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GENETIC DIVERSITY OF NORTH SUMATRA UPLAND RED RICE GENOTYPE

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Abstract

Germplasm or genetic resources (GR) is a very important biodiversity and is the basic capital needed in developing the agricultural industry including in creating new varieties for increased production in support of food security and sustainable agriculture. Rice (*Oryza sativ*a L.) or rice is a very important food crop as the main staple food for the people of Indonesia. One type of upland rice in North Sumatra that is widely planted by the community is the upland red rice. The purpose of this study is to obtain information and data; Agronomic, morphological, and molecular characteristics. The research was conducted beginning with exploration activities in several districts in North Sumatra from early 2015 to December 2016 through literature study, interview and direct visit to Farmer field. Collection and storage for consolidation and characterization of upland red rice was conducted in Experimental Garden and Laboratory of Faculty of Agriculture UISU Medan and UNAND Padang. Results obtained; (1) Acquired 19 upland red rice cultivars and most cultivars were found in areas of moderate to high altitude, with flat topography, bumpy to hilly; (2). All upland red rice cultivars have a good diversity from agronomy, harvest age and production (3). Red Sigambiri cultivars are the most widely grown rice based on planting area in several districts (4). Based on grain and seeds local upland red rice, North Sumatra is grouped into 3 groups.

Keywords: Biodiversity, characterization, food security, red rice, sustainable agriculture.

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1. Introduction

Rice (*Oryza sativa* L.) or rice is the main staple food for the people of Indonesia and is an important component in the national food security system (Damardjati, 2006). In addition, rice is also a raw material of various foods, such as flour for cakes, noodles, and baby food (brown rice). Rice also contains proteins, and some minerals, including Fe and Zn. Rice accounts for 60-65% of total energy consumption. The need for rice each year increases with the increase in population. Indonesian rice consumption is 135 / capita / year. Of the 39.7 million ha of mainland Indonesia, an area of 20.5% is planted with rice. In 2013 the area of Indonesia's rice harvest is 13.83 million ha with the products of 5.15 ton/ha and production of 71.28 million tons (Zaini, Benedicto, & Diah, 2014). Rice production increased from 52 million tons in 2000 to about 66 million tons in 2010, or an increase of 2.68% per annum on a 1.24% increase in harvested area and a 1.41% annual increase in productivity. According to Badan Pusat Statistik (2011), Indonesia's rice production decreased 1.08 million tonnes compared to the previous year. The low increase in harvested area shows that increased rice production has been increasingly difficult to cultivate especially in Java, Sumatera and Nusatenggara (as cited in MOA, 2013; Atomos, 2014). In addition, the decline in production is also caused by the occurrence of an increase in the potential yield of existing rice cultivars. This is due to the narrowness of the genetic diversity of rice that exists as a result of the many released rice cultivars that are related to each other. As a result, rice diversity is reduced and the yield potential is no different. This causes the existence of local rice both rice paddy and upland rice, currently more abandoned farmers and threatened extinction (Toha, 2005).

Indonesia is a tropical country with a huge wealth of biodiversity and belongs to the second largest country. The high level of biodiversity of germplasm or genetic resources (GR) is because Indonesia has a vast landscape with the spread and condition of geographic areas that vary (Sujiprihati & Syukur, 2012). Germplasm or GR is one of the most important natural resources and is the basic capital needed to develop the agricultural industry. Genetic Resources management is considered successful if it has been able to provide access to GR as a source of donor genes in breeding programs, and plant breeding is considered to be successful if it has utilized the genetic properties available in GR collections (Sumarno & Zuraida, 2004). Local cultivars are seen as a very valuable asset and need to be well managed. Local rice (landrace) is an GR that has a certain genetic advantage, has been cultivated for generations so that the genotype has adapted well to the various land conditions and specific climate in the area of development. In addition, local rice is naturally resistant to pests and diseases, tolerant to abiotic stress, and has a good quality of rice and generally has a taste and aroma favoured by the community (Siwi & Kartowinoto, 1989; Hayward, Boseman, & Ramagesa, 1993; Sitaresmi, Wening, Rakhmi, Yunani, & Susanto, 2013).

