INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 9, No. 6, p. 114-124, 2016

RESEARCH PAPER OPEN ACCESS

Performing of agronomic characters of M6 of local rice mutant lines of South Kalimantan

Raihani Wahdah*, Gusti Rusmayadi, Rahmi Zulhidiani

Department of Agronomy, Lambung Mangkurat University, Banjarbaru, Indonesia

Key words: Agronomic characters, Local rice, Mutant lines.

http://dx.doi.org/10.12692/ijb/9.6.114-124 Article published on December 11, 2016

Abstract

To increase productivity and rice cropping index in South Kalimantan, it is necessary to plant short-lived and high yielding are generated through plant breeding.. The purpose of this study was to evaluate some agronomic characters of M6 of mutant lines. The experiment consisted of 50 of M6 mutant lines and 3 control by Randomized Block Design in Sungai Rangas Hambuku Village, Martapura Barat District, Banjar Regency, South Kalimantan Province, Indonesia. The variables analyzed were plant age, plant height, number and length of panicle, number of filled and empty grains per panicle, percentage of empty grains, grains weight per panicle, weight of 1000 grains, and yield. If the analysis of variance significantly different, then followed by least significant difference (LSD) test with only compare each M6 of mutant line with every control. There are M6 of mutant lines that have the character better than control. Plant height and age of all M6 of mutant lines classified as short namely ranged from 90.48 cm .- 100.70 cm for plant height and 111.00 – 115.00 days after seeding for plant age. The yields ranged from 3.83 t ha^{-1} - 6.03 t ha^{-1}, while the yields of Bestari, Inpara-2, and Cantik were 5.06 t ha^{-1}, 6.79 t ha^{-1} and 3.09 t ha^{-1}respectivily.

* **Corresponding Author:** Raihani Wahdah ✉ raihn_pascagro@yahoo.com

Introduction

Rice development to swamp area is an alternative to support national rice production enhancement program in Indonesia. The program was developed in a way to intensification through increased cropping index, increased productivity, and the expansion of planting area to the sub-optimal land including wetlands (Koesrini and Nursyamsi, 2012).

However the use of high yielding varieties of rice in wetlands that are not based on local varieties are not adopted by farmers (Simanungkalit, 2004; Wahdah and Langai, 2009). High preference of farmers to local rice varieties due to the ease of cultivation, using the little input, higher selling prices, and has the characteristics of a preferred rice (Wahdah and Langai, 2010). The urgency of this study is an effort to overcome the problem arising from global climate change in relation to producing short-lived varieties (<130 days after seeding). The plant age of parents more than 160 days after seeding (Wahdah and Langai, 2010).

The genetic variation gives chance to obtain recombinant for the improvement of plant traits (Oladosu *et al.*, 2014).

Mutation breeding techniques suitable to do if genetic resources are not available in the germplasm used for hybridization and selection (Fehr, 1987). According to Oka, Hayashi, and Shiojiri (1958), the use of x-rays on rice mutation causes changes in the variability of quantitative characters. The use of gamma rays has managed to improve rice crop (Dwimahyani 1990; Ismachin and Sobrizal 2006; Mugiono *et al.*, 2009).

Attempts to produce new superior varieties based on local varieties through mutation induction by gamma rays have been performed in South Kalimantan (Wahdah and Langai 2009; Wahdah and Langai 2010; Wahdah *et al.*, 2012; Wahdah and Zulhidiani, 2014) one of them to overcome the weaknesses of rice local that long-lived and low-yielding. The purpose of this study was to evaluate agronomic performance of M6 of mutant lines as a consideration selection on next generation.

Materials and methods

Rice cultivation for 5 months was carried out in Sungai Rangas Hambuku Village, Martapura Barat District, Banjar Regency, South Kalimantan Province, Indonesia.

Materials

The materials used are 50 lines of M6 of mutant lines and three controls (Bestari and Inpara-2 as high yielding varieties and Cantik local varieties), fertilizer (Phonska and Urea), pesticides (insecticide, fungicide, and moluscocide), and herbicide.

Cultivation techniques

Seeding done per row per mutant line and transplanted 25 days after seeding in each plot measuring 3 m x 4 m. Spacing used was 25 cm x 30 cm based on 2 : 1 of "legowo" planting system (two rows planted and one row unplanted). Fertilization of 300 kg Phonska ha^{-1} given at the age of 4 weeks after planting. Fertilization of 100 kg Urea ha^{-1} given twice (50 kg ha^{-1} at 2 weeks after planting and 50 kg ha^{-1} at 6 weeks after planting). Pests control is done with pesticides as needed, while the weeds control is done manually and with herbicide according to recommended dosage. Harvesting is done if more than 90 percent of the panicles have matured.

Methods

The research was conducted by Randomized Block Design with 2 replication. Factor to be tested was genotypes (25 lines and 3 controls). Variables analyzed were plant age, plant height, panicles number, panicle length, number of filled grains and empty grains per panicle, number of total grains per panicle, percentage of empty grains, weight of filled grains per panicle, and weight of 1000 grains. If the results of analysis of variance showed a significant difference, then followed by Least Significant Difference (LSD) test (Steel and Torrie, 1994).

