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The resistance of restorer lines and F1 hybrids to bacterial leaf blight disease

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Abstract. Bacterial leaf blights (BLB) is one of a major problem in hybrid rice cultivation cause yield losses from 15 to 80%. The disease is caused by the bacterium of Xanthomonas oryzae pv. oryzae (Xoo). To overcome this problem, improvement of hybrid rice parental lines have been conducted since 2010 in the Indonesian Center for Rice Research. There were two activities conducted in the research i.e. evaluation of some improved parental lines resistance to BLB and evaluation of their F1 hybrid for yield and agronomic traits during the dry season of 2015 in a field station. Results showed that several Restorer lines were resistant to BLB. The restorer lines CRS850, CRS851, CRS882, 890, and CRS982 have been identified as resistant lines in early tillering and booting stages to both Xoo IV and VII races. Those Restorer lines are the potential to use as parental lines to develop new hybrid varieties possessing resistance to BLB. The best F1 hybrids with resistance to BLB was GMJ7/CRS850 that showed resistance in early tillering and booting stages to both Xoo IV and VIII races. GMJ12/CRS890 hybrid showed the best performance and yielded higher than that of the check variety.

1. Introduction

Hybrid rice is a type of rice that has been bred from two distinctive parental lines. Hybrid rice technology is recognized as one of the alternative solutions to increase rice yield. In Indonesia, three lines system used in hybrid rice breeding was conducted by crossing Cytoplasmic Male Sterile (A line) with the restorer (R line) [1].

Climate change influences rice pest-disease infestation. Rice diseases such as rice blast, rice tungro virus (RTV), and bacterial leaf blight (BLB) could become more widespread in Indonesia. Generally, changes in wind patterns may also change the spread of both wind-borne pests and of bacteria and fungi that are the major agents of crop disease. Hence, the use of resistant variety is a cost-effective and environmentally safe approach to reduce yield loss.

Bacterial leaf blight (BLB) caused by Xanthomonas oryzae pv. oryzae (Xoo) is the most significant disease of irrigated land. The BLB can diminish grain yield by up to 50% [2] or maybe up to 80% [3]. This disease also sources low-quality fodder. Resistant varieties are needed as the main component in integrated disease control of BLB [4].

Breeding programs to improve the resistance of parental lines and the F1 hybrid have been established [5]. Parental lines of the hybrids developed in Indonesia are mostly derived from introduced lines, which are commonly more susceptible to pests and diseases. Hence, it is imperative to develop a hybrid variety using the Indonesian parental lines, which is well adjusted to the environment by identifying lines as restorer and maintainer parents [6] or crossing the existing parental lines with donor varieties.
Most of the hybrid rice varieties released in Indonesia were liable to major pests and diseases such as brown planthopper (BPH), BLB, and RTV [7]. The resistance of hybrid rice depends on the resistance of their respective parental lines. Heterosis does not make hybrid rice more or less resistant compared to their parental lines [8]. Wild abortive CMS system is not correlated to susceptibility to blast, BLB, BPH, and white back plant hopper [9].

Hybrid rice developed using three parental lines might be resistant to BLB if on condition that their respective parental lines possessing the resistance genes to those diseases. Therefore, parental lines should be selected very tightly. The objectives of the research were identified the resistance of restorer lines and F1 hybrids to BLB and also evaluated the grain yield and its components of F1 hybrids rice.

2. Materials and methods

2.1. Evaluation resistance to BLB

The differential variety was included on the test i.e. Code was used as resistant checks. Tested lines were inoculated on 15-21 days after sowing (seedling stage) using *Xanthomonas oryzae pv. Oryzae* suspension with 108cfu (colony forming unit) of concentration. Inoculations were conducted by leaf cutting. The leaf cuttings were done using scissors that have put on the suspension of inoculums. The observation was started when Code (resistant check variety) have totally damaged or 14 days after inoculation. The length of lesion and leaf length were observed and the percentage of the lesion was counted. Scoring is conducting based on the modified standard evaluation system of rice (SES)[9].

