

Susceptibility of Milled Rice Varieties to the Lesser Grain Borer (*Rhyzopertha dominica*, F)

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Abstract

The susceptibility of six milled rice varieties (IR-64, Ciherang, Membramo, Cibogo, Sembada, and Intani-2) to the Lesser Grain Borer (*Rhyzopertha dominica*, F) was studied by No Choice Test Method under laboratory condition ($27 \pm 2^\circ\text{C}$ and $65 \pm 5\%$ RH). The Susceptibility was assessed on the basis of eggs number laid by female insects, the number of F₁ progeny emerged, the weight loss of infested samples and also the Dobie's Index of susceptibility. The results revealed that the number of eggs laid by female insects, the number of F₁ progeny emerged and weight loss of infested samples were significantly low in Membramo variety followed by Ciherang, IR-64, Cibogo, Sembada and Intani-2. Based on the index of susceptibility, the milled rice variety of Membramo had the lowest susceptibility index and was regarded as resistant. While the milled rice varieties of Ciherang, IR-64, Cibogo and Sembada were considered as moderately resistant, Intani-2 seen as the most highly susceptible. These results imply that the milled rice variety with high phenolic content and hardness potentially revealed resistant to the *R. dominica* infestation.

Keywords: *Rhyzopertha dominica*, milled rice, resistant variety, Susceptibility Index

1. Introduction

Rice (*Oryza sativa* L.) is playing an important role in Indonesian livelihood. It is a staple for all classes in Indonesia and also holds the central place in Indonesian culture and cuisine. Government program for increasing rice production, both through extensification and intensification had yielded some success. Unfortunately, the quantity and quality of rice can be easily dropped and damaged by several species of insects during storage. Hence, in addition to agronomic obstacles, storage insect is the major problems to attain rice self sufficiency. Head of East Java Indonesian Logistic Bureau (BULOG) stated that every year the lost due to insect storage in average of 10 -25%. In India, the quantitative losses caused by storage insects are in the range of 5-25% per year (Prakash & Rao, 1995).

There are many kind of insects that reduce the quality of rice in storage. Some of them are Lesser Grain Borer (*Rhyzopertha dominica* (F)), Rice Weevil (*Sitophilus oryzae* (L)), Red Flour Beetle (*Tribolium castaneum* (H)), Rusty Grain Beetle (*Cryptolestes ferrugineus* (S)) and also Saw-toothed Grain Beetle (*Oryzaephilus surinamensis* (L)) (Prakash & Rao, 1995). At the end of 2008, there was a serious damage in the Indonesia government storage (BULOG) caused by *R. dominica* (Susanto, 2010: Personal communication). This insect infestation has made rice broken into dust (Emery & Nayak, 2007). Sittisuang and Imura (1987) stated that brown rice lost 40% of initial weight over the 14 weeks through infestation of *R. dominica*.

The common treatment to minimize insect infestation in rice storage is the ecosystem approach. Ecosystem approach was done by altering both the rice and environment so that the insect cannot develop. These include alterations of the abiotic components of storage such as grain moisture content, temperature, condition and type of storage structure and additional components include the use of synthetic and botanical grain protectants and other nonconventional methods such as grain resistance (Prakash & Rao, 1995). According to Cogburn et al. (1983), McGaughey et al. (1990); Arnason et al. (1992) and Chanbang et al. (2008), grain characteristics such as grain grade, silica content, thickness of husk, relative hardness of grain kernel, phenolic, protein and amylase content were associated with different responses to the attack of stored products insects.

Recently, many rice cultivars are developed to increase its productivity, but there have been few assessment of varietal susceptibility to *R. dominica* (Chanbang et al., 2008). Therefore, the objectives of this research were to: (1) assess varieties of milled rice for susceptibility to *R. dominica* and (2) determine if there will be any specific characteristics of milled rice variety confer susceptibility to *R. dominica*.

