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Identification of the resistance of local Banten rice to biotype 2 brown planthoppers (*Nilaparvata lugens* stål.)

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Abstract. The brown planthopper (BPH) is one of the major pests of rice that causes significant losses. One of the control efforts against BPH is using resistant varieties. Local rice varieties serve as germplasm resources that can be utilized to develop resistant varieties. This research aims to identify the resistance of four local rice varieties from Banten to BPH and to identify the biotype of the tested BPH insect used in this study. The study was conducted from November 2018 to April 2019 at the greenhouse of the Banten Assessment Institute for Agricultural Technology. Resistance identification against BPH was performed on Banten local rice varieties: Gadog, Rabig, Ketan Gadung, and Apel Merah, with TN1 used as a susceptible control variety. Resistance testing used BPH field populations from Pontang District, Serang Regency, on 7-day-old seedlings. Furthermore, biotype identification of the BPH insect was conducted using differential varieties: TN1, Mudgo, ASD7, and Rathu Heenati. BPH biotype determination followed the Standard Evaluation System for Rice by IRRI. The results of the resistance testing showed that Gadog rice was highly susceptible, Rabig and Ketan Gadung were susceptible, and Apel Merah was resistant to the tested BPH population. The identification of the test insect revealed biotype 2.

1 Introduction

For millions of people around the world, rice is a basic staple food that sustains their way of life. Rice farming is especially important in areas like Banten, Indonesia, where it is essential to local agriculture and food security. However, pests like the brown planthopper (*Nilaparvata lugens* Stål) frequently threaten the yield of rice crops.

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The brown planthopper is a monophagous pest that attacks rice at different phases of growth, resulting in mild to severe damage (hopperburn) and ultimately crop failure [1–6]. By sucking plant sap, BPH can directly harm plants by causing desiccation and death (hopperburn); indirectly, it can spread the rice grassy stunt virus and rice ragged stunt virus [7].

Yield losses due to BPH attacks and these viral diseases can reach up to 70% [8]. During the vegetative stage, attacks by Rice ragged stunt virus cause stunted plant growth, with a reduction in plant height by 24-67%, delayed panicle emergence by up to 10 days, and distortion of the flag leaf. At the fruiting stage, the grains do not fill and become empty [9].

The existence of distinct biotypes, each exhibiting differing degrees of virulence and resistance to various rice cultivars, exacerbates the effects of BPH damage. Four BPH biotypes are found in a number of nations, including China, Taiwan, the Philippines, and India. BPH biotypes 2, 3, and 4 have been found to be distributed throughout East Java, Central Java, West Java, Lampung, and North Sumatra, Indonesia [10].

One of the control measures for BPH is the use of resistant varieties. The use of resistant varieties is considered an ideal control method because it is more economical, efficient, and environmentally friendly [6]. These varieties can reduce the damage caused by this pest, decrease dependence on chemical controls, and promote sustainable rice farming practices. However, identifying rice varieties with effective resistance to specific biotypes requires targeted research and evaluation.

The use of resistant varieties should be diverse and appropriate to the BPH biotype, as the continuous planting of a single resistant variety can lead to the breakdown of resistance and biotype changes [11] [12]. Testing location-specific resistant varieties can be done through screening of local rice that has been traditionally grown by local communities. The province of Banten, with its enduring local cultural diversity, has many local varieties known for their adaptation to environmental conditions and specific agricultural practices. Banten's local rice is suspected to have valuable resistance traits against BPH. Despite their traditional importance, there is limited systematic research on their resistance capabilities. This presents a significant opportunity to explore and document the resistance profiles of these local varieties.

Previous research shows that local varieties have potential resistance to BPH. Local Banten varieties such as Jawara hawara, Jalawara, Tambleg, Gadog, Kewal Bulu Putih, and Kewal Benur have been identified to possess resistance to BPH biotype 3 based on molecular markers SSR RM17 and RM25, similar to new superior varieties IR64, IR42, Inpari 13, and Inpari 35 [13]. Other studies report that the local Boyan variety has potential resistance to BPH comparable to the resistance of the IR64 variety [14]. Therefore, research to identify the resistance of local varieties to BPH needs to be conducted, considering the number and types of local varieties in Indonesia, especially in Banten, are many and not yet fully identified.

The purpose of this research is to identify the resistance of local Banten rice to BPH (Nilaparvata lugens Stål.) and identify the BPH biotypes used in the testing. It is hoped that the results of this research can contribute information for the development of germplasm for breeding new BPH-resistant varieties. In the future, it is also hoped to support improved pest management to support sustainable agricultural practices and enhance food security in Indonesia.

