genotypes in cluster analysis according to plant morphological markers, grain, and caryopsis. To find the similarity between local rice genotypes, all data were analyzed by calculating the Euclidean distance linked based on the closest kinship with the help of a computer using the Minitab program. Based on the 32.12% similarity level, the 23 local rice genotypes were grouped into five groups. The first group was genotype 9, the second group was genotype 18, the third group consisted of seven genotypes, i.e., 4,7,11,12,14,16, and 22. Genotypes 3,5,6,8,10 and 21 were in the fourth group. Eight genotypes, i.e., 1,2,13,15,17,19,20 and 23 were in the fifth group (Figure 6). Especially for genotypes 9 and 18 appear to form one straight line that indicates no kinship with other genotypes. There may be a high degree of similarity to the morphological characters of several local rice, this occurs because the seeds planted are obtained from hereditary (Susila et al. 2015).

Morphological characteristics of 23 local rice genotypes from Deli Serdang District, North Sumatra, Indonesia, obtained various characters. Several genotypes have superior characteristics such as has short culm length, thick culm diameter, the leaf-blade length very long, and the leaf-blade width intermediate, high the culm of grain-bearing tillers, long panicles, the rice shape of a long spindle, and rice color of brown, red and black, such as Black Rice, Red Wangi, Serang, Red Ramos, and Sirabut. Most of the local rice genotypes have erect culm habits, making them suitable for cultivation in open habitats, and several genotypes have open culm habits and were more suitable for cultivation in slightly shaded habitats as Sirabut dan Sigimbal. There is no early harvest age. All local rice genotypes had moderate to deep harvesting ages. However, some genotypes have a harvest age that is close to an early age, such as Pandan Wangi, Black Rice, and Serang. The superior characters owned by several local rice genotypes of Deli Serdang can be used as a source of genetic material in plant breeding programs and developed into superior local varieties.

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