2. Materials and Methods

The research was conducted from November 2010 to July 2011. The experiment was conducted by No Choice Test method at Pest Laboratory, Department of Plant Protection, Agriculture Faculty of Brawijaya University, Malang, Indonesia. During the study, the laboratory condition was kept at a temperature of $27 \pm 2^\circ\text{C}$ and $60 \pm 5\%$ relative humidity. The hardness of milled rice variety were analyzed at the Laboratory of Food Quality and Food Safety, Faculty of Agriculture Technology. The phenolic content analysis was done at the Environmental Laboratory, Faculty of Mathematic and Life Sciences and the other chemicals content were analyzed at Central Laboratory of Life Sciences, Brawijaya University, Malang, Indonesia.

Six rice varieties; namely IR 64, Ciherang, Membramo, Cibogo, Sembada, and Intani-2 were tested for their susceptibility to *R. dominica*. These six rice varieties were arranged in Completely Randomized Design with five replications.

The rice sample used was obtained from the local farmers at Malang district. These farmers obtained their seeds from local Agriculture Services of Malang, Indonesia. The milled rice sample was sterilized at -15°C for a week and then removed to 5°C for another week. Before used in the study, the samples were preconditioned at room temperature ($27 \pm 2^\circ\text{C}$) for two weeks. *R. dominica* adult was obtained from the farmer's storage which has been infested by *R. dominica* at Rejoso vilage, Junrejo, Batu, East Java, Indonesia. These insects were then reared in the pest laboratory as the stock culture.

Thirty g of each sterilized milled rice variety was put in glass vials (7 x 4.5 cm). Then, the 15 pairs of 2 to 3 weeks old adults *R. Dominica* was transferred from stock culture and covered with muslin cloth on top. The adult of *R. dominica* allowed to infest for seven days. At the end of seven days oviposition period, the adult of *R. dominica* were discharged and the number of egg was recorded. After which, the rice samples with eggs of *R. dominica* were kept under the experiment conditions to assessed the emergence of F_1 progeny. Emerging progeny was counted in each vial on each assesment day. This observation continued until all F_1 progeny was expected to have emerged before the F_2 generation starts (Bashir, 2002).

The hardness of milled rice variety was determined using digital force gauge zp 200 N. The phenolic content was determined using spectrofotometric apparatus (ASTM, 1976), fat was determined by the method by Pendl et al. (1998) and protein content were analyzed by Kjeldahl Method. The moisture content was determined using method of SNI 01-2891-1992 point 5. 1 and ash content was determined by the method of SNI 01-2891-1992 point 6. 1. The carbohydrate content was calculated by different (i.e $100\% - \text{protein content} (\%) - \text{fat content} (\%) - \text{ash content} (\%) - \text{moisture content} (\%)$).

The data were analyzed by analysis of variance (ANOVA), while the significant means were determined by using Least Significant Difference (LSD) at 5% level of significance. The correlation analysis was used to determine the relation among the physico-chemicals of milled rice varieties with the eggs number of *R. dominica*, the number of F_1 progeny emerged, the median developmental time and the index of susceptibility.

The index of susceptibility was calculated using the method of Dobie and Kilminster (1977) which given by $\left| (\log_e F)/D \times 100 \right|$ where F is the number of F_1 insects developing from eggs laid by 15 pairs of adult *R. dominica* during seven days and D is the median development period, estimated as the time (days) from the middle of the oviposition period to the emergence of 50% of the F_1 generation. The susceptibility index ranging from 0 to 11, was used to categorized the milled rice varieties, where: 0 - 3 = resistant, 4 - 7 = moderately resistant, 8 - 10 = susceptible and ≤ 11 = highly susceptible (Dobie, 1974).

