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Diversity of Quantitative and Qualitative Characters of Rice Grain from Riau Province, Indonesia

(Keragaman Karakter Kualitatif dan Kuantitatif Bulir Padi dari Provinsi Riau, Indonesia)

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ABSTRAK

Padi ditanam di hampir seluruh wilayah di Indonesia, termasuk Provinsi Riau, sebagai makanan pokok. Meskipun padi merupakan tanaman pangan yang paling banyak ditanam dibanding dengan tanaman lainnya, produksi beras dari daerah ini belum mampu memenuhi kebutuhan penduduk Riau. Untuk memenuhi kebutuhan beras, masyarakat Riau masih harus mendatangkannya dari daerah lain. Provinsi Riau memiliki koleksi plasma nutfah padi yang beragam untuk swasembada pangan. Beberapa aksesi padi dari daerah tersebut telah dikumpulkan dan dikonservasi di Bank Gen Pertanian Badan Penelitian dan Pengembangan Pertanian-Balai Besar Penelitian dan Pengembangan Bioteknologi dan Sumber Daya Genetik Pertanian. Penelitian ini dimaksudkan untuk mengkaji keanekaragaman padi dari Provinsi Riau berdasarkan karakteristik bijinya. Sebanyak 25 aksesi padi asal Riau yang dikonservasi di Bank Gen Pertanian Balitbangtan-BB Biogen telah diamati karakter bijinya, meliputi karakter panjang gabah, bentuk, dan warna mengikuti deskriptor standar internasional untuk beras oleh IRRI dan IBPGR, sedangkan bobot 1.000 butir diukur menggunakan standar operasional prosedur dari ISTA. Keragaman biji dianalisis menggunakan perangkat lunak NTSYS-pc versi 2.2. Rata-rata ukuran panjang, lebar, dan tebal gabah masing-masing adalah sebesar 7,9, 3,0, dan 1,9 mm. Bobot 1.000 butir berkisar antara 20,37 sampai 25,67 dengan rata-rata 23,02 g. Sebagian besar aksesi memiliki lemma-palea dengan alur atau bercak cokelat pada latar warna jerami, dengan apikulus warna jerami, lemma steril berukuran sedang, dan tidak berbulu. Sebagian besar butiran beras berukuran sedang, berukuran panjang 5,24 mm dan lebar 2,24 mm. Sebagian besar aksesi merupakan beras berwarna putih. Aksesi dari Riau dapat dibagi menjadi lima kelompok berdasarkan tujuh karakteristik butir padi. Pengelompokan tersebut tidak ada hubungannya dengan kabupaten asal aksesi tersebut, yang berarti bahwa penyebaran dan pertukaran plasma nutfah yang melewati batas kabupaten.

Kata kunci: Bank Gen Pertanian Balitbangtan-BB Biogen, keragaman padi, Provinsi Riau.

ABSTRACT

Rice is grown in almost all regions in Indonesia, including Riau Province, as a staple food. Although rice is the most widely grown food crop in comparison to other crops, rice production from this region has not been able to meet the needs of the Riau population. To meet the needs of rice, the people of Riau still have to bring it from other regions. Riau Province has a large collection of diverse rice germplasm for food self-sufficiency. Several rice accessions from the area have been collected and conserved in the Genebank of the Indonesian Agency for Agricultural Research and Development (IAARD), located at Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development (ICABIOGRAD). This study was intended to assess the diversity of rice from Riau Province based on the grain characteristics. A total of 25 rice accessions from Riau which were conserved in the IAARD-ICABIOGRAD Genebank were examined. Grain length, shape, color, and other grain-related characters were observed following the international standard descriptors for rice by IRRI and IBPGR. While the thousand-grain weight was measured using the standardized operational procedure from ISTA. The grain diversity was analyzed using the NTSYS-pc software version 2.2. The average of length, width, and thickness of the unhulled paddy was measured at 7.9, 3.0, and 1.9 mm, respectively. The weight of 1,000 grains ranged from 20.37 to 25.67 with an average of 23.02 g. Most of the accessions had a brown furrow or spot on straw background lemma-palea, with a straw apiculus a medium-sized sterile lemma, and were awnless. The majority of the rice grain was medium size, measuring 5.24 mm in length and 2.24 mm in width. White grain makes up the majority of the accessions. Accessions from Riau can be divided into five groups based on the seven characteristics of rice grains. Those groupings were unrelated to the district from which the accessions were obtained, illustrating the beyond boundaries of germplasm distribution and transfer of germplasm within this district.