The exploration, collection and conservation of GR has become a global concern, thus forming an international body of the International Plant Genetic Resource Institute (IPGRI) based in Rome, which plays a role in the management of germplasm for a particular commodity Exploration is an activity to find, find, and collect certain SDGs to secure them from extinction. In order for the SDG to be more efficient it is necessary to do more dynamic conservation such as *in situ conservation* and *on-farm conservation*. Swasti, Suliansyah, and Syarif, (2007), has explored 182 local rice in West Sumatra, but more directed to wetland rice (Warman, Suliansyah, Syarif, & Swasti, 2011), in West Sumatra there are still 15 local upland rice cultivars that are still cultivated by the community in dry land/hills. From the local upland rice cultivars

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there is an upland rice that has a black endosperm color (black rice). One type of upland rice in North Sumatra is a lot of community planted upland red rice. Red rice has the advantage of both a sense of taste and function for the body. Red rice is known to be very beneficial to health, as well as staple foods, among others, to prevent food shortages and nutrition and cure diseases. The content of anthocyanin in red rice is believed to prevent various diseases such as cancer, cholesterol, and coronary heart (Fitriani, 2006).

The use of improved varieties is a reliable technology in increasing the production of food crops. This technology is considered safer and more environmentally friendly and cheaper for farmers. Therefore, the effort to obtain superior varieties through breeding research needs to be given attention so that the local genetic quality of rice can be improved. Indonesian plant breeders successfully tested 180-day-old rice with production of 2-3 tons/ha to be 105 days old with 6-8 tons/ha productivity such as local rice Aek Sibundong local varieties of North Sumatra. To support the sustainability of paddy production in the regions and to support the increase of national rice production, varieties are needed that are adaptive to environmental conditions in the country (Hairmansis et al., 2015).

2. Problem Statement

The development of upland rice is an alternative to increasing national rice production and plays an important role in the Indonesian people's agricultural system, as wetland rice expansion becomes more difficult. Potential development of upland rice in North Sumatra is mostly located in the highlands (> 800 m asl). Particularly in North Sumatra, the opportunity for developing upland rice is in addition to traditional land as well as intercropping plants in line with the opening of new land for plantations.

Local cultivars are seen as a very valuable asset and need to be well managed. Local rice (landrace) is an GR that has a certain genetic advantage, has been cultivated for generations so that the genotype has adapted well to the various land conditions and specific climate in the area of development.

3. Research Questions

The specific objectives of the study are as follows:

3.1. Getting, and collecting and consolidating the local red rice in North Sumatra as a first step in conservation.

3.2. Characterization of morphology, especially morphology of red rice from exploration results

3.3. Knowing the genetic kinship of local red rice in North Sumatra

4. Purpose of the Study

The specific purpose of this research is to explore and characterize the various local rice characters of North Sumatra red rice, and then to improve the nature of North Sumatera rice paddy (landrace) of North Sumatra through further breeding activities. Character that will be improved primarily is the age of plants, posture, and production.

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5. Research Methods

The research was conducted in eight districts in North Sumatra Province from early 2015 to December 2016 (continued). The method used by the study of literature, interviews to the relevant agencies, the Department of Agriculture, Ministry of Agriculture, Indonesian Center for Rice Research (BB Penelitian Padi Indonesia), Agricultural Extension (PPL), the Village Head, and Farmer Groups, as well as visits and interviews directly to the fields Farmers in the District which is a regional producer of rice and has the potential the existence of local upland red rice

Research conducted several stages of research activities, namely:

5.1. Exploration and Collection of Upland Red Rice of North Sumatra

Local SDG rice exploration activities are carried out in several regencies in North Sumatra Province. Each of these districts is eligible for exploration activities because it stores the diversity of paddy GR and is preserved for years to come. Prior to the initial exploration conducted preliminary survey, for data collection that contains about the existence of local upland red rice species or even wild relatives in the area. Visits and interviews directly to the fields Farmers in the District which is a regional producer of rice and has the potential the existence of local upland red rice.

Data collection includes name of cultivar, number and origin of collection, based on predefined sampling method. The paddy seeds are then collected and stored in appropriate places and temperatures for the purpose of collecting GR and for characterization purposes

5.2. Characterization of Grain Morphology

Cultivars collected from farmers' fields next, collected and identified (characterization) and stored. A total of 19 cultivars derived planted in the garden trial and the Green house Faculty of Agriculture UISU Medan and UNAND Padang, for evaluation, stabilization, and characterization.