2.2. Evaluation F1 hybrids for yield and agronomic traits

Thirty-six new promising hybrid rice are used as genetic materials, compared to Hipa Jatim2 and Inpari 13 as check varieties. Field experiments were conducted during the 2015 dry season (DS) at Sukamandi, West Java (Alluvial, 16 m above sea level), Indonesia. Experiments were laid out in a randomized complete block design (RCBD) involving 38 genotypes with three replications. The plot size was 2 x 5 m2.

The rice cultivation and postharvest practices were carried out based on an integrated crop management system. Grain yield and yield components were recorded. Grain yield data and yield components were analyzed using SAS (version 9.1.3) and the analysis of variance in RCBD was used [10]. Hybrid yield performance was compared with check varieties based on the least significant difference (LSD) value at the 5%.

3. Results

Bacterial Leaf Blight (BLB) is a pathogen affected leaf of rice in altogether growth phases. Evidence on the vegetative phase of the plant is named kresek and which at the generative phase is called blight. When the infection appeared within the generative phase, the grain filling process was ended, resulting in less than perfect grains [4]. During this research, screening to BLB was conducted at two growth stages i.e. early tillering stage and booting stage.

3.1. Improvement of restorer lines resistance to Bacterial Leaf Blight (BLB)

Disease severity BLB caused by *Xanthomonas oryzae pv. Oryzae* race IV ranged from 0.42% to 23.24% and 1% to 32.44% at early tillering and booting stage, respectively. For Xoo race VIII incidence of BLB varied from 0.25% to 23.19% and 0.95% to 38.34% (Table 1). Results revealed that out of tested 27, five restorer lines i.e. CRS850, CRS851, CRS882, CRS 890, and CRS982 were found to be resistant at both early tillering and booting stages to both Xoo IV and VII races (Table 1).
Table 1. Resistant reactions of restorer lines to the two pathotypes of *Xanthomonas oryzae pv. oryzae* (Xoo) at early tillering (TS) and booting (BS) stages.

| No | Restorer lines (male parent) | Resistance level to BLB (Xoo) at two growth stage |
|----|-----------------------------|-----------------------------------------------|
|    |                             | Early tillering stage | Booting stage | Early tillering stage | Booting stage |
|    |                             | LAI (%)  | DS   | PR  | LAI (%)  | DS   | PR  | LAI (%)  | DS   | PR  |
| 1  | CRS828                      | 23.24    | 4    | MS  | 32.34    | 5    | S   | 22.36    | 4    | MS  |
| 2  | CRS832                      | 15.05    | 4    | MS  | 28.67    | 5    | S   | 16.69    | 4    | MS  |
| 3  | CRS834                      | 13.51    | 4    | MS  | 21.41    | 4    | MS  | 20.13    | 4    | MS  |
| 4  | CRS842                      | 8.14     | 3    | MR  | 11.91    | 3    | MR  | 18.31    | 4    | MS  |
| 5  | CRS848                      | 15.91    | 4    | MS  | 31.25    | 5    | S   | 14.97    | 4    | MS  |
| 6  | CRS849                      | 11.63    | 3    | MR  | 19.25    | 4    | MS  | 9.34     | 3    | MR  |
| 7  | CRS850                      | 1.1      | 1    | HR  | 1.58     | 1    | HR  | 0.33     | 1    | HR  |
| 8  | CRS851                      | 0.42     | 1    | HR  | 1.08     | 1    | HR  | 0.42     | 1    | HR  |
| 9  | CRS854                      | 12.42    | 4    | MS  | 21.25    | 4    | MS  | 12.75    | 3    | MR  |
| 10 | CRS857                      | 13.17    | 4    | MS  | 20.25    | 4    | MS  | 14      | 4    | MS  |
| 11 | CRS860                      | 12.29    | 3    | MR  | 16.83    | 4    | MS  | 11.75    | 3    | MR  |
| 12 | CRS864                      | 9.92     | 3    | MR  | 14      | 4    | MS  | 12.17    | 3    | MR  |
| 13 | CRS 865                     | 10.92    | 3    | MR  | 32.44    | 5    | S   | 12.81    | 3    | MR  |
| 14 | CRS 882                     | 0.6      | 1    | HR  | 1       | 1    | HR  | 0.25     | 1    | HR  |
| 15 | CRS 883                     | 12.17    | 3    | MR  | 20.25    | 4    | MS  | 0.52     | 1    | R   |
| 16 | CRS 887                     | 5        | 2    | R   | 14.75    | 4    | MS  | 7.5      | 3    | MR  |
| 17 | CRS 888                     | 10.17    | 3    | MR  | 18.83    | 4    | MS  | 8.92     | 3    | MR  |
| 18 | CRS 889                     | 8.25     | 3    | MR  | 11.67    | 3    | MR  | 6.08     | 2    | R   |
| 19 | CRS 890                     | 3        | 1    | HR  | 7.83     | 3    | MR  | 0.28     | 1    | HR  |
| 20 | CRS900                      | 10.79    | 3    | MR  | 14.08    | 4    | MS  | 12.08    | 3    | MR  |
| 21 | CRS 939                     | 11.1     | 3    | MR  | 13.68    | 4    | MS  | 13.06    | 4    | MS  |
| 22 | CRS 942                     | 11.32    | 3    | MR  | 11.47    | 3    | MR  | 23.19    | 4    | MS  |
| 23 | CRS 952                     | 9.75     | 3    | MR  | 16.75    | 4    | MS  | 16.17    | 4    | MS  |
| 24 | CRS961                      | 7.9      | 3    | MR  | 12.08    | 3    | MR  | 5.17     | 2    | R   |
| 25 | CRS 963                     | 8.92     | 3    | MR  | 15.08    | 4    | MS  | 7.49     | 3    | MR  |
| 26 | CRS982                      | 0.83     | 1    | HR  | 5.58     | 2    | HR  | 0.35     | 1    | HR  |
| 27 | CRS1002                     | 7.67     | 3    | MR  | 12.08    | 3    | MR  | 6.93     | 2    | R   |

