Genetic Improvement of North Sumatra Upland Red Rice through Exploration and Induced Mutations

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Abstract: Genetic resources is very important biodiversity and the basic capital needed in development agricultural industry including new varieties inventionin order to increase productionto support food security and sustainable agriculture. One type of local upland rice in North Sumatra that is widely planted by the community is the type of upland red rice, which adapts well to the area of origin with the taste of rice and aroma according to the tastes of the local communityand health function for the body. Local varieties usually have disadvantages such as inner age, high stems so that it is easy to fall, unresponsive to fertilization and low production.The income of superior varieties to increase production in support of food security and sustainable agriculture needs to be carried out in one exploration activity, and mutation breeding. The study was carried out in two stages; (1) Exploration was carried out in North Sumatra from August 2015 to March 2016 through literature studies, interviews and direct visits to farmers' fields in regencies which are rice-producing areas and have the potential for local upland rice. Of the 22 cultivars collected, the information obtained were environmental conditions, farming systems, farmer characteristics, and cropping conditions,1 local upland rice cultivar (*Sigambiri Merah*) was selected to be improved through mutation breeding (induced mutation). (2). Induced mutations carried out from April 2016 to June 2017 aim to improve genetic *Sigambiri Merah*, especially related to the age of plants to be early matured and dwarf/ semi-dwarf stems. The seeds are irradiated with gamma rays Co-60 at the Center for National Isotopes and Radiation Applications of the Nuclear Energy Agency (PAIR-BATAN), Jakarta. M1 planting was carried out at BPTP North Sumatra. From the observation of the percentage of seedling growth, plant height and root length in the nursery phase, and the percentage of grain blanket in M1 plants obtained irradiation dose 200 - 300 Gy is an effective dose in generating genetic diversity. M1 plant seeds will certainly be very useful as an initial plant material in the improvement of red rice varieties in the future stages of plant breeding programs.

1 INTRODUCTION

Paddy (*Oryzasativa* L.) or rice is the main staple food for the people of Indonesia, and an important component in the national food security system. In addition, rice is also one of raw materials of various foods, such as cakes flour, noodles, and baby food (brown rice). The need for rice each year increases with the increasing of population (Amrizalet al. 2010).The demand for rice each year increases in line with the increasing of population. Indonesian rice consumption is 135 kgs/capita/year. Out of the 39.7 million hectares of Indonesian mainland, 20.5% is planted with rice (Abdurachmanet al, 2008). In 2013, harvested area of Indonesia's rice was 13.83 million hectares resulting the productivity of 5.15 t/ha and total production of 71.28 million tons (Zainiet al,2014).

The lowness increase in harvested area shows that to increase rice production has been more difficult especially in Java, Sumatera and Nusatenggara (MOA, 2013 and Atomos, 2014). In addition, the declination in production is also caused by the occurrence of decreasing in the potential yield of existing rice cultivars. This is due to the narrowness of the genetic diversity of existing rice caused by many released rice cultivars that are related one to each other. As a result, rice diversity

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is reduced and the yield potential is no different. This facts endanger the existence of local rice both wetland and upland rice cultivars, which currently more abandoned by farmers and threatened in extinction (Toha, 2005).

Indonesia is a tropical country with a huge potential and belongs to the second largest country on biodiversity. The high level of biodiversity of germ-plasma or genetic resources (GR) is because Indonesia has a vast landscape with the spread and condition of geographic areas that vary (Sujiprihati and Syukur, 2012). A genetic resource 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 and Zuraida, 2004). Local cultivars are seen as a very valuable asset and need to be well managed. Local rice (landrace) is a 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 people (Siwi and Kartowinoto, 1989; Hayward et al.1993 and Sitaresmiet al.2013).

The exploration, collection and conservation of GR has become a global concern, by forming an international body of the International Plant Genetic Resource Institute (IPGRI) based in Rome, which plays a role in the management of germ-plasma for some particular commodities (Poespodarsono, 1988).

Exploration is an activity to seek, find, and collect certain GR to secure them from extinction. In order for the GR to be more efficiently secured it is necessary to conduct more dynamic conservation such as in situ conservation or on-farm conservation (Swastiet al.2007), has explored 182 local rice inWest Sumatra, but more directed to wetland rice (Warmanet al.2011). In West Sumatra there are still 15 local upland rice cultivars that are still cultivated by the farmer in dry land/hills. From the local upland rice cultivars there is an upland rice that has black endosperm colour (black rice).