Results and discussion

Recapitulation of variance analysis of characters can be seen on Table 1.

Table 1. Recapitulation of analysis of variance.

Characters	df	Sum of Squares	Mean Squares	F-values
Plant age	52	4983.396	95.8345	52.66**
Plant height	52	1885.567	36.2609	3.53*
Panicle length	52	101.6235	1.9543	1.88*
Panicles number (√x)	52	17.5364	0.3372	1.01
Filled grains number (√x)	52	18.6455	0.3586	1.03
Empty grains number	52	3.1338	0.0603	2.38*
Total grains number (√x)	52	17.5364	0.3372	1.00
Percentage of empty grains	52	77.5108	1.4906	3.19*
Weight of 1000 grains (√x)	52	5.6426	0.1085	2.17*
Weight of filled grains per panicle	52	10.1923	0.1960	1.70*
Yield ha^{-1}	52	34.7274	0.6678	2.42*

** = highly significant, * = significant.

All characters showed significant difference unless for panicles number, filled grains number, and total grains number. Results of Least Significant Different Test and recapitulation of LSD test can be seen on Table 2 and Table 3 respectively, whereas the maximum and minimum values of M6 of mutant lines and avarage values of Bestari, Inpara-2, and Cantik can be seen in Table 4.

Plant age and Plant Height

Based on Table 3 can be seen that 100% of lines (50 lines) have a shorter plant age than the control, either Bestari, Inpara-2, and Cantik.

Plant height of lines were not significantly difference with Bestari but significantly shorter than Inpara-2 and Cantik.

Table 2. Mean performance of 53 genotypes (consist of 50 of M6 of mutant lines and 3 of control).

Lines/ Control	Plant Height (cm)	Plant Age (das)	Panicle Length (cm)	Number of Empty Seed (grains)	% of Empty Seed	1000 Weight of Seeds (g)	Weight per Panicle (g)	Yield per ha (t ha^{-1})
G-1	93.78	112	24.43	3.29	3.17	4.85	2.54	6.05
G-2	94.95	112	24.86	3.35	3.32	4.89	2.44	5.31
G-3	92.99	114	25.30	4.60	4.37	4.65	2.38	3.83
G-4	95.56	112	26.69	3.96	3.65	5.03	2.98	6.05
G-5	95.91	113	26.26	3.87	3.66	5.03	2.81	5.56
G-6	99.56	112	25.08	3.98	4.03	4.97	2.42	5.43
G-7	100.70	111	26.16	3.53	3.35	5.03	2.82	5.56
G-8	95.34	114	25.89	2.94	2.88	5.11	2.71	5.81
G-9	91.78	115	24.20	3.02	2.92	5.06	2.74	5.07
G-10	94.11	113	24.83	3.79	3.64	4.95	2.69	5.93
G-11	95.16	112	25.00	3.68	3.62	4.86	2.49	5.44
G-12	96.23	114	25.61	3.74	3.71	5.00	2.55	5.07
G-13	96.09	112	24.65	3.30	3.26	4.92	2.50	5.80
G-14	92.53	115	23.05	2.77	2.93	5.27	2.46	5.56
G-15	96.20	113	26.15	3.54	3.21	4.92	2.95	5.56
G-16	98.94	112	25.49	3.92	3.83	4.94	2.62	6.18
G-17	94.71	112	26.65	3.62	3.50	5.21	2.90	5.93
G-18	92.10	114	23.73	3.07	3.14	4.98	2.38	4.69
G-19	91.71	113	24.55	2.98	2.95	4.92	2.46	5.44
G-20	91.38	115	24.66	3.08	3.04	4.90	2.50	5.81
G-21	94.60	114	25.86	3.79	3.48	4.80	2.70	5.68

