Advanced Yield Trial of F7 Upland Rice Lines with Lodging Resistance in Bangka Regency, Bangka Belitung Islands Province, Indonesia

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Advanced Yield Trial of F7 Upland Rice Lines with Lodging Resistance in Bangka Regency, Bangka Belitung Islands Province, Indonesia

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Abstract. Upland rice with a high yield becomes a priority in rice breeding activities. High yield can be obtained if the rice plant has lodging resistance. This study aims to determine the yield and selection of F7 upland rice lines as the candidate for superior varieties with lodging resistance. The research was conducted in ultisol land, Bangka Regency, Bangka Belitung Islands Province. The study used the experiment method with randomized block design (RBD) with three replications. The treatment used F7 upland rice lines and 5 genotypes as check varieties. The five of F7 lines used were 19I-06-09-23-03, 21B-57-21-21-23, 23F-04-10-18-18, 23A-56-20-07-20 and 23A-56-22-20-05. The five check viarieties used were Danau Gaung, Inpago 8, Inpago 12, Rindang and Situ Patenggang. Data was analyzed using ANOVA and Least Significant Increase (LSI) test. The results showed that 2 lines had a higher yield than the comparison genotypes were 23A-56-22-20- 05 and 23F-04-10-18-18. Hence, the recommended lines as the candidates for superior varieties with lodging resistance are 23A-56-22-20-05 for red rice type and 23F-04-10-18-18 for white rice type.

1. Introduction

The development of upland rice plants was developed in addition to increase production and also get the short plants that resistant to lodging. Bangka local rice is classified as a tall plant with an average plant height of >100 cm. Bangka local rice also has the tiller number from 7.4-8.8 tiller per plant, the productive tiller number ranges from 7.03-8.50 per plant, the flowering time between 9– 101 DAP, and panicle length between 20.8–26.4 cm [1].

Upland rice production in Indonesia recorded in 2017 was 3,872,211 tons and in 2018 it increased, which was 4,178,567 tons [2]. The increase in the amount of rice production must be accompanied by a variety of rice plants that have high production resistant to lodging, and tolerant to ultisol soil. Moreover, some areas in Bangka Regency are known with an average soil pH below 5. In addition, Bangka upland local rice production is lower compared to national varieties and can not be resistant to lodging [1]. Therefore, it needs to be crossed with national superior varieties that have a high production rate and resistant to lodging.

Crossing between Bangka upland local rice with national varieties has been done and obtained F_6 upland rice lines. The previous research showed on the F4 lines, about 64.2% lines have been selected

with plant height < 90 cm and resistance to lodging. Based on the stem strength character, the 21B-29-13- 12 line showed the best result than other F4 lines [3]. The results from preliminary yield trials on F_6 lines have recommended 23A-56-22-20-05 and 23A-56-20-07-20 lines as candidates for new superior varieties because they have better yield and higher production than parental plant [4]. These F_6 lines need to be continued to advanced yield trials to see the potential yield of rice lines.

Advanced yield trial is a stage that must be done in plant breeding activities. The purpose of the trial is to determine the potential yield of plants before the multilocation trial and release of varieties [5]. In this research, an advanced yield trial aimed to get high yield lines with lodging resistance. The selected promising lines will be continued for multilocation trial in further research.

2. Research Methods

This research was conducted from December 2020 to May 2021. Research was held in ultisol site of experimental and research station, University of Bangka Belitung, Bangka Belitung Islands Province. The research used experimental method randomized block design (RBD) with three replications. The treatment used 5 F7 upland rice lines (19I-06-09-23-03, 21B-57-21-21-23, 23F-04-10-18-18, 23A-56-20-07-20 and 23A-56-22-20-05) and 5 check varieties (Danau Gaung, Inpago 8, Inpago 12, Rindang and Situ Patenggang). Plot size was 4 x 5 m with 320 plants for each plot.

The observed characters were plant height (cm), flag leaf length (cm), productive tiller number, flowering age (DAP), panicle length (cm), harvest age (DAP), number of filled grain, yield per plot (kg), number of grain per panicle, and weight of 1000 seeds (gr). The data were analyzed using the Fisher test (ANOVA) at α 5% and Least Significant Increase (LSI) test [6].

$$LSI = t_{(0,05;\mathrm{db})}\sqrt{\frac{MSE}{r}}$$

Description: $t_{(0,05;db)}$ = t value α = 0.05
MSE = Mean Square Error
r = replication

3. Results and Discussion

The ANOVA results showed very significant differences for almost all rice characters observed, except productive tiller numbers and weight of 1000 seeds. Productive tiller numbers showed a siginificant difference while no significant diference at the weight of 1000 seeds (Table 1). The test was conducted to obtain promising lines that can be used as superior variety [7]. In previous research, the F_6 lines that have been tested showed no significant difference with comparison varieties. Rice plants resulting from crosses need to be selected to obtain superior character or genotypes [3]. The stability of the F_7 lines needs to be ensured through advanced yield trials.