One type of upland rice in North Sumatra, which is widely planted by farmers, is red upland rice. Red (brown) rice has the advantage of both itstenderness and benefit for the human body. Red rice is known to be very beneficial to health, as well as staple foods, among others, to prevent food and nutrition shortages and cure diseases. The content of anthocyanin in brown rice is believed to prevent various diseases such as cancer, cholesterol, and coronary heart (Fitriani, 2006).

The utilization 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, attention to the effort obtaining superior varieties through breeding research needs to be given so that genetic quality of the local rice can be improved. Indonesian plant breeders successfully bred 180-day-old rice with productivity of 2-3 tons /ha to 105 days old with 6-8 tons / ha productivity such as *AekSibundong* a local rice varieties of North Sumatra (Irianto, 2008). To support the sustainability of paddy production in the regions and the increasing of national rice production, varieties that are adaptive to environmental conditions in the country are needed (Hairmansis et al.2015). Therefore, breeding efforts are needed to increase the age of the plant to obtain higher production intensity.

Basically, plant breeding is to choose the character of the plant in accordance with the breeder's purpose. Choosing or selecting plants will be more flexible if there is extensive genetic diversity in the population. To expand genetic diversity can be done by several methods, including through induction mutations, which are effective ways to enrich GR, as well as to improve cultivars, by changing the genetic makeup of plants using mutagen. The aim is to obtain new properties that are superior to the parent variety. Mutation breeding is considered to be better for the improvement of only a few properties by not changing most of the properties of the original plants that have been favoured and relatively requiring a shorter time in the purification process (Amano, 2006 and Ismachin, 2007).

The specific purpose of this research is to explore and characterize the various local rice characters of North Sumatra red rice, and followed by characters improvement of North Sumatra upland red rice through further breeding activities. Characters that will be improved primarily are the age of plants, posture, and production. While the specific objectives of the study are as follows:

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

2. Characterization of morphology, especially morphology of rice grain of red rice from exploration results
3. Producing plant material for the improvement of local red rice cultivars.

2 METHODOLOGY

2.1 Research Design

The research was conducted in eight districts in North Sumatra Province from January 2015 until December 2016. The method included the study of literature, interviews to the relevant agencies, the Department of Agriculture, Ministry of Agriculture, Indonesian Center for Rice Research Agricultural Extension (PPL), the Village Head, and Farmer Groups, as well as visits and interviews directly to the Farmers fields in the District which are regional producer of rice and have the potential existence of local upland red rice. The research was conducted on several stages of research activities, namely: 1) exploration and rice collection of red rice in North Sumatra and 2) characterization of morphology of upland red rice in North Sumatera results of exploration activities.

Data collected in this study were primary and secondary data. Primary data collected directly through interviews with respondents using a questionnaire to determine the existence and identify the red rice geographic, agricultural systems, farmers' character, agronomic characters, morphology, and production covenant, plant height, date of harvest, production per hectare, 1000 grain weight, grain shape, and color of grain. Secondary data related to this study were obtained through the agencies associated with this research. From the data obtained, one of the best cultivars was selected based on existing data criteria for research on genetic improvement of North Sumatra's local upland red rice through induced mutations.

2.2 Exploration and Collection of Upland Red Rice of North Sumatra

Local GR rice exploration activities were carried out in several regencies in North Sumatra Province. Each of these districts was eligible for exploration activities because it stores the diversity of paddy GRwhich was preserved for years to come. Prior to the initial exploration preliminary survey was conducted, for data collection that contains about the existence of local upland rice species or even wild relatives in the area.Visited and interviewed directly to the fields Farmers in the District which were regional producers of rice and had the potential of the existence of local upland red rice. Data collection included name of cultivar, number and origin of collection, based on predefined sampling method. The collected cultivars are collected and stored in cold storage.

2.3 Characterization of Grain Morphology

Cultivars collected from farmers' fields, then identified (characterization) and stored. A total of 22 cultivars, 21 cultivars were planted in the experimental fieldand the green house of Faculty of Agriculture UISU Medan and Andalas University Padang, for evaluation, stabilization, and characterization. Stages of observation of red rice character were done by observing grain quantitatively and qualitatively. All quantitative data was determined by measuring all grain characteristics in accordance with the rice descriptor issued by IRRI and WARDA, 2007). Fromquantitative data obtained, the processed with Minitab program version 16.14 was considered (Iriawan and Astuti, 2006).

