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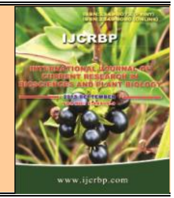

Original Research Article

Short Mutant Characters and Early Maturing of M2 Generation of Local Rice Ase Lapang upon Gamma Radiation

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Abstract

A research on the mutant character of the local rice for M2 generation of local rice, Ase Lapang upon gamma ray radiation has been done with dose 0 Gray, 200 Gray and 300 gray of local rice germplasm in Pangkep, South Sulawesi, Indonesia. It aims to determine the morphological characteristics and agronomic mutants, early maturity and short growth in local rice Ase as a result of gamma radiation. This study used a simple randomized block design (RBD). The results showed that the morphological characters with gamma radiation dose of 300 Gray showed that the average plant height of 135.31 cm (shortest) and the least number of productive tillers of 13.63. Likewise, for agronomic observations the radiation dose of 300 Gray showed that the age of flowering (81.37 days) and harvesting (120 days) were fastest. The benefit of this research was to obtain mutants with early maturing short variety that can be maintained continuously.

Keywords

Ase Lapang local rice
Early maturing
Gamma rays
Mutants

Introduction

Prediction of National rice production in 2013 to 2014 would decrease, but the government is still sure not to import rice in Indonesia. It is due to the national rice production which is still surplus. The Central Statistics Agency (BPS) predicted that the production will reach 69.87 million tons of milled rice (GKG) in 2014 which is down by 1.41 million tonnes or 1.98% compared to 2013. Based on the data, the agriculture ministry calculated that 40 million tons of rice can be produced from 69.87 million tons of GKG is able to produce 40 million tons of rice. It is an amount that exceeds the total national rice requirement of 34.4 million tonnes. The assumption is that the population of Indonesia (247 million people) with 139 kg of rice consumption per capita, there is still a surplus of 5 million tonnes (BPS, 2014).

Reduced biodiversity in Indonesia provide inspiration to secure biodiversity. Biological security efforts should have the support of all parties. Steps that can be done is by implementing biotechnological methods to rescue biodiversity in an area that could potentially be lost or extinct (Zunariah, 2012). As well as local varieties of germplasm of Ase Lapang in Pangkep South Sulawesi Indonesia, can be preserved by using gamma radiation to produce the expected mutant. Various studies have been done for more than ten years to investigate the effect of radiation treatment or additional treatment before and after the radiation so that the result will be more focused and more practical. Since then, the use of artificial mutations in plant breeding began to grow in developing countries, especially in Asia. In some varieties of crops artificial mutation has acquired and developed a new variety (Mugiono, 2001).

Induction of mutations to obtain tolerant rice to Al has also been done by Hutabarat (1991) and Rahayu and Yeni (2009). In Asia Pacific, there are approximately 343 mutant rice varieties have been removed (Ahloowalie et al., 2004). Research on the characteristics of local varieties of rice plants have been carried out and obtained some varieties that favored consumers but its progenies are difficult to obtain due to the limitations of cultivation (Harris et al., 2013). Common obstacles in the development of local rice include low crop productivity, relatively long harvest time and lack of cultivable land with farmers (Muhiddin et al., 2013).

To test piloted mutants obtained from the M1 generation to continue to the next generation (M2) for the mutants with early maturity and short growth. The preliminary study obtained is the M1 generation plants derived directly from seeds that have been irradiated with doses of 200 and 300 Gray. The observation results on the height of the plant in M1 generation showed their real influence among the irradiated and non-irradiated plants. The results showed that radiation at a dose of 300 Gray obtained shortest plants and significantly different with a dose of 200 Gray and without radiation. The analysis also showed that higher the radiation dose, shorter the plants (Harris et al., 2013).

Gamma radiation exposure of rice seeds can lead to mutations in chromosome segments of embryonic cells. The results are consistent with research conducted by Rahayu and Yeni (2009) who found that the radiation dose of 200 to 300 gray is able to induce mutants in rice seed IR64 and Hawara Bunar. Subsequently it is described that the mutation is most easily seen in case of changes in shape, size or color between plants irradiated and non-irradiated. M1 agronomic plants as result of radiation of 200 and 300 Gray showed that there were significant differences in the parameters that are not irradiated at the age of harvest, the amount of grain, the percentage of empty grain and filled grain (Harris et al., 2013). The results of the same study also showed that gamma-ray radiation of 300 Gray mutants were 1.45 % shorter than the parent, but the grain production was lower than the parent (Harris et al., 2013).

Research reports of Herison et al. (2008) suggested that the greater chances of mutation in the generation of self-pollinated offspring of irradiated seeds namely the M2 generation. On the generation, segregation has occurred in mutated loci, so the chances of the emergence of a new character or the expected character is even greater. Essential expected character from this research is that the improvements of morphological characters such as the shorter plants so that the plants do not easily fall which will reduce the quantity and quality of production. Besides, improvements of agronomic characters are also very necessary as early maturity with early harvest time; high yielding varieties of Ase Lapang from lower productive variety. On another hand, the impact of longer harvest time and low productivity can be eliminated by rice varieties. Farmers prefer to cultivate rice varieties that are short-lived (Hadini et al., 2002 cited in Muhiddin, 2013).

Therefore, it is necessary to repair/assemble the local varieties, such as the improvement of age and growth of plant to get the expected varieties.

Problem statement

The specialty of the local varieties is their ability to adapt to local environmental conditions and high economic value, so the local varieties require special attention with regard to the preservation of the germplasm. Among the local varieties found in South Sulawesi, varieties that are favored by consumers, namely Ase Lapang in Pangkep regency. Therefore, it is necessary to repair or conserve the local varieties.

Experience of National Atomic Energy Agency (BATAN) in maturing rice plants earlier can be used as a foothold effort in maturing crops earlier. Indonesia needs this technology to deal with climate change. BATAN managed maturing methods originally to Pandan Wangi rice for its harvest age is usually in 6 months (180 days) and it can be matured just in 115-120 days (4 months) for lowland and 125-130 days to plateau. That means the radiation has caused Panan

Wangi maturing in 2 months ahead of the original (Mugiono and Rustandi, 1991).

Mugiono and Rustandi (1991) research results suggested that the application of mutation induction techniques to get early maturing rice varieties has a great chance to succeed. Use of radiation at a dose of 0.2 to 0.3 kGy give the best results to obtain mutant varieties of early maturing on Cisadane. The research of Edi (2004), on the application of gamma-ray radiation in rice callus decreased regeneration power in line with increasing doses of gamma ray irradiation.

Gamma ray has high penetrating power and has a shorter wavelength than X-rays (Soeminto, 1985). Induction of mutations by radiation of gamma rays is one way to produce a mutant character in the Ase Lapang local varieties in the field. Research by the induction of gamma radiation in rice plants have been carried out, such as to obtain mutants that have the nature of disease resistance, early maturity and better productivity of germplasm origin.

The important part is how to produce plants that are short growth morphologically with early maturity and also resistant to drought, pests and diseases (Harahap et al., 2013). In Asia Pacific there are approximately 343 mutant rice had been removed (Ahloowalie et al, 2004), while in Indonesia until the end of 2006 BATAN has produced 13 varieties of paddy rice, *Atomita* 1, 2, 3, 4, *Cilosari, Merauke, Woyla, Kahayan, Winogo, Diah SUci, Yuwono, Mayang* and the last is the *Mira; Situ Gintung* - an upland rice variety. Priority activities in breeding by induced mutation aimed at improving rice varieties, namely early maturity, short plant morphology, resistant to pathogen attack and drought as well as preferred the taste quality (Soejono, 2003).

Based on the formulation of the problem, the research questions are as follows:

1. How does the induction of gamma-ray radiation from M1 generation can produce local rice of Ase Lapang mutants to be early maturing and short -lived growth in the M2 generation.

2. On how concentration of gamma ray radiation from M generation is used to produce local rice of Ase Lapang mutants to be early maturing and short -lived growth in the M2 generation.

Objective and purpose

The research aims to obtain local rice mutant Ase Lapang for M2 generation which are early maturing and short-lived growth through induction of gamma radiation. In order to realize these objectives, it is made a special study of the following:

a. To know and study the effect of gamma ray irradiation induced to produce local rice of Ase Lapang mutants to be early maturing and short -lived growth in the M2 generation.

b. To know the concentration of gamma-ray radiation used from M1 generation local rice of Ase Lapang mutants to be early maturing and short-lived growth in the M2 generation.

This study has been expected to provide information about the potential use of gamma radiation to produce local rice mutant character of Ase Lapang to be early maturing and short-lived growth. Also, it also serves as material for further research.

Hypothesis

Based on the descriptions, then Hypothesis of this study was conducted to answer the following issues:

a. Results of gamma radiation on the M1 can cause local rice mutant on Ase Lapang diverse in M2 generation.

b. Dose of gamma radiation of local rice Ase Lapang of M1 generation is found to produce mutants character with early maturing and short -lived growth in the M2 generation.

Novelty

Induction of mutations in the rice to get rice varieties had been done a lot already, such as to obtain mutants that have the nature of disease resistance, early maturity and better productivity of germplasm origin. Through irradiation techniques, it can produce mutants or mutated plants with properties expected after a series of testing, selection and certification. However, research for local rice types such as Ase Lapang in Pangkep South Sulawesi Indonesia, to obtain early maturing and short-lived growth mutants has never been done. This is a study of local rice germplasm originated only in South Sulawesi.

Materials and methods

This study was the continuation of two (2) series of experiments of the results of gamma-ray radiation of M1 generation to M2 generation. Radiation studies were conducted at the Center for Isotope and Radiation Applications of BATAN Jakarta, and preliminary experiments were carried out in the Laboratory and Field Crops, Faculty of Agriculture UMI Makassar. Research in the form of experiments using the Selection Method was done from January to June 2014.

Materials used in this study were the local rice seeds Ase Lapang as results of radiation with a dose of 200 and 300 Gray of M1 generation with a seed in the radiation (0 Gray) as a comparison or control. Experiments were conducted using a randomized block design (RBD). Each treatment dose was classified into three groups of replication. Each repetition was planted with 200 seeds. The control was not repeated. From each treatment group 100 samples of plants were taken for observation. The plant samples were taken based on systematic random method. The observations on the results were obtained for M2 generation.

The observation of morphological characters included plant height and number of productive tillers; while the nature of the agronomic observations included age of flowering and harvesting. The data was then analyzed using ANOVA to determine the effect of a given treatment.

Results and discussion

Morphological characters

Radiation is a radiant energy through a material or space in the form of heat, particles or electromagnetic waves of a source of energy (Batan, 2008). Results of analysis of variance showed that the height of plant in rice radiation treatment significantly affected the height of plant. Gamma ray irradiation causes damage to the leaves of plants including chlorosis, necrosis on leaves and flowers, growth retardation, and death of the plant (Manners, 2011).

The radiation of rice seeds have the potential to be developed in the next generation which is expected to have the morphological and agronomic characters which are better than native plants. The use of gene mutations may produce variations (Sasikala and Kalaiyarasi, 2010). Research reports by Herison et al. (2008) suggested that the greater chances of mutation in the generation of self-pollinated offsprings of irradiated seeds the M2 generation.

The BNT (Table 1) shows that shortest growth of the plant was obtained at a dose of 300 Gray and significantly different from the samples without radiation (0 Gray) but not significantly different with a radiation dose of 200 Gray.

According to Muhidin et al. (2013) that increased doses of radiation tended to suppress height of plant and it was lower than the height of the plant cultivars that were not irradiated. The decrease in the height of the plant occurred because of the damage to plant chromosomes. Ionization due to radiation can cause grouping of molecules along ion pathways left behind and causes gene mutation or chromosomal damage (Aisyah, 2006). Mugiono and Rustandi (1991) research results illustrate that the application of mutation induction techniques to obtain the age of early maturing rice varieties have a great chance to succeed. Use of radiation at a dose of 0.2-0.3 k GRY gave the best results to obtain mutant varieties of early maturing on Cisadane.

Table 1. Average height of plant (cm) at the M2 generation gamma-ray radiation treatment.

Treatment	Average height (cm)	NP. BNT 0.05
0 Gray	183.54 a	24.96
200 Gray	143.17 b	
300 Gray	135.31 b	
Note: The numbers followed by different letters (a, b) means significantly different.		

The numbers of productive tillers of rice plants where manifold fingerprint results indicate that gamma-ray radiation treatment significantly affected the number of productive tillers. The BNT test result is 0.05 in Table 2 as a result of the radiation (0 Gray) showed the average number of productive tillers was highest and significantly different from the radiation treatments at 200 and 300 Gray. The number of productive tillers at a dose of 200

Gray was significantly different from that of 300 Gray radiation dose. In general, radiation treatment can reduce the number of tillers as in the treatment of 200 Gray which was fewer than the number recorded for 0 Gray radiation. The dose of 300 Gray radiation showed still less tillers than found in 200 Gray radiation treatment. The higher the radiation dose, the fewer the number of productive tillers formed.

Table 2. Average number of tillers produced by M2 generation in gamma ray radiation treatment.

Treatment	Average no. of tillers	NP.BNT 0.05
0 Gray	18.63 a	2.04
200 Gray	15.98 b	
300 Gray	13.63 c	
Note: The numbers followed by different letters (a, b) means significantly different.		

