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GENETICS DIVERSITY AND AGRONOMIC CHARACTERS OF F3 LINES SELECTED BY RECURRENT SELECTION FOR DROUGHT TOLERANCE AND BLAST RESISTANCE OF BENGKULU LOCAL RICE VARIETIES

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Abstract— **Recurrent selection (RS) is a selection method by crossing selected plants from the population to develop new high yielding varieties. Recurrent selection has been carried out on local varieties to produce drought tolerance and blast resistance of rice lines. This research was conducted at Experimental Station, Indonesian Center for Rice Research, Muara Bogor, West Java and Pondok Kelapa, Bengkulu, Indonesia. A number of F2 RS line used as based population and F3 populations had been identified. The potential of agronomic characteristics had produced some selected lines. There was an increase in the value of the average the number of filled grains/panicle which grain fertility was compared with its constituent elders. Selection based on plant height, the number of productive tillers, the number of grains per panicle, the number of filled grain per panicle and grain weight/hill will be effective in the beginning generations because it had high heritability values and broad genetic diversities. Further evaluation of lines should be arranged on the specific environment in order to obtain superior lines as previously intended.**

Keywords— **Recurrent selection, genetic diversity, local rice, drought tolerance, blast resistance**

I. INTRODUCTION

Rice breeding to get inbreds homogeneous needs to be selected to obtain information on the agronomic traits of high yielding lines, lines need to be planted again as plants observation and yield trials. Based on these experiences, should be developed further by way of exploring the local varieties are high yielding, but does not have the properties of drought resistance and blast disease that often struck planting upland rice in Indonesia.

Local varieties had been used in the breeding program to improve genetic potential. Local varieties had been planted by farmers for many generations on the specific agroecological region so that presumably they are resistant/tolerant to biotic or abiotic stresses in a specific location. Use of local varieties as parental hybridization is recommended for getting superior specific genotype on the new varieties so that released varieties should have a broad genetic variability ([1],[2],[3]). Specific local rice breeding in conventional methods in a dry land to improved high yielding couldn't do without known genetic problems and the way of heritability desiring. Populations have high genetic diversity will give a good response to selection for high genetic diversity will provide great opportunities to get the right cross combination with the superior combined properties. To achieve the purpose of the selection so that the selection of one or more characters can be made more effective and it is necessary to know the relationship between the agronomic character, yield and yield components ([4],[5]).

Conventional breeding method to improve high yielding specific local rice in the dry land needs proper knowledge about genetic problems and the way of heritability desired. The selection will give an optimum response if using the criteria. The selection methods commonly applied to rice breeding in Indonesia are are pedigree, bulk and a modified bulk-pedigree. [6]. These methods suspended the natural accumulation of desired characters from the elder of plant/line [6]. The most effective breeding method to improve single-gene controlled characters is backcross, but to improve more than one of characters using recurrent selection method. Recurrent selection (RS) is a selection method from crossing selected populations to develop new superior populations ([7],[8]-[10]). In the other hand, this method is a powerful procedure to accumulate desirable genes from crossing recombination between continuously selected segregants to get the best new population than before, because it consists of plants that have a combination of traits is desired. The method has been done and succeeds in breeding some crops, such as corn and wheat ([7],[11]). Reference [12] showed that recurrent selection applied to genetically different populations would have a substantial advantage for grain yields, the results observed in the second and first cycles were significantly different.

Breeding technique in RS method has applied to the estimate of genetic progress after eight cycles for the yield of regular bean seeds [13], but still not effective in the self-pollinated plant like soybean [7]. RS have applied well in Brazilian upland rice breeding [10] and maize using the 11th cycle of reciprocal recurrent selection [4]. In soybean, RS can improve yield each cycle [7]. Reference [8] using both combinations between RS and anther culture to accelerate the improvement of new plant type variety of rice in breeding programs, thus increasing the efficiency of breeding programs. The result lines of the RS method from B11742 crossing combination produced plant segregate which has new plant type and resistance to leaf blight disease and better quality of rice [14]. Newest reported by [15] that the effect of recurrent selection on drought tolerance also identifies potential lines with high yield and drought tolerance for improvement variety further, especially for Breat Wheat in limited water areas.