Observations consisted of quantitative and qualitative observation. 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 consisted of grain colour surface colour, rice colour, and shape of rice. The data of morphological characterization (phenotypic data) were then used for the analysis of diversity and kinship.

2.4 Induced Mutations

This research was carried out in greenhouses and experimental gardens of BPTP North Sumatra since April 2016 to June 2017. The plant material used was upland rice cultivars *SigambiriMerah*which is one of the local rice cultivars of North Sumatra. The seeds were irradiated with 0 Gy (control), 100, 200, 300, 400, 500, 600, 700, 800, 900, and 1000 Gy of 250 g per dose. Seed irradiation was carried out at the Centre for Isotope and Radiation Applications, National Nuclear Energy Agency (PAIR-BATAN), *PasarJumat*, Jakarta with a radiation source γ used by Iradiator Gamma Cell Co-60.

2.4.1 Dosage Orientation

After the rice seeds were irradiated, each irradiation dose of 100 seeds/ seedbed. It was observed for three weeks to see the pattern of growth. The parameters observed in this study are the percentage of living seeds, seed height and root length. Lethal Dose 50 (LD50) was obtained from the percentage of germination, seedling height and root length data. Data were analyzed further using DMRT.

Irradiation dose orientation activity is continued by observing the level of sterility in M1 plants, to get the seeds to be used as material for M2 population. In this activity, 300 seedlings / plot (4x5 m) of each irradiated dose were planted in the field (rice field). Planting M1 of each irradiation dose (parent plant (control), 100, 200, 300, 400, and 500 Gy) was carried out with a spacing of 25 x 25 with 1 stem per planting hole. Each dose was planted as many as 12 plots (4 plots/replications). Observations were made on the level of grain sterility, namely the percentage of empty grains per panicle. Harvesting is done by taking 3 main panicles from each plant to be used as M2 lines.Research was using non-factorial RBD with 3 replications.

3 RESULT AND DISCUSSIONS

3.1 Upland Red Rice Data Collected

From the exploration result that in the 11 visited districts were obtained 22 local rice cultivars of upland red rice, and agronomic data obtained (Appendix).TanahKaro and Deli Serdang districts had the largest number and varieties of upland red rice, followed by Simalungun compared to other districts, especially in the area around medium to high altitude, where until now upland red rice cultivation still maintained for generations due to local culture. These 11 District (1) Deli Serdang; (2) Tanah Karo; (3) SerdangBedagai; (4) Simalungun; (5) Dairi; (6) Pakpak Bharat; (7) Samosir; (8) HumbangHasundutan; (9) Nias Selatan; (10) Tapanuli Selatan; and (11 Padang Sidempuan, planting areas were situated in different ecosystems with varying altitudes from medium to high plains with flat, uneven to hilly topography.From the literature data obtained local varieties (accessions) both in BB Padi and BB Biogen that the collection of rice plants in general in North Sumatra including upland rice as much as 175, while the collection of rice crops in general in Indonesia including 750 (BB Biogen) gogo rice; 29 varieties of upland rice, and there are 1729 local rice including 37 from North Sumatra, but not yet explored more related to location or area (village name), lowland, medium or high land location, and type of wetland rice , rain-fed, or *gogo*.For that still needed exploration activities of local rice cultivars in and subsequently carried out conservation activities and collection of local varieties.Meanwhile, the potential for development of upland rice in North Sumatra is mostly located in the highlands (> 700 m asl).

In 2011, based on the temporary figures (Asem), the area of upland rice harvest has reached 52,401 hectares with the production amount of 161,279 tons. Of this area, 77% (40,419 ha) are in the highlands and spread in Simalungun regency (14,708 ha), Dairi(9,056 ha), Tanah Karo (8,793 ha), North Tapanuli (3,744 ha), Pakpak Bharat (3,465 ha), Humbanghasundutan (529 ha), and Toba Samosir area of 124 ha (Sumatra In Numbers, 2011), while in the lowlands, farmers no longer plant upland rice as many turn to other more profitable commodities such as oil palm. The farming or cultivation system was still relatively simple and upland rice wasplanted as intercropping plants with some annual crops such as rubber, palm oil, and coffee. It's also intercropped with horticultural plants, such as bananas, and oranges. Then the planting sites were always altered depend on the condition of the land or could be said as shifting cultivation.