Keywords: IAARD-ICABIOGRAD Genebank, rice diversity, Riau Province.

INTRODUCTION

Rice belongs to the genus *Oryza* and the tribe Oryzeae of the family Gramineae (Poaceae). Among other species in this genus, *Oryza sativa* L. is the most extensively cultivated rice species. As the main staple food for most Indonesia population, rice is very important crop in Indonesia (BPS 2018). Over 90% of Indonesians consume rice as part of their daily diet (Kemendag 2013; Pusdatin 2013). Rice is essential for Indonesia's economy since it provides not just food for consumption but also a source of income and labor absorption. Agricultural labor (in the narrow sense) is the largest labor force, according to the statistics from the Employment of Agriculture Sector for the Year 2020 (Pusdatin 2020). Considering those various important aspects, rice has a strategic role in food security, economic resilience, and national political stability (BPS 2018).

The rice demand in Riau Province necessitates imports from outside the region, as the rice production system is not in line with population growth. Between 2010 and 2014, there was a reduction in harvested area and rice production (Erwandari 2017), but population and rice consumption increased (Zara et al. 2018). This trend of decline in rice production and rising rice demand continued to the period of 2016 to 2018. Riau's overall food production in the period of 2016 to 2018 was insufficient to meet the food demand of the population. The province's rice production can only provide 52.2% of the demand (Erwandari 2017). There was also an increase in the price of rice in the market during this time (Dinas Ketahanan Pangan Riau 2019). This dependence on supply causes rice prices to fluctuate greatly. However, the fluctuations that occur in Riau Province are relatively stable (Jusar et al. 2017). The decrement of the rice plantation is correlated with land conversion to the oil palm industrial plantation. The oil palm plantation is considered more economical (Erwandari 2017).

Food safety can be pursued through various approaches and its dynamic is greatly influenced by population growth. In the continuously growing population, the demand for food availability is automatically increased. This increasing demand for food production can be met through efforts of expanding the growing area or increasing production. However, due to various factors, expanding the planting area is considered less feasible. Thus, the effort of increasing rice production must rely on the utilization of high-yielding rice varieties.

The development of high-yielding varieties requires the availability of genotypes with high yield potential characters. These types of rice genotypes can be used directly in the production system or indirectly as resources in the breeding programs. In a rice crop, high yields are determined by three main components, i.e. panicles number, number of seeds per panicle, and the seed/grain weight (Huang et al. 2013; Li et al. 2019). Of the three components, seed weight is considered as the most obvious character related to yield. Furthermore, the grain weight is determined by its size. Therefore, grain size is considered a very important factor and determines the yield (Li et al. 2019).

Currently, in addition to the sufficiency of food availability, consumers also demand other characters that will determine their preferences. Several characteristics such as size, shape, color, and taste are among the quality factors that determine the preference and economic value of rice. Grain size and shape are important quality parameters and affect the level of consumer preference (Li et al. 2019). Different seed shapes are preferred by people in different areas (Huang et al. 2013). A study conducted on consumer behavior in one district in Riau Province shows that color, aroma, and taste are important factors in determining the level of consumer satisfaction (Kusmariza et al. 2019). Because of this important nature, grain size is among the selection factor during domestication and in breeding activities.

Riau Province is not considered that lacks rice germplasm. Some areas are reported to have a quite high diversity of local germplasm, such as in Rokan Hilir District, which is one of the centers of rice. Diversity of rice panicles was reported from this area (Ngatiman et al. 2019). Several rice collections in Riau Province have also been

explored and conserved at the IAARD-ICABIOGRAD Genebank. Local varieties of Indonesian rice have been collected from the fields since 1972 (Silitonga 2004). There are at least 62 rice accessions collected from 6 districts in Riau.

This study aimed to determine the diversity of rice accessions from Riau Province which have been conserved *ex situ* in the IAARD-ICABIOGRAD Genebank. Information regarding the rice diversity, including the diversity of grain sizes and shapes, is expected to provide an overview of the richness of rice germplasm that has ever existed and been cultivated by people in Riau Province, and its potential to be developed to support food self-sufficiency in the province.

MATERIALS AND METHOD

The research was conducted at the Genebank Laboratory of the IAARD-ICABIOGRAD in February 2021. A total of 25 rice accessions from the IAARD-ICABIOGRAD Genebank collections originating from Riau Province were observed for the grain characteristics in the form of unhulled paddy and dehulled rice.

The characters observed in paddy form included length, width, and thickness of grain, 1,000 grain weight, length of the sterile lemma, and the color of paddy and the sterile lemma. The 1,000 grain weight was performed according to the International Rules for Seed Testing developed by International Seed Testing Association (ISTA 2019). The grain weight was calculated by accumulating ten measurements of 100-grain weight each per accession. The seed moisture content during measurement was recorded. In the dehulled rice sample, observations were made on the caryopsis color, length, width, and shape. Measurements of length, width, and thickness were carried out on five grains per accession using a caliper. The length of the grain is measured from the base to the tip of the seed (excluding hairs), while the width of the grain is measured from the outer boundary of the lemma and palea. Measurement of rice is carried out in the same way for manually unhulled rice. Caryopsis length is categorized based on the classification developed by IRRI and IBPGR (1980). Rice grain length was classified as: very long (>7.50 mm), long (6.61 to 7.50 mm), medium (5.51 to 6.60 mm), and short (<5.50 mm). The shape of the caryopsis is classified based on the ratio of length and width, namely: slim (>3.0), medium (2.1 to 3.0), bold (1.1 to 2.0), and round (<1.0). Observation of the quality characters of grain and caryopsis was carried out by referring to the rice descriptor (IRRI and IBPGR 1980).

The data obtained were analyzed using simple statistics to obtain an overview of the range, mean, and variability of seed size, shape, and color. Cluster analysis was performed by the Numerical Taxonomy and Multivariate Analysis System (NTSYS)-pc software version 2.02 using the Sequential Agglomerative Hierarchical and Nested-Unweighted Pair Group Method With Arithmetic (SAHN-UPGMA) software (Rohlf 2015).

RESULTS AND DISCUSSION

Observations on unhulled paddy and dehulled rice accessions showed the diversity of rice germplasm from Riau Province. Variations were observed in grain size and color and caryopsis size, shape, and color. Clustering of the accessions based on the respective characters grouped the rice accession into five clusters at the similarity level of 50%.

The Paddy, Unhulled Rice Characteristics

Paddy rice exhibited diversity in length, width, and thickness. The grain length varied from 7.23 to 9.85 mm with an average of 8.57 mm; the rice width ranged from 2.04 to 3.16 mm with an average of 2.92 mm and the thickness varied from 1.04 to 2.17 mm with an average of 1.89 mm (Table 1).

The rice accession from Riau Province may be classified as *Indica*, *Javanica*, *Japonica*, and hybrid type based on its length, width, and thickness. The majority of the rice accessions in this study were *Indica* and *Javanica* types (Figure 1). The subspecies or varietal groups of *O. sativa*

viz., *Indica*, *Japonica*, and *Javanica*, are the results of centuries of selection by man and nature for desired quality and adaptation to new niches (India MoEF and DBT 2011). The grain form of *Indica* type of rice is slender-flat, whereas *Javanica* rice is broad-thick (Chang and Bardenas 1965). The presence of these diverse rice types in this study indicated the long history of rice cultivation in Riau Province as well as across Indonesia.

The color of paddy, which is attributed to the lemma and palea, ranged from straw, brown spots on straw, brown furrows on straw, and brown. In terms of awn, most of the collection were awnless, except for three accessions that have partially short-awned with a straw color. The majority had a medium and straw sterile lemma with only a few having red sterile lemma (Figure 1, Table 2).

The lemma and palea are grass-specific perianth organs that surround the inner floral organs, the lodicule, stamen, and pistil (Yoshida and Nagato 2011). There is a wide diversity in the distribution, intensity, and location of pigment in the lemma and palea. Due to the similar pattern of pigmentation, lemma, and palea are treated together (Ghose et al. 1960). The absence of certain hue in the rice collection from Riau Province does not imply the absence of the respective color in the field. Ngatiman et al. (2019) observed varied color of apiculus (tip of panicle) and lemma-palea presence on rice accessions in Rokan Hilir District of Riau Province.

Thousand Grain Weight (TGW)

Thousand-grain weight (TGW) was the weight ratio of 1,000 seeds produced by a type of plant or variety. TGW was used to determine the appropriate seeding rate. The constant weight of a variety can be used as the basis for determining the seed requirement per hectare (Kustanti 2016).

Table 1. Quantitative characteristics of rough rice.

Grain characters	Minimum value	Maximum value	Average value
Grain length (mm)	7.24	9.85	8.57
Grain width (mm)	2.04	3.16	2.92
Grain thickness (mm)	1. 04	2.17	1.89
Sterile lemma length (mm)	1.75	2.9	2.28
1,000 grain weight (g)	16.34	25.66	21.78

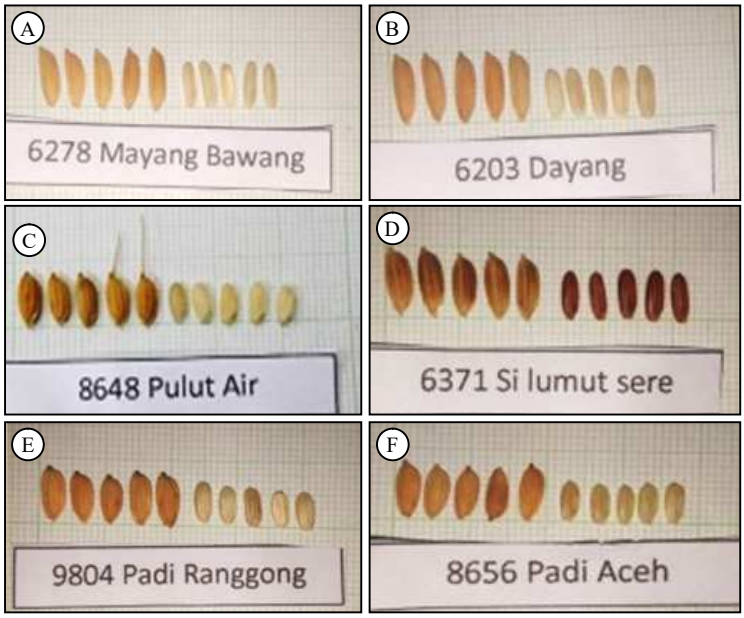

Figure 1. Diversity of grain characteristics of rice accessions from Riau Province.
The figure representing typical of *Indica* rice type (A, B), *Javanica* type (C, D), and *Japonica* type (E, F).

Generally, TGW is associated with yield potential. Grain yield is coordinately controlled by grain weight, grain number per panicle, panicle number per plant, and grain filling ratio (Fang et al. 2016). TGW, together with grains per panicle, has the most direct effect on seed yield (Singh et al. 1979). There is a positive correlation between TGW with grain yield in *Indica* type of rice (Li et al. 2019). TGW is an important factor affecting grain yield as well as grain quality in rice (Yu et al. 2008). Thus, measuring TGW is often a component in seed quality testing.