Stages of observation of red rice paddy character is done by observing grain quantitatively and qualitatively. All quantitative data is determined by measuring all grain characteristics in accordance with the rice descriptor. From quantitative data obtained, then processed with Minitab program version 16.14 (Iriawan & Astuti, 2006). Observations consist of quantitative and qualitative observations. Quantitative quantities consisting of grain length, grain width, grain thickness, and grain length as measured by using digital slurry in mm, and weight of 100 grains as measured by analytical scales in grams. While qualitative observations consist of grain color surface color, rice color, and shape of rice. The data of morphological characterization (phenotypic data) is then used for the analysis of diversity and kinship. To analyze kinship, the NTSYS Spc 2.02 (Numerical Taxonomy and Multivariate Analysys Systems) program is used.

6. Findings

6.1. Upland Genetic Resources Data in Location Collection Field Visit

From the exploration result in 11 regencies, there were 22 cultivars of upland red rice, and agronomic data obtained map location (Figure 01) and (Table 01).

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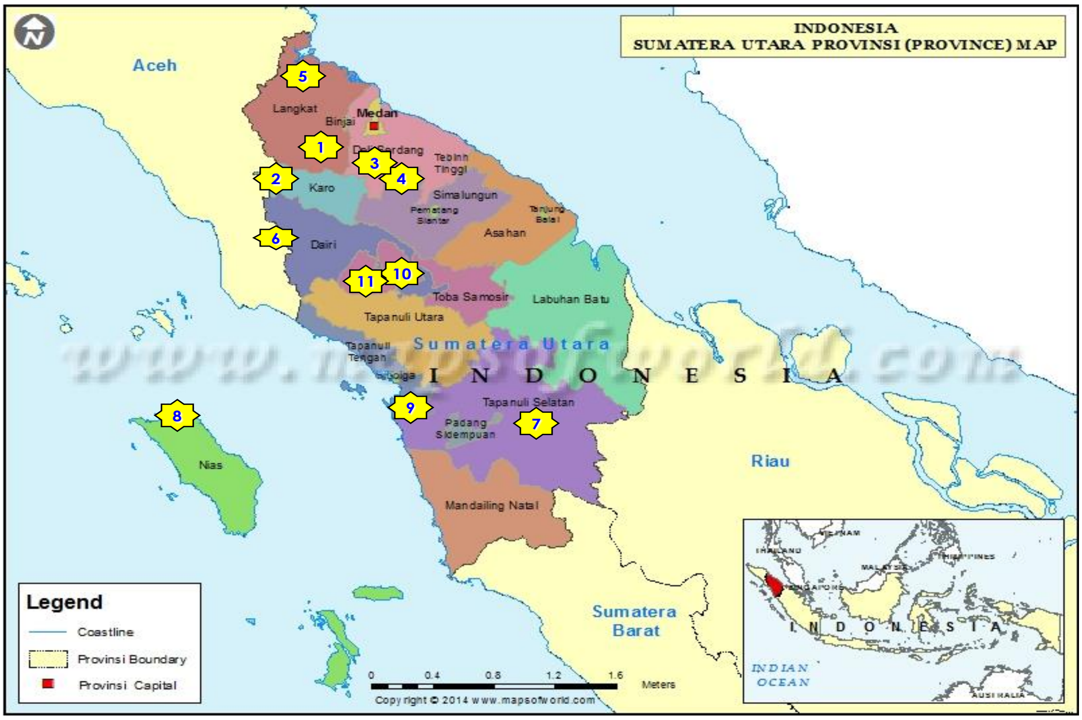

Figure 01. North Sumatra Map (Location of Distribution Upland red Rice

From Figure 01 and Table 01 it can be explained that the exploration results in the 11 visited districts were obtained by 21 local rice cultivars of upland red rice, ie: (1) Deli Serdang: 4 genotipe, (2) Serdang Bedagai: 1 genotipe, (3) Simalungun: 3 genotipe, (4) Tanah Karo: 4 genotipe, (5) Dairi: 1 genotipe, (6) Nias Selatan: 1 genotipe, (7) Tapanuli Selatan: 2 genotipe, (8) Padang Sidempuan: 1 genotipe (9) Samosir: 1 genotipe, (10) Pakpak Bharat: 1 genotipe; and (11) Humbang Hasundutan: 2 genotipe.