2 Methodology

The study was conducted from November 2018 to April 2019 at the greenhouse of the Banten Assessment Institute for Agricultural Technology (Banten AIAT), Ciruas District, Serang Regency. The research was divided into two parts: the identification of local rice resistance to BPH and the identification of the BPH biotypes used for testing local rice resistance.

2.1 Identification of local rice resistance to BPH

The local rice used for testing was a collection of local rice seeds from Banten AIAT, obtained from Lebak Regency, including Gadog, Rabig, Ketan Gadung, and Apel Merah. The susceptible comparison variety used was TNI. Furthermore, the test BPH used field populations from Pontang District, Serang Regency.

2.1.1 Preparation for plant testing

Local rice seeds Gadog, Rabig, Ketan Gadung, and Apel Merah, as well as TN1 as the control, were planted in seed trays containing a 1:1 mixture of soil and sand. Each tray consisted of the tested local rice with its comparison. The planting was done in rows with a spacing of 4 x 2 cm and an 8 cm distance between cultivars. The number of test plants was 20 for each replicate. The testing was conducted with three replicates.

2.1.2 Preparation for BPH testing

BPH was obtained from rice fields planted with the Ciherang variety 40-45 days after planting. The BPH were then propagated in rearing boxes planted with the Pelita rice variety in buckets with paddy soil. The Pelita rice variety does not have genes for BPH resistance. Subsequently, 25 female adult BPH from the field were infested on each clump of 30-day-old Pelita rice prepared beforehand. To obtain uniform nymphs, after 2-3 days (when egg-laying is assumed to have occurred), the adult BPH were removed from the rearing box. The nymphs were reared until they reached the 2nd-3rd instar stage to be used as test insects [15].

2.1.3 Plant resistance testing

The resistance testing of the plants was conducted by infesting each plant with 8 BPH nymphs at the 2-3 instar stage, at 7 days after planting. Plant damage symptoms were observed daily from 1 to 10 days after infestation (DAI). The scoring of plants followed the Standard Evaluation System for Rice [16] as shown in Table 1.

Table 1. Determination of plant damage score

Score	Seedling damage
0	no damage
1	very slight damage
3	the first and second leaves of most plants are partially yellow
5	pronounced yellowing and stunting or about half of the plants wilting or dead
7	more than half of the plants are wilting or dead
9	all plants dead

The determination of plant resistance levels was made when 90% of the susceptible control plants, TN1, had a score of 9 (dead plants). From the scoring results, the mode value can be analyzed to determine the final scoring and the resistance level criteria against BPH. The resistance criteria and scoring values can be seen in Table 2 [16, [17].

In addition to observing the plant resistance levels, BPH population observations were also conducted to determine the insect's preference. Observations were made daily from 1 to

10 DAI by counting the number of BPH on the plant surfaces. The data was then tabulated and analyzed descriptively.

Table 2. Determination of rice plant resistance levels based on scoring results

Score	Seedling damage
0	highly resistant
1	resistant
3	moderately resistant
5	moderately susceptible
7	susceptible
9	highly susceptible

2.2 Identification of BPH biotype

The stages for testing BPH biotypes, from plant preparation to BPH propagation, follow the same procedures as the testing of local rice resistance to BPH. However, the rice infested by the test BPH are different varieties, i.e. TN1, Mudgo, ASD7, and Rathu Heenati. Infestation of 2-3 instar nymphs on differential varieties is done at 7 days after planting, with 8 nymphs per plant. The testing is conducted with three replicates, each consisting of 20 plants.

The determination of resistance response in differential varieties is made when 90% of TN1 plants are dead. The scoring value is determined by analyzing the mode value of plant damage scores. Subsequently, the determination of the biotype is based on the response of differential plants, following the guidelines as shown in Table 3 [18].

Table 3. Identification of BPH biotypes based on the response of differential rice varieties

Biotype	**Response of differential rice varieties**			
	TN1	**Mudgo (*Bph1*)**	**ASD7 (*bph2*)**	**Rathu Heenati (*Bph3*)**
1	S	R	R	R
2	S	S	R	R
3	S	R	S	R
4	S	S	S	R

R: resistance; S: Susceptible

3 Result and discussion

3.1 Agroecology and characteristics of local rice

The local rice tested in this study belongs to the indica group and has been cultivated for more than 50 years in each location. The characteristics of this local rice generally include a growing period of more than 4 months, tall plant stature, narrow leaves, and few tillers (Table 4).