Note: LAI: Lesion area infection (%), DS: Disease scale, PR: Plant response, HR: Highly resistant, MR: Moderately resistant, R: Resistant, MS: Moderately Susceptible, S: Susceptible, HS: Highly susceptible.

3.2. Improvement of F1 hybrid rice combinations resistance to Bacterial Leaf Blight

All the F1 hybrids rice showed varied disease severity to Xoo race IV at the early tillering stage with the average percentage of the lesion ranging from 0.42% to 31.33%. At the booting stage, most of the F1 plants exhibited increased resistance to Xoo race IV as to those at the early tillering stage, with disease severity from 8% to 39.67%. Whereas, the result of disease severity BLB Xoo race VIII ranged from 0.40% to 14.66% and 0.70% to 35.67% at early tillering and booting stage, respectively (Table 2).
Table 2. Resistant reactions of F1 hybrid rice combinations to the two patotype of Xanthomonas oryzae pv. oryzae (Xoo) at early tillering (TS) and booting (BS) stages.

| No | F1 hybrid rice combinations | Resistance level to BLB (Xoo) at two growth stage |  |
|----|-----------------------------|---------------------------------------------------|---|
|    |                             | Early tillering stage                               | Booting stage | Xoo race IV | Xoo race VIII |  |
|    |                             | LAI (%) DS PR                                       | LAI (%) DS PR | Early tillering stage | Booting stage | LAI (%) DS PR |
| 1  | GMJ12/CRS887                | 9.00 3 MR 8.00 3 MR                                | 12.43 3 MR 16.32 4 MS |  |
| 2  | GMJ12/CRS890                | 27.33 5 S 11.67 3 MR                              | 7.56 3 MR 12.87 3 MR |  |
| 3  | GMJ12 / CRS963              | 19.58 4 MS 13.67 4 MS                              | 7.17 3 MR 9.42 3 MR |  |
| 4  | GMJ6/CRS900                 | 8.92 3 MR 13.42 4 MS                               | 8.33 3 MR 8.26 3 MR |  |
| 5  | GMJ7/CRS900                 | 15.36 4 MS 20.00 4 MS                              | 14.08 4 MS 23.11 4 MS |  |
| 6  | GMJ12/CRS849                | 11.00 3 MR 13.33 4 MS                              | 10.91 3 MR 17.24 4 MS |  |
| 7  | GMJ12/CRS848                | 14.92 4 MS 16.17 4 MS                              | 12.82 3 MR 16.93 4 MS |  |
| 8  | GMJ12/CRS850                | 8.08 3 MR 16.92 4 MS                               | 9.63 3 MR 20.46 4 MS |  |
| 9  | GMJ12/CRS900                | 10.67 3 MR 14.93 4 MS                              | 3.80 1 R 3.18 2 R  |  |
| 10 | A7/CRS860                   | 16.83 4 MS 19.94 4 MS                              | 14.22 4 MS 35.67 5 S  |  |
| 11 | A7/CRS939                   | 20.17 4 MS 16.50 4 MS                              | 7.64 3 MR 14.02 4 MS |  |
| 12 | GM12/CRS860                 | 14.17 4 MS 23.67 4 MS                              | 10.97 3 MR 21.38 4 MS |  |