The TWG of rice accessions from Riau Province ranged from 16.34 g to 25.66 g with an average of 21.78 g (Table 1). The Pearson coefficient showed a weak positive correlation

Table 2. Variation on rice grain characteristics in Riau Province.

No.	Accession number	Variety name	District	Characteristics
1.	05020-05562	Buruk Bakul	Indragiri Hilir	*Indica* type of rice, awnless with medium length of sterile lemma, brown furrows on straw colored lemma-palea with straw colored apiculus; short length and medium shape, brown colored grain
2.	05020-05564	Bujang Berinai	Indragiri Hilir	*Javanica* type of rice, awnless, medium-length sterile lemma, brown furrows on straw lemma-palea, straw apiculus; medium length and medium shape, brown grain
3.	05020-05566	Rumbai	Indragiri Hilir	*Japonica* type of rice, awnless, medium-length sterile lemma; straw lemma-palea, straw apiculus; medium length and medium shape, white grain
4.	05020-05567	Dube	Indragiri Hilir	Hybrid type of rice, awnless, long-length sterile lemma, brown spots on straw lemma-palea, straw apiculus; long and slender, white grain
5.	05020-05763	Bulu Jadi	Pekanbaru	*Indica* type of rice, awnless, medium-length sterile lemma; brown lemma-palea, straw apiculus; medium length and medium shape, white grain
6.	05020-05764	Sempati Telor	Pekanbaru	*Javanica* type of rice, awnless, medium-length sterile lemma; brown furrows on straw lemma-palea, brown apiculus; short length and medium shape, white grain
7.	05020-05767	Putih	Pekanbaru	*Japonica* type of rice, awnless, medium-length sterile lemma, brown spots on straw lemma-palea, brown apiculus; medium length and medium shape, white grain
8.	05020-06202	Aceh-aceh	Kampar	*Indica* type of rice, awnless, with long sterile lemma; straw lemma-palea; straw-colored apiculus; long and slender, light brown grain
9.	05020-06203	Dayang	Kampar	*Indica* type of rice, awnless, medium-length sterile lemma, brown furrows on straw lemma-palea, brown apiculus; long and slender, white grain
10.	05020-06278	Mayang Bawang	Indragiri Hulu	*Indica* type of rice, awnless, long-sterile lemma; straw lemma-palea, straw apiculus; long and slender, white grain
11.	05020-06371	Si Lumut Sere	Kampar	*Javanica* type of rice, awnless, long sterile lemma, brown furrows on straw lemma-palea, straw apiculus; long and slender, brown grain
12.	05020-06373	Katimbung	Kampar	*Javanica* type of rice, awnless, medium-length sterile lemma, brown spots on straw lemma-palea, straw apiculus; medium length and medium shape, brown grain
13.	05020-06374	Si Opuk	Kampar	*Indica* type of rice, awnless, medium-length sterile lemma, brown spots on straw lemma-palea, brown apiculus; medium length and medium shape, white grain
14.	05020-06375	Si Topas	Kampar	*Indica* type of rice, short-partly awned, medium-length of sterile lemma, brown spots on straw lemma-palea, brown apiculus; medium length and medium shape, white grain
15.	05020-08638	Paulut Garu	Indragiri Hilir	*Japonica* type of rice, awnless, medium-length sterile lemma, brown furrows on straw lemma-palea, straw apiculus; medium length and medium shape, white grain
16.	05020-08640	Padi Koran	Indragiri Hilir	*Javanica* type of rice, awnless, medium-length sterile lemma, brown spots on straw lemma-palea, straw apiculus; short length and medium shape, white grain
17.	05020-08641	Pulut Kemenyan	Indragiri Hilir	*Indica* type of rice, short-partly awned, long sterile lemma, brown spots on straw lemma-palea, straw apiculus; long and slender, white grain
18.	05020-08648	Pulut Air	Indragiri Hilir	*Javanica* type of rice, short-partly awned, medium-length of sterile lemma, brown spots on straw lemma-palea, brown apiculus; medium length and medium shape, white grain
19.	05020-08656	Padi Aceh	Indragiri Hilir	*Japonica* type of rice, awnless, medium-length sterile lemma, brown furrows on straw lemma-palea, brown apiculus; short length and medium shape, white grain
20.	05020-08661	Kwatik Undur	Indragiri Hilir	*Javanica* type of rice, awnless, long sterile lemma, brown furrows on straw lemma-palea, brown apiculus; medium length and medium shape, white grain
21.	05020-09709	Randah cupak	Indragiri Hilir	*Javanica* type of rice, awnless, medium-length sterile lemma, brown furrows on straw lemma-palea, brown apiculus; short length and medium shape, white grain
22.	05020-09719	Langkong	Indragiri Hilir	*Indica* type of rice, awnless, medium-length sterile lemma, brown furrows on straw lemma-palea, brown apiculus; medium length and medium shape, white grain
23.	05020-09722	Raden Mas	Indragiri Hilir	*Indica* type of rice, awnless, long sterile lemma; straw lemma-palea, straw apiculus; medium length and medium shape, white grain
24.	05020-09770	Maisuri	Indragiri Hilir	*Indica* type of rice, awnless, medium-length sterile lemma; straw lemma-palea, straw apiculus; medium length and medium shape, white grain
25.	05020-09804	Padi Ranggong	Indragiri Hilir	*Japonica* type of rice, awnless, medium-length sterile lemma, brown spots on straw lemma-palea, brown apiculus; short length and bold shape, white grain