This research aims to study genetic diversity and agronomic character of F3 lines population using RS method for selection purpose of the next generation population.

II. MATERIALS AND METHODS

The research was conducted at Experimental Station, Indonesian Center for Rice Research, Muara Bogor, West Java and at Pondok Kelapa district, Bengkulu, Indonesia. The base population materials are 12 numbers of F2 RS from local Bengkulu upland rice varieties hybrid (Bugis and Sriwijaya) wich it has blast resistance and IR7858-1 and IR148 + lines wich it has drought tolerant.

The experimental design used Augmented Design according to [16]. The average of the adjusted genotypes were obtained after calculated the effect of the block with the formula:

$$Pj = Bj - M$$

The adjusted average value = Yi - Pj

where: Pj = effect blocks all j

Bj = average control in one block j

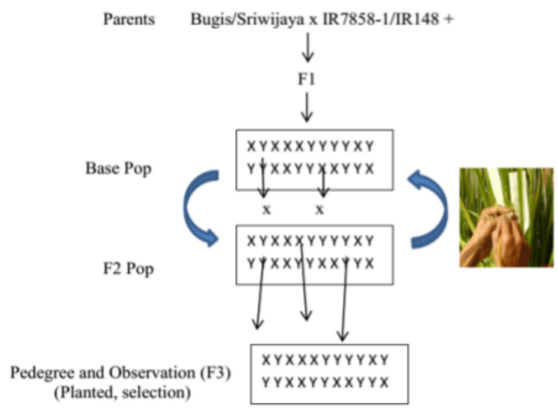
M = average common control

Yi = the value of the i-th observation genotype

Plots measuring 6 m x 5 m consisting of 12 F1 lines. Each line planted two rows of each row contained 12 holes planting, and planted two seeds per hole. Each plot planted four lines and four elders as checks. There are five plots experiment as a block for the 20 lines tested. Fourth elders planted in all plots. Spacing 20 cm x 30 cm and the distance between lines of 40 cm. Fertilization is done with 200 kg Urea, 100 kg SP36 and 100 kg KCl per hectare. The whole SP36 and KCl gave at the time of planting, Urea given three times, each third dose at planting, 4 weeks and 7 weeks after planting. control of pests, diseases and weeds are done in accordance with the needs.

Populations are observed for their appearance in agronomic characters. Several populations that show good segregation of the selected plants will be used as the baseline population. Plants that are selected among populations that have good agronomic characters will be selected by crossing as in Figure 1. This procedure is repeated until a population that has the desired character is obtained. The selection method individually. The selected plants were then planted and evaluated in a pedigree nursery for their agronomic performance characteristics, such as plant vigor, plant height, the number of tillers, flowering and maturity, a length of panicle, the number of filled grains per panicle, the number of unfilled grains, and weight of grains per hill.

Fig. 1. Recurrent Selection (RS)



Genetic variability was estimated from (σ^2g) and standard deviation ($\sigma\sigma^2g$). A character is considered to have wide genetic diversity if $\sigma^2g > 2\sigma\sigma^2g$ [17]. Criteria of genotypes variability coefficient (GVC) and phenotypic variability coefficient (PVC) is relatively low ($0 < x < 25$ %), rather lower ($25\ \% < x < 50\ \%$), quite high ($50\% < x < 75\%$), and high ($75\ \% < x < 100\ \%$) [18]. Heritability values (h^2_{bs}) were classified according methods developed by [19]: high ($0.50 < h^2_{bs} < 1.00$); medium ($0.20 < h^2_{bs} < 0.50$); and low ($h^2_{bs} < 0.20$). Lines were grouped based on plant height, number of productive tillers, and maturity. The Standard Evaluation System (SES) was used for scoring the agronomic characters developed by the International Rice Research Institute [20].