From this data it can be seen that the cultivation of upland rice was still an unimportant crop, although it generally proven to have high adaptation and tolerance to pests and diseases while the land was still available. This was because the field priority of farmers to plant rice, which they would choose irrigated rice fields first, followed by rainfed lowland, and the last option was dry land for upland rice cultivation.

For farmers who did not have wetland or where rice field was limited, then dry land was choosen to cultivate upland rice. In the other words, the cultivation of upland rice was more directed by the interests to fulfil farmer's household consumption. Harvest age was long (>145 days), ranging from 150.00 to 180.00 days after seed (DAS), and production was still low to moderate (1.0 - 3.5 t/ha). All of harvest ages of cultivars could be categorized in the age of the deep category. The higher the place was planted; the appearance of harvest age would tend to be longer than the plants grown on the lowlands. Farmers tent to choose high potentially yielding cultivars, and moderate to low plant height characters. This was done by farmers to avoid the risk of crop failure due to lodging in the rainy season.

The productivity of upland rice were lower primarily due to climatic and soil conditions varations, unoptimal cultivation technology, especially in the use of high yielding varieties, fertilizing and controlling blast disease (Toha, 2005;Hairmansis et al. 2015). In addition, the decline in production was also caused by the sloping increase in the potential yield of existing rice cultivars. This was due to the narrowness of the genetic diversity of existing rice cultivars as a result of releasing many rice cultivars that were related one to each other. This caused the existence of local rice both wetland and upland rice, currently increasingly abandoned farmers and threatened extinction (Toha, 2005).

North Sumatra Province had local varieties of upland rice which was very popular as consumer products. Local varieties were in fact a major provider of rice in upland area of Bukit Barisan, North Sumatra. Although there had been a lot of upland rice varieties released by the Government, but no one had been able to adapt well in the highlands. High yielding varieties that had been released, such as Situ Patenggang, Towuti, Situ Bagendit, BatuTegi, and Limboto that had relatively high yield potential (> 3.5 t/ha), but the level of adaptation was still limited appropriate only in the lowlands (< 500 mdpl) (Toha, 2006 and Yusuf, 2009).

Then, the development of upland rice planting should consider soil conservation, productivity levels, taste, also the resistance to pests and diseases through modelling approaches of integrated crop management and resource (ICM) in the area of specific locations, to achieve food security and sustainable agricultural systems (Toha, 2005).

Base on morphological character (phenotypic data) of 22 local red rice cultivars, there were variations of each cultivar as follows: Plant height was high > 125 cm (score 7) (Figure 1). Productive tillers was classified as little < 10 (score 3) ranging from 5,78 - 9,78 tillers. Long panicle was medium with score 20 - 30 cm to long (31 - 40 cm) ranging from 21.7 - 35 cm.

3.2 Character of Grain Morphology

From the exploration result in 11 regencies, 22 local rice cultivars of upland red rice from North Sumatra were obtained. Grain morphological (lemma/palea and seeds (caryopsis) characteristics of 19 local upland red rice cultivars are presented in Figures 1.

Figure1: Grain and rice husked rice from the North Sumatra red rice.

Based on the observations obtained, the longest length of red rice grains are genotypes BM 01 and BM 06, while the shortest is genotype BM 15. IRRI and WARDA (2007) divide the length of grain in three classes, ie short (<7.5 mm), medium (7.5-12 mm), and long (> 12 mm). Based on the classification of IRRI and WARDA (2007), we obtained short, medium and long red rice genotypes.

The result of qualitative observation on red rice grain showed the variation between each genotype. Grain of red rice both non-hulled and hulled had varying surface and shape colours (Figure 1). Based on the observation on the qualitative character, the colour of the grain surface was generally collared yellow straw, brownish, and brownish red.

According to IRRI and WARDA, 2007), the colours of the grain surface were quite diverse, ie brownish yellow, brownish white, brownish orange, light brown, brownish red, and greenish brown. Similarly, there are also variations on the colour of the seed (caryopsis), namely red, pink, blackish-red rice. Different rice colours were genetically regulated, due to differences in genes that regulate aleuroniccolour, endosperm colour, and starch composition in endosperm.The shape of rice also showed variations, which were round, semi-round, and oval. Most of the red rice form found to be oval followed by a semi-spherical shape and the smallest was round.According to Putra, the colours of the grain surface were quite diverse, namely brownish yellow, brownish white, brownish orange, light brown, brownish red, and greenish brown (Putra et al. 2010). Likewise there were also variations considering the colours of the seed (caryopsis). Most of the hulled grains were dark red, pink, and blackish red. According to Indrasari, different hulled grains colours were genetically regulated due to differences in genes that regulate aleuroniccolour,

colour of endosperm, and starch composition in endosperm (Indrasari, 2006).

3.3 Induced Mutations

3.3.1 Dosage Orientation

At M1 the irradiation effect can be seen in germination percentage, growth rate and sterility percentage. The results of γ ray irradiation at a dose of 0 to 1000 Gy affect the germination percentage and seedling growth. The response of the gamma ray irradiation treatment at various doses to the germination and growth of seedlings at the M1 stage at age 21 DAS can be seen in Table 1 and Figure 2.

Table 1: Germination response and growth of upland red rice seedlings at various stages of γ irradiation dose at stage M1 age 21 DAS and Percentage of Sterilityat >70 DAP.

Dose Irradiation (Gy)	Percentage of Growth (%)	Plant of Height (cm)	Length of Root (cm)	Percentage of Sterility (%)
0	99.33 a	35.1 a	12.67 a	7.49 a
100	96.67 ab	32.9 b	12.00 a	9.25 b
200	92.00 ab	32.6 b	10.67 b	9.95 c
300	89.33 ab	32.3 b	9.63 b	15.08 d
400	84.00 ab	27.2 c	7.33 c	17.65 e
500	82.00 b	26.4 c	6.67 c	20.12 f
600	40.00 c	12.9 d	5.33 d	-
700	32.00 c	6.4 e	3.57 e	-
800	0.00 d	0.0 f	0 f	-
900	0.00 d	0.0f	0 f	-
1000	0.00 d	0.0f	0 f	-
KK (%)	4.56	11.08	7.02	

Remarks: The numbers in the same column followed by the same lowercase letters are significantly different at the 0.05% level according to DMRT.

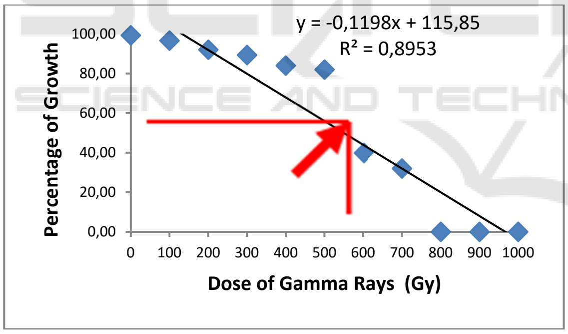

Figure 2: Curve of γ ray irradiation treatment at various doses towards germination and growth of red rice upland rice seedlings at M1 stage at age 21 DAS; (The Red Arrow indicates the LD50 value).

In Table 1 and Figure 2, it is known that the response of seed growth and germination is very diverse. The dose of 0 Gy shows a different response to the percentage of seed germination irradiated. However, with increasing irradiation doses it gives a very real response to the reduction in the percentage of seed germination and seedling growth. Even the irradiation dose > 500 Gy only produces a percentage of growth below 50%, while the doses of 800, 900, and 1000 Gy are die. Death of plants after irradiation can occur due to deterministic effects due to gamma ray irradiation. Deterministic effects are effects caused by cell death due to radiation exposure (physical mutations) (Poehlman and Sleper, 1995). The deterministic effect arises when the dose received by the plant is above the threshold dose and generally arises shortly after irradiation (Ismachin, 2007). The severity of the deterministic effect will increase if the dose received is greater than the threshold dose. The lower the threshold dose is closely related to the radio sensitivity of plant genotypes. Radio sensitivity is the level of plant sensitivity to radiation (Harten, 1998and Data, 2001). Radio sensitivity levels between genotypes and plant conditions when irradiated vary widely.