3. Results and Discussion

The experimental result shows that there was a significant different in the number of eggs between rice varieties (Table 1). The highest egg number (263.6) was observed on Intani-2 milled rice variety, whereas the lowest egg number (52.2) was observed on Membramo variety. Furthermore, Table 1 also show that Membramo variety had the lowest F_1 progeny emerged (16.4), which is significantly different with the other varieties. The highest F_1 progeny emerged (36.6) was observed on Intani-2 variety. By this result it could be said that the Membramo variety is more resistant than the other rice variety. One of the reasons for this phenomenon it might be due to the different of physical characteristics and chemical content of milled rice variety. Noris and Kogan (1980) said

that plant defense to the insect attack by its physical characteristics and chemical content such as the phenolic compounds.

If the number of eggs and F₁ progeny emerged could be regarded as the infestation intensity, then it could be suggested that the weight loss due to the infestation of *R. dominica* corresponds with the infestation intensity. This suggestion was supported by the data presented in Table 1 which show that the lowest weight loss (0.43%) occurred on Membramo variety, although it did not significantly different with IR-64 and Ciherang, but significantly different with the other three varieties. The highest weight loss (12.06%) occurred on Intani-2 variety. This is significantly higher than that of Cibogo and Sembada varieties.

Table 1. The Means Number of Eggs (from 15 Females which were Infested), the Number of F₁ Progeny Emerged of *R. dominica* and Weight Loss on Six Milled Rice Varieties

No.	Variety of Rice	Numbers of Eggs	Numbers of F ₁ Progeny Emerged	Weight Loss (%)
1.	IR-64	125.0 c	21.4 b	2.14 a
2.	Ciherang	92.9 b	23.0 b	1.17 a
3.	Membramo	52.2 a	16.4 a	0.43 a
4.	Cibogo	167.0 d	29.6 c	3.93 b
5.	Sembada	212.2 e	31.0 c	5.55 b
6.	Intani-2	263.6 f	36.6 d	12.06 c

*Values with the same letters in the same column are non-significant ($\alpha < 0.05$)

Shafique and Chaudry (2007) suggested that the low insect population and low weight loss of grain can be used as one of the attribute of the grain resistance to insects. Hence, based on the data presented in Table 2, it could be concluded that Membramo variety was the most resistant variety, and Intani-2 was the most susceptible variety to *R. dominica*. In addition to weight loss and number of F₁ progeny, Abebe et al. (2009) used median developmental time, and percentage of seed damage as indicators of the susceptibility of maize varieties to the attack of *S. zeamais* (Motsch).

The mean of median developmental time of *R. dominica*, susceptibility index of six milled rice varieties, and resistance category can be seen in Table 2. The range of median developmental time of *R. dominica* on the six milled rice varieties are 32.1 days to 83.1 days. From Table 2., it also showed that the Intani-2 variety has the shortest median developmental time (32.1 days), while Membramo has the longest median developmental time (83.1 days). By the variable of median developmental time shows that *R. dominica* rapidly develops on the Intani-2 variety, while the slowest development is on the Membramo variety. Based on the median developmental time variable and the numbers of F₁ progeny emerged were created the susceptibility index. By that categorization it can be said that the lowest susceptibility index is shown by the Membramo variety (3.355), while the highest one is on the Intani-2 variety (11.213).

Table 2. Median Developmental Time of *R. dominica*, Susceptibility Index of Six Milled Rice Varieties and Resistance Category

Milled Rice Variety	Median Developmental Time (days)	Susceptibility Index	Resistance Category
IR-64	59.3 c	5.381 c	Moderately Resistant
Ciherang	69.5 d	4.504 b	Moderately Resistant
Membramo	83.1 e	3.355 a	Resistant
Cibogo	47.9 b	7.071 d	Moderately Resistant
Sembada	45.5 b	7.525 e	Moderately Resistant
Intani-2	32.1 a	11.213 f	Highly Susceptible

*Values with the same letters in the same column are non-significant ($\alpha < 0.05$).

Following the criteria developed by Dobie (1974), the rice varieties tested in this study could be categorized into: (a) resistance variety which consists of Membramo, (b) moderately resistance which consists of Ciherang, IR-64, Cibogo, and Sembada, and (c) high susceptible which consist of Intani-2 variety (Table 3).