Deli Serdang and Tanah Karo districts have the largest number and varieties of upland red rice, followed by Simalungun compared to other districts, especially in the area around medium to high soil, until now still maintained for generations due to local culture. Of the 11 District planting areas are found in different ecosystems with varying heights from medium to high plains with flat topography, bumpy to hilly. The farming or cultivation system is still relatively simple and the planting of upland rice is planted as intercropping plants, intercropping plants in some annual crops such as rubber, palm oil, and coffee. Also found in horticultural plants, such as bananas, and oranges. From this data it can be seen that the cultivation of upland rice is still an odd plant, although the available land is still wide, generally high adaptation and tolerance to pests and diseases. For farmers who do not have wetland or rice field is limited, then on the dry land it has will be cultivated upland rice

In other words, the cultivation of upland rice is more directed to fulfill the interests of household consumption of farmers. Harvest age is long (>145 days), ranging from 145.00 to 180.00 days after seed (DAS), and production is still low to moderate (1.0 - 4.0 ton/ha). All ages of cultivars are categorized in the age of the deep category. This is due to the age of harvest can be affected by the height of the place and climatic conditions. This is because the collection area is done on medium to high which is above 400 mdpl

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Table 01. Upland red rice from exploration in Provincial Districts North Sumatra

No	Local name (Cultivar)	Sub-district	Plant height (cm) /Age Production (day)	Production (ton)	Grouped
1	Gara Geduk	STM Hulu/Deli Serdang	180 / 180	1,0 – 1,5	Indica (Cere)
2	Belacan TM	STM Hulu/Deli Serdang	180 / 170	1,0 – 1,5	Indica (Cere)
3	SiPote	Bintang Bayu/Serdang Bedagai	160 / 165	1,5 – 2,0	Japonica
4	SiPala	Raya/Simalungun	180 / 170	2,0 – 2,5	Indica (Cere)
5	SiGambiri SM	Seribu Dolok/Simalungun	180 /170	2,5 – 3,0	Indica (Cere)
6	Pagai Gara	STM Hulu/Deli Serdang	180 / 170	1,0 – 1,5	Indica (Cere)
7	SiPenuh	Barus Jahe/Tanah Karo	170 / 170	1,5 – 2,0	Indica (Cere)
8	Belacan TB	STM Hulu/Deli Serdang	160 / 170	1,0 – 1,5	Indica (Cere)
9	SiBuah	Raya/Simalungun	180 / 170	2,5 – 3,0	Indica (Cere)
10	Condong	Barus Jahe/Tanah Karo	150 /160	2,0 – 2,5	Indica (Cere)
11	Kabanjahe	Brampu/Dairi	180 / 165	2,5 – 3,0	Indica (Cere)
12	SiKembiri	Dolat Rayat/Tanah Karo	180 / 175	1,5 – 2,0	Indica (Cere)
13	SiLottik	Marancar/Tapanuli Selatan	170 / 160	2,5 – 3,0	Indica (Cere)
14	SiGambiri GB	Munte/Tanah Karo	170 / 165	3,5 – 4.0	Indica (Cere)
15	Ro’e	Sanayama/Nias Selatan	155 / 160	2,0 – 3,0	Japonica
16	SiKariting	Simanindo/Samosir	160 / 165	1,5 – 2,0	Javanica
17	SiGambiri PB	PakpakBharat/Pakpak Bharat	165 / 165	3,5 – 4.0	Indica (Cere)
18	Eme Najaro	Bakti Raja/HumbangHasundutan	155 /160	2,5 – 3,0	Indica (Cere)
19	Eme Si Garang2	Bakti Raja/HumbangHasundutan	155 / 160	1,0 – 1,5	Indica (Cere)
20	SiLabundong	Padang Sidempuan/ P.Sidempuan	160 / 170	2,5 – 3,0	Indica (Cere)
21	Si Babimbing	Sipirok/Tapanuli Selatan	170 / 180	1,5 – 3,0	Indica (Cere)

