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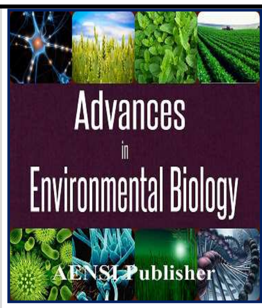

Yield Potency And Adaptability Of Mutant Rice Genotype Resulted From Gamma Ray Irradiation At Six Locations Of Farmers' Groups

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ABSTRACT

Limitation in variety numbers and low productivity of non-irrigated rice caused difficulties in developing varieties on this typical dry land. Presence of mutant genotypes resulted from gamma ray irradiation technique adaptive to drought and high yield could be used as candidates for non-irrigated rice varieties. The research was aimed to assess yield and stability of mutant genotypes adaptive to drought and high yield. The research was conducted at six locations of farmers' groups in Maros Regency, South Sulawesi Province from July until October 2013. A Randomized Blocked Design was utilized with Genotype numbers as treatments and four replications. The used seven mutant Genotypes' were IR 1-8, IR 4-1, IR 6-3, IR 5-3, IR 7-3, IR 3-1 and one existing variety of Situ Bagendit as comparison. The results showed that an interaction was occurred between Genotypes and planting environment. The mutant Genotype of IR 1-8, IR 7-3 and IR 6-3 indicated higher yield component than the comparison control. The mutant Genotype of IR 1-8, IR 7-3 and IR 6-3 were categorized as stable with harvested yield of 7.23 t ha^{-1}, 6.99 t ha^{-1} and 5.82 t ha^{-1}, respectively. IR 5-3, IR 4-1 and IR 3-1 were categorized as unstable with harvested yield of 4.17 t ha^{-1}, 4.72 t ha^{-1} and 4.79 t ha^{-1}, respectively. IR 1-8 and IR 7-3 adapted well in suboptimal environment while IR 6-3 adapted well in lush environment.

KEYWORDS: Mutan rice; gamma ray; drought; dry land and stability.

INTRODUCTION

A sustainable production of rice as a staple of most Indonesian people has caused a demand of the availability of this product in sufficient quantity, quality and affordable. Rice is the main staple food for Indonesia. Until now, the government is still working hard so that Indonesia can be self sufficient in rice as well as back in 1984. Today, efforts to conserve the rice self-sufficiency has been the concern of government, this was due to a stagnant condition in the increase of paddy production (*leveling off*) [22]. Various attempts have been made to increase the production and productivity of rice, including through the application of modern technologies in the genetic engineering field such as the assembly of new varieties.

The availability of the rice mutant genotypes expected to tolerant to drought through gamma-ray irradiation technique has opened an opportunity for material selection to obtain rice mutant candidates as new rice varieties [10]. Previous study of the selection of mutant genotypes in drought stress treatment obtained six drought tolerant genotypes and mutant production is higher than comparable varieties and other genotypes [9]. The six genotypes need to be tested on the potential consistency and yield stability on dry land involving farmers who are members of farmer groups as well as the demands of the research program MP3EI scheme that applied research (action research) based.

A common way to determine the genotype of mutant varieties as an ideal candidate is by testing the yield potential of the mutant genotype in multiple planting environments. Hence, analysis of variance will reveal the interaction between the genotype and the environment. If interaction occurs, it will be difficult to identify the ideal genotype [12]. Thus, a genotype shows highest yield in a particular environment may not necessarily have the highest yields in different environments. Genotype by environment interactions can be used to measure the stability of a genotype [7,11]. Therefore, the interaction of genotype and its planting environment is extremely important in determining yield stability and adaptability of a genotype in a growing environment [16, 19, 21]. This study aims to assess the yield and stability of the mutant genotypes tolerant to drought stress with high production in dry land belonging to farmer groups.

MATERIALS AND METHODS

Materials research are six mutant genotypes, resulted from genotype selection in previous studies, namely the mutant genotype IR 1-8, IR 7-3, IR 6-3, IR 4-1, IR 5-3, IR 3-1 and Situ Bagendit (upland rice as comparison). The experiment was conducted at six sites in Maros regency. This study used a Randomized Block Design, consisting of seven treatments: (1) IR 1-8, (2) IR 5-3, (3) IR Som 6-3, (4) IR Som 4-1; (5) ; IR 7-3; (6) IR 3-1; (7) Situ Bagendit variety (comparator variety), the treatments were repeated four times. To determine the effect of the location of the study, a combined analysis was performed using a linear randomized design model.

The parameters used to determine the stability (adaptability) is the regression coefficient. The method has been used by [5]. This model is also used by Suwarwono *et al*. [20], Harsanti *et al*. [8] and Amir *et al*. [2] on lowland rice commodities. The stability parameter estimators are determined by the linear model with equations [3]: $Yij = \mu i + \beta i + dij$, where: yij = average value of i^{th} genotype in the j^{th} environment (location), μi = the average value of the common from i^{th} genotype in all environments (locations), βi = coefficient regression of the measured response of mutant genotypes in different environments (locations), Ij = environmental index derived from the average of all genotypes in j^{th} environments minus the average value of the public. $Ij = \Sigma\ yij / v - \Sigma\Sigma Yij / vn$, $dij = yij - Yj$, $bij = \Sigma\ yij\ I / \Sigma\ Ij$. Stability parameters ($SD^2$) is obtained from $= \Sigma\Sigma\ dij / (n-2) - SE^2 / r$.

To determine the adaptability of a test genotype, regression analysis was used. A genotype that has a regression coefficient (bi) = 1 and the regression coefficient deviation (CD^2) = 0 means the genotype is stable. If bi> 1 means that the genotype will adapt to the lush environment. If bi < 1 means that the genotype will adapt to the environment that are less fertile.

Procedures used in the study were each mutant seeds were soaked in warm water with a temperature of approximately 30 ° C, for 8 hours. Before the seeds are planted, land preparation was made in six locations belong to farmers groups. At each test site, preparation was performed including land clearing, cultivation and manufacture of experimental plots. The plot was made with size of 12 m^2, the distance between plots within one repeat was 100 cm and 200 cm between plots. At each study site consisted of 28 plots. Seeds were planted in a manner drill with two seeds placed per hole.

Fertilizers used were organic chicken manure fertilizer 10 tons ha^{-1} (12 kg $plot^{-1}$), urea 150 kg ha^{-1} (180 g $plot^{-1}$), SP-36 100 kg ha^{-1} (120 g $plot^{-1}$) and KCl 100 kg ha^{-1} (120 g $plot^{-1}$). The organic fertilizer was applied at the final land preparation, SP-36 and KCl were given at planting time, one-third dose of urea fertilizer was applied at planting, 30 and 50 days after planting. Control of pests, diseases and weeds were adjusted as needed based on the principles of integrated pest management.

Growth components observed were: (1) The number of productive tillers, determined by counting tillers that produce panicles, (2) Number of filled grains per panicle, calculated at harvest, (3) Weight 1000 g of pithy grain, weighed 1000 grains of rice at moisture content of 14 %, (4) Grain yield per plot, determined by pithy grain dry weight from one plot (WC = 14 %) further converted into ton ha^{-1}.

RESULT AND DISCUSSION

Yield Potential and Genotype Interaction with Location:

Results of research showed that there is a genotype by environment interaction. Observation on number of productive tillers parameter component showed that genotype IR 1-8 and IR 7-3 tillers have significantly more number of tillers than Situ Bagendit variety in all farmer group locations, with the average number of tillers (IR 1-8: 25.5 - 30.9 tillers), (IR 7-3: 24.8 - 29.9 tillers) and Situ Bagendit varietay (18.0 - 22.3 tillers). Based on the component of filled grain number per panicle, IR 1-8 IR, IR 6-3 and IR 7-3 had significantly more number of filled grain than Situ Bagendit variety at all locations farmer groups with average number of filled grain (IR 1-8: 196.8 - 239.0 grains, IR 6-3: 174.1 - 209.1 grains, IR 7-3: 208.8 - 244.5 grains and Situ Bagendit variety : 134.6 - 161.1 grains). The lowest number of filled grains per panicle showed by IR 5-3 genotypes (91.9 - 139.0

grains) and IR 4-1 (125.2 - 146.8 grain). Based on parameter of 1000 pithy grain weight component, genotypes IR 1-8, IR 7-3 and IR 6-3 1000 grains had grain weight that significantly higher variety compared with Situ Bagendit variety in locations KT-1, KT-3, KT-4 and KT-5. At the location of the KT-5, only IR 1-8 that was significantly heavier than the Situbagnedit, similarly on the location of the KT-6, IR 7-3 genotype was significantly heavier than the Situ Bagendit variety. In line with the observation component of number of productive tillers, number of grains per panicle and weight of 1000 grains milled rice converted to hectare shows that IR 7-3, IR 6-3 and IR 1-8 had 1000 grains milled grain that was heavier than Situ Bagendit at all study sites except at the location of the KT-6.

Table 1: Yield components of rice mutant genotypes and Situ Bagnedit variety in six locations of farmer groups

Genotype	KT-1	KT-2	KT-3	KT-4	KT-5	KT-6	Mean
The number of productive tillers (stems)							
IR 1-8	23.83^{ab}	31.67^{a}	27.10^{a}	31.33^{a}	27.10^{a}	28.33^{a}	25.5-30.9
IR 5-3	19.10^{cd}	22.27^{d}	23.43^{abc}	25.20^{b}	22.60^{bc}	24.43^{bc}	20.9 - 24.8
IR 6-3	19.50^{cd}	28.57^{ab}	24.50^{ab}	23.40^{bc}	21.10^{c}	22.47^{c}	20.4 - 26.1
IR 4-1	20.67^{bc}	26.23^{bc}	23.83^{abc}	23.83^{bc}	20.73^{c}	22.40^{c}	21.0 - 24.9
IR 7-3	25.17^{a}	32.10^{a}	25.17^{a}	29.07^{a}	25.13^{ab}	27.50^{ab}	24.8 - 29.9
IR 3-1	16.67^{d}	20.27^{d}	21.33^{bc}	25.17^{b}	22.63^{bc}	24.50^{bc}	18.9 - 24.6
S-bagendit	16.00^{d}	23.23^{cd}	20.50^{c}	20.83^{c}	19.57^{c}	20.83^{c}	18.0 - 22.3
Number of filled grains per panicle (grains)							
IR 1-8	190.47^{a}	215.33^{ab}	195.95^{ab}	234.71^{ab}	212.02^{ab}	234.76^{ab}	196.8 - 239.0
IR 5-3	104.33^{c}	100.73^{e}	91.67^{e}	148.33^{c}	99.18^{e}	148.38^{c}	91.9 - 139.0
IR 6-3	163.50^{b}	194.33^{bc}	176.84^{bc}	211.82^{b}	191.34^{bc}	211.87^{b}	174.1 - 209.1
IR 4-1	121.33^{c}	136.90^{d}	124.58^{d}	149.22^{c}	134.79^{d}	149.27^{c}	125.2 - 146.8
IR 7-3	202.60^{a}	228.00^{a}	207.48^{a}	248.52^{a}	224.49^{a}	248.57^{a}	208.8 - 244.5
IR 3-1	152.67^{b}	143.33^{d}	130.43^{d}	156.23^{c}	141.13^{d}	156.28^{c}	137.3 - 156.0
S-bagendit	126.93^{c}	149.83^{d}	136.35^{d}	163.32^{c}	147.53^{d}	163.37^{c}	134.6 - 161.1
Weight of 1000 grains (g)							
IR 1-8	25.56^{bcd}	25.41^{b}	24.58^{b}	26.24^{a}	23.39^{ab}	27.70^{a}	23.2 - 26.7
IR 5-3	23.47^{b}	23.28^{b}	23.31^{bc}	23.34^{bc}	21.12^{bc}	25.40^{bc}	22.1 - 24.6
IR 6-3	24.11^{d}	23.23^{b}	24.26^{bc}	24.54^{ab}	24.31^{ab}	26.70^{ab}	23.5 - 25.6
IR 4-1	23.35^{bcd}	22.18^{b}	23.11^{c}	23.22^{c}	20.02^{c}	24.28^{c}	21.4 - 24.0
IR 7-3	25.73^{ab}	25.31^{b}	25.49^{b}	26.69^{a}	25.65^{a}	27.25^{a}	25.3 - 26.7
IR 3-1	23.40^{bc}	23.27^{b}	23.30^{bc}	24.50^{abc}	24.41^{a}	23.56^{abc}	23.2 - 24.3
S-bagendit	23.17^{cd}	23.25^{b}	23.18^{c}	24.23^{c}	24.03^{c}	22.29^{c}	22.7 - 24.0
Dry grain yield (t ha^{-1})							
IR 1-8	7.45a	7.06a	7.04a	7.11a	6.65a	6.18a	6.51 - 7.32
IR 5-3	3.44c	3.68d	3.46c	6.06b	3.32c	5.07b	3.14 - 5.20
IR 6-3	4.65b	6.90b	6.26a	5.99b	6.47a	4.64b	4.95 - 6.69
IR 4-1	4.52b	5.30c	4.36b	5.50b	3.92bc	5.31b	4.23 - 5.40
IR 7-3	7.05a	7.29ab	6.75a	7.41a	6.58a	6.85a	6.70 - 7.28
IR 3-1	4.24bc	4.73c	4.46b	5.54b	4.55b	5.20b	4.34 - 5.33
S-bagendit	4.32b	5.39c	4.25bc	4.18c	4.43b	4.53b	4.11 - 4.92

Notes : Mean followed by different letters in the same column, means significantly different by HSD test level of 5%. KT-1= Masserekana farmer group (FG) location + FG Polewali, Bantimurung district; KT-2= Integrated FG location + FG Sipakatau, Bantimurung district; KT-3= FG Tanadidi Location + FG Bajiminasa, Simbang district; KT-4 = FG cambaya location + FG Reski, Tanralili district; KT-5= FG Rumbiya location + FG Lambare, Tompobulu district; KT-6=FG Tamalanrea Location + FG Simpati, Bantimurung district.