G-22	97.13	112	25.95	4.17	4.02	4.78	2.52	5.68
G-23	97.23	113	26.33	4.76	4.72	4.97	2.50	6.05
G-24	94.74	111	25.16	3.17	3.12	5.37	3.01	6.05
G-25	92.48	113	25.20	3.49	3.41	4.94	2.55	5.81
G-26	98.33	112	25.81	3.83	3.46	4.87	2.90	5.68
G-27	95.50	112	24.75	3.22	3.19	4.80	2.38	5.81
G-28	90.79	114	23.31	3.47	3.69	4.83	2.09	5.43
G-29	93.13	113	26.05	3.35	3.04	4.86	2.88	5.56
G-30	96.76	114	24.59	3.33	3.35	4.85	2.32	4.94
G-31	96.20	113	25.55	3.52	3.46	5.21	2.84	5.07
G-32	94.95	113	25.03	4.20	4.37	4.91	2.20	5.56
G-33	94.90	111	24.65	3.44	3.45	4.87	2.42	6.05
G-34	94.88	112	25.13	4.07	3.76	5.00	2.88	5.56
G-35	97.06	115	26.31	4.62	4.45	5.00	2.69	6.05
G-36	96.91	112	25.81	3.53	3.36	4.74	2.48	5.81
G-37	97.01	111	24.30	3.45	3.52	4.75	2.19	5.68
G-38	95.06	111	25.80	4.35	4.28	4.90	2.49	6.18
G-39	97.51	111	25.36	3.48	3.32	4.98	2.82	5.44
G-40	98.71	112	26.15	2.98	2.81	4.95	2.76	5.68
G-41	96.95	114	25.14	4.06	4.02	4.78	2.32	6.05
G-42	93.59	112	25.81	4.70	4.58	4.83	2.51	6.30
G-43	92.01	115	24.54	3.25	3.23	5.32	2.88	5.93
G-44	97.19	112	25.70	3.97	3.99	5.35	2.88	6.05
G-45	93.15	113	27.03	3.23	2.99	5.15	3.15	5.80
G-46	92.84	112	25.95	3.35	3.20	4.72	2.47	5.93
G-47	90.48	112	25.81	3.67	3.51	4.83	2.56	5.93
G-48	90.75	113	25.55	3.67	3.57	4.81	2.45	5.56
G-49	92.40	112	25.73	2.77	2.69	5.37	3.03	5.43
G-50	92.44	115	24.30	3.34	3.20	4.92	2.63	6.05
Bestari	96.71	118	23.35	3.93	3.90	4.97	2.66	5.06
Inpara-2	113.85	119	23.94	5.00	4.75	4.81	2.54	6.79
Cantik	112.65	162	22.06	7.47	8.67	3.78	1.10	3.09
LSD-$_{0.05}$	6.44	2.71	2.05	0.32	1.37	0.45	0.68	1.16
CV (%)	1.60	10.74	4.12	1.32	12.83	1.01	4.47	4.92

The range of plant age of M6 of mutant lines are 111-115 days after seeding, 3-7 days shorter than Bestari and 4-8 days more than Inpara-2, and 46-51 days shorter than Cantik (Table 4). Bestari and Inpara-2 are high yielding varieties and Cantik is local rice variety. The similar thing has been reported by Zen (2013) on, the reducing the age of the rice crop has been widely reported among others by Ismachin. and Sobrizal (2006); Mohammad, *et al*. (1994); Sobrizal (2008); Mohammad *et al*., (2006); New (2006). Mutant population of *Ocimum sanctum* Linn. have flowering age were 19-29 days after germination, whereas parent were 40-50 after germination (Nasare and Choudary, 2011). Plant age of rice are grouped into: ultra-early maturing (< 90 days after seeding), very early maturing (90-104 days after seeding), early maturing (105-124 days after seeding), moderate maturing (125-150 days after seeding), and late maturing, namely > 150 days after seeding (Silitonga *et al*., 2003). The results of research showed that plant age of Bestari and Inpara-2 varieties were early maturing (118 and 119 days after seeding respectively), and Cantik local variety classiefied as late maturing namely 162 days after seeding (Table 2). Plant age of Bestari and Inpara-2 varieties based on it's descriptions are 115-120 and 128 days after seeding respectively (Rice Research Institute of Indonesia, 2008a; Rice Research Institute of Indonesia, 2008b). These showed that the Inpara-2 in this experiment shorter-lived than in the description of variety, while Bestari in the range of variety description.

Table 3. Number of lines that significantly different from control by LSD test at alpha level of 5% for plant age and plant height.

Characters	Lines number compared with								
	Bestari			Inpara-2			Cantik		
	<	=	>	<	=	>	<	=	>
Plant age	50	0	0	50	0	0	50	0	0
Plant height	0	50	0	50	0	0	50	0	0
Panicle length	0	25	25	0	40	10	0	3	47
Panicles number	0	50	0	0	50	0	0	50	0
Filled grains number	0	50	0	0	50	0	0	50	0
Empty grains number	27	17	6	48	2	0	50	0	0
Total grains number	0	50	0	0	50	0	0	50	0
Percentage of empty grains	0	50	0	23	27	0	50	0	0
Weight of 1000 grains	0	50	0	0	45	5	0	0	50
Weight of filled grains/panicle	0	50	0	0	50	0	0	0	50
Yield ha^{-1}	1	46	3	26	24	0	0	1	49

These indicate there are a genetic x environment interaction. Rice grown in drought stress, earlier flowering than in a normal environment (Yamin *et al*., 2012; Supriyanto, 2013). According to Koesrini and Nursyamsi (2012), cropping index (CI) of rice crops in swamp area is currently estimated to 1.05, because in general the swamp just planted once a year. The use of superior swamp rice varieties that are early maturity and higher yielding can increase the rice cropping index and finally Indonesian rice production.

Table 3 shows that plant height of M6 of mutant lines were not significantly different with Bestari variety. All M6 of mutant lines were shorter significantly than Inpara-2 variety and Cantik local variety. Thus, it can be stated that the plant height of all M6 of mutant lines equivalent with Bestari superior variety, but all lines shorter than Inpara-2 was assembled by crossing local variety x superior variety. All lines of M6 of mutant have a shorter plant height than Cantik which is the local rice variety. Giberilin function abnormalities can cause the plant to be short (Sasaki *et al*., 2002). Induction of mutations can cause shortening of the plant. New (2006) reported that shortening of the mutant rice due to mutation induction by gamma radiation has occurred in Myanmar, namely from 167 cm to 117 cm. (New, 2006). Plant height of M6 of mutant lines ranged from 90.48 cm - 100.70 cm (short), while Bestari, Inpara-2, and Cantik were 96.70 cm (short), 113.90 cm (medium), and 112.70 cm (medium) respectively as can be seen in Table 4. Induction of mutations can cause shortening of the plant. Shortening rice plant height due to mutation induction by gamma rays also occured in Myanmar (New, 2006). Plant height of all lines of M6 of mutant were included short and shorter than Bestari, Inpara-2, and Cantik (Table 4). Silitonga *et al*. (2003), classify the rice plant height into 3 groups, namely short (<110 cm), moderate (110 cm - 130 cm), and high (> 130 cm). Plant height of Inpara-2 is 103 cm (Rice research institute of Indonesia, 2008a), was shorter than the height of this study namely 113.9 cm, whereas Bestari according to Rice Research Institute of Indonesia (2008b) has a height ranged 100-115 cm, but in this research, the height of Bestari variety was only 96.7 cm. The difference between plant height of Inpara-2 and Bestari in this study with the varieties description estimated because of the interaction between genetic x environment, According Supriyanto (2013) and Tubur *et al*. (2012) environmental stress such as drought can reduce the height of rice plants. Stature of Cantik local variety is higher than the M6 of mutant lines. The difference of plant height thought to be caused by the partition of fotosintat focused on filling seed in mutant lines and superior varieties, while fotosintat of Cantik local varieties still used for the vegetative growth of plant. According Saidah *et al.* (2015), Bari-bari local rice variety in Southeast Sulawesi higher than Inpara-5 superior variety. There are differences in the average values of plant height of short-lived high altitude rice promising lines (Zen, 2013).

Dwarf mutants have a number of panicles that much (Ishikawa *et al.*, 2005; Arite *et al.*, 2007) and small seed size (Ishikawa *et al.*, 2005). Local variety of rice generally has high plant height, while superior variety has a shorter plant height (Jumberi and Alihamsjah, 2005). However, through the induction of mutations by gamma rays, can be obtained short rice plants as reported by Sobrizal *et al.* (2004), that the application of gamma rays on Atomita-4 has produced a mutant that is short.

Table 4. The maximum and minimum values of characters of lines, average values of Bestari, Inpara-2.

Characters	Max	Min	The average of		
			Bestari	Inpara-2	Cantik
Plant age (days after seeding)	115.00	111.00	118.00	119.00	162.00
Plant height (cm)	100.70	90.48	96.70	113.90	112.70
Panicle lenght (cm)	27.03	23.05	23.40	23.94	22.1
Panicle number (sheets)	38.63	19.63	29.50	29.63	23.63
Filled grains number (grains)	122.13	88.34	107.25	107.25	75.13
Empty grains number (grains)	24.25	7.75	16.50	25.75	55.75
Total of grains number (grains)	137.00	97.00	123.75	135.88	130.88
Percentageof empty grains (%)	7.30	23.4	13.33	18.95	42.6
Weight of 1000 grains (g)	29	21.7	24.68	23.11	14.36
Weight of filled grains (g)	3.44	2.09	2.658	2.54	1.095
Yield ha^{-1} (ton)	3.83	6.30	5.06	6.79	3.09

Panicle Length, Panicles Number, Filled Grains per Panicle, Empty Grains per Panicle, and Total Grains per Panicle , and Percentage of Empty Grains

There are differences of panicle length (Table 1). A total of 50% (25 lines) have panicle length were longer than the Bestari, 20% (10 lines) longer than Inpara-2, and 94% (47 lines) longer than the Cantik (Table 3). The range of panicle length of M6 of mutant line was 23.05 cm - 27.03 cm, while each control Bestari, Inpara-2, dan Cantik were 23.40 cm, 23.94 cm and 22.10 cm respectivily (Table 4).