III. RESULTS AND DISCUSSION

A. Evaluation of Genetic Diversity

This research resulted in 180 numbers F3 lines selected from recurrent selection (RS). The next evaluation, selection lines in Bengkulu specific locations, to get adapted specific lines generation in the previous growing season. Analysis of variance showed that there were significant differences in all characters were observed (Table 1). Genetic diversity can be estimated from genetic diversity (σ^2g) and the standard deviation of the genetic diversity ($\sigma\sigma^2g$). A character has a wide genetic diversity if $\sigma^2g > 2\sigma\sigma^2g$. The value of plant genetic parameter estimation showed that the character of flowering, harvesting, plant height, productive tiller, panicle length, the number of filled grains/panicle, the number of unfilled grains/panicle and weight of grains/hill has a wide genetic diversity (Table 1).

Criteria of genotypes variability coefficient (GVC) and phenotypic variability coefficient (PVC) is relatively low (0 < x < 25 %), rather lower (25 % < x < 50 %), quite high (50% < x < 75%), and high (75 % < x < 100 %) [18]. This show that the criteria GVC and PVC is relatively close to the low (0 < x < 0:31), is rather low (0.31 < x < 0.63), is quite high (0.63 < x < 0.93) , and high (0.93 < x < 1:31); PVC is relatively low (0 < x < 8.0), is rather low (8.0 < x < 16.0), high enough (16.0 < x < 24.0), and high (24.0 < x < 32.0). The coefficient of genotypic diversity (GVC) and phenotype (PVC) for the character panicle length, the number of filled grain/panicle, the number of unfill grains/panicle and grain weight/hill between broad to very broad, and has a high heritability value between 0.83-0.91 (Table 1).

The heritability estimates for the character of the observed range from 0.39 to a number of tillers and 0.91 for panicle length. Base on the criteria [19]: 0.50 < h2bs< 1.00 = high; 0.20 < h2bs< 0.50 = medium; h2bs< 0.20= low, characters of plant height, flowering and maturity, panicle length, number of fill grains per panicle and grain weight/hill in this study has high heritability (h2bs). Reported by ([5],[21]) that the selected characters, namely the number of productive tillers, the number of filled grains per panicle, and the percentage of empty grains were very effective because they were correlated with grain weight per hill, had high heritability values, and had broad genetic variability. It's mean that the characters which have a high heritability values indicate that genetic factors contribute greater than the environment so that the selection of these characters begin in early generations. The same observations were reported by ([21],[22]) showed moderate genotypic and phenotypic coefficient of variation, heritability in broad sense, moderate genetic advance and moderate genetic advance in percentage of mean indicated that the low influence of environmental on expression of genes controlling the characters. In other words, the expression of these traits is due more to genetic factors than to environmental influences. Broad genetic variability is useful for further selection processes.

B. Agronomy Characters of Upland Rice Population Crosses Sriwijaya, Bugis, IR7858-1, and IR148

1). Growth Component

Agronomic characters were observed in a population of RS, as well as the parent is presented in Table 2 and Fig. 2. There was a diversity of agronomic characters in all character observed. Plant height of populations derived Bugis/IR7858-1 and Bugis/IR148 were very tall (>131cm), as same as Sriwijaya/IR148 ranges between 103-140 cm (Table 3). Plant height derived Bugis/IR7858-1 taller than elders. According to plant height standards developed by [20], the population of lines generated Bugis by RS result is more directed at the parent which is between tall to very tall (Table 3). The Sriwijaya as parental had moderate plant height criteria, and Bugis had a very tall, while IR7858-1 and IR148 had criteria between moderate to tall, indicating that the two parents are not stable and there is still segregation between populations.

Fig. 2. Performance of agronomic characters of F3 lines selected by Recurrent Selection (RS)

TABLE I

ANALYSIS OF VARIANCES AND GENETIC VARIABILITY OF AGRONOMICAL CHARACTERS OF RICE LINE POPULATION DERIVED SRIWIJAYA, BUGIS, IR7858-1, AND IR148

Characters	MS	F value	GV	PV	2xSDGV	GVC (%)	PVC (%)	h^2bs
Flowering (dap)	968.72	125.2**	48.05	55.79	35.37	0.08	0.08	0.86
Maturity (dap)	1259.52	26.2**	60.57	108.74	45.99	0.06	0.08	0.56
Plant Height (cm)	5885.19	64.6**	289.7	380.81	214.9	0.15	0.17	0.76
Number of productive tiller	227.23	13.8**	10.54	27.05	8.3	0.29	0.47	0.39
Penicle length (cm)	2474.78	200.6**	123.12	135.46	90.37	0.73	0.76	0.91
Number of filled grains/panicle	50583	1254.6**	2527.1	2567.45	1847.03	1.31	1.32	0.98
Number of unfilled grains/panicle	1629.44	97.3**	80.63	97.38	59.5	0.66	0.72	0.83
Grain weight /hill (g)	1821.88	136.68**	90.43	103.76	66.53	0.66	0.71	0.87

*Note: MS=Mean Square; GV=Genotipic Variability; PV=Phenotypic Variability; SDGV=Standar Deviation of Genotipic Variability; GVC= Genotipic Variability Coefficient; PVC= Phenotypic Variability Coefficient;h2bs=Heritability; dap=day after planting; **significant at α = 1%*

TABLE 2

AGRONOMICAL CHARACTERS OF F3 RECURRENT SELECTION FROM PARENT OF SRIWIJAYA, BUGIS, IR7858-1, DAN IR148

Characters	X± SD*	Range of the population**				Means Square***			
		Bugis/IR 7878-1	Bugis/IR 148	Sriwijaya /IR148	Sriwijaya /IR7858-1	Sriwijaya	Bugis	IR7858-1	IR148
Flowering (dap)	89.5±3.9	83-110	80-94	85-95	85-95	82	98	84	91
Maturity (dap)	119.5±4.1	112-140	109-124	114-126	115-125	112	128	114	120
Plant Height (cm)	126.9±13.7	104-155	94-160	103-140	91-128	107	160	114	111
Number of productive tiller	8.28±3.9	2.0-21.0	1.0-17.0	2.0-28.0	3.0-20.0	15	6	14	12
Penicle length (cm)	21.9±1.3	19.9-27.2	19.7-24.1	18.2-22.8	20.0-23.1	19	24	21	20
Number of filled grains per panicle	68.1±8.7	51.7-96.7	23.3-75.3	56.7-78.7	57.3-81.7	65	129	79	81
Number of unfilled grains per panicle	18.9±4.7	10.7-40.7	11.3-30.3	9.3-23.3	11.7-21.7	17	29	19	15
Grain weight per hill (g)	19.4±2.4	15.3-24.7	15.1-23.5	13.9-23.1	15.3-22.6	13,5	24	19	20

*Note:*X± SD=mean±Standar Deviation;**Population F3 range of 37 hill each; ***Population parent of 15 hill each; dap=day after planting*

TABLE 3

GROUPING OF THE F3 RS POPULATION BASE ON NUMBER PLANT HEIGHT

Population	Grouping of plant height				
	short (<90cm)	moderate (91-110 cm)	tall (111-130 cm)	very tall (>131cm)	Total
Bugis/IR7858-1	0	6	38	106	150
Bugis/IR148	0	4	38	98	140
Sriwijaya/IR148	0	24	117	6	147
Sriwijaya/IR7858-1	0	36	71	0	107
Sriwijya	0	20	0	0	20
Bugis	0	0	0	20	20
IR7858-1	0	2	18	0	20
IR148	0	19	1	0	20

Note: Base on IRRI (1996)

TABLE 4

GROUPING OF THE F3 RS POPULATION BASE ON NUMBER OF TILLERS

Population	Grouping of number of tillers				
	very low (<5)	Low (5-9)	medium (10-19)	high (>19)	Total
Bugis/IR7858-1	28	62	59	1	150
Bugis/IR148	52	72	16	0	140
Sriwijaya/IR148	10	68	68	1	147
Sriwijaya/IR7858-1	5	45	56	1	107
Sriwijya	0	0	20	0	20
Bugis	0	20	0	0	20
IR7858-1	0	0	20	0	20
IR148	0	0	20	0	20

