Field resistant test of new superior varieties of rice in lowland irrigation agroecosystem against rice blast disease

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Abstract. Rice blast disease is one of the main problems for increasing rice production in Indonesia. It can be controlled by planting new superior varieties of rice. Therefore the rotation of varieties is very important. The research aims to obtain disease control methods through the use of new superior varieties (VUB) of lowland rice. The study was carried out in Sambasule, Meluhu Sub-district, Konawe District, Southeast Sulawesi during the rainy season of 2016. The experiment was arranged in a randomized block design (RBD) with seven treatments and four replications. Each plot was 50 m x 50 m, so the total land area of the experiment was 10,000 m². Plants were maintained through the Integrated Crop Management (IPM) of lowland rice approach. Disease incidence of the rice blast was observed based on the Standard Evaluation System of rice from the International Rice Research Institute (IRRI). The results showed that Inpari 32, Inpari Blas, Inpari 22 and Ciherang were moderately resistant to leaf blast and insignificantly different to Inpari 26, Inpari 27 and IPB4S. In addition, Inpari 32 is moderately resistant to neck blasts and insignificantly different to Inpari 26, Inpari 27 and IPB4S. In addition, Inpari 32 is moderately resistant to neck blasts and insignificantly different to Inpari 22, Inpari Blas and Ciherang.

1. Introduction
Southeast Sulawesi is a rice producing province which contributes to national rice self-sufficiency. The challenges in achieving rice self-sufficiency are high population growth rates, conversion of rice fields, increase of inter-farm competition, limited water resources, floods and droughts due to climate change caused by global warming [20].

Climate change has affected the dynamics of plant pests and diseases, such as rice blast. Rice blast plays an important role in decreasing worldwide rice production, where yield loss ranges from 1 - 50% [8]. Under a favorable environment, rice blast is widely distributed and very destructive. In Indonesia, however, rice blast is one of the major diseases, both on upland and lowland rice. Recently, the incidence of rice blast is also found in tides and swamps.

In 2016, the major rice disease in the lowland area of Southeast Sulawesi was rice blast with an incidence of 3,262 ha [3]. [13] reported that the rice blast incidences reached up to 40.25% over the total area of rice growing in Konawe District. Therefore, the high incidence of rice blast needs extraordinary attention to prevent its spread.

Rice blast, caused by *Pyricularia oryzae*, is one of the main problems for increasing rice production in Indonesia. In general, there are two types of rice blasts, namely: leaf blasts and panicle neck blast. Leaf blast occurred when the pathogen infects rice plants during the vegetative phase. On the other hand, panicle neck blasts occurred when the pathogen infects rice plants during the generative phase. Furthermore, pathogen infection at the panicle of rice causes hollow grains...
Modification of cultivation techniques, especially the use of resistant varieties is generally applied in controlling rice blast [14],[1]. However, the pathogen overcomes the resistance of varieties easily due to high genetic diversity (various pathotypes/races) [19].

Rice blast can be controlled through an integrated crop management approach, such as the use of resistant varieties, diversification of varieties, cultivation techniques, and chemicals [17]. The use of resistant varieties is an effective, inexpensive and environmentally friendly mean to control rice blast. However, the resistance of variety is easily overcome by the pathogen after the variety planted in several seasons. Resistant variety deployment should be suitable with the distribution of dominant races of rice blast in an area. If rice is planted throughout the year, the variety must be rotated as well as gene rotation [15]. In addition, recent study revealed that strong winds with speeds ranging from 2.0 to > 7.3 m/s are more effective in controlling blast disease than conventional fungicides [22].

The Indonesian Agency for Agricultural Research and Development has released superior rice varieties that are resistant to rice blast and high productivity. Some of those varieties have been grown widely in Indonesia. Therefore, some of the varieties need to be tested and adapted in Southeast Sulawesi. The study aims to obtain recommendations for managing rice blast through the use of new superior rice varieties in lowland agroecosystem.

2. Materials and Methods
The assessment was carried out in Sambasule village, Meluhu sub-district, Konawe District, Southeast Sulawesi from January to December 2016. The experiment was arranged a randomized block design with seven treatments and four replications. The treatments were seven superior rice varieties, namely: Inpari 22, Inpari 26, Inpari 27, Inpari 32, Inpari Blas, IPB-4S and Ciherang. The plot was 50m x 50m and the total area of the experimental field was 10,000 m². Rice plants were maintained by an integrated crop management approach.

