

Phenotype of M2 Generation of Mutant Black Rice (*Oryza sativa* L)

Aprida¹, Suhadi Sapto Yuwono²

^{1,2}Trainers of National Agricultural Training Center of Lampung – Ministry of Agriculture
Jl. Raden Gunawan Hajimena Bandar Lampung City – Lampung Province - Indonesia

Abstract

Black rice (*Oryza sativa*, L) is popular rice as functional food containing anthocyanin as antioxidant content that is useful for health. Black rice height is approximately 150 cm, long in days to harvesting (5 months) and low in productivity. Induced mutation technique using gamma ray irradiation has been used to improve the genetic of rice. Stability of the plant genotypes from irradiation process needs to be tested until M7 (seventh generation). The aim of this experiment was to investigate the performance of M2 plants from irradiated seeds (M1) that was expected get the mutation of genetic improvement. The results of the experiment showed that there were opportunities of genetic improvement in plant height character in all of strain, the days of harvesting improvement was in strain C11, C12a, and C12b while the productivity character wasn't showed the improvement.

Keywords: black rice, M2, Mutant, gamma ray irradiation.

I. INTRODUCTION

Black rice (*Oryza sativa* L.) is a local rice producing anthocyanin in high intensity. Black rice is more popular and consumed widely as functional food (Kristamtini *et al.*, 2012). Black rice can be consumed to decrease the risk of fatty liver disease (Jang *et al.*, 2012), heart disease due to high cholesterol (Salgado *et al.*, 2010) and inhibit cancer development (Chen *et al.*, 2006). High antioxidant compound in black rice extract is useful as anti-aging material (Kaneda, 2006). Black rice contains low protein but high iron (15.52 ppm), it is higher than other cultivars of rice (Suardi and Ridwan, 2009).

Local rice cultivar generally has weaknesses in days to harvesting and low in productivity (Wahdah and Langai, 2009). Days to harvesting of Cempo ireng cultivar are about 5 months and the productivity is only 4.5 tons/ha (Suardi and Ridwan, 2009). Cempo ireng height is more than 130 cm (Kristamtini *et al.*, 2012). Woja laka cultivar has the productivity of 6 tons/ha (Budiman *et al.*, 2012). Longer days to harvesting and low productivity are the inhibit factors in providing black rice. Too-high plant height will be potentially resulting in plant fall-down.

The breeding of crop cultivar for new food is one attempt of improving production to meet the increasing food demand (Indiarto *et al.*, 2006). The creation of new crops cultivar could be achieved by

increasing genetic diversity through introduction, selection, hybridization, mutation, and biotechnology. Induced mutation is directed to change one or some important favorable characters. Irradiation gamma ray to plant is aimed to get new variants of plant through genetic mutation in plant. The objectives of research were to study effect of irradiation gamma ray on three local black rice cultivars and to know the opportunity of shorter days to harvesting of black rice mutant, shorter plant height and increased productivity by inducing mutation.

Genetic variability could be appeared at M1 generation after seeds being irradiation. Plants mutation were resulted from irradiation would be seemed at the phenotypic, that were the good mutation for improvement or the bad mutation that could be made the plant died. Knowing genetic stability of the plants is important, the mutant needs to be planted till M5 or M7 generation. The objectives of the research is to know performance of the M2 Plants from M1 seeds of black rice irradiated by gamma ray.

II. MATERIALS AND METHODS

The research was conducted from Juli 2016 to December 2016 in National Agricultural Training Center of Lampung. Seeds was taken from the M1 generation of black rice irradiated by gamma ray. The seeds namely C11, C12, C32a, C12b, C21, C32b and C33.

M1 Black rice seeds was sowed within 21 days and planted on paddy field with range 25 cm x 25 cm. Paddy field was cultivated and made 7 part with 2x 6 meter in wide. Fertilizing land was done in three times, that were base fertilizer, second fertilizer and 3 fertilizer using dose 200 kg/ha of urea, 200 kg of SP 36 and 150 Kg/ha of KCL.

Data were taken on agronomic character; plant height, number of productive tiller, days of harvesting, panicle length and number grain each panicle. The data of observation results were analyzed descriptively.

III. RESULT AND DISCUSSION

Table 1. Mean of Plant Height, Number of Productive Tiller and Days to Harvesting

Strain	Agronomic Characters		
	Plant height (cm)	Productive tiller	Days to harvesting
C11	120	10.3	136
C12a	122	12	134
C32a	125	13.8	128
C12b	126	16.3	125
C21	136	15.2	155
C32b	132	18.7	158
C33	135	10.8	150
Mean	126.1	13.9	143.0

From table 1. showed that all strain have plant height between 120 cm till 135 cm, it revealed an improvement from the origin cultivars with plant height 150 cm. The most reducing of plant height were in C11 strain, followed by C12, C32a and C12b. The reduction of plant height could be caused by free radical activity that inhibits growth of the plant (Shah *et al.*, 2008). Kiong *et al.*, (2008) mentioned that increasing of chromosome destruction caused by gamma ray was carried out of plant height reducing. Plant height character is important thing in rice breeding because it relates with effectivity of assimilate use to improve the productivity of plants. Cultivar having high productivity is short stem because distributing of assimilate result would be very effective for the vegetative growth (Oladosu *et al.*, 2014). The rice with short stem, has many tillers, straight and has green color of leaf is more responsive to nitrogen fertilizer to increase biomass (Chandler, 1969 *cit* Abdullah, 2009). The height of the rice is also effecting on plant falldown and the efficiency on harvesting (Diptaningsari, 2013).

The character of number of productive tillers, strain C32b gave mean of the productive tiller 18.7. number of productive tiller is important to definite in rice productivity because it directly relating with result of number of panicle each area (Oladosu *et al.*, 2014). Type of rice with many tiller could be made low harvesting index and low in rice quality. Low tiller results low panicle, more tiller cause many unproductive tiller, short panicle, low in filled grain and reduce the productivity (Pandey *et al.*, 2009). Providing enough nutrition would make the mitosis cell high and plant and tiller growth generally on the vegetative phase will be pushed. Based on Shu *et al.*, (2012) the physiologic and genetic change could be expressed with varied phenotypic changing of the mutant.

The character of days to harvesting, C32 and C12 strain gave days to harvesting faster compared with other strain that were 125 and 128 days after sowing. Rice productivity is influenced by the growth period or the plant. Growth period of rice could be showed with days to flowering (Wei *et al.*, 2015). Average range of days to flowering and days to

harvesting rice is 25-35 days. Days to flowering relates to days to harvesting. The more days to flowering, the more days to harvesting. Days to flowering is important compound to determine productivity of rice (Zhan *et al.*, 2015). Days to flowering is positively correlated with the period of plant life. The influenced factors in days to flowering are temperature and sunlight intensity. The best temperature for plant growth is 23°C, too high temperature at the time will caused more empty grain because it prevented in photosynthesis process. Cultivar with short period of life will be very valuable for development of dry resistant rice (Oladosu, 2014).

Table 2. Mean of Panicle Length and Number of Grain Per Panicle

Strain	Character	
	Panicle Length (cm)	Grain per panicle
C11	24.4	133
C12	23.8	127
C32a	25.2	124
C12b	24.5	144
C21	24.1	148
C32b	23.5	119
C33	22.3	109
Mean	24.0	129.1

The table 2 showed that mean of panicle length is 24 cm, the longest panicle length is C32a strain, 25.2 cm. Mean number grain per panicle is 129.1 and the strain that most number grain per panicle is C21 strain that was 140 grain. Panicle length determines number of grain finding in panicle. Generally long panicle produces more grain compared with short panicle. Eventhough, productivity per area is influenced by empty grain and filled grain. However, long panicle has an opportunity to produce more productivity. Chakraborty dan Chakraborty (2010) reported that there was a significant positive relation between panicle length and number on grain each tiller. Number grain per panicle could be influenced by number of leaf. Low temperature dan low light in the forming of panicle can be influenced the formation of empty grain. Long panicle, more grain, more filled grain and low empty grain can be earned, if environmental condition is optimum for plant growth.

IV. CONCLUSIONS

All strain of M2 generation from irradiation of gamma ray identified showing an improvement mutation on plant height character, that was shorter than 150 cm. In the character of days to harvesting, strain C11, C12, C32a and C12b showed faster, below 5 months. Nevertheless, the productivity did not show an improvement. The strain with potential of genetic improvement need to be tested in the M3 generation to know the genetic stability.

ACKNOWLEDGMENT

The authors expressed thanks to the Head Office of National Agricultural Training Center of Lampung and all staffs for supporting and facilitating the research.

REFERENCES

- [1] Abdullah, B. 2009. Perakitan dan Pengembangan Varietas Padi Tipe Baru. Balai Besar Penelitian Tanaman Padi. Sukamandi. Jawa Barat. Hal 67-89.
- [2] Budiman; E. Arisoelaningsih and R.B.E. Wibowo., 2012. Growth Adaptation of Two Indonesian Black Rice Origin NTT Cultivating in Organic Paddy Field, Malang-East Java. The Journal Of Tropical Life Science, 2(3):77-80.
- [3] Chakraborty, R. and S. Chakraborty. 2010. Genetic Variability and Correlation of Some Morphometric Traits with Grain Yield in Bold Grained Rice (*Oryza sativa* L.) Gene Pool of Barrack Valley. American-Eurasian Journal of Sustainable Agriculture, Vol 4. No. 1. Hal 26-29
- [4] Chen, P.N., W.H. Kuo, C.L. Chiang, H.L. Chiou, Y.S. Hsieh, and S.C. Chu. 2006. Black Rice Anthocyanins Inhibit Cancer Cells Invasion Via Repressions of MMPs and u-PA Expression. Chemico-Biological Interactions 163: 218-229.
- [5] Diptaningsari, D. 2013. Analisis Keragaan Karakter Agronomis dan Stabilitas Galur Harapan Padi Gogo Turunan Padi Lokal Pulau Buru Hasil Kultur Antera. Sekolah Pasca Sarjana. Institut Pertanian Bogor. Bogor Jawa Barat. Tesis.
- [6] Indarto.Y.P, J. Hadoyo dan C. Setiani. 2004. Uji Daya Hasil Padi Sawah. Prosiding Lokakarya Perhimpunan Ilmu Pemuliaan Indonesia VII. Perhimpunan Ilmu Pemuliaan Indonesia Bekerja sama dengan Balai Penelitian Tanaman Kacang-kacangan dan Umbi-umbian. hal.248.
- [7] Jang, H.H., M.Y. Park, H.W. Kim, Y.M. Lee, K.A. Hwang, J.H. Park, D.S. Park, and O. Kwon. 2012 Black Rice (*Oryza sativa* L.) Extract Attenuates Hepatic Steatosis in C57BL/6 J Fed a High-Fat Diet Via Fatty Acid Oxidation. Nutrition and Metabolism 2012,9:27.
- [8] Kaneda, I., F. Kubo, and H. Sakurai. 2006. Antiokxidative Compounds in the Extract of Black Rice Brans. Journal of Health Science, 52 (5) 495-511 (2006).
- [9] Kiong A.L.P, A.G. Lai, S. Hussein and A.R. Harun. 2008. Physiological Responses of *Orthosiphon stamineus* Plantles to Gamma Irradiation. American-Eurasian Journal of Sustainable Agriculture 2(2):135-149
- [10] Kristamtini, Taryono, P. Basunanda, R.H. Murti, S. Supriyatna, Widayanti and Sutarno. 2012 Morphological and Genetic Relations among Black Rice Landraces from Jogjakarta and Surrounding Areas. ARPN Journal of Agriculturean and Biological Scince. 7(12):982-987.
- [11] Oladosu, Y., M.Y. Rafii., N. Abdullah., M.A. Malek., H.A. Rasim., G. Hussin., M.A. Latief and I. Kareem. 2014. Genetic Variability and Selection Criteria in Rice Mutant Lines as Revelaed by Quantitative Traits. The Scientific World Journal Volume 14; article Id 190531.
- [12] Pandey, P., P. John Anuraq, D.K. Tiwari, S.K. Yadav and B. Kumar. 2009. Genetic Variability, Diversity and Association of Quantitative Traits with Grain Yield in Rice (*Oryza sativa* L.). Journal of Bio-Science Vol 17 No 1:77-82
- [13] Piri, I., M. Babayan, Tavvasolli and M. Javaheri. 2011. The Use Of Gamma Irradiation In Agriculture. African Journal Of Microbiology Research Vol. 5 (32) pp.5806-5811.
- [14] Salqado, M.S., A.G.C. Oliveria, D.N. Mansi, C.M.D. Pestana, C.R. Bastos and F.K. Marcondes. 2010. The Role of Black Rice (*Oryza sativa* L.) in the Control of Hypercholesterolemia in Rats. Journal of Medicinal Food 13(6): 1355-1362
- [15] Shah, T.M., J. Mirza, M.A. Haq and B.M. Atta. 2008. Radiosensitivity of Chickpea Genotypes in M1 Generation Laboratory Studies. Pakistan Journal of Botany 40(2): 649-665
- [16] Shu, Q.Y., B.P. Forster and H. Nakahawa. 2012. Plant Mutation Breeding and Biotechnology. CAB International and FAO. Wallingford. United Kingdom.
- [17] Shu, Q.Y., B.P. Forster and H. Nakahawa. 2012. Plant Mutation Breeding and Biotechnology. CAB International and FAO. Wallingford. United Kingdom.
- [18] Suardi, D. dan I. Ridwan. 2009. Beras Hitam, Pangan Berkhasiat Yang Belum Populer. Warta Penelitian dan Pengembangan Pertanian 31(2): 9-10.
- [19] Wahdah, R. dan B.F. Langai, 2009. Observasi Varietas Padi Lokal di Lahan Pasang Surut Kalimantan Selatan. Agroscentiae 16(3):177-184
- [20] Zhan, X., B. Sun., Z. Lin., Z. Gao., P. Yu., Q. Liu., X. Shen., Y. Zhang., D. Chen., S. Cheng., L. Cao. 2015. Genetic Mapping of a QTL Controlling Source-Sink Size and Heading Date Rice. Gene Journal (2015) 263-270.