The results on the number of seedlings or tillers of rice plant variety of Ase Lapang without radiation treatment at 0 Gray gave the highest value of 18.63 tillers. This is due to the treatment plant which suffered no damage and no mutations. Ase Lapang variety of rice plants at a concentration of 300 Gray gave low number of tillers (13.6). This is caused due to the high concentration of radiation given to rice plant seeds which also damaged the genes in plants further.

Agronomic characters

Haris et al. (2013) found that in their study that the nature of M1 agronomic crop radiation at 200 and 300 Gray resulted in noticeable difference with the parameters found in irradiated plants in flowering age, harvesting age, the amount of grain, the percentage of empty grain and filled grain. While in the present study, the results of analysis of variance showed that the radiation treatment on M2 generation significantly affected the flowering in rice plants.

The BNT test result in Table 3 shows that the average age of flowering plants was best in radiation dose of 300 Gray and it did not differ significantly with 200 Gray. However, it was significantly different from 0 Gray radiation treatment. The results of present study in this respect are in line with the study conducted by Rahayu and Yeni (2009) who found that the radiation doses of 200-300 Gray is able to induce mutants in rice seed of IR64 and Hawara Bunar varieties. Subsequently, as described by Joseph (2001) that the mutation is most easily seen in case of changes in shape, size or color between plants irradiated and non-irradiated.

Table 3. Average flowering age (days) at various doses of gamma rays.

Treatment	Average flowering age in days	NP, BNT0.05
0 Gray	111.83 a	3.54
200 Gray	83.43 b	
300 Gray	81.37 b	
Note: The numbers followed by different letters (a, b) means significantly different.		

The observation on the average flowering age of Ase Lapang rice at a dose of 300 Gray showed the best results with a fastest flowering age of 81.37 days and were not significantly different at a dose of 200 Gray which reached the age of flowering at 83.43 days, however, it significantly differed from 0 Gray dose of radiation (111.83 day). Data on harvesting observations are presented in Table 4. The results on the analysis of variance showed that gamma-ray radiation treatment significantly affected rice crop harvesting in rice field.

Table 4. The average age of harvest (days) at various doses of gamma rays.

Treatment	Average flowering age in days	NP. BNT 0.05
0 Gray	160.88 a	0.99
200 Gray	120.15 b	
300 Gray	116.63 b	
Note: The numbers followed by different letters (a, b) means significantly different.		

The average age of harvest was faster in crops at a radiation dose of 300 Gray which did not differ significantly with 200 Gray radiation, and was insignificant at 0 Gray dose. The irradiated plants tend to accelerate issuing of flowers whose direction can cause a rapid harvest (Muhidin et al., 2013).

The average harvest in rice field of Ase Lapang received a dose of 300 Gray dose showed the best results with the fastest time of harvest at 116.63 days and was not significantly different at a dose of 200 Gray which achieved the age of harvest in 120 days, but significantly different from 0 Gray dose of radiation that was harvested in 111.83 days.

In general, the results of this study indicate that treatment of gamma radiation at various doses of M2 generation can change phenotype and genotype on local rice variety, Ase Lapang. Different genotypes show different appearance after interacting with the environment and cultivation techniques or different treatments. It is appropriate with Syafrullah (1995) opinion, each crop variety has different characteristics which are determined by the interaction between genetic trait, growth and environmental management techniques.

The observations on the height of the plant with radiation treatment can shorten the growth and tend to have a slight amount of puppies, especially at the doses compared with a dose of 300 Gray than 200 Gray. It is in line with the acceleration of the harvest that the radiation treatment may shorten the period of harvest. Acceleration of harvesting period can occur due to the shortening phase of vegetative growth, which is characterized by the rapid exit of flowers. The production and quality of the results are still to be tested in the next generation, and it is with the hope to achieve in conditions of stable growth. But according to Syukur (2000), who stated that the breeding with mutations also own a few weakness properties that cannot be obtained in predicting stability of genetic traits that appear in the next generation.

Conclusion

Based on the results of the study, it is concluded that the gamma radiation can affect the morphological and agronomic characters of local variety of rice, Ase Lapang. On morphological characters, it is granting gamma radiation dose of 300 Gray that can suppress the growth i.e., height of plant and number of tillers, while the agronomic characters, in the treatment of 300 Gray radiation can accelerate flowering age and harvesting time. All parameters observed in the treatment of gamma radiation at 200 and 300 Gray for M2 generation is significantly different from the irradiated plants (0 Gray). The dose of gamma radiation in the present study exhibited mutant characters with early maturity and short-growth in M2 generation of local rice Ase Lapang.

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