Primary data were obtained from field observations and direct interviews with farmers. Growth of rice varieties was observed by measuring agronomic traits, such as: plant height, number of tillers per hill, number and length of panicle, number of grains per panicle, number of unfilled grains per panicle, the weight of 1000 grains, and yields. The severity of leaf blast was determined by severity scale based on the Standard Evaluation System for Rice [6]. Data were submitted to Analysis of Variance (ANOVA) and means were compared by Duncan’s Multiple Range Test (DMRT) at P ≤ 0.05. Secondary data were obtained from relevant institutions or agencies.

3. Results and Discussion
3.1. Agronomic performance
Table 1. Agronomic performances of several rice varieties in Sambasule, Konawe District, Southeast Sulawesi, Wet season 2016

| No | Varieties   | Number of Maximum tillers per hill | Number of Productive tillers per hill | Plant height (cm) | Panicle length (cm) |
|----|-------------|-----------------------------------|--------------------------------------|-------------------|---------------------|
| 1  | Inpari 22   | 12.33 a                           | 9.00a                                | 87.67 a           | 21.66 ab            |
| 2  | Inpari 26   | 11.00 ab                          | 8.25a                                | 87.00a            | 21.25 bc            |
| 3  | Inpari 27   | 12.00 ab                          | 9.25a                                | 85.25a            | 20.75 bc            |
| 4  | Inpari 32   | 11.00 ab                          | 9.00a                                | 87.75a            | 19.75 c             |
| 5  | Inpari Blas | 12.00 ab                          | 9.25a                                | 93.00a            | 20.75 bc            |
| 6  | IPB-4S      | 10.50b                            | 7.75a                                | 93.25a            | 23.00a              |
| 7  | Ciherang    | 11.00 ab                          | 8.25a                                | 73.50a            | 20.75 bc            |

Means in the same column followed by the different letters differ significantly under DMRT (α≤ 5%)
3.1.1 Maximum tillers and productive tillers. Table 1 shows the number of maximum tillers ranging from 10-12 per hill. Inpari 22 had the highest number of maximum tillers which was 12.33 tillers per hill but not significantly different among other varieties, except for IPB4S which had 10.50 tillers per hill. Moreover, the number of productive tillers was not significantly different among all varieties. The diversity of the rice characteristics was determined by the diversity of environment and genotypes, as well as its interactions [16]. According to [12], plant height and number of tillers are genotypically inherited by the variety. Maximum growth of tillers can be achieved if the variety has good genetic traits and a favorable environment for the plant growth [5].

3.1.2 Plant height and panicle length. Table 1 showed that there were no significant differences in plant height among the seven varieties tested. The highest plant height was IPB4S (93.25 cm), followed by Inpari blas (93.00 cm), Inpari 32 (87.75 cm), Inpari 22 (87.67 cm), Inpari 26 (87.00 cm), Inpari 27 (85.25 cm) and Ciherang (73.50 cm) respectively. Furthermore, the panicle length of the seven varieties tested was varied at 19.75-23.00 cm. The longest panicle length was Inpari IPB4S (23.00 cm) insignificantly different to Inpari 22 (21.66 cm). However, it was significantly different to Inpari 26 (21.25 cm), Inpari 27 (20.75 cm), Ciherang (20.75 cm) and Inpari 32 (19.75 cm). The unfavorable environment was thought to inhibit plant growth. Vigorous plants were able to absorb soil nutrient and it has better capability to utilize sunlight for photosynthesis which could increase plant growth and yields.

3.2. Yield performances.

Table 2. Yield performances of several rice varieties in Sambasule, Konawe District, Southeast Sulawesi, Wet season 2016

| No | Varieties | Number of Filled grains per panicle | Number of Unfilled grains per panicle | Weight of 1000 grains (gram) | Yield (ton/ha) |
|----|-----------|-------------------------------------|---------------------------------------|----------------------------|---------------|
| 1  | Inpari 22 | 77.75 ab                            | 14.00 a                               | 28.33 a                    | 3.66 a        |
| 2  | Inpari 26 | 50.76 c                             | 17.00 a                               | 27.50 a                    | 1.75 c        |
| 3  | Inpari 27 | 63.75 bc                            | 14.75 a                               | 26.75 a                    | 3.00 ab       |
| 4  | Inpari 32 | 84.00a                              | 12.33 a                               | 28.50 a                    | 3.75 a        |
| 5  | Inpari Blas | 74.75 ab                         | 13.50 a                               | 28.25 a                    | 3.00 ab       |
| 6  | IPB4S     | 61.00 bc                            | 14.50 a                               | 28.75 a                    | 2.50 bc       |
| 7  | Ciherang  | 73.50ab                             | 14.00a                                | 28.50 a                    | 3.25 ab       |

Means in the same column followed by the different letters differ significantly under DMRT (α≤ 5%)

3.2.1 Filled and unfilled grains. The highest average of filled grain is Inpari 32 (84.00) insignificantly different to Inpari 22 (77.75), Inpari Blas (74.75) and Ciherang (73.75), but significantly different to Inpari 27 (63.75), IPB4S (61.00) and Inpari 26 (50.76). Furthermore, there was no difference in unfilled grains among varieties. The number of filled grains is influenced by its variety and it is also an important trait which correlates to the potential yield of rice. Therefore, lines, which have high number of filled grains, were more likely to give higher yields [4].

3.2.2 Weight of 1000 grains and yields. The results showed that the weight of 1000 grains was similar among varieties. [7] reported that the optimum number of grain could be achieved by adjusting plant space for optimum population density and optimum fertilization by giving N fertilizer as well as organic fertilizer according to a site-specific recommendation. This study showed that the highest yield achieved by Inpari 32 (3.75t/ha) insignificantly different to Inpari 22 (3.66t / ha), Inpari 27 (3.00 t / ha), Inpari Blas (3.00 t / ha), and Ciherang (3.25 t / ha), but significantly different to Inpari 26 (1.75
t/ha) and IPB4S (2.50 t/ha). [24] revealed that grain yields were strongly influenced by the varieties planted, the incidence and severity of pests and diseases, and environmental conditions (water availability, appropriate fertilization, plant splinters due to strong wind).

3.3 Incidence of rice blast

Initial incidence of leaf blast was observed at 28 days after planting (dap), when the first fertilization (complete fertilizer Nitrogen, Phosphor, Potassium) has been applied. The highest incidence of the leaf blast was IPB4S (10.75%) insignificantly different to Inpari Blas (8.00%) but significantly different to Ciherang (1.00%), Inpari 27 (2.00%), Inpari 32 (2.50%), Inpari 22 (3.25%) and Inpari 26 (4.00%) respectively. The incidence of leaf blast increased at 42 dap, where the highest incidence was Inpari Blas (28.75%) insignificantly different to four other varieties, namely IPB4S (24.25%), Inpari 27 (23.50%), Inpari 26 (20.00%) and Inpari 22 (18.75%) respectively, but significantly different to Inpari 32 (6.25%) and Ciherang (6.255%). Increased incidence of leaf blasts due to the experimental site is an endemic area of rice blast and also application of second fertilizer (Nitrogen fertilizer) at 35 dap which triggers pathogen development. High-dosed nitrogen fertilization and high density of plants induce the development of blast disease due to increased humidity under plant canopy [11]. Different rates of Nitrogen application positively correlated to rice blast incidence. Furthermore, the application of silicates and potassium (KCl-based fertilizer) plays an important role to improve plant rigidity, stimulate root growth, and plant resistance to pests and diseases [2].

Table 3. Disease incidence of leaf blast on several rice varieties in Sambasule, Konawe District, Southeast Sulawesi, Wet season 2016

| Varieties   | Incidence (%) | 14 dap | 28 dap | 42 dap | 56 dap | 70 dap |
|------------|---------------|--------|--------|--------|--------|--------|
| Inpari 22  | 0 a           | 3.25 bc| 18.75 a| 6.75 ab| 3.33 a |        |
| Inpari 26  | 0 a           | 4.00 bc| 20.00 a| 6.25 ab| 6.50 a |        |
| Inpari 27  | 0 a           | 2.00 c | 23.50 a| 10.00 a| 5.75 a |        |
| Inpari 32  | 0 a           | 2.50 bc| 6.25 b | 2.00 b | 1.75 a |        |
| Inpari Blas| 0 a           | 8.00 ab| 28.75 a| 6.00 ab| 2.50 a |        |
| IPB4S      | 0 a           | 10.75 a| 24.25 a| 8.75 a | 6.00 a |        |
| Ciherang   | 0 a           | 1.00 c | 6.25 b | 3.25 b | 3.75 a |        |