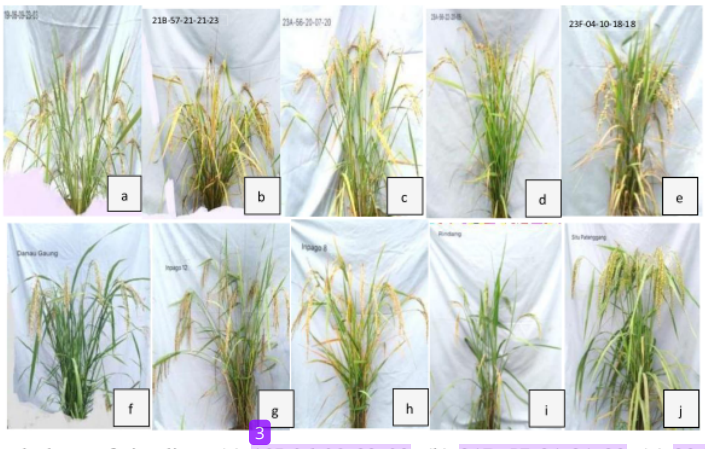
Tabel 1. ANOVA results for all characters.

Character	F Count	Pr>F	CV%
Plant height	40.03**	<0.0001	5.87
Flag leaf length	17.97**	<0.0001	9.05
Productive tiller number	3.19*	0.0171	24.58
Flowering age	15.19**	<0.0001	1.26
Panicle lenght	11.75**	0.000007	6.75
Harvest age	16.98**	<0.0001	1.8
Number of filled grain	5.63**	0.0009	24.96
Yield per plot (t)	8.72**	<0.0001	35.20
Grain number per panicle	11.78**	<0.0001	25.55
Weight of 1000 seeds	1.20^{ns}	0.3483	16.08

**: Very significant difference (α 1%), *: significant difference (α 5%), ns: no significant difference, CV: Coefficient of Varians, Pr>F: Probability value, (t): Data is transformed using arc-sin transformation ($\sin^{-1}\sqrt{X}$).

The F7 rice lines whice show greater than the check rice varieties based on LSI test will have the potential to be a superior genotype [8]. Genotypes that have higher character values than check varieties in the LSI test indicate strains that perform well and include superior genotypes [9]. Table 2 shows the rice line that had the shortest plant height was 23A-56-22-20-05, which is 63.83 cm. The plant height of 5 (five) line showed shorter than the check varieties. The plant height of F7 lines that belonged to the moderate category was found in the strain 23A-56-20-07-20 (98.30 cm). The plant height is influenced by the genetic factors of a cultivar [10]. The growth of plants that are not uniformly influenced by genetic differences cause that each cultivar has special characteristics and properties [11].

There were three F7 lines that had longer flag leaves compared to the Inpago 8 variety. Those were 19I-06-09-23-03 (35.02 cm), 21B-57-21-21-23 (29.05 cm) and 23F-04- 10-18-18 (29.26 cm). Only 2 lines, 23A-56-22-20-05 and 23A-56-20-07-20, indicate the flag leaves were no longer than all their comparing varieties (Table 2). Flag leaves have an important role in producing assimilate during the seed filling process. The length and width of the flag leaves affect the ability of plants to act as a source [12]. According to [13], width of the flag leaf plays important role in the process of forming seeds. The length of the flag leaf can be used as a potential phenotypic marker for superior traits in achieving high production yields [14].



Figures 1. Morphology of rice lines (a) 19I-06-09-23-03, (b) 21B-57-21-21-23, (c) 23A-56-20-07-20, (d) 23A-56-22-20-05, (e) 23F-04-10-18-18, and check varieties (f) Danau Gaung, (g) Inpago 12, (h) Inpago 8, (i) Rindang, and (j) Situ Patenggang.

The F7 line has a more productive tiller number than the comparison varieties. The production rate of rice crops is influenced by the productive tillers number [15]. The F7 line which has the most productive tiller number was 23A-56-22-20-05 (43.65 tiller per plant). According to [16], rice plants that have a large number of productive tillers produce a high number of panicles, which has an impact on high production.

Table 2. Result of LSI test

Genotypes	Plant height (cm)	Flag leaf length (cm)	Productive tiller number	Flowering age (DAP)	Panicle length (cm)	Harvest age (DAP)	Number of filled grain	Yield per plot (kg)	Grain number per panicle	Weight of 1000 seeds (gr)
19I-06-09-23-03	77.12 abcdef	35.02 bcf	40.48 abcde	75.60 acde	23.44	124.13 ac	1536.56	9.17	64.12	29.53 bde
21B-57-21-21-23	90.87 abcde	29.05 c	32.92 abde	73.54 acde	23.88	113.67 abcdf	1599.03	12.01 a	76.95	29.21 bde
23A-56-20-07-20	98.30 abcde	25.95	40.62 abcde	71.60 abcdef	25.24	112.00 abcdef	1580.86	12.51 a	63.29	27.89 de
23A-56-22-20-05	63.83 abcdef	25.19	43.65 abcde	73.57 acde	22.07	114.07 abcdf	1449.53	12.87 ad	57.89	28.23 de
23F-04-10-18-18	77.96 abcdef	29.26 c	39.75 abcde	72.04 abcdef	24.77	115.00 acdf	1453.63	12.80 a	59.62	28.56 de
Danau Gaung+LSI (a)	141.92	42.11	30.45	77.51	33.08	126.61	2649.23	9.73	133.55	34.34
Inpago 12+LSI (b)	119.10	32.05	30.28	73.25	26.88	116.61	2566.39	13.24	131.69	28.99
Inpago 8+LSI (c)	116.00	28.29	35.45	78.91	26.50	125.98	1726.63	13.79	87.62	32-38
Rindang+LSI (d)	131.13	38.16	29.92	76.25	28.47	119.94	1853.49	12.83	96.12	26.85
Situ Patenggang+LSI (e)	123.33	41.83	24.28	78.41	27.80	113.61	2068.53	17.17	134.25	27.11
$\bar{g}$ + LSI (f)	82.01	33.28	49.80	73.27	26.60	115.77	2078.18	14.12	91.95	35.02
LSI	**9.99**	**4.39**	**10.31**	**1.61**	**2.72**	**3.61**	**554.25**	**2.25**	**27.58**	**6.33**

The letters listed behind the numbers indicate that: (a) better than Danau Gaung, (b) better than Inpago 12, (c) better than Inpago 8, (d) better than Rindang, and (e) better than Situ Patenggang; The letter in parentheses is a symbol to indicate the check rice varieties; $\bar{g}$ = Average value of F_7 lines; The test lines are better than the check plant when the value of lines ≥ the value of the check + LSI, except for plant height, flowering age, and harvest age is betterwhen the value of lines ≤ the check value – LSI.

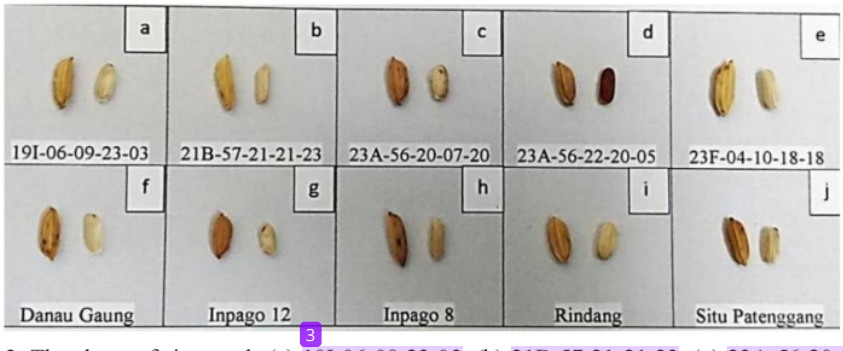


Figure 2. The shape of rice seeds (a) 19I-06-09-23-03, (b) 21B-57-21-21-23, (c) 23A-56-20-07-20, (d)23A-56-22-20-05, (e) 23F-04-10-18-18, and Comparison Varieties (f) Danau Gaung, (g) Inpago 12, (h) Inpago 8, (i) Rindang, and (j) Situ Patenggang.

All F_7 lines had no more number of filled grain than check ries varieties. The lowest number of filled grain was 23A-56-22-20-05 (449.53 grains/plant). Check varieties that have the highest number of filled grain in the variety of Danau Gaung with 2649.23 grains/plant, while for the F_7 lines most filled grain found in 21B-57-21-21-23 line with 1599.03 grains/plant. The number of grain in panicles depends on the genetic properties of the plant, such as the length of the panicle, the branch of the panicle, and the photosynthesis process produced by the plant [17]. The amount of grains in the panicle is also influenced by pest and diseasefactors [18].

The highest yield per plot was found in the 23A-56-22-20-05 line (12.87 kg/plots). This yields were higher than the check varieties of Danau Gaung and Rindang. The yield is influencedby the genetic influence of a plant as well as pest and disease attacks [19]. Low yields are influenced by seed size, where small seeds have a low seed weight [20]. The 19I-06-09-23-03 line has the heaviest of 1000 seeds (29.53 g). Lines of 19I-06-09-23-03 and 21B-57-21-21-23. have a larger seed size than the Inpago 12, Rindang and Situ Patenggang varieties. The weightof 1000 seeds is determined by the size of the seed [21].

The F_7 line that showed the highest yield was 23A-56-22-20-05. Line of 23A-56-22-20-05 resulted has advantages on the plant height, productive tiller number, flowering age, harvest age, yield per plot, and weight of 1000 seeds. This line is a type of upland red rice. The 23A-56-22-20-05 line was able to produce 6.43 tons/ha of rice yield. The second highest yield was 23F-04-10- 18-18 line with the production approximately 6.40 tons/ha of rice yield.

4. Conclusion

The yield of the F_7 lines from a cross between local accessions and national varieties were around 9.17-12.87 kg/plot or the equivalent of 4.58-6.43 tons/ha. The recommended F_7 lines as candidates for superior varieties with lodging resistance were 23A-56-22-20-05 line for red rice types and 23F-04-10-18-18 line for white rice types.

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