RELATIVE RESISTANCE OF DIFFERENT RICE VARIETIES AGAINST *Sitotroga cerealella* Oliv. (LEPIDOPTERA : GELECHIIDAE)

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Abstract

The relative resistance of rice varieties to attack by *Sitotroga cerealella* Oliv. was studied under controlled laboratory conditions. The rice varieties were Ariette, Cigalon, Delta, Lido, Onda, IR-42, Cisadane, Sirendah, Hawara-Batu, Bah-Butong and Pandan-Wangi. The first five were cultivated in France while the remaining samples were obtained from Indonesia.

Both paddy and brown rice were used and were infested with eggs of *S. cerealella*. The experiment was conducted in climatic chamber at 25°C and 80% RH. The parameters observed were percentage larval penetration, percentage adult emergence and index of susceptibility.

As paddy, Cisadane, Bah-Butong, IR-42 and Delta were found to be resistant to *S. cerealella* attack while Cigalon, Ariette and Lido were susceptible. When the husk was removed, slight modification was observed. Delta, for example, which was resistant became susceptible to *S. cereallela* along with Ariette and Onda, while IR-42 was the most resistant variety along with Bah-Butong.

It was concluded that "Indonesian" varieties were relatively resistant to *S. cerealella* attack as compared with "French" varieties except Delta in the form of paddy.

INTRODUCTION

Rice is one of the most important cereals in the world especially in Asia. During storage it is subjected to various degree of losses caused by insect pests. Among these is *Sitotroga cerealella* Oliv. which is widely distributed in warmer climate where most of rice is produced, stored and commercialised. Using different techniques earlier investigators (Cohen and Russel, 1970; Russel, 1976; Cogburn, 1977; Uttam *et al.*, 1984; Gerding and Heinrich, 1986; Sauphanor, 1988) demonstrated that *S. cerealella* showed different responses to different rice varieties.

The present study was conducted to find out the relative resistance of different varieties, in form of paddy and brown rice, cultivated in different region of production (principally a comparison between French and Indonesian varieties) to a laboratory strain of *S. cerealella*.

MATERIALS AND METHODS

The strain of *S. cerealella* used in this study was obtained from our stock culture maintained on corn cob for several years at 25°C and 70% RH. Based on the finding of Russel (1976), eggs were used to infest the rice and were obtained according to the technique of Stockel and Turtaut (1970). After the oviposition period (normally 4 days) clusters of eggs attached to black paper were counted under binocular microscope. Total number of eggs in each cluster was written on the black paper to simplify the recounting of hatched eggs after the incubation period. The paper containing counted eggs was then cut into pieces.

Both paddy and brown rice were tested for their relative resistance against *S. cerealella*. The rice varieties were Ariette, Cigalon, Delta, Lido, Onda, IR-42, Cisadane, Sirendah, Hawara-Batu, Bah-Butong and Pandan-Wangi. The first five were cultivated in southern region of France while the rest were obtained from Indonesia.

Before experiment, all samples were stored at -20°C in airtight plastic bag for more than one week to kill any insects or mites present.

In this experiment, the paddy grains used were those with intact husk as seen by naked eye, meanwhile for brown rice were those with intact germ. For every serie of experiment (paddy or brown rice), five replicates of 200 grains were placed in transparent plastic box (8.5 x 6 x 2.5 cm) provided with aerated lid. The grain were allowed to equilibrate in climatic chamber at 25°C and 80% RH for a minimum one week. Thereafter, pieces of black paper containing in total 200 eggs of *S. cerealella* were placed in each box. The experiment was conducted in complete darkness. After one week, hatched eggs were counted so that percentage larval penetration and percentage adult emergence could be calculated. Two weeks later the grains in the boxes were radiographed using SIGMA 2060 X-ray Unit at 20 kV and 6 mA for 30 seconds (Fleurat-Lessard, 1982) on Kodak Ready Pack M film. The boxes were returned immediately to the experimental chamber. Based on the number of hidden insects shown on the radiographic film, percentage larval penetration was calculated from number of hatched larvae. Adult emergence was observed about 30 days after the initial infestation. Adults were removed and counted daily until emergence ceased and adult emergence was calculated as percentage from hatched larvae. At the end of the experiment the paddy grains which showed emergence holes were verified for site of larval entry.

Developmental period was calculated from mid-oviposition period to the time when 50% of the total adults had emerged. Based on percentage adult emergence and developmental period, the index of susceptibility (Dobie, 1974) were calculated based on the suggestion of Howe (1971).

The data were subjected to analyse of variance and means were compared by Newman-Keuls's test. The data of percentage larval penetration and percentage adult emergence were analysed after angular transformation (Snedecor and Cochran, 1971).

RESULTS

Percentage of eggs hatching for both series of experiments were satisfactory (Table I) and statistical analysis of the data showed no significant difference between varieties for both series.

Table I. Percentage of *S. cerealella* eggs hatching in experiment with paddy and brown rice*

Variety	Paddy	Brown rice
Ariette	92.9	87.5
Cigalon	93.5	94.1
Delta	90.0	84.0
Lido	93.0	90.5
Onda	87.7	88.8
IR-42	92.1	91.8
Cisadane	90.0	92.6
Sirendah	90.8	92.5
Hawara-Batu	90.8	90.7
Bah-Butong	91.2	91.4
Pandan-Wangi	91.2	86.7

*Effect of treatment was not statistically significant ($P>0.05$)

Relative resistance of paddy

Among the 11 varieties tested, Cisadane was the most resistant (Table II). Significantly fewer larvae made their entry into the grain and although developmental period of *S. cerealella* in this variety was not significantly different ($P>0,05$) from developmental period of other varieties, it was among the longest (40.91 days). Cigalon was exactly opposit with significantly higher percentage larval penetration and higher percentage adult emergence ($P<0.05$) than in any other varieties except in Ariette and Lido for larval penetration. Moreover, the developmental period of *S. cerealella* on variety Cigalon was the shortest (38.39 days), although it was not significantly different from those on other varieties. Indeed, there was no varietal effect on the developmental period of *S. cerealella* between all varieties of paddy.

Based on the index of susceptibility, Cisadane was the most resistant but its index of susceptibility (0.45) was not significantly different from those for other 5 most resistant varieties (Bah-Butong, IR-42, Delta, Hawara-Batu and Pandan-Wangi). Cigalon was the most susceptible variety as its index of susceptibility was the highest (3.33) and was significantly different from indice of susceptibility of other varieties except Lido and Ariette.

In the present study on paddy, Cisadane, Bah-Butong, IR-42 and Delta could be grouped as relatively resistant varieties while Cigalon, Ariette and Lido as susceptible varieties.

Table II. Parameters observed on the relative resistance of paddy to *S. cerealella*

Variety	% larval penetration*	% adult emergence*	Developmental period (days)	Index of susceptibility
Ariette	18.27 ab	13.96 b	39.14	2.91 ab
Cigalon	21.05 a	19.00 a	38.39	3.33 a
Delta	5.01 de	2.84 d	39.23	1.03 d
Lido	17.28 ab	13.94 b	39.77	2.85 ab
Onda	14.53 b	8.67 c	39.33	2.33 bc
IR-42	3.80 def	2.84 d	40.21	1.03 d
Cisadane	1.97 f	1.65 d	40.91	0.45 d
Sirendah	10.72 c	7.34 c	39.89	2.14 c
Hawara-Batu	7.35 d	3.04 d	39.70	1.09 d
Bah-Butong	3.38 ef	2.07 d	41.61	0.67 d
Pandan-Wangi	4.90 de	3.26 d	38.90	1.26 d

Means within a column followed by the same letter are not significantly different ($P>0.05$; Newman-Keuls's test)
***Data were transformed using angular transformation for analysis**

Relative resistance of brown rice

When the husk was removed from the grain, hatched larvae had more chance to penetrate into the grain as shown in Table III. However, the results are less clear than in paddy in term of groups of resistant and susceptible varieties.

Table III. Parameters observed on the relative resistance of brown rice to *S. cerealella*

Variety	% larval penetration*	% adult emergence*	Developmental period (days)	Index of susceptibility
Ariette	57.15 ab	53.40 ab	42.40 b	4.07 b
Cigalon	43.04 bc	41.11 bcd	41.49 bc	3.83 bc
Delta	68.30 a	62.71 a	40.89 bc	4.39 a
Lido	49.43 bc	45.68 bc	41.89 bc	3.94 bc
Onda	56.73 ab	51.47 ab	42.36 b	4.03 b
IR-42	20.85 d	13.71 f	40.70 bc	2.77 d
Cisadane	37.37 c	27.87 de	40.29 c	3.54 c
Sirendah	37.85 c	34.96 cde	41.73 bc	3.66 bc
Hawara-Batu	48.40 bc	35.12 cde	42.26 b	3.65 bc
Bah-Butong	37.74 c	23.46 e	45.93 a	2.95 d
Pandan-Wangi	38.38 c	32.63 cde	41.44 bc	3.63 bc

Means within a column followed by the same letter are not significantly different ($P>0.05$; Newman-Keuls's test)
***Data were transformed using angular transformation for analysis**

In the form of brown rice, IR-42 was the most resistant variety. Its percentage larval penetration and percentage adult emergence were significantly different ($P<0.05$) from those of other varieties (Table III). In contrast, Delta, although it was not significantly different from Ariette and Onda, showed higher percentage larval penetration as well as adult emergence.

Contrary to the results for pady, brown rice showed a different response for the developmental period of *S. cerealella*. The developmental period on Bah-Butong was significantly the longest. Although it did not differ significantly from other varieties except Ariette, Onda, Hawara-Batu, and Bah-Butong, developmental period of *S. cerealella* on Cisadane was the shortest.

When index of susceptibility was assessed, it was clearly shown (Table III) that the indices of susceptibility of IR-42 and Bah-Butong were significantly lower, indicating their relative resistance againt *S. cerealella* attack. In contrast, Delta, which was grouped as resistant variety in the form of paddy, became the most susceptible variety when de-husked to brown rice. Its index of susceptibility was significantly the highest.

In the test with brown rice, IR-42 and Bah-Butong were relatively resistant while Delta was the most susceptible variety, along with Ariette and Onda.

DISCUSSION

Technique of infestation and determination of developmental period of S. cerealella

The technique of infestation of rice by *S. cerealella* using its eggs was quite satisfactory as the percentage of egg hatching was high and the effect of the variety was not statistically significant (Table I). Different methods have been suggested to calculate the developmental period. It is ideal to use newly hatched (0-24 hours) larvae to infest the grains so that 0 day in the calculation of developmental period will be easily and accurately determined. Nevertheless, that would be impossible if large quantity of larvae were needed, since the task would be too laborious. In the present study, the developmental period was calculated on the basis of the mid-oviposition time as 0 day and until 50% of total adult emergence. Therefore, the duration of the oviposition period is very important. In other experiment conducted in our laboratory, it was found that oviposition period was between 1 and 6 days (depending on the quantity of eggs needed) and the formula of calculation is valid statistically (unpublished data). In the present study, four days oviposition period was the most convenient.

Responses of paddy and brown rice to S. cerealella

The data on percentage larval penetration were clearly lower in paddy. This indicated that husk serves as barrier for entry of larvae into the grains (Cogburn, 1974). In this study only intact paddy grains were used. Although only small part of the newly hatched larvae made their entry into the grains, especially in the relatively resistance varieties, there were still successfull entries suggesting that there were weak parts of the husk for larvae to enter. Cohen and Russel (1970) showed that number of grains having gaps between lemma and palea correlated with degree of infestation on paddy. In the present study, we used the paddy grains with intact husk as seen by naked eye. Observation at the end of experiment on grains having emergence holes showed that those considered as intact grains had gaps between lemma and palea, notably in variety Cigalon. Cogburn *et al.* (1983) discovered that larvae of *S. cerealella* can penetrate via the central vascular bundle in the abscision scar of paddy grain. Our observation on grain having emergence holes confirmed their finding. In our case, therefore, larval entry into paddy grains was either through the central vascular bundle of the abscision scar or joints between lemma and palea.

When the husk was removed, theorically there was no barrier for larval entry. However, the effect of variety on percentage larval penetration was highly significant indicating that there was some resistance among the varieties. In the relatively resistant varieties, the newly hatched larvae were either prevented from penetrating or did not prefer the grain. Cogburn *et al.*(1983) found no statistical difference in percent emergence of *S. cerealella* on different varieties of rice if husk was deliberately broken, suggesting that husk is only barrier for larval entry into grain in resistant variety of paddy. We suggest that, in the case of paddy, resistance was caused principally by physical characteristics rather than nutritional factors, while in brown rice resistance was caused by nutritional factors only.

There was no statistical separation on developmental period on paddy, whereas on brown rice this was evident. The variability of the results with brown rice may be caused by different site of entry of larvae. In clusters of brown rice grains, larvae made their entry on the site of contact between two grains. Site of entry affect significantly the developmental period of *S. cerealella* on wheat (Mills, 1965), those that entered through germ or near to it will be shorter than those that entered through endosperm. In the case of paddy, site of entry was found mostly on or around germ.

Responses of rice produced in two different climatic regions

The study on relative resistance of different rice varieties originating from two different climatic regions (temperate-France and tropical-Indonesia), showed clearly that for both paddy and brown rice, the relatively resistant group includes most "Indonesian" varieties, while the relatively susceptible group includes only "French" varieties (Table IV). Russel (1976) and Cogburn *et al.* (1983) reported that rices originated in the East-Asia were generally more resistant than those originated in the USA. The East-Asian varieties from the USDA World Collection when grown in the USA and subjected to the resistance test to *S. cerealella* tended to remain resistant (Cogburn *et al.*, 1980).

Table IV. Summary of resistance/susceptibility test of rice to *S. cerealella*

Resistance or Susceptible	Paddy	Brown rice
Relatively resistant	Cisadane** Bah-Butong** IR-42** