Breeding of Rice Variety(s) for High Yielding and Early Maturity Through a Wide Cross and Mutation

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Abstract

To fulfill the Indonesian domestic demand in which the annual population growth is still more than 1.4%, Indonesian rice production should be increased. This can be achieved by increasing rice productivity and harvesting index through growing high yielding and early maturity of rice varieties. In previous research, breeding lines that have wide genetic diversity have been constructed through Indica-Japonica cross of IR36/Koshihikari. To gather the desirable characters in one lines some of breeding lines were crossed each other and some improved lines were obtained. To remove undesirable characters in improved lines some of these limes were irradiated by gamma ray and 12 promising mutant lines with high yield and early maturities were selected. The growth durations of these mutant lines were ranging from 93.7 to 99.3 days from sowing to harvesting, significantly shorter than those of original line SKI 88, national leading variety Ciherang and the early maturity national leading variety INPARI 13. Yield of most mutant lines were not significantly difference with that of original line, SKI 88 and national leading variety, Ciherang, but significantly higher than that of INPARI 13. To fulfill the requirement of variety release in Indonesia, other multi-location yield trials and other examinations such as pests, diseases as well as other grain quality examinations should be conducted.

Key words: rice, high yield, early maturity, wide cross, mutation

Introduction

Rice is a staple food of majority Indonesian population. In the mid-1980s Indonesia firstly achieved self-sufficiency for rice, however the growth of rice production has slowed down since the 1990s (BAPENAS, 2002). The decline in rice production is frequently attributed to loss of rice fields caused by conversion to non-agricultural uses, and to the declining productivity. To fulfill the domestic demand in which the annual population growth is still more than 1.4 %, Indonesian rice production should be increased. This can be achieved by increasing rice productivity and harvesting index through growing high yielding and early maturity of rice varieties.

Since the release of IR8 varieties in 1966 (Cantrell and Hettel, 2004), the potential for paddy production has not been significantly increased (Sobrizal and Ismachin, 2006). The formation of new varieties is only able to maintain the potential of IR8 by improving the growth duration, grain quality, and its adaptability to environmental stress. The narrowness of the genetic diversity of the released rice varieties contributes to the occurrence of slowed down of growth yield potential. Many released rice varieties are related to each other, so the diversity is less and yield potentials are almost same (Susanto *et al.*, 2003). In 1982 the national average production was 4.04 t / ha, while in 2016 it was 5.24 t / ha (BPS, 2017), so the 34-year increase was only 1.20 t / ha. In order to increase the yield potential for future, different genetic resources are needed in the new varieties assembly program.

In previous research, breeding lines that have wide genetic diversity have been constructed through Indica-Japonica cross of IR36/Koshihikari (Sobrizal, 2008). Intra sub-specific crossing with large genetic distances between the two parents allow for the occurrence of transgressive segregation so that it will produce a progeny with a relatively large genetic diversity. Transgressive segregation is the emergence of an individual in a segregated population in which the individual phenotype exceeds that of both parental phenotypes and is commonly found in progeny derived from inter and intra-specific crosses (Vega and Frey, 2004). Great genetic diversity will provide flexibility in selection, including selection towards increased yield potential. The selected plants are purified to become pure lines, and can be used as breeding materials in subsequent breeding programs. By using these unique germplasms as well as mutations 12 rice promising lines with high yield and early maturities have been constructed. The objective of this research is to develop high yielding and early maturities of rice varieties.

Materials and Methods

Construction of Breeding Materials

To increase the genetic variability of breeding materials, IR36 and Koshihikari were crossed, and developing of pure lines from this cross was conducted as described in Sobrizal 2013. To gather desirable characters in a line some of selected pure lines were crossed as shown in Fig. 1. From these crosses selected pure lines (SKI 64, SKI 88, SKI 153, and SKI 276) were used as further breeding materials. These lines showed good performance with high yield potency, but long growth durations. To reduce their growth durations, 50 gram seeds of each line were irradiated by 200 Gy of gamma ray at Center for the Application of Isotopes and Radiation Technology, Pasar Jumat, Jakarta. Irradiated M_1 seeds were sown, and twenty day-old seedlings were transplanted to paddy field by planting a single seedling per hole at experimental field, Sawangan, Depok with 20 cm spacing between plants.

Five hundred M_1 plants were harvested individually to obtain the M_2 seeds. Harvesting was conducted by collecting only one main panicle in each M_1 plant. M_2 seeds were sown, and 20 M_2 plants derived from each M_1 plant were transplanted to develop M_2 lines. Selections of early maturity plants were conducted in each M_2 lines and selected plants were harvested individually.

Selected early maturity plants were purified up to M_5 generations, then, selected pure lines were designated as RSKI #. RSKI lines were subjected to yield trials. Breeding scheme of plant materials used in this study can be shown in Fig. 1.

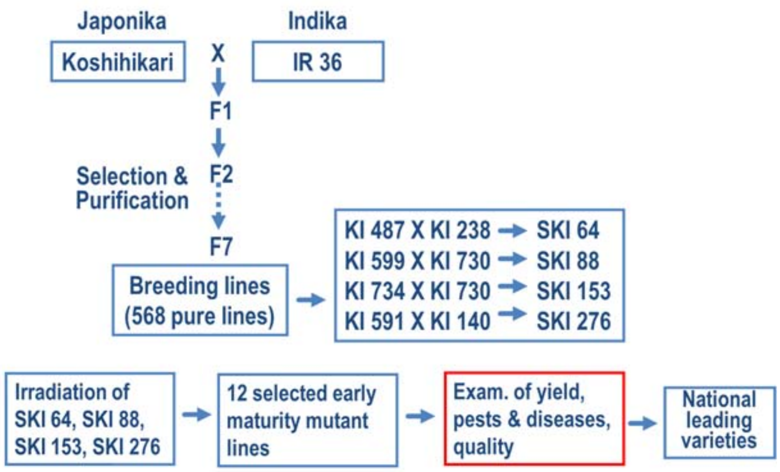

Fig. 1. Breeding scheme of plant materials used in this study.

Yield trials

Yield trials were conducted using 12 selected early maturity mutant lines, check varieties of original line SKI 88, national leading variety Ciherang and national leading early maturity variety INPARI 13. Seedlings were transplanted to plot with plot size of 4 x 5 m and planting spacing of 25 x 25 cm. Experiments were arranged in RBD with 3 replications.

Results and Discussion

In this study, all the F_1 plants derived from crosses of KI lines as in Fig. 1 grew well and selection was conducted in F_2 population with emphasis on agronomical characters. Selected plants were purified and selected pure lines were designated as SKI #. Among selected pure lines, the seeds of SKI 64, SKI 88, SKI 153, and SKI 276 lines were irradiated by 200 Gy of gamma ray. As much as 500 M_1 plants were harvested individually to obtain M_2 seeds. Selection for early maturity was conducted in M_2 lines and 105 selected lines were purified up to M_6 generations. From field observation of 105 lines in rainy growing season of 2012/2013, 12 homogeneous early maturity M_7 mutant lines were selected. These lines were evaluated for yield performance at Pusakanagara Experimental Farm in dry growing season of 2013 and wet growing season of 2013/2014. The results were shown in Table 1.

Table 1. Growth duration and yield of lines/varieties tested.

LINE	DURATION (DAYS)		YIELD (T/HA)	
	DS (2013)*	WS (2013/14)*	DS (2013)*	WS (2013/14)*
RSKI 64-1	98.7 d c	94.3 a	8.88 a b c d	7.70 a b c
RSKI 64-2	99.3 e	97.0 c d e	9.53 a b c	6.71 a b c d
RSKI 88-1	98.0 d	96.3 b c d	8.54 a b c d	6.98 a b c d
RSKI 88-2	94.3 a b	95.0 a b	8.25 b c d	6.51 c d
RSKI 88-3	95.7 c	97.7 d e	8.92 a b c d	7.23 a b c d
RSKI 88-4	96.0 c	96.3 b c d	8.88 a b c d	5.93 d
RSKI 88-5	95.0 b c	95.7 a b c	9.33 a b c	6.51 c d
RSKI 88-6	99.0 d e	97.0 c d e	7.90 d	6.62 b c d
RSKI 88-7	98.3 d e	96.3 b c d	9.74 a	7.93 a b
RSKI 153-1	95.7 c	98.3 e	9.79 a	7.81 a b c
RSKI 276-1	95.0 b c	97.0 c d e	9.75 a	7.70 a b c
RSKI 276-2	93.7 a	100.3 f	7.83 d	5.89 d
SKI 88	117.3 g	123.3 h	9.61 a b	8.12 a
CIHERANG	118.7 h	123.0 h	9.45 a b c	7.48 a b c
INPARI 13	103,7 f	114.3 g	8.16 c d	7.03 a b c d

*) The numbers followed by different characters are significantly different for 5% level.

Table 1 showed that growth durations of mutant lines were ranging from 93.7 to 99.3 days from sowing to harvesting. They were significantly shorter than growth durations of original line SKI 88, national leading variety Ciherang and the early maturity national leading variety INPARI 13. The growth duration of SKI 88 was 117.3 days, Ciherang was 118.7 days and INPARI 13 was 103.7 days.

Yield of mutant lines were ranging from 7.83 to 9.79 t/ha, while SKI 88 was 9.61 ton/ha, Ciherang was 9.45 ton/ha and INPARI 13 was 8.16 t/ha. The yields of ten mutant lines (RSKI 64-1, RSKI 64-2, RSKI 88-1, RSKI 88-2, RSKI 88-3, RSKI 88-4, RSKI 88-5, RSKI 88-7, RSKI 153-1, RSKI 276-1, RSKI 276-2) were not significantly difference with that of original line, SKI 88 and national leading variety, Ciherang, but significantly higher than that of INPARI 13. More over the growth durations of these ten mutant lines were significantly shorter than that of the national leading early maturity, INPARI 13. Performance of mutant RSKI 88-7 and its original plant SKI 88 shown in Fig. 2. Figure 2 shows that the panicles of mutant plants of RSKI 88-7 have appeared while its original plant of SKI 88 has not appeared yet.

Fig. 2. Comparison of early maturity mutant line of RSKI 88-7 and its original line of SKI 88.

To confirm the performance of growth duration and yield of selected lines, these lines were evaluated by growing them at farmer field in Musi Rawas District, South Sumatera and the result sown in Table 2. Table 2 showed that the growth duration of all selected early maturity lines were significantly shorter than that of original line and Ciherang. Even all selected lines were significantly earlier than national early maturity variety INPARI 13. The yields of some selected early maturity lines (RSKI 64-2, RSKI 88-1, RSKI 88-3, RSKI 88-5, RSKI 153-1, RSKI 276-1) were not significantly different from that of national leading early maturity variety INPARI 13. The yields of other selected early maturity lines were significantly lower than that of national leading early maturity variety INPARI 13.

Table 2. Result of yield trial of selected lines in Musi Rawas district.

LINE	GROWTH DURATION (DAYS)*	YIELD (T/HA)*
RSKI 64-1	88.0 g h	5.01 efg
RSKI 64-2	94.0 e	5.81 def
RSKI 88-1	94.7 e	6.0 cde
RSKI 88-2	100,2 d	4.8 fgh
RSKI 88-3	92.7 e f	7.4 b
RSKI 88-4	89.0 f g	4.6 gh
RSKI 88-5	89.3 f g	6.8 bc
RSKI 88-6	91.7 e f g	3.9 h
RSKI 88-7	92.3 e f g	5.2 efg
RSKI 153-1	84.7 h	7.2 b
RSKI 276-1	93.3 e f	7.3 b
RSKI 276-2	112.3 b	5.2 efg
SKI 88	106.1 c	8.7 a
CIHERANG	120,3 a	7.7 b
INPARI 13	100.3 d	6.7 bcd

*) The numbers followed by different characters are significantly different for 5% level.

To further evaluate the yield performances, selected early maturity lines were subjected to yield trials in five locations. The highest average yield in five locations is 8.58 t/ha for RSKI 64-2 and followed by 8.48 t/ha for RSKI 153-1 and 8.48 t/ha for RSKI 276-2, whereas the average yield of an original line SKI 88, a national leading variety Ciherang, and a national leading early maturity variety were only 8.06 t/ha, 8.22 t/ha, and 7.54 t/ha, respectively (Table 3). Multi-location yield trials to reach at least 16 locations as well as other examinations such as pest and diseases, grain quality should be continued as a requirement of variety release in Indonesia.

Table 3. Yield of tested lines in 5 locations of yield trials.

	YIELD (TON/HA)*					
LINE	MATARAM	MURA	SLEMAN	BANTAENG	BNYUWNGI	AVERAGE
RSKI 64-1	8.2 bc	6.5 abc	8.5 abc	6.9 d	7.6 cd	7.54
RSKI 64-2	10.3 a	6.1 bc	10.6 a	7.2 bcd	8.7 abc	8.58
RSKI 88-1	5.8 ef	5.5 c	8.5 abc	6.9 d	7.3 d	7.34
RSKI 88-2	5.7 f	6.5 abc	9.7 ab	7.7 bcd	8.7 abc	7.66
RSKI 88-3	7.8 bc	7.0 abc	7.4 bc	7.1 cd	8.3 abcd	7.52
RSKI 88-4	6.5 def	7.6 ab	9.7 ab	7.2 bcd	8.2 abcd	7.84
RSKI 88-5	6.3 ef	8.1 a	8.2 abc	7.3 bcd	8.1 bcd	7.60
RSKI 88-6	6.7 de	7.2 abc	8.3 abc	7.2 bcd	7.8 bcd	7.44
RSKI 88-7	8.3 b	7.0 abc	7.1 c	8.5 abcd	7.8 bcd	7.74
RSKI 153-1	10.7 a	6.0 bc	6.8 c	10.1a	8.8 abc	8.48
RSKI 276-1	6.0 ef	7.0 abc	7.2 c	7.1 cd	8.2 abcd	7.10
RSKI 276-2	7.7 bc	7.4 abc	8.7 abc	9.3 ab	8.3 abcd	8.28
SKI 88	8.3 b	6.7 abc	7.2 c	9.1 abc	9.0 ab	8.06
CIHERANG	7.7 bc	6.0 bc	8.2 abc	9.9 a	9.3 a	8.22
INPARI 13	7.3 cd	6.1 bc	7.0 c	8.8 abcd	8.5 abcd	7.54

*) The numbers followed by different characters are significantly different for 5% level.

Conclusions

Based on the results it can be concluded as follow;

1. The growth durations of mutant lines were ranging from 93.7 to 99.3 days from sowing to harvesting, they were significantly shorter than those of original line SKI 88, national leading variety Ciherang and the early maturity national leading variety INPARI 13.
2. Yield of most mutant lines were not significantly difference with that of original line, SKI 88 and national leading variety, Ciherang, but significantly higher than that of INPARI 13.
3. To fulfill the requirement of variety release in Indonesia, other multi-location yield trials and other examinations such as pests, diseases and other grain quality examinations should be conducted.

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