In Lebak Regency, particularly in the Kasepuhan areas, the preservation of local rice continues due to local wisdom believed to be an ancestral heritage. Leuwidamar District is part of the Kasepuhan Baduy area, while Bayah and Banjarsari Districts are included in the Kasepuhan Banten Kidul/Cisungsang area. As an effort to protect the local Gadog rice variety, it has been registered with the Plant Variety Protection and Agricultural Licensing Center (PPVTPP) under the number 772/PVL/2018.

Table 4. Agroecology and characteristics of local rice

Local Rice	Location	Agroecology	Plant age (day)	Plant height (cm)	Tiller number	Rice colour
Gadog	Kerta Village, Banjarsari District, Lebak Regency (120 masl)	upland	±150	> 125	10-16	White rice
Rabig	Kanekes Village, Leuwidamar District, Lebak Regency (230 masl)	upland	±150	130-150	8-10	White rice
Ketan Gadung	Kerta Village, Banjarsari District, Lebak Regency (120 masl)	upland	±150	130-150	8-9	White glutinous rice
Apel Merah	Pasir Gombong Village, Bayah District, Lebak Regency (200 masl)	lowland	±150	130-150	10-15	Red rice

3.2 Local rice resistance to BPH

Damage symptoms on the plants appeared 3-5 days after infestation (DAI) by BPH, indicated by the leaf tips turning brown and drying out (Table 5). Gadog and TN1 rice showed symptoms earlier compared to Rabig, Ketan Gadung, and Apel Merah. TN1 (Taichung Native1) is a variety known to lack BPH resistance genes [18], making it a comparison variety for susceptible plants [19].

Table 5. Development of damage to local rice plants 1-10 DAI

Cultivars	Score plant damage (DAI)									
	1	2	3	4	5	6	7	8	9	10
TN1	0	0	1	1	1	3	3	5	7	9
Gadog	0	0	1	1	1	5	5	7	9	9
Rabig	0	0	0	0	1	1	3	5	7	7
Ketan Gadung	0	0	0	0	1	1	1	3	5	7
Apel Merah	0	0	0	0	1	1	1	1	1	1

Resistance determination was made when at least 90% of TN1 plants reached a damage score of 9. This occurred on the 10^{th} DAI. Observations showed varying damage scores for the local rice varieties. A score of 1 for Apel Merah indicated that this variety has resistance to BPH. The other varieties, Ketan Gadung, Rabig, and Gadog, were found to be susceptible and highly susceptible (Table 6, Figure 1).

Several local rice varieties have been reported to have resistance to BPH, including Si Rendah Putih, Torondol Kuning, Ampek Panjang, Ase Puteh, Badik, Bapuk, Bidai, Bintang Landang, Buban, Bulang, Bulu Hideung, Buntok, Cecek Beleleng, Cempo Telouluk, and Cere Beurem [20]. These varieties can be used as sources of donor-resistance genes in the development of BPH-resistant varieties, such as the Apel Merah cultivar from Lebak Regency, Banten Province.

Table 6. Resistance Response of Local Banten Rice to BPH

Cultivar	Damage seedling score	Response
TN1	9	highly susceptible
Gadog	9	highly susceptible
Rabig	7	susceptible
Ketan Gadung	7	susceptible
Apel Merah	1	resistance

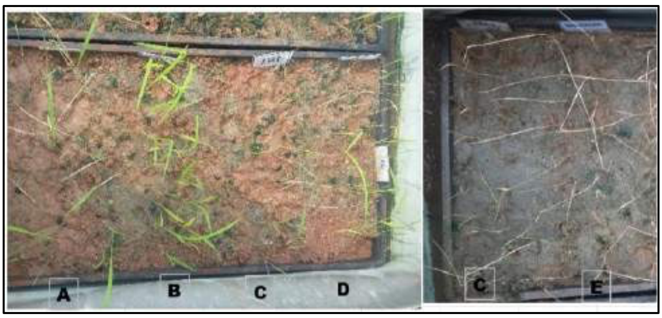

Fig. 1. Response of local variety rice to BPH (A: Ketan Gadung; B: Apel Merah; C: TN1; D: Rabig; E: Gadog)

Tolerance, antibiosis, and non-preference/antixenosis are the methods by which plants survive insect pests [21]. The host plant may exhibit morphological, physiological, or biochemical resistance mechanisms. For instance, compared to susceptible cultivars (resistance to Pelita I/1) [22], the plant hairs in resistant cultivars are bigger/longer, greater in number, and grow tighter. From a biological standpoint, the amount of sucrose and oxalic acid in plants is directly linked to their resistance to BPH. Compared to sensitive rice cultivars, BPH-resistant rice variants contain less sugar and more oxalic acid [12].