Source: Farmer information and field visits

Low productivity of lowland rice is mainly caused by environmental stresses, both biotic and abiotic (Hairmansis et al., 2015), and varying climatic and soil conditions, the application of cultivation technology that has not been optimum, especially in the use of improved varieties (VU), fertilization and blast disease control (Toha, 2005). The higher the place is planted, the appearance of harvest age will tend to be longer

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than the plants grown on the lowlands. Farmers tend to choose potentially high yielding cultivars, and moderately to low plant height characters. This is done by farmers to avoid the risk of crop failure due to fall in the rainy season. Low temperatures in the highlands can inhibit the growth of seedlings and saplings, causing leaf discoloration (yellowing leaves), slow down the flowering time, eksersi abnormal panicles, panicle sterility increases, maturation tassel irregular, and the resulting decline). The productivity of upland rice were lower primarily due to climatic and soil conditions vary, cultivation technology is not optimal, especially in the use of high yielding varieties, fertilizing and controlling blast disease (Toha, 2005), also due to various environmental stress both biotic and abiotic (Hairmansis et al., 2015).

In addition, the decline in production is also caused by the sloping increase in the potential yield of existing rice cultivars. This is due to the narrowness of the genetic diversity of rice that is present as a result of many releasing rice cultivars that are related to each other. As a result, rice diversity is reduced and the potential yields are no different. This causes the existence of local rice both rice paddy and upland rice, currently increasingly abandoned farmers and threatened extinction (Toha, 2005). North Sumatra Province has local varieties of upland rice is very popular consumer products. Local varieties are in fact a major provider of rice in upland area of Bukit Barisan, North Sumatra. Although there has been a lot of upland rice varieties released by the Government, but no one has been able to adapt well in the highlands. High yielding varieties that have been released, such as Situ Patenggang, Towuti, Situ Bagendit, Batu Tegi, and Limboto that have relatively high yield potential (> 3.5 ton/ha), but the rate of adaptation is still limited that is only appropriate in the lowlands (< 500 mdpl) (Toha, 2006; Yusuf, 2009). The results of the field visit and interview with (Mr. Amrizal Yusuf, researcher and breeder of BPTP Sumatera Utara) in terms of releasing varieties in 2016, red rice is the most widely planted by farmers in several cities, including Tanah Karo, Simalungun, Dairi and Pakphak Barat.

In general, farmers cultivate local varieties (Sunjaya, 2011) that taste good, tolerant of marginal land, is resistant to some kinds of pests and diseases, requiring low fertilizer inputs as well as easy and simple maintenance. However, it has low production (Ahadiyat, 2011). Then to the development of planting upland rice should consider soil conservation, productivity levels, sense, also resistance to pests and diseases through modeling approaches crop management and resource integrated (ICM) in the area of specific locations, to achieve food security and sustainable agricultural systems (Toha, 2005).

From the results of rejuvenation and observation of morphological character of upland red rice from 11 regencies obtained 14 cultivars of local upland red rice from North Sumatera. Observations both in the field and by conducting initial studies then obtained morphological characters and component results in Figure 02.

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Figure 02. The raising of 14 cultivars of Upland Red Rice North Sumatra

The cultivars that have been collected from the farmers' fields are collected and stored in cold storage, and some are planted for consolidation and rejuvenation by *ex situ* or *in situ*. For rejuvenation of acquired rice cultivars planted in experimental garden of agriculture faculty UISU Medan (as many as 14 cultivars). Furthermore, identification is done. The data taken are morphological character and production component. Data observed is still limited to the initial character include, plant height, number of productive tillers, panicle length, flowering age, 1000 grain, grain shape, and grain color

From the Figure 02 above, there are several variations of 14 cultivars of upland rice in 11 districts grown for further rejuvenation. Characterization of all the important morphological and agronomic properties of GR exploration results is carried out on several morphological characters and agronomic characters (yield component) by IRRI standard. The data collected are Morphological character (phenotypic data) 14 local red rice cultivars of rice, there are variations of each cultivar are as follows: Plant height is high > 125 cm (score 7) ie (135,55 - 160 , 78 cm). Productive tillers classified as little < 10 (score 3) that is (5,78 - 9,78 tillers). Long panicle is medium score (20 - 30 cm) - long (31 - 40 cm) that is 21.7 - 35 cm.