The sensitivity to radiation can be measured based on the lethal dose 50 (LD50), which is the dose that causes the death of 50% of the population of irradiated plants. The LD50 value in this study is high (range 530 Gy). This may be due to the water content contained in the seed before irradiating. Seed moisture content in the storage stage before being irradiated is 12-14%. According to Ahnstrom, Harten, Herisonet aland Shu et al,the high and low LD50 values are strongly influenced by the water and oxygen content of the seeds. At the height of the seedlings and the length of the roots it is also seen that the higher the dose of irradiation also affects the growth response(Ahnstrom, 1977;Harten, 1998; Herisonet al. 2008 andShu et al. 2012).The growth response of seed height and root length decreases due to the increasing dose of irradiation. This is in line with the opinion of Ismachin,which explains that certain mutagen treatments in serealea have a correlation with high M1 sprouts, M1 germination power and mutation frequency(Ismachin, 2007).

In observing the percentage of void grain per panicle (sterility) it was observed at various doses (0 - 500 Gy) at >70 DAPthat the higher the irradiation dose treatment caused the increase in the percentage of void grain per panicle. Sterility percentage treatment of 0 Gy (7.49%) to 500 Gy (20.12%) irradiation doses gave a significant effect on seed void percentage per panicle, while between doses of 100 Gy (9.25%) and 200 Gy (9.95%) did not have a significant effect(Table 1).

However, the treatment of irradiation doses above 300 Gy caused the percentage of void to increase significantly (> 15%). The response was curve for the percentage of seed void per panicle on M1. As well as the effect of plant radio sensitivity on irradiation doses, the high percentage of seedlessness per panicle is also an indicator of physical damage due to deterministic effects of irradiation treatment.When M1 was planted in the field, it was seen that the plant growth pattern was normal and there was no significant difference between the dose of irradiation with one another. However, irradiation affects the emptiness of seeds in panicles. The percentage of avoid of seeds will increase along with the increase in irradiation doses. One thing that is highly expected in an induction mutation is the smallest physiological damage and the maximum frequency of mutations. This is a very useful factor in generating genetic variability.High radiation dose will increase the sterility of the M1 plant panicle. One thing that is really expected in an induction mutation is the smallest physiological damage and genetic damage. This is a very valuable factor in producing high genetic variability. For the purpose of induction of genetic diversity, it is desirable to induce mutations that cause at least chromosomal aberration, physical damage and sterility, and at the same time be controlled to produce the desired mutation(Datta, 2001). This study is very useful in providing information especially in inducing genetic diversity. Other reports also show that the dose range of 200-300 is an irradiation dose that is quite effective in producing genetic diversity in rice plants such as the Zhong-Hua-11 variety irradiated with gamma rays at a dose of 300-350 Gy (Zhu et al. 2006), a dose of 200 Gy in Hitomebore variety (Kawaguchi, 2006), and dosage of 200 Gy in Kuriakkusuik and RandahPutiahvarieties (Sobrizal, 2007).

4 CONCLUSION

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

1. Results of exploration in 11 districts obtained 22 local rice genotypes of upland red rice in North Sumatra. Meanwhile, the potential development of upland rice in North Sumatra is mostly located in the highlands.
2. Grain morphology characterization results indicated the variations on quantitative and qualitative characters. The widest level of diversity was obtained from the long feather characters. Correlation analysis results showed the correlation between some variables of morphology of grain and caryopsis.
3. The dose range of 200-300 Gy is an irradiation dose that is quite effective in producing genetic diversity in rice plants. The efforts of genetic improvement of upland red rice are currently being implemented for SigambiriMerah varieties through induce mutations.

REFERENCES

Abdurachman A, Dariah A, Mulyani A., 2008. Strategy and technology of dry land management to support national food production, *Journal Research on Agricultural Development* Vo; 27, No7.

Ahnstrom, G., 1977. “Radiobiology,” *In Manual on Mutation Breeding*, 2nd Ed., IAEA, Vienna, 21-27.

Amano, E., 2006. “Used of induced mutants in rice breeding in Japan,” *Plant Mutation Report,***I**(21).

Atomos. 2014. Rice of Superior Variety, Combination Result of Radiation and Cutting Mutation Techniques Atomos, Information Media of Nuclear Science and Technology, Isotop and Radiation Application Center (IRAC) BATAN Jakarta.

Cheema, A.A., and B.M. Atta., 2003. Radiosensitivity studies in Basmati Rice. Pak. *J. Bot.,* 35(2): 197-207.

Daradjat, A.A., Silitonga, S., and Nafisah., 2008. Availability of Germplasm for Improvement of Rice Varieties, Indonesian Centre for Rice Research.

Datta, SK., 2001. “Mutation studies on garden chrysanthemum: A review,” *Sci. Hort*. 7:159-199.

Fitriani, V., 2006, Red rice is not full but healthy, http://www.Trubus.co.id. [2 March 2016].

Hairmansis, A., Supartopo,Yullianda, Sunaryo, Warsono, Sukirman, and Suwarno., 2015. Utilization of rice germplasm (*Oryzasativa*) for improved upland rice properties‖, Proceedings of Indonesian Biodiversity Society Conference. Volume 1, No 1, March 2015 Page:14-18.

Harten, A.M.Van., 1998. "Mutation breeding; Theory and practical application," *Cambridge University Press*.

Hayward. M. D, N. O. Boseman and Ramagesa., 1993. Plant Breeding Prospect, Chapman and Hall. 55 pp.

Herison, C., Rustikawati, Sujono H. S., Syarifah I. A., 2008. "I Induction of mutations through gamma rays against seeds to increase the diversity of corn base populations (*Zea mays* L.)," *AktaAgrosia,***11** (1), 57-62.

IAARD. 2008. Integrated Crop Management for Upland Rice. IAARD, Jakarta.

Indonesian Centre for Rice Research. 2015.Germplasm, Information. Indonesian Agency for Agricultural Research and Development. Sukamandi.

Indrasari, S.D., 2006. Rice of AekSibundong; Functional Food, News Research and Development of Agriculture Vol; 28.No.6, 1-3.

Iriawan, N dan S. P. Astuti., 2006. Processing Statistics Using Easy Data Minitab 14. Andi.Yogyakarta,.

IRRI and WARDA., 2007. Descriptors for wild and cultivated rice (*Oryza*spp.). Bioversity International, Rome, Italy; International Rice Research Institute, Los Banos,Philippines; WARDA, Africa Rice Center, Cotonou, Benin.

Ismachin, M.,2007. ""Development of mutation breeding in Indonesia," Mutation Breeding Training. BATAN, Jakarta.

Kawaguchi, H., Morishita, T., Degi, K., Tanaka, A., Shikazono, N., and Hase, Y., 2006. "Effect of carbon-ion beams irradiation on mutation induction in rice," *Plant Mutation Reports,* 1 (1).

MOA (Ministry of Agriculture). 2013. Agricultural Statistics 2013.Center for Agricultural Data and Information System Ministry of Agriculture Republic of Indonesia, Jakarta.

Poehlman. J. M. and D. A. Sleper., 1995. "Breeding Field Crop," Lowa State University.*PressAmes.*Lowa,.

Shu, QY., Forster B.P., Nakahawa H., 2012. "Plant Mutation Breeding and Biotechnology," *CAB International dan FAO*. Wallingford. United Kingdom. 608 hal.

Sitaresmi, T., R.H. Wening, A.T. Rakhmi, N. Yunani, and U. Susanto., 2013. Utilization of local rice plant in the assembling of superior varieties‖, *Journal of Food Crop Sci. and Tech.* Vol. 8 No. 1.

Siwi, B.H., and S. Kartowinoto., 1989. Genetic Resources of Rice.*In Rice Book 2*, Center for Food Crops Research and Development. Bogor.

Sobrizal., 2007. "Selection of early maturing mutant in M2 population of KuriakKusuik and RandahTinggiPutiah variety rice plants, "*J. Agrotropika*, 1.

Sujiprihati, S., and Syukur, M., 2012. Conservation of Plant germplasm In Revolutionizing the Green Revolution, Great Teacher Thoughts IPB: 528 – 536.

Sumarno, Zuraida, N., 2004. Integrated Germplasm Management with Seed Breeding and Industry Program, Proceedings Simposium PERIPI, 5 – 7 August 2004.

Swasti, E., I. Suliansyah and A.A. Syarif. 2007. Exploration, identification and consolidation collection of the rice plasmanutfah from West Sumatra. Andalas University Research Institute of Padang.