The characteristics of grain resistance to stored insects, is still debatable (Dobie, 1974; Safique & Chaudry, 2007a; Abebe et al., 2009; & Nadeem et al., 2011). As Arnason et al. (1992) stated that high phenolic content of maize grain was strongly and negatively correlated with resistance to *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae). There was also evidence that the larval development of *T.castaneum* and *Trogoderma granarium* (Everts.) was inhibited by the thought siliceous hull of paddy (Shafique & Chaudry, 2007b). Hull morphology was thus considered an unreliable base of resistance as the effectiveness varied with species of insects. Cogburn et al. (1983) and Ahmad et al. (1998) stated that varieties resistance to stored rice insects is related to grain hardness, amylase content, non-chalkiness and phenolic content in the rice kernels. The research on grain hardness in its relation with index susceptibility has been conducted by McGaughey et al. (1990) on wheat grain. He stated that the hardness characteristics of wheat will strongly affect the attack of *S. oryzae*.

In this study, it was suggested that protein, fat, ash, carbohydrate, phenolic content and the hardness characteristics would be the important characteristics that determined the resistance to stored insect. To test this hypothesis was conducted by calculating the correlation coefficient between protein, fat, ash, carbohydrate, phenolic content and milled rice hardness with the number of eggs, F₁ progeny emerged, median developmental time of *R. dominica* and the susceptibility index. The result of this analysis can be seen at Table 3. The variables of protein, fat and carbohydrate content are not significantly correlated with variables of eggs number, F₁ progeny emerged, median developmental time, and the susceptibility index. On the other hand, variable of ash content positively correlated with the variable of eggs number, F₁ progeny emerged of *R. dominica*, and the susceptibility index.

Table 3. The Matrix Correlation Coefficient (r) between Physico-Chemical Characteristics of Milled Rice Varieties and Eggs Number, F₁ Progeny Emerged, Median Developmental Time of *R. dominica* and the Susceptibility Index

Physico-Chemical Characteristic	Number of eggs	F ₁ Progeny Emerged	Median Developmental Time	Susceptibility Index
Protein	0.741	0.682	-0.646	0.728
Fat	0.483	0.509	-0.560	0.393
Ash	0.915*	0.896*	-0.849*	0.963*
Carbohydrate	-0.285	-0.345	0.357	-0.180
Phenolic	-0.962*	-0.892*	0.990*	-0.898*
Hardness	-0.838*	-0.833*	0.936*	-0.946*

* Significant at $\alpha < 0.05$.

Furthermore, the result in Table 3 show that ash content negatively correlated with the median developmental time. It means that the milled rice varieties with the high ash content would effect the high number of eggs, high number of F₁ progeny emerged of *R. dominica* and faster development and consequently would be susceptible to the *R. dominica* attacks. On the other hand, variable of phenolic content and the hardness characteristics of milled rice have significantly negative correlation with the number of eggs, F₁ progeny emerged, and the susceptibility index. Furthermore, those two variables, that are phenolic content and hardness, have positively correlated with the median developmental time. By this result appear that high phenolic content and hardness characteristics attributed low number of eggs, low number of F₁ progeny emerged, and the slow development of *R. dominica*. As a result, the milled rice variety, with the high phenolic content and hardness characteristics appear to be resistant to the *R. dominica* attacks.

4. Conclusions

The study reported here show that Membramo milled rice variety is the resistance variety to *R. dominica*. The milled rice varieties with higher phenolic content and hardness would be more resistant to *R. dominica*. The milled rice variety with higher ash content would be more susceptible to *R. dominica* infestation. Protein, fat, and carbohydrate content do not correlate with the susceptibility to the *R. dominica*.

This research showed that it was also important to breed of paddy rice considered on the low ash content and high phenolic content and also the hardness characteristics in order to get milled rice variety which is resistant to *R. dominica* infestation.

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