6.2. Character of Grain Morphology by Quantitative Character

From the exploration result in 11 regencies, 21 local rice cultivars of upland red rice from North Sumatra were obtained. Observations both in the field and by conducting initial studies then obtained some characters, both morphological and anatomical characters. Morphological and anatomical characteristics of 19 local upland red rice cultivars. The result of quantitative observation on red rice grain shows the variation between each genotype. Grain and red rice have varying surface and shape colors (Table 02 and Figure 03).

Table 02. The quantitative character of upland red rice grain

	Observation of Grain (G) and Rice (R) (Long (L), Width (W) Thick (T) = mm); Weight = g)						
	L (G)	**W (G)**	**T (G)**	**L (R)**	W	**T (R)**	**Weight 100 (g)**
1	8.66	2.28	1.66	8.64	2.24	1.63	2.72
2	8.75	2.02	1.54	8.73	2.00	1.52	2.42
3	7.05	2.39	1.62	6.72	2.22	1.69	1.69
4	9.00	2.35	1.62	8.99	2.33	1.60	2.10
5	7.96	2.91	1.89	7.91	2.87	1.88	3.34

6	8.71	2.18	1.64	8.67	2.16	1.62	2.42
7	8.09	2.78	1.93	8.03	2.78	1.92	3.23
8	8.85	1.97	1.57	8.86	1.95	1.57	2.43
9	7.21	2.25	1.61	7.19	2.23	1.59	2.27
10	9.14	2.21	**1.53**	9.13	2.19	**1.51**	2.62
11	7.75	2.69	1.77	7.73	2.67	1.74	2.75
12	7.77	2.74	2.02	7.76	2.72	2.00	3.32
13	8.55	**1.85**	1.54	8.53	**1.83**	1.52	2.33
14	7.19	2.85	1.92	7.15	2.85	1.89	2.68
15	**6.72**	2.41	1.68	**6.70**	2.38	1.66	**1.66**
16	9.36	2.23	1.80	9.33	2.21	1.77	2.36
17	7.61	**2.96**	**2.17**	7.58	**2.94**	**2.08**	2.66
18	9.34	2.37	1.75	9.31	2.34	1.73	**3.46**
19	**9.60**	2.26	1.65	**9.57**	2.24	1.62	2.77
Average	**8.28**	**2.40**	**1.73**	**8.24**	**2.38**	**1.71**	**2.59**
Ragam	0.76	0.11	0.03	0.81	0.11	0.03	0.25
SD	0.87	0.33	0.18	0.90	0.33	0.17	0.50
2.SD	1.74	0.65	0.36	1.80	0.66	0.34	1.01
Variability	Narrow	Narrow	Narrow	Narrow	Narrow	Narrow	Narrow

In general, there is a difference in the characteristics of each of the rice genotypes of red rice. The observation of quantitative variables on grain shows that the length of grain ranged from 6.72 - 9.60 mm. The width of grain ranges from 1.85 - 2.96 mm. Grain thickness ranges from 1.53 - 2.17 mm. The weight of 100 grain seeds ranged from 1.66 to 3.46 g.

Based on observations obtained in Table 02, the longest length of red rice grass is Silabundong genotype (9,60 mm), while the shortest is Ro'e genotype (6,72 mm). IRRI and WARDA (2007) divide the length of grain in three classes, ie short (<7.5 mm), medium (7.5-12 mm), and length (> 12 mm). Based on the classification of IRRI and WARDA (2007), we obtained a red short size rice genotype and the remaining medium size. Weight 1000 grains between 20 - 30 g. Based on the observation on qualitative character, the color of the grain surface is generally yellow straw, brownish, dark red, and red black. According to IRRI and WARDA (2007), the color of the grain surface is quite diverse, namely brownish yellow, brownish white, brownish orange, light brown, brownish red, and greenish brown. The colour of the grain surface is quite diverse, namely brownish yellow, brownish white, brownish orange, light brown, brownish red, and greenish brown. Likewise with the color of the seed (caryopsis) there are also variations. Most of the rice is dark red, pink, and blackish red, different rice colors are genetically regulated, due to differences in genes that regulate aleuron color, color of endospermia, and starch composition in endosperm. The shape of rice also shows the variation, namely round, semi-round, and oval. Most of the red rice forms found are oval, followed by semi-spherical, and the smallest is round. Shape of Grain form starts from oval, round, and semi of round, brown grain color (brown), brown spots, and brown furrows. Caryopsis color obtained starting from red, red brown, and dark red. From the color of this seed allows the existence of differences in nutritional and nutritional content in brown rice. To see the color of the seeds of the 19 existing cultivars we can see on the characterization of grain (lemma/palea and seeds (caryopsis).

Based on the clustering of red rice genotypes grouping at 79.79% similarity, the upland red rice genotypes were grouped nto three groups. The first group consisted of 10 genotypes, 1, 2, 8, 6, 13, 10, 16,

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19, 4, and 18. The second group consisted of 3 genotypes, 3, 15, and 9. The third group consisted of 6 genotypes, ie 5, 7, 12, 11, 17 and 14. Dendogram of grouping results based on genotype is shown in Figure 03.

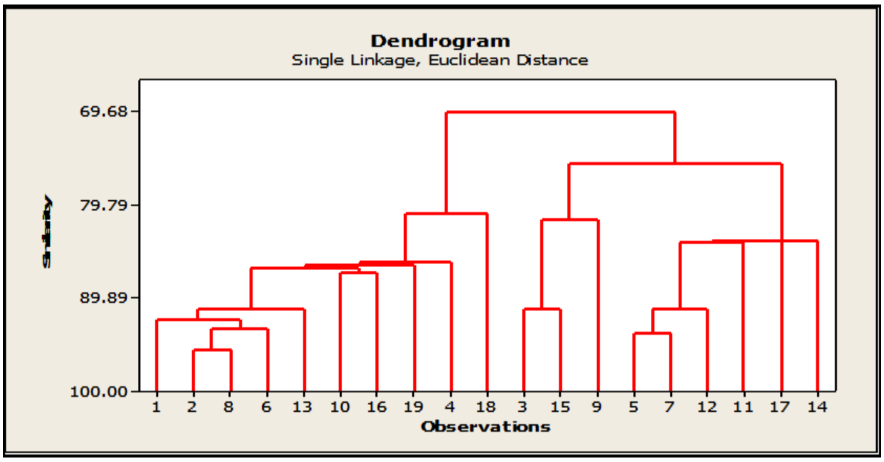

Figure 03. Dendogram grouping based on grain morphology

Figure 03 shows the level of kinship of each upland red rice genotype in North Sumatera Province. The close relationship of kinship can be seen from the percentage of similarity. The size of the percentage of similarity is influenced by the extent or narrowness of diversity (variability). According to generally a high level of variability of morphological characters would complicate the limitation of taxon under the type.

The level of kinship should be known to facilitate breeders in producing new varieties that have a wide or narrow diversity through crosses. To produce varieties with a narrow diversity varieties are used that close kinship level, while to produce a wide level of diversity crossing of varieties that have A distant kinship level. The further the kinship relationship, the recombinant will be more diverse. To determine the proximity of kinship relationships between plant taxon can be done by determining the similarity between plant taxon using morphological properties because morphological properties can be used to recognize and describe kinship of type. In the characterization activities that have been done can be known the character of each cultivar to be used and developed in plant breeding activities in accordance with the purpose of superior varieties who want assembled. Given this variation, further selection activities can be performed because the selection will be successful if the plant population to be selected has variation or diversity.

7. Conclusion

From the results of research on the following conclusions can be taken:

7.1. Germplasm exploration/conservation plays an important role in avoiding the extinction of local/wild rice species due to the rapid growth of modern high yielding varieties, the opening of new land, the transition of rice cultivation to other crops, and the development of settlement.

7.2. Results of exploration in 11 districts obtained 22 local rice genotypes of upland red rice in North Sumatra.

7.3. Grain morphology characterization and molecular analysis results indicate variation on quantitative and qualitative characters. The widest level of diversity is obtained from the long feather characters.

7.4. Based on the morphological character of grain at the similarity level of 79.79%, the genotype of upland red rice of North Sumatra can be grouped into three.

This study suggests the **n**eed to be collaboration between government, farmers, businessmen, and colleges in the application of technology for the development of upland rice, including conservation and collection of local cultivars to the next can produce new varieties in order to support food security and sustainable agriculture, as well as the welfare of farmers.

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