Note: Base on IRRI (1996)

TABLE 5

GROUPING OF THE F3 RS POPULATION BASE ON MATURITIES

Population	Grouping of maturity				
	earlier (<115 dap)	medium (115-125 dap)	late (126-150 dap)	extremely late (>151 dap)	Total
Bugis/IR7858-1	8	108	34	0	150
Bugis/IR148	23	117	0	0	140
Sriwijaya/IR148	2	144	1	0	147
Sriwijaya/IR7858-1	0	107	0	0	107
Sriwijya	20	0	0	0	20
Bugis	0	0	20	0	20
IR7858-1	18	2	0	0	20
IR148	2	18	0	0	20

Note: Base on IRRI (1996)

The frequency of distribution of the F3 population leads to be moderate to very tall criteria (Table 3). Based on grouping the number of tillers [20], the number of productive tillers in Bugis/IR7858-1 ranged from 2.0-21.0, whereas Bugis/IR148 had 1.0-17.0 (Table 4). Therefore, population of lines derived Bugis/IR7858-1 more dominant being moderate to high, and can be grouped into 62 medium productivity lines (10-19) and 59 high productivity lines (> 19), whereas those 140 genotypes derived from Bugis/IR148 had 52 very low productivity lines (<5) and two had low productivity lines (5-9) (Table 4).

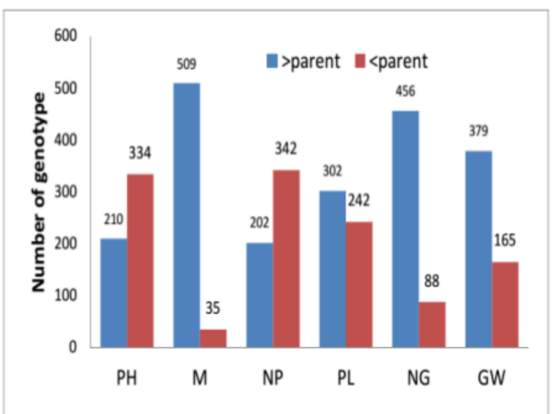


Fig. 3. The frequency distributions of the six agronomic traits,i.e. PH(plant height), M(maturity), NP(the number of productive tillers),PL(panicle length), NG(the number of filled grains per panicle), GW (grain weight per hill)

The number of productive tillers in genotype results of crossing Sriwijaya/IR148 and Sriwijaya/IR7858-1 more dominant in low to medium productivity lines (Table 4). The frequency distribution of the parental population tends to be low to medium productivity lines (Table 2).

Flowering in the genotype result of all crosses more dominant in the medium lines (115-125 days after planting), this shows that there is still segregation occurs in genotypes populations (Table 2). The frequency distribution of the Sriwijaya parental more directed at early maturity group, while Bugis is more directed at the late age groups. Therefore, both IR148 and IR7858-1 parental more lead to be the early maturity group to medium. This shows that the two parents still segregating (Table 5). Reference [6] stated that the repairing of very early harvesting lines and high yields in a short time through recurrent selection showed that this way was more efficient and promising in rice improvement.

Wide segregation was seen in the elite hybrid breeds in the F3 generation. The separation ranges of six important agronomic traits, namely plant height, maturity, number of productive tillers, panicle length, number of filled grains and grain weight of each clump are presented in Figure 3. The sixth frequency distribution of the F3 RS agronomic traits showed a uniform genotype distribution with some values on the higher side of the parent and some on the lower side. This shows that there were still segregating between genotype. Recurrent selection (RS) is a method of selecting plants and crossing from a systematic population to develop new superior plat ([7],[8]-[10]). In the other hand, this method is a powerful procedure to accumulate desirable genes from crossing recombination between continuously selected segregants to get the best new population than before, because it consists of plants that have a combination of traits is desired. The sixty-one percentage lines had shorter plant height than parents. For maturity 93 percent had higher leads to elders. The distribution of the number of productive tillers, panicle length, the number of filled grains, and grain weight per hill were 55, 37, 83, and 69 percent respectively more than parent. Wide diversity will more benefit for the next selection process.

Overall, the analysis of variance showed that there were significant differences in all the observed agronomic characters of the F3 line (Table 1). Populations have high genetic diversity will give a good response to selection for high genetic diversity will provide great opportunities to get the right cross combination with the superior combined properties. Reported by ([4],[5]) that it is important to achieve the purpose of the selection so that the selection of one or more characters can be made more effective, should be known relationships between agronomic characters, yield and yield components.

B. Yields Component

The average of panicle length was 21.99 cm with a standard deviation of 1.3. Bugis had 24 cm of panicles length range, so its derivatives on cross Bugis/IR7858-1 and

Bugis/IR148 had a range of higher panicle length compared Sriwijaya (Table 2). Generally long panicles produce more grains than short panicles. However, productivity is more influenced by grain density than panicle length.

The average number of fill grains/panicle was 68.04 and 8.67 of SD. The derivative crosses Bugis/IR7858-1, Sriwijya/IR148 and Sriwijya/IR7858-1 had higher potential average fill grains than the Bugis/IR148. Lines derived from Bugis/IR7858-1 had the most filled grain i.e. 96.67 grains, while Bugis/IR148 had the lowest. There was considerable variability in the total grain standard deviation and the number of filled grains per panicle between lines (Table 2). The limited distribution sink to source, or earlier senescence might have been the cause of the large percentage of unfill grains. Reference [23] reported that the activity of ribulose bisphosphate carboxylase activase and Rubisco-binding protein subunits that regulate photosynthate accumulation during the replenishment period will decrease at the end of the filling period, or during the aging period.

The number of unfilled grains/panicle result of cross Bugis higher than that more. Low fertility due to the void that is high enough on the elders constituent namely Bugis (29 grains/panicle) which resulted in some derivative lines has a fairly high emptiness.

Average grain weight per hill is 19.43 g with SD 1.36. Lines derived Bugis/IR7858-1 had the most grain weight/hill (24.70 g), whereas Sriwijaya/IR7858-1 had 26.50 g. These values were higher than those from their parental lines, i.e. 24 g in Bugis and 19 g in Sriwijaya (Table 2). In general, there had been an increase in the average value of the all the characters were observed. Recurrent Selection (RS) have a greater chance produce superior lines expected because elite population having good properties result from crosses between selected plant is kept constantly. Reference [12] demonstrated that recurrent selection applied to genetically different populations in the first and second cycles showed significant and high yields (369.9 kg / ha (6.65%) and 259.9 kg / ha (4.67), respectively. %). Reported by [8] used a combination of recurrent selection and anther culture in a breeding program to accelerate the formation of new type lines, so it can improve the efficiency of breeding programs. RS lines result of the combination segregate cross B11742 produce plants that have the nature of new type rice and HDB resistance and better quality rice [14]. All agronomic characters were observed in populations F3 RS plants varied, in some of which are similar to one parent, there are intermediates, and there were exceed two parents. A high diversity is highly advantageous for the stage the next selection. Expected in the next generation will appear genotypes superior caused by segregation in the population as material selection, and will be obtained superior lines as previously intended.

IV. Conclusions

The recurrent selection had been implemented in local varieties to produce drought tolerance and blast resistance rice lines. A number of F2 RS line used as based population and F3 RS population had been identified. The potential for agronomic characters had produced some selected lines. There was an increase in the value of the average number of filled grains/panicle and grain fertility compared with its constituent elders.

Selection based on plant height, the number of productive tillers, the number of grains per panicle, the number of filled grain per panicle and grain weight/hill will be effective in early generations because it had high heritability values and broad genetic diversities. Further evaluation of lines should be arranged on the specific environment in order to obtain superior lines as previously intended.

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