Toha, M.H., 2005. Upland Rice and its Development Pattern, Indonesian Agency for Agricultural Research and Development, Agriculture Department, Jakarta.

Toha, H.M., 2006.Upland rice productivity as intercropping plantation of young teak forest, National Seminar on Agricultural Technology Innovation Society as the National Food Security Endeavorl, BPTP NTB – BBPP Agricultural Technology, Mataram.

Warman, B., I. Suliansyah., A.A. Syarif., and E. Swasti., 2011. Exploration, characterization of local rice of West Sumatra. *Prosiding Seminar Nasional BKS PTN.* UNSRI, Palembang.

Yusuf, A., 2009.Assessment of four upland rice varieties as intercropping of plantation crops, Rice technology innovation anticipates global climate change supports food security/ Research Center for Food Crops Development, Agency for Agricultural Development, Ministry of Agriculture. Page: 1269-1279.

Zaini, Z., Benedicto, R., and Diah, W., 2014. Planting Rice Growing Partnership, 40 Years of Cooperation Indonesia-IRRI, Research Center for Food Crops Development, Agency for Agricultural Development, Ministry of Agriculture.

Zhu, X.D., Chen, H.Q., and J.X. Shan., 2006. "Nuclear techniques for rice improvement and mutant induction in China National Rice Research Intitute," *Plant Mutation Report* 1.

APPENDIX

Upland Red rice from exploration in Provincial of North Sumatra Districts

Genotipe Code/ LocalName (Accession) / Class	**Sub District/ District**	**Plant height (cm) / AgeProduction (day)**	**High area (m-asl)**
(BM01)GaraGeduk/Indica (Cere)	STM Hulu/ Deli Serdang	180 /180	500-1000
(BM02) BelacanTM/Indica(Cere)	STM Hulu/ Deli Serdang	180/170	500-1000
(BM03) SiPote/ Japonica	Bintang Bayu/ Serdang Bedagai	160/165	500-1000
(BM04) SiPala/ Indica (Cere)	Raya/ Simalungun	180/170	500-1000
(BM05)SiGambiriSM/ Indica	SeribDolok/ Simalungun	180/170	750-1300

(Cere)			
(BM06) PagaiGara/ Indica (Cere)	STM Hulu/ Deli Serdang	180/170	500-1000
(BM07) SiPenuh/ Indica (Cere)	BarusJahe/ Tanah Karo	170/170	750-1000
(BM08) Belacan TB/ Indica (Cere)	STM Hulu/ Deli Serdang	160/170	500-1000
(BM09) SiBuah/ Indica (Cere)	Raya/ Simalungun	180/170	500-1000
(BM10)Condong / Indica (Cere)	BarusJahe/ Tanah Karo	150/160	750-1000
(BM11) Kabanjahe/ Indica (Cere)	Brampu/Dairi	180/165	750-1200
(BM12) SiKembiri/ Indica (Cere)	DolatRayat/ Tanah Karo	180/175	750-1000
(BM13) SiLottik/ Indica (Cere)	Marancar/ Tapanuli Selatan	170/160	750-1300
(BM14) SiGambiri GB/ Indica (Cere)	Munte/ Tanah Karo	170/165	750-1500
(BM15) Ro'e/ Japonica	Sanayama/ Nias Selatan	155/160	500-1000
(BM16) SiKariting/ Javanica	Simanindo/ Samosir	160/165	750-1000
(BM17)SiGambiri PB/ Indica (Cere)	PakpakBharat/ Pakpak Bharat	165/165	750-1000
(BM18) EmeNajaro/ Indica (Cere)	Bakti Raja/ Hum. Hasundutan	155 /160	750-1000
(BM19) Eme Si Garang2/Indica (Cere)	Bakti Raja/ Hum. Hasundutan	155 /160	750-1000
(BM20)SiLabundong/ Indica (Cere)	P. Sidempuan/ P. Sidempuan	160 / 170	750-1200
(BM21) Si Babimbing/ Indica (Cere)	Sipirok/ Tapanuli Selatan	160 / 170	750–1200
(BM22) Sirata / Indica (Cere)	Kutalimbaru/ Deli Serdang	130 / 140	500-1000

Source: Farmer's information and field visits and observation in the field