Means in the same column followed by the different letters differ significantly under DMRT (α≤ 5%)
Table 4. Disease incidence of panicle blast on several rice varieties in Sambasule, Konawe District, Southeast Sulawesi, Wet season 2016

| Varieties      | Disease incidence (%) |
|----------------|-----------------------|
|                | 14 dap | 28 dap | 42 dap | 56 dap | 70 dap | 84 dap |
| Inpari 22      | 0 a    | 0 a    | 0 a    | 0 a    | 0 a    | 12.66 bc |
| Inpari 26      | 0 a    | 0 a    | 0 a    | 0 a    | 0 a    | 37.75 a  |
| Inpari 27      | 0 a    | 0 a    | 0 a    | 0 a    | 0 a    | 28.50 ab |
| Inpari Blas    | 0 a    | 0 a    | 0 a    | 0 a    | 0 a    | 4.50 c   |
| IPB4S          | 0 a    | 0 a    | 0 a    | 0 a    | 0 a    | 26.25 ab |
| Ciherang       | 0 a    | 0 a    | 0 a    | 0 a    | 0 a    | 6.25 c   |

* dap: day after planting

Means in the same column followed by the different letters differ significantly under DMRT (∝≤ 5%)

The severity of neck blast varies greatly in the range of 4.50-37.75%. This shows that the resistance of varieties plays an important role in rice performance. Table 4 shows that Inpari 32 and Ciherang are moderately resistant to neck blast with disease severity of <10% insignificantly different to Inpari 22 (12.66%) and Inpari Blas (9.50%), but significantly different to Inpari 26 (37.75%), Inpari 27 (28.50%) and IPB4S (26.25%). The moderately resistant varieties are expected to be used as recommendations for improving rice varieties to obtain superior rice varieties which are resistant to race-specific rice blast developed in the study area. The use of resistant varieties is considered as an effective way to control rice blast. Studies in Indramayu in the 2003/2004 rain season, Limboto, Way Rarem, and Batutugi varieties were classified as resistant. On the other hand, Towuti, Cirata and Fatmawati varieties were classified as susceptible to neck blast disease [18].

Varieties reaction to the rice blast was determined by dynamics of dominant races composition in certain distribution area. Recently, 64 rice blast races have been detected, some of which were found in Situng (West Sumatra). Novel races were mainly found in Karang Agung (South Sumatra) and West Java. Those races commonly infect Lematang, Kapuas, Krueng Aceh, IR64, Cisokan and Cisadane varieties. In Situng, rice blast races infect upland rice, such as: Sentani, Tondano, Maninjau, Ranau, Arias, Bicol, and C-22 varieties. However, [10] reported that the Semariti and Sirendah varieties were still able to survive. In addition, resistance genes play an important role in enhancing defend mechanism against abiotic and biotic stresses in some varieties or lines which have Pup1 locus [9],[23].

Monitoring of the rice blast races population in Lampung during 2000 - 2004 stated that there were 13-17 rice blast races with diverse race compositions. During the five years of monitoring, a total of 26 different races were identified, including 7 races presence in every year, namely race 001, 023, 033, 073, 101, 133, and 173. Monitoring of rice blast races during 2007 - 2008 in several locations in Indonesia such as Sumatra (Kayu Agung, Lampung), Central Kalimantan (Dadahup), Bali (Tabanan) and West Java (Kuningan), has identified 18 races such as race 001, 021, 040, 041, 051, 061, 071, 073, 100, 101, 121, 201, 203, 241, 301, 333, 341, and 343 [15]. Race composition in each growing season is always dynamic, both in number and dominance. Race 001, 003, 033 and 173 are always present in every growing season. In addition, races 041, 043, 051, 061, 073, 141, 161, 163, and 173 can infect IR64 varieties.
4. Conclusion

Inpari 32, Inpari Blas, Inpari 22 and Ciherang varieties were moderately resistant to leaf blast and insignificantly different to Inpari 26, Inpari 27 and IPB4S. Inpari 32 is moderately resistant to neck blasts and insignificantly different to Inpari 22, Inpari Blas and Ciherang. Inpari 32 has the highest yield and insignificantly different to Inpari 22, Inpari 27, Inpari Blas, and Ciherang (3.25 t / ha GKP) but significantly different to Inpari 26 and IPB4S varieties.

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