Yield stability:

The results of the stability analysis are presented in Table 2. It shows that the genotypes that have a regression coefficient is not significantly different from 1 (one) or the deviation of the regression is not significantly different from 0 (zero) or a value of KT regression (KT-reg) is not significantly different from 0 (zero) can be categorized as a stable genotype. Thus, the IR 1-8; IR 6-3; IR 7-3 and Situ Bagendit variety considered as stable, while the genotypes IR 5-3, IR 3-1 and IR 4-1 can be categorized as unstable.

Table 2: Average yield of dry grain (water conten = 14 %) (tons ha^{-1}) and the regression coefficient (bi)of mutant genotype and check varieties at six locations of farmer groups

Genotype	Yield (t ha^{-1})	Regression coeffient (bi)		Deviation of regression (SE)	KT- reg		Category
IR 1-8	7.23	0.545	ns	0.383161	0.158	ns	Stable
IR 5-3	4.17	2.177	*	1.830609	2.513	*	Unstable
IR 6-3	5.82	1.399	ns	1.957201	1.038	ns	Stable
IR 4-1	4.82	1.582	*	0.345744	1.327	*	Unstable

IR 7-3	6.99	0.715	ns	0.114921	0.271	ns	Stable
IR 3-1	4.79	1.132	*	0.251001	0.680	ns	Unstable
S-bagendit	4.52	0.575	ns	0.376996	0.175	ns	Unstable

Notes: ns = not significantly different; * = significantly different.

Result of the recent research indicating that there is interaction between genotype and study site of farmer groups location on all growth components observed (Table 1). This interaction cannot be separated from the response of each mutant genotype in different environments. Locations of farmer groups in this study have different land characters based on the level of soil fertility due to variations in the culture practices applied for the previous crop. Genotypes IR 1-8 and IR 7-3 generally respond better to different environmental conditions such as farmer groups locations. The presence of interaction between genotype and location indicates phenotypic failure in genotypes tested in providing the same performance on different environmental conditions. Conditions like this will bring up a environmental specific. On the other hand, if there is no interaction between genotype and environment tested (location), means that the tested genotype capable to result in same performance in different environments [13, 1]. The magnitude of interaction between the genotype and planting environment can be used as a basis for determining the location or area of adaptation as well as to assess the role of environmental factors on genetic potential and determine the degree of adaptability and stability of genotypes or strains [15, 17].

The significant interaction between genotype and location on the yield showed a close correlation between genotype and location of farmer groups. The influence showed the expression of the tested mutant genotypes genes to obtain high yields [3]. Genotype by environment interaction (G x E) is associated with adaptation capabilities possessed by an individual or a population of plants in a particular environment [14]. Based on average yields (t ha^{-1}) showed that the mutant genotype IR 1-8, IR 7-3 and IR 6-3 in a row has the highest yield compared with other genotypes tested and Situ Bagendit variety. This indicates that all three of these genotypes have a common adaptation or can adapt well to dry land, especially for the specific location. According to Finaly and Wilkonson and Chal and Gosal, genotypes show a regression coefficient (bi) that significantly not different to 1 and yield higher than all genotypes tested have a chance to adapt well in all planting environment tested. Further, Harsanti *et al*. [8], Somsona *et al*. [18] stated that one of the advantages using regression coefficient (bi) as estimator of adaptability is that the ability of this method to determine whether the adaptation direction tend to fertile or infertile environment. Genotypes with regression coefficient (bi) > 1 and yield more than the general average yield will adapt well to more productive planting environment, while genotypes with regression coefficient (bi) < 1 and yield more than the general average yield will adapt well to marginal planting environment. Therefore, IR 1-8 and IR 7-3 can adapt well in drought stressed environment, while IR 6-3 will adapt to productive environment.

Contribution to research was create a new varieties of high yielding and high yield of drought tolerant [6] so can be widely utilized by farmers in order to increase production and productivity so as to increase the income and welfare of farmers. As well as new germ plasma for further breeding programs.

Conclusion:

There was an interaction between genotype and environmental research, where mutant genotypes IR 1-8, IR 6-3 and IR 1-7 harvested grain yield higher than Situ Bagendit variety (as control) and three other genotypes. Average yield of mutant genotypes IR 1-8, IR 1-7 and IR 6-3 : 7.23 t ha^{-1}; 6.99 t ha^{-1} and 5.82 t ha^{-1}, respectively considered stable when planting at six dry land locations of groups' farmer. While genotype IR 5-3, IR 4-1 and IR 3-1 can be categorized as unstable.

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