| 13 | GMJ12/CRS842                | 9.83 3 MR 21.83 4 MS                               | 8.01 3 MR 16.19 4 MS |  |
| 14 | GMJ12/CRS851                | 4.25 2 R 18.83 4 MS                               | 6.96 2 R 13.12 4 MS |  |
| 15 | A7/CRS900                   | 9.50 3 MR 23.33 4 MS                               | 14.66 4 MS 21.84 4 MS |  |
| 16 | GMJ12/CRS882                | 8.50 3 MR 14.25 4 MS                               | 1.41 1 R 11.10 3 MR |  |
| 17 | GMJ12/CRS961                | 8.58 3 MR 15.08 4 MS                               | 11.06 3 MR 20.48 4 MS |  |
| 18 | A7/CRS828                   | 14.17 4 MS 39.67 5 S                               | 11.78 3 MR 21.31 4 MS |  |
| 19 | GMJ12/CRS982                | 7.67 3 MR 14.25 4 MS                               | 8.17 3 MR 11.06 3 MR |  |
| 20 | GMJ12/CRS889                | 9.67 3 MR 13.17 4 MS                               | 7.81 3 MR 20.83 4 MS |  |
| 21 | GMJ10/CRS883                | 3.58 1 R 10.75 3 MR                                | 9.26 3 MR 12.43 3 MR |  |
| 22 | GMJ12/CRS857                | 8.33 3 MR 15.75 4 MS                               | 14.16 4 MS 18.97 4 MS |  |
| 23 | A7/CRS888                   | 8.25 3 MR 20.75 4 MS                               | 10.33 3 MR 16.24 4 MS |  |
| 24 | GMJ7/CRS850                 | 0.42 1 R 8.42 3 MR                                 | 0.40 1 R 0.70 1 R  |  |
| 25 | GMJ12/CRS1002               | 5.00 2 R 14.08 4 MS                                | 6.94 2 R 25.80 4 MS |  |
| 26 | GMJ12/CRS832                | 15.63 4 MS 16.17 4 MS                              | 9.59 3 MR 20.23 4 MS |  |
| 27 | GMJ7/CRS834                 | 12.08 3 MR 16.83 4 MS                              | 14.61 4 MS 22.36 4 MS |  |
| 28 | GMJ10/CRS864                | 11.67 3 MR 17.25 4 MS                              | 10.31 3 MR 12.38 3 MR |  |
| 29 | A7/CRS1002                  | 10.67 3 MR 15.75 4 MS                              | 13.84 4 MS 16.71 4 MS |  |
| 30 | GMJ12/CRS942                | 9.83 3 MR 20.50 4 MS                               | 9.28 3 MR 18.17 4 MS |  |
| 31 | GMJ7/CRS872                 | 10.83 3 MR 14.33 4 MS                              | 4.53 2 R 11.00 3 MR |  |
| 32 | GMJ12/CRS939                | 31.33 5 S 15.25 4 MS                               | 5.29 2 R 14.75 4 MS |  |
| 33 | GMJ12/CRS865                | 10.08 3 MR 17.17 4 MS                              | 9.75 3 MR 13.47 4 MS |  |
| 34 | GMJ10/CRS860                | 12.67 3 MR 20.33 4 MS                              | 5.01 2 R 20.57 4 MS |  |
| 35 | GMJ12/CRS854                | 10.33 3 MR 20.00 4 MS                              | 13.71 4 MS 16.90 4 MS |  |
| 36 | A7/CRS952                   | 15.32 4 MS 20.25 4 MS                               | 7.02 3 MR 9.17 3 MR  |  |