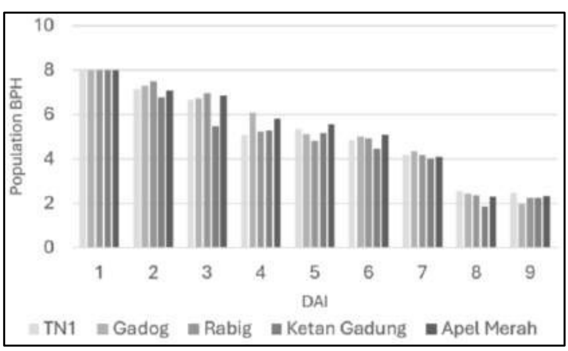

Fig. 2. BPH population per plant from 1-9 DAI

In Figure 2, the BPH population on each local rice variety and TN1 from 1-9 DAI is almost the same. This indicates that BPH preference for each cultivar tends to be similar, both for the resistant Apel Merah cultivar and the susceptible cultivars Gadog, Rabig, and Ketan Gadung. Although the BPH preference for landing on rice varieties reflects behaviour related to the plant's resistance mechanisms [7], this test did not show a non-preference mechanism. Therefore, it is suspected that the resistance mechanism that may occur is tolerance in Apel Merah. However, this research is a preliminary study, so to determine the presence of antixenosis and antibiosis mechanisms of rice varieties to BPH, further evaluation is needed by measuring the feeding, oviposition, and functional plant loss index [19].

3.3 BPH biotype identification

The biotype testing of BPH used four differential varieties: TN1, Mudgo, ASD7, and Rathu Heenati. Testing with these differential varieties has been widely conducted to identify BPH biotypes as well as to compare plant resistance [15,17]. TN1 is a variety that does not have BPH resistance genes. Mudgo has the Bph1 resistance gene, ASD7 has the bph2 resistance gene, and Rathu Heenati has the bph3 resistance gene [18, [23]. The cultivar Rathu Heenati, a Sri Lankan indica rice, was found to be resistant to all four biotypes of BPH [24].

The results of the biotype testing of BPH from the field population in Pontang District, Serang Regency, used in this study showed resistance in the ASD7 and Rathu Heenati varieties, while they reacted as susceptible in the TN1 and Mudgo varieties (Table 7 and Figure 3). This indicates that the BPH in this test is biotype 2.

The mapping of BPH biotypes in Indonesia in 2010 showed the distribution of biotypes 1, 2, 3, and 4 in several rice-growing regions. In the areas of Jember, Banyuwangi, Situbondo, and Sidoarjo (East Java Province), there are mixed biotypes of 2, 3, and 4. In the areas of Klaten, Boyolali, Karanganyar, Banjarnegara (Central Java) and Sukamandi (West Java), mixed biotypes of 3 and 4 are found. The biotype in Bandar Lampung (Lampung) is a mix of biotypes 2 and 4. In Simalungun and Deli Serdang (North Sumatra), there are mixed biotypes of 3 and 4 [10].

In Banten Province, the mapping of BPH biotypes was conducted in 2016, showing the distribution of biotype 2 in Warung Gunung and Rangkas Bitung Districts (Lebak Regency), Menes District (Pandeglang Regency), and Kasemen District (Serang City). Biotype 3 was found in Panggarangan District (Lebak Regency), Sindang Resmi District (Pandeglang Regency), and Sukadiri District (Tangerang Regency). Biotype 4 was found in Banjarsari District (Lebak Regency) and Petir District (Serang Regency) [25].

Table 7. Resistance Response of Differential Varieties to Test Insect BPH

Cultivar	Damage seedling score	Response
TN1	9	highly susceptible
Mudgo	9	highly susceptible
ASD7	3	moderately resistant
Rathu Heenati	1	resistance

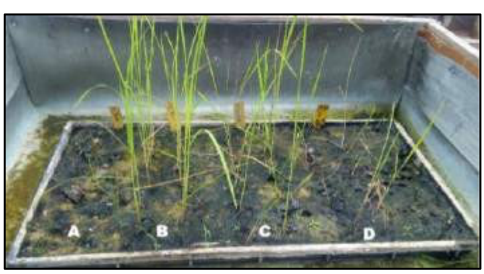

Fig. 3. Resistance response of differential varieties (A: TN1; B: Rathu Heenati; C: ASD7; D: Mudgo) to BPH from Pontang District, Serang Regency, Banten Province.

4 Conclusion

The resistance of local Banten rice shows that Gadog rice was highly susceptible, Rabig and Ketan Gadung were susceptible, and Apel Merah was resistant to the tested BPH population. The identification of the BPH population of the test insect revealed biotype 2.

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