between TGW and seed length, width, and thickness with the r-value of 0.18, 0.04, and 0.25, respectively. This is consistent with the previous finding that grain weight is positively associated with grain size, which is determined by grain length, grain width, and grain thickness (Fang et al. 2016). In addition to other features, the presence of TGW variation in rice collection from this area provided an alternative and option for the development of high-yielding rice varieties.

The Dehulled Rice Grain Characteristics

The rice caryopsis varies in terms of sizes, shapes, and colors. The caryopsis length ranged from 5.02 to 7.06 mm with an average of 6.03 mm, while the width ranged from 2.02 to 2.44 mm with an average of 2.06 mm. The caryopsis length can be classified as long, medium, and short based on its length measurement, with the majority being medium. The caryopsis shape, which is indicated by the ratio of caryopsis length over caryopsis width, can be categorized as a slender, medium, and round. The majority of the rice accessions from Riau Province had a medium length with a medium shape. In terms of caryopsis color, there were three different colors found in the collection: white, light brown, and brown (Figure 1, Table 2).

The grain color is generally associated with its nutritional content. This is probably because of the higher value of the antioxidant component of the bran layer compared to other fractions of rice grain. Because the bran harbors most of the antioxidant compounds, the bran fraction shows higher values of antioxidant activities compared with the other fractions, regardless of the antioxidant activity assay used, which is usually followed by the husk, whole grain, and endosperm. Pigmented rice is claimed to contain a higher phenolic acid content, flavonoid composition, and anthocyanin concentration (Goufo and Trindade 2014). Only 5 of 25 accessions in this research had pigmented grain. The small portion of the pigmented rice reflects consumer and/or farmer preferences. It was reported that pigmented rice tends to have low eating quality/palatability (Mardiah et al. 2017) and high plant vigor (Efendi et al. 2016).

Cluster analysis grouped the rice accessions into five main clusters at a 50% level of similarity. The five groups included two single lines, one major cluster consisted of 14 accessions, and two additional groups of 4 and 5 accessions, respectively (Figure 2). Some accessions in the same cluster had a high similarity. Rumbai and Paulut Garu, Si Opuk and Si Topas, Sempati Telor

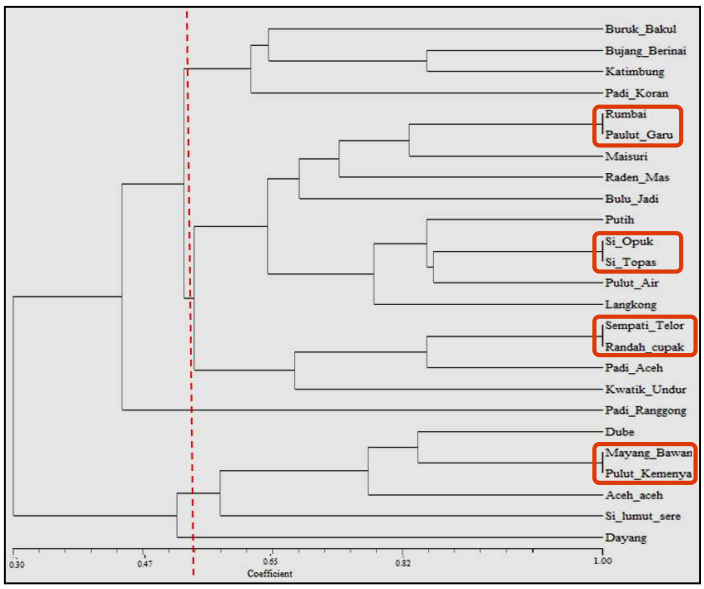

Figure 2. Dendrogram of rice accessions from Riau Province, based on grain characteristic.
Striped line drew in approximately 50% similarity; red-round rectangle drew for two high similarity cluster.

and Randah Cupak, as well as Mayang Bawang and Pulut Kemenyan were the accessions with high similarity. These accessions had similar characters or differ from others only by one character.

There was no group-specific for the particular district when the clusters are correlated to the areas (district) to which they belong. Cluster-1 consisted of four accessions from Indragiri Hilir and Kampar District. Cluster-2, which was the major cluster with 14 members, consisted of accessions from three different regencies. Even in cluster-3, which had just five members, the accessions were representing from four different regencies. Two of three small clusters with the highest similarity consisted of accessions from the different regencies. This revealed the distribution, transfer, and exchange of rice accessions throughout the province.

Implication and Recommendation for Future *Ex Situ* Conservation

In general, there was a diversity of rice from Riau Province. The absence of some specific features in this observation does not imply the absence of accessions with having particular characteristics. The number of accessions that were observed in this study does not represent the Riau Province's rice diversity. In the IAARD-ICABIOGRAD Genebank, only 62 accessions from 5 regencies in Riau are conserved, and only 25 accessions were used in this study. Thus, this collection cannot reflect the entire rice diversity of Riau Province, which is made up of ten districts and two autonomous cities. An on-farm report on the grain diversity from a specific location revealed the existence of rice diversity that has not yet been *ex situ* conserved. This circumstance highlighted the IAARD-ICABIOGRAD Genebank rice collection gap. This sort of gap in genebank collections is globally noticed. The germplasm currently maintained in genebanks does not represent the full range of PGRFA diversity (CGRFA-FAO 2011). In the physical color references developed by the IAARD-ICABIOGRAD Genebank, only six of the eleven color categories were found in the genebank (Hidayatun et al. 2020). To collect the remaining rice diversity that exists on-farm, a targeted collection mission should be organized. Area coverage is one of the factor to consider when planning focused collection missions for *ex situ* conservation (CGRFA-FAO 2011). Apart from bridging the gap of collection, this endeavor is essential for providing better conservation and promoting its utilization.

CONCLUSION

Rice germplasm from Riau Province in the IAARD-ICABIOGRAD Genebank collection varied in terms of grain characteristics, both quantitative and qualitative. This genetic diversity can be utilized to support food security in the province. A targeted collection mission should be planned to collect the remaining rice diversity that exists on-farm to provide better conservation, unravel its potential, and promote its utilization.

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