Note. LAI: Lesion area infection (%), DS: Disease scale, PR: Plant response, HR: Highly resistant, MR: Moderately resistant, R: Resistant, MS: Moderately Susceptible, S: Susceptible, HS: Highly susceptible.
Table 3. Agronomic performance of F1 hybrid rice combinations tested under normal field conditions during 2015 dry season in Sukamandi, West Java.

| No. | F1 hybrid rice combinations | Plant height (cm) | Number of productive tillers | Seed set (%) | 1000 grain weight (g) |
|-----|-----------------------------|-------------------|-----------------------------|--------------|----------------------|
| 1   | GMJ12/CRS887                | 118.0             | 13                          | 68.0         | 27.0                 |
| 2   | GMJ12/CRS890                | 120.8             | 13                          | 70.8         | 27.4                 |
| 3   | GMJ12/CRS963                | 118.7             | 13                          | 68.6         | 27.5                 |
| 4   | GMJ6/CRS900                 | 119.1             | 14                          | 64.9         | 26.3                 |
| 5   | GMJ7/CRS900                 | 121.6             | 13                          | 63.3         | 26.8                 |
| 6   | GMJ12/CRS849                | 120.8             | 12                          | 67.1         | 26.3                 |
| 7   | GMJ12/CRS848                | 121.5             | 13                          | 64.4         | 25.8                 |
| 8   | GMJ12/CRS850                | 114.6             | 14                          | 72.6         | 26.1                 |
| 9   | GMJ12/CRS900                | 119.0             | 13                          | 67.2         | 26.5                 |
| 10  | A7/CRS860                   | 122.0             | 14                          | 74.3         | 26.1                 |
| 11  | A7/CRS939                   | 121.2             | 13                          | 74.4         | 26.3                 |
| 12  | GM12/CRS860                 | 118.7             | 13                          | 78.0         | 27.8                 |
| 13  | GM12/CRS842                 | 121.0             | 13                          | 71.1         | 27.4                 |
| 14  | GM12/CRS851                 | 119.2             | 12                          | 68.4         | 27.9                 |
| 15  | A7/CRS900                   | 119.5             | 14                          | 64.1         | 27.0                 |
| 16  | GM12/CRS882                 | 119.1             | 13                          | 71.7         | 26.9                 |
| 17  | GM12/CRS961                 | 120.9             | 13                          | 64.4         | 28.2                 |
| 18  | A7/CRS828                   | 119.6             | 13                          | 78.1         | 26.6                 |
| 19  | GMJ12/CRS892                | 115.9             | 13                          | 68.0         | 26.8                 |
| 20  | GMJ12/CRS889                | 112.0             | 12                          | 64.8         | 26.4                 |
| 21  | GMJ10/CRS883                | 111.7             | 14                          | 81.7         | 24.9                 |
| 22  | GMJ12/CRS857                | 116.4             | 13                          | 71.8         | 28.4                 |
| 23  | A7/CRS888                   | 116.1             | 14                          | 54.0         | 27.5                 |
| 24  | GMJ7/CRS850                 | 115.1             | 13                          | 69.7         | 26.4                 |
| 25  | GMJ12/CRS1002               | 118.2             | 14                          | 71.0         | 27.3                 |
| 26  | GMJ12/CRS832                | 118.2             | 13                          | 66.3         | 28.1                 |
| 27  | GMJ7/CRS834                 | 116.4             | 14                          | 67.2         | 26.7                 |
| 28  | GMJ10/CRS864                | 119.1             | 13                          | 72.8         | 29.2                 |
| 29  | A7/CRS1002                  | 119.0             | 14                          | 73.0         | 26.6                 |
| 30  | GMJ12/CRS942                | 115.1             | 13                          | 68.0         | 26.9                 |
| 31  | GMJ7/CRS872                 | 119.9             | 13                          | 59.8         | 26.2                 |
| 32  | GMJ12/CRS939                | 114.4             | 14                          | 69.8         | 26.8                 |
| 33  | GMJ12/CRS865                | 116.3             | 12                          | 67.2         | 27.1                 |
| 34  | GMJ10/CRS860                | 118.1             | 12                          | 80.3         | 29.6                 |
| 35  | GMJ12/CRS854                | 117.9             | 13                          | 67.1         | 27.5                 |
| 36  | A7/CRS952                   | 118.3             | 13                          | 71.8         | 27.7                 |
| 37  | Hipa Jatim2                 | 119.4             | 13                          | 73.8         | 27.7                 |
| 38  | Inpari 31                   | 115.5             | 13                          | 75.6         | 25.9                 |

LSD (%)  2.9  48.4  11.2  32.0
CV (%)  2.7  5.2  6.3  7.1

3.3. Agronomic traits and grain yield of F1 hybrid rice combinations
Some hybrids selected from the preliminary yield trial conducted during the dry season of 2015 is listed in Table 3. Some of the hybrids had better agronomic characters than check varieties. Regarding plant height, A7/CRS860 (122.0 cm) was the highest while GMJ10/CRS883 (111.7 cm) was the shortest. The number of productive tillers of F1 hybrids varied from 12 to 14. The percentage of seed
set was the highest in GMJ7/CRS883 (81.7%) but the lowest in A7/CRS888 (54%). Thousand-grain weights of GMJ10/CRS860 (29.6 g) were heavier than other F1 combinations (Table 3).

Grain yield and standard heterosis value of yield character of the 36 hybrids are shown in Table 4. Table 5 shows that the range of grain yield of F1 hybrid between 4.23 t/ha (GMJ7/CRS872) to 7.91 t/ha (GMJ12/CRS890). The best hybrid was GMJ12/CRS890 with a heterosis value of 16.36% higher than Inpari31 (inbred rice variety) and 8.83% higher than Hipa 18 (hybrid rice variety).

| No. | F1 hybrid rice combinations | Grain yield (ton/ha) | Standard heterosis (%) compared to: |
|-----|-----------------------------|----------------------|------------------------------------|
|     |                             |                      | Inpari 31 | Hipa 18 |
| 1   | GMJ12/CRS887                | 7.59                 | 11.68    | 4.46    |
| 2   | GMJ12/CRS890                | 7.91                 | 16.36    | 8.83    |
| 3   | GMJ12 / CRS963              | 7.12                 | 4.64     | -2.13   |
| 4   | GMJ6/CRS900                 | 7.26                 | 6.80     | -0.10   |
| 5   | GMJ7/CRS900                 | 5.67                 | -16.59   | -21.98  |
| 6   | GMJ12/CRS849                | 7.36                 | 8.22     | 1.22    |
| 7   | GMJ12/CRS848                | 7.20                 | 5.92     | -0.92   |
| 8   | GMJ12/CRS850                | 7.48                 | 9.99     | 2.88    |
| 9   | GMJ12/CRS900                | 7.25                 | 6.68     | -0.22   |
| 10  | A7/CRS860                   | 6.99                 | 2.73     | -3.91   |
| 11  | A7/CRS939                   | 6.72                 | -1.24    | -7.63   |
| 12  | GMJ12/CRS860                | 7.20                 | 5.86     | -0.98   |
| 13  | GMJ12/CRS842                | 7.37                 | 8.35     | 1.34    |
| 14  | GMJ12/CRS851                | 7.36                 | 8.22     | 1.22    |
| 15  | A7/CRS900                   | 6.43                 | -5.44    | -11.55  |
| 16  | GMJ12/CRS882                | 7.55                 | 11.04    | 3.87    |
| 17  | GMJ12 / CRS961              | 7.22                 | 6.18     | -0.68   |
| 18  | A7/CRS828                   | 7.21                 | 6.00     | -0.86   |
| 19  | GMJ12 / CRS982              | 6.42                 | -5.63    | -1.73   |
| 20  | GMJ12/CRS889                | 6.48                 | -4.74    | -10.90  |
| 21  | GMJ10/CRS883                | 6.28                 | -7.59    | -13.57  |
| 22  | GMJ12/CRS857                | 6.73                 | -1.08    | -7.47   |
| 23  | A7/CRS888                   | 4.63                 | -31.86   | -36.26  |
| 24  | GMJ7/CRS850                 | 6.28                 | -7.65    | -13.62  |
| 25  | GMJ12 / CRS1002             | 7.78                 | 14.45    | 7.05    |
| 26  | GMJ12/CRS832                | 6.55                 | -3.68    | -9.91   |
| 27  | GMJ7/CRS834                 | 5.28                 | -22.30   | -27.32  |
| 28  | GMJ10/CRS864                | 5.01                 | -26.38   | -31.14  |
| 29  | A7 / CRS1002                | 7.23                 | 6.30     | -0.57   |
| 30  | GMJ12 / CRS942              | 7.15                 | 5.08     | -1.72   |
| 31  | GMJ7/CRS872                 | 4.23                 | -37.83   | -41.85  |
| 32  | GMJ12 / CRS939              | 7.45                 | 9.61     | 2.52    |
| 33  | GMJ12/CRS865                | 6.18                 | -9.11    | -14.99  |
| 34  | GMJ10/CRS860                | 6.65                 | -2.14    | -8.46   |
| 35  | GMJ12/CRS854                | 7.44                 | 9.41     | 2.34    |
| 36  | A7 / CRS952                 | 6.75                 | -0.71    | -7.13   |
| 37  | Hipa Jatim2                 | 7.27                 |          |         |
| 38  | Inpari 31                   | 6.80                 |          |         |

LSD (%) 12.56  
CV (%) 0.69

4. Discussions
The currency of BLB disease in Indonesia is threatening the development of hybrids rice as a reaction to their susceptibility. The term in hybrid rice breeding for disease BLB is improving the resistance of
its parental lines (CMS, maintainer, and restorer lines) to BLB disease. Beginning from 2010, improvement of parental lines, for example, restorer, CMS, and maintainer line have been conducting by conventional crossing between the parental lines and a few donor lines of local and elite lines.

This program has crossed existing R lines with donors from released varieties (Maros and Siakraya), isogenic lines (IRBB 57), and elite lines (BIG12-3, RCN-B-94-19, IR71103) that have resistance to HDB. The isogenic lines with pyramiding genes were IRBB 55, IRBB 57, IRBB 60, IRBB 61, etc. can be used in the breeding of resistant new varieties to BLB [11]. The identification [12] showed that the most important resistance Xa genes in Indonesia were x5, Xa7, and Xa21.

The parental lines are important for the development of BLB resistance in hybrid rice breeding. The research identified five restorer lines having a high level of resistance all Xoo race. The restorer has resistance to HDB with a score around 1–3 (Table 2). Some HDB-resistant restorers can reduce hybrids that also have resistance, but the reaction of these hybrids is not always the same as the restorer reaction [13].

There were different reactions between BLB-resistant restorers and F1 hybrids. For example, the restorer lines (CRS 882 and CRS 982) had high resistance to BLB (Table 1), however, the reaction to BLB of F1 hybrids (GMJ12/CRS882 and GMJ12/CRS982) was only moderately resistant (Table 2). Furthermore, the resistance level of F1 was dominated by the interaction between CMS and restorer line when CMS was resistant. We saw that restorer lines with Xa21 (CRS888, CRS889, and CRS890) and their derived hybrid combinations were moderately resistant to all IV and VII races tested particularly at booting stages.

As shown in this study, the parental lines conveying resistant genes (CRS883 and CRS850) and express high resistance in its F1 hybrids (GMJ7/CRS883 and GMJ10/CRS850), did not generally exhibit good agronomic traits. Subsequently, the program to improve the resistance to BLB of the parental lines must be completed simultaneously by testing the combining ability F1 hybrid rice.

5. Conclusion
The restorer lines with resistance to BLB were CRS850, CRS851, CRS882, 890, and CRS982 that showed resistance at both early tillering and booting stages to both Xoo IV and VIII races. The best F1 hybrids with resistance to BLB was GMJ7/CRS850 that showed resistance at both early tillering and booting stages to both Xoo IV and VIII races. GMJ12/CRS890 hybrid has the best performance with a higher grain yield than that of the check varieties.

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