There are no differences in the number of panicles (Table 1). The number of panicles of all control varieties were very much, namely 29.50, 29.63, and 23.63 respectivily (Table 4). Number of tillers were grouped into very much (> 25 tillers per plant), much (20-25 tillers per plant), moderate (10-19 tillers per plant, a few (5-9 tillers per plant), and very few (<5 plants per plant), according Silitonga *et al.* (2003). The number of panicles of Bestari and Inpara-2 were more than the description of varieties. Based on description of Bestari and Inpara-2, each having a number of panicles as 16 (Rice research institute of Indonesia, 2008 a) and 15-20 strands resvectively (Rice research institute of Indonesia, 2008b). It also indicates the genetic x environment interaction. Tubur *et al.* (2012) reported a genetic x environment interaction on the number of panicles of rice. Afandi *et al.* (2014), also reported the similar thing at 7 genotypes of Japonica rice. Although analysis of variance showed no significant difference between panicle number of M6 of mutant lines (Table 1), but the range of its values between 19.63 (medium) - 38.63 (very much) were quite large, so it requires further evaluation, especially for lines that are at or near the maximum value. Zen (2013) has been reported that the variation in the number of panicles short-lived upland rice. The filled grains number were not significantly different (Table 1).

A total of 54% (27 lines) have less empty grains number than Bestari, 96% (48 lines) less than Inpara-2, and 100 % (50 lines) of M6 of mutant lines less than Cantik. The percentage of empty grains of M6 of mutant lines were equivalent to Bestari, but compared to Inpara-2, there are 54% (27 lines) were similar while the remaining 23 lines (46%) fewer (Table 3). Empty grains number per panicle of M6 of mutant lines range between 7.75 - 24.25 grains, while Bestari, Inpara-2, and Beauty were 16.5, 25.75, and 55.75 grains respectively (Table 4). Thus it can be stated that empty grains number per panicle of M6 of mutant lines less than Inpara-2 and the Cantik so that there are opportunities for screening lines that have empty grains number per panicle less than Bestari.

There are no difference in the number of filled grains (Table 1). This means the number of filled grains per panicle equivalent to Bestari, Inpara-2, and Cantik. Number of filled grains of M6 of mutant lines ranged from 88.34 - 122.13 grains, while Bestari and Inpara-2 were 107.25 grains and Cantik was 75.13 grains (Table 4). Zen (2013) stated that there are significant difference of grains number per panicle inter promising lines of short-lived upland rice. Thus, although there are no significant difference by F test, but there are M6 of mutant lines that have filled grains number more than Bestari, Inpara-2, and Cantik. Potential yield of rice genotypes also determined by the grains characters, namely the grains number per panicle and percentage of filled grains per panicle. According to the Indonesian Agency for Agricultural Research and Development (2009) ,ideal number of grains per panicle are about 100-150 grains per panicle. Thus, the number of grains on the M6 of mutant lines on this research is partially included in that range. There are differences in the average value of fillied grains per panicle of short-lived rice promising lines adapted in high latitude (Zen, 2013).

The percentage of empty grains of M6 of mutant lines were equivalent to Bestari, but compared to Inpara-2, there are 54% (27 lines) were similar while the remaining 23 lines (46%) fewer. All lines have percentage of empty grains of M6 of mutant lines were fewer than Cantik (Table 3). The percentage of empty grains of M6 of mutant lines range between 7.30 % – 23.40%, while Bestari, Inpara-2, and Cantik were 13.33%, 18.95 %, and 42.60 % respectively (Table 4). Thus it can be stated that all M6 of mutant line have less percentage of empty grains than Cantik, so that there are opportunities for screening of lines that have percentage of empty grains less than Bestari and Inpara-2. There is a genetic influence on the percentage of empty grains (Tubur *et al.*, 2012).

In addition to the number of grains per panicle, the potential yield of rice genotypes is also determined by the percentage of filled grains per panicle. According to the Indonesian Agency for Agricultural Research and Development (2009) the percentage of filled grains per panicle is an indicator of grains fertility. Silitonga *et al.* (2003) divides the grain fertility into five criteria, namely very fertile (> 90%), fertile (75-89%), partially sterile (50-74%), sterile (<50%) and very sterile (0%). Based on that classification, then M6 of mutant lines classified as fertile - very fertile (76.60% - 92.70%) while Bestari and Inpara-2 as fertile ie. 83.33% and 76.99% respectively, and Cantik as relatively sterile (24.41%). The high percentage of empty grains estimated cause of the drought that occurred in began in August 2015 in which the local variety of long-lived Love is still at the grain filling period while other lines are already harvesting.

Weight of 1000 Grains, Weight of Filled Grains, and Yield per Hectare

All M6 of mutant lines have a 1000 grains weight equivalent to Bestari, 90% equivalent to Inpara-2, and 10% greater than Inpara-2. All of M6 of mutant lines have a 1000 grains weight were higher than Cantik. All of M6 of mutant lines have a grains weight per panicle which is equivalent to Bestari and Inpara-2 and higher than Cantik (Table 3).

Zen (2013) reported that there are differences in the average of 1000 grains weight of short-lived rice promising lines adapted in high altitude. Compared with Bestari, 1 lines (2%) of M6 of mutant lines has lower yield, 46 lines (92%) were equivalent, and 3 lines (6%) were higher. Compared with Inpara-2, there are 26 lines (52%) having lower yields and three lines (6%) were higher. When compared Cantik, then there is 1 lines (2%) was equivalent to Cantik and the remaining 49 strains (98%) were higher (Table 4). Aryana (2009) also reported yield differences between red rice lines in three enviroments. There is a genetic influence on the weight of 1000 grains (Tubur *et al.*, 2012), According Sajak *et al.* (2012), weight of 1000 grains classified as heavy (> 30 g), moderate (25-30 g), and light (< 25 g). The weight of 1000 grains of M6 of mutant lines ranged from 21.7 g - 29.0 g (light - moderate), while Bestari, Inpara-2, and Cantik are respectively 24.68 g (moderate), 23.11 g (moderate), and 14.36 g (light), as shown in Table 4. Based on these data can be selected M6 of mutant lines which have a higher 1000 grains weight than Bestari and Inpara-2. Cantik variety have the 1000 grains weight is lighter than all of M6 of mutant lines. Tubur *et al.* (2012) reported a decrease in weight of 1000 grains due to increased drought stress duration. The data in this study shows that the weight of 1000 grains of Bestari variety on this research is lower than 1000 grains weight in the variety description of varieties that according to Rice research institute of Indonesia (2008a) was 25.6 g, as well Inpara-2, which according to the description of variety, weight of 1000 grains of Inpara-2 was 27.71 g (Rice Research Institute of Indonesia, 2008b).

All of mutant lines have grains weight per panicles are better than Cantik, but equivalent with Bestari and Inpara-2 (Table 3). Grains weight per panicle of M6 of mutant lines ranged from 2.09 – 3.44 g, whereas Bestari, Inpara-2, and Cantik are respectively 2.66 g, 2.54 g, and 1.10 g (Table 4). The data shown that the lines which have a grains weight per panicle better than Bestari, Inpara-2, and Cantik can be selected from M6 of mutant lines. *Tubur et al.* (2012) reported there are different responses of varieties on some level of water stress.

There are three of lines have higher yield than Bestari while 46 of lines are equivalent. Twenty four of lines have higher yield than Inpara-2 while 26 lines are equivalent. Fourty nine of lines have higher yield than Cantik (Table 3). Yield per hectare of M6 of mutant lines ranged from 3.83 t ha^{-1} – 6.30 t ha^{-1}, whereas Bestari, Inpara-2, and Cantik respectively ere 5.06 t ha^{-1}, 6.79 t ha^{-1}, and 3:09 t ha^{-1} (Table 4).

The average of yield of local rice varieties in South Kalimantan are 1,00 t ha^{-1}– 2.25 t ha^{-1} (Noorsjamsi *et al.*, 1984).

Thus, based on these results, selection can be made on lines that have higher yields than Bestari and Cantik. The variation of rice yield per ha were also reported by Zen (2013). According to the Indonesian Center for Rice Research (2008a), the average yield of Bestari was 5.1 t ha^{-1} with a potential yield was 6.08 t ha^{-1}, while the yield potential of Inpara-2 was 6.56 t ha^{-1} with potential yield was 9.42 t ha^{-1} (Indonesian Center for Rice Research, 2008b). Bestari variety recommended for tidal wetlands and swampy (Indonesian Center for Rice Research, 2008a). It appears also that the yield of Inpara-2 and Bestari in this study were lower than the variety description. It also indicates a genetic x environment interaction. Their genetic x environment interaction (season) for the character of grains weight per plot have been reported by Afandi *et al.* (2014). In the extreme, the effect of seasons because of differences in rainfall that has implications for differences in soil water availability for plants (Nusifera and Karuniawan, 2008).

Conclusion

There are M6 of mutant lines that have some characters better than the control, either in superior (Bestari and Inpara-2) or local variety (Cantik), except for the number of panicle, number of filled grains per panicle, and the total number of grains per panicle. All lines classified as short, namely ranged from 90.48 cm .- 100.70 cm for plant height and 111.00 – 115.00 days after seeding for plant age. The yields ranged from 3.83 t ha^{-1} - 6.03 t ha^{-1}, while the yields of Bestari, Inpara-2, and Cantik were 5.06 t ha^{-1}, 6.79 t ha^{-1} and 3.09 t ha^{-1}respectivily.

Acknowledgement

The Ministry of Research and Technology and Higher Education of Republic of Indonesia for the research fund in 2015.

The National Nuclear Energy Agency of Indonesia for aplication of gamma irradiation in 2010

References

Afandi SW, Soetopo L, Purnamaningsih SL. 2014. Penampilan tujuh genotype padi (*Oryza sativa* L.) hibrida japonica pada dua musim tanam. Jurnal Pro-duksi Tanaman **2(7),** 583-591. http://protan.studentjournal.ub.ac.id/index.php/protan/article/view/147

Arite T, Iwata H, Ohshima K, Maekawa M, Nakajima M, Kojima M, Sakakibara H, Kyozuka J. 2007. Dwarf 10, an RMS1/MAX4/DAD1 ortholog, controls lateral bud outgrowth in rice. The Plant Journal **51(6),** 1019–1029. http://onlinelibrary.wiley.com/doi/10.1111/j.1365-313X.2007.03210.x/full

Aryana IGPM. 2009. Adaptasi dan stabilitas hasil galur-galur padi beras merah pada tiga lingkungan tumbuh . Jurnal Agrononomi Indonesia **37(2),** 95 – 100. http://journal.ipb.ac.id/index.php/jurnalagronomi/article/viewArticle/1400

Badan Penelitian dan Pengembangan Pertanian (Indonesian Agency for Agricultural Research and Development). 2009. Pengelolaan Tanaman Terpadu Padi Gogo. Badan Penelitian dan Pengembangan Pertanian. Jakarta. 28 hal.

Balai Besar Penelitian Tanaman Padi (Indonesian Center for Rice Research). 2008a. Deskripsi Padi Rawa Varietas Bestari`. Informasi Ringkas Bank Pengetahuan Padi Indonesia.

Balai Besar Penelitian Tanaman Padi (Indonesian Center for Rice Research). 2008b.Deskripsi Padi Rawa Varietas Inpara 2. Informasi Ringkas Bank Pengetahuan Padi Indonesia.

Dwimahyani I. 1990. Studi sifat-sifat mutan padi gogo. Pusat Aplikasi Isotop dan Radiasi. Batan. p351-363.

Fehr WR. 1987. Principles of Cultivar Development. Vol.I. Theory and Tecnique. Macmillan Publ. Co., New York.

Ishikawa S, Maekawa M, Arite T, Onishi K, Takamure I, Kyozuka J. 2005. Suppression of tiller bud activity in tillering dwarf mutants of rice. Plant Cell Physiology **46(1),** 79–86. http://pcp.oxfordjournals.org/content/46/1/79.shor

Ismachin M, Sobrizal. 2006. A significant contribution of mutation techniques to rice breeding in Indonesia. Plant Mutation Reports **1(1),** 18-21. https://inis.iaea.org/search/search.aspx?orig_q=RN:38047368

Jumberi A, Alihamsyah T. 2005. Pengembangan lahan rawa berbasis inovasi teknologi. Prosiding Seminar Nasional Inovasi Teknologi Pengelolaan Sumberdaya Lahan Rawa dan Pengendalian Pencemaran Lingkungan. Puslitbang Tanah dan Agroklimat. Banjarbaru, 5-7 Oktrober 2005.

Koesrini & Nursyamsi D. 2012. Inpara: Varietas Padi Adaptif Rawa. Rabu, 12 Desember 2912. 08:09. Balitra Banjarbaru.

Mohamad O, Ramli O, Mahmud J. 1994. A glutinous and short-stature mutant of the rice variety Manik. Mardi Res. J. **22(1),** 23–28.

Mohamad O, Nazir BM, Alia B, Azlan S, Rahim HA, Abdullah MZ, Othman O, Hadzim K, Saad A, Habibuddin H, Golam F. 2006. Development of improved rice varieties through the use of induced mutations in Malaysia. Plant Mutation Reports **1(1),** 27-33. https://inis.iaea.org/search/search.aspx?orig_q=RN:38047371

Mugiono, Harsanti L, Dewi AK. 2009. Perbaikan padi varietas Cisantana dengan mutasi induksi .Jurnal Ilmiah Aplikasi Isotop dan Radiasi. A Scientific Journal for The Applications of Isotopes and Radiation **5(2),** 194-210. http://jurnal.batan.go.id/index.php/jair/article/viewFile/534/464

Nasare PN, Choudhary AD. 2011. Early flowering and high yielding mutants in *Ocimum sanctum* Linn. Indian Streams Research Journal. 1(III), 202-204. http://isrj.org/UploadedData/120.pdf

New KT. 2006. Rice mutation breeding for varietal improvement in Myanmar. Plant Mutation Reports **1(1),** 34-36. https://inis.iaea.org/search/searchaspx?orig_q=RN:38047372

Noorsyamsi H, Anwarhan, Sulaiman S, Beachell HM. 1984. Rice cultivation of the tidal swamps of Kalimantan. In. Workshop on Research Priorities in Tidal Swamp Rice. IRRI. Philippines.

Nusifera S, Karuniawan A. 2008. Analisis stabilitas hasil ubi 27 genotipe bengkuang (*Pachyrhizus erosus* L. Urban) di Jatinangor Jawa Barat berdasarkan model AMMI. Buletin Plasma Nutfah **14(1),** 19-25. http://indoplasma.or.id/publikasi/buletin_pn/pdf/buletin_pn_14_1_2008_19-25_sosiawan.pdf

Oka HI, Hayashi J, Shiojiri I. 1958. Induced mutation of polygenes for quatitative characters in rice. Journal of Heredity **49(1),** 11-14. http://jhered.oxfordjournals.org/

Oladosu Y, Rafii MY, Abdullah N, Malek MA, Rahim HA, Hussin G, Latif MA, Kareem I. 2014. Research Article : Genetic variability and selection criteria in rice mutant lines as revealed by quantitative traits. Hindawi Publishing Corporation. The Scientific World Journal Volume 2014, Article ID 190531, 12 pages. http://dx.doi.org/10.1155/2014/190531

Saidah, Irmadamayanti A, Syafrudin. 2015. Pertumbuhan dan produktivitas beberapa varietas unggul baru dan local padi rawa melalui pengelolaan tanaman terpadu di Sulawesi Tengah. Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia **1(4),** 935-940. http://biodiversitas.mipa.uns.ac.id/M/M0104/M010450.pdf

Sajak A, Masniawati A, Juhriah E, Tambaru. 2014. Karakterisasi morfologi malai plasma nutfah padi lokal asal Kabupaten Tana Toraja Utara, Sulawesi Selatan. Jurusan Biologi, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Hasanuddin. 7 p. http://repository.unhas.ac.id/handle/123456789/4119

Sasaki A, Ashikari M, Ueguchi-Tanaka M, Itoh H, Nishimura A, Swapan D, Ishiyama K, Saito T, Kobayashi M, Khush GS, Kitano H, Matsuoka M. 2002. Green Revolution : A mutant gibberellin-synthesis gene in rice. Nature : **416(-),** 701-702. http://www.nature.com/nature/journal/v416/n6882/abs/416701a.html.

Silitonga T, Somantri IH, Daradjat AA, Kurniawan H. 2003. Panduan Sistem Karakterisasi dan Evalusi Tanaman Padi. Departemen Pertanian. Badan Penelitian dan Pengembangan Pertanian. Komisi Nasional Plasma Nutfah. Jakarta.

Simanungkalit D. 2004. Pengembangan pertanian lahan rawa di Kalimantan Selatan. Seminar Nasional Pengelolaan Lahan Basah di Indonesia yang Berkelanjutan. Disperta Kalimantan Selatan. Banjarbaru 3 Agustus 2004.

Sobrizal. Sanjaya S, Carkum, Ismachin M. 2004. Mutan padi pendek hasil iradiasi sinar gamma, 2 kGy pada varietas Atomita 4. Risalah Seminar Ilmiah Litbang Aplikasi Isotop dan Radiasi. Puslitbang Teknologi Isotop dan Radiasi, Batan. Jakarta. 5p. http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/44/069/44069195.pdf

Sobrizal. 2008. Pemuliaan mutasi dalam peningkatan manfaat galur-galur terseleksi asal persilangan antar sub-spesies padi. Jurnal Ilmiah Aplikasi Isotop dan Radiasi **4(1),** 1-4.

Steel RGD, Torrie JH. 1994. Prinsip dan Prosedur Statistika. Edisi 2. Terjemahan Sumantri B. PT Gramedia Pustaka Utama. Jakarta.

Supriyanto B. 2013. Pengaruh cekaman kekeringan terhadap pertumbuhan dan hasil padi gogo lokal kultivar jambu (*Oryza sativa* Linn). Jurnal Agrifor **XII(1),** 77-82. http://ejurnal.untagsmd.ac.id/index.php/AG/article/view/182

Tubur HW, Chozin MA, Santosa E, Junaedi A. 2012. Respon agronomi varietas padi terhadap periode kekeringan pada sistem sawah. Jurnal Agronomi Indonesia **40 (3),** 167 – 173. http://mail.student.ipb.ac.id/index.php/jurnalagronomi/article/view/6819.

Wahdah R, Langai BF. 2009. Observasi Varietas padi lokal di lahan pasang surut Kalimantan Selatan. Agroscientiae **16(3),** 177-184

Wahdah R. dan Langai BF. 2010. Preferensi petani terhadap varietas padi lokal di area pasang surut Kabupaten Tanah Laut dan Kabupaten Barito Kuala. Media Sains **2(1),** 114-120.

Wahdah R, Langai BF, Sitaresmi T. 2012. Keragaman varietas lokal padi pasang surut Kalimantan Selatan. Jurnal Penelitian Pertanian **31(03),** 158-165. http://ejurnal.litbang.pertanian.go.id/

Wahdah R, Zulhidiani R. 2014. Viabilitas benih beberapa varietas padi lokal pasang surut Kalimantan Selatan yang diiradiasi dengan sinar gamma. Agroscientiae **21(1),** 9-6. http://ppjp.unlam.ac.id/journal/index.php/agrisciencteae/article/download/1346/1152

Yamin M, Suprihatno B, Rustiati T, Sitaresmi T. 2012. Toleransi bebe-rapa genotipe padi umur pendek terhadap pasokan air terbatas. J.Penelitian Pertanian Tanaman Pangan **31(2),** 71-78. http://ejurnal.litbang.pertanian.go.id/

Zen S. 2013. Galur harapan padi sawah dataran tinggi berumur genjah. Jurnal Penelitian Pertanian Terapan **13(3),** 197-205. http://jptonline.or.id/index.php/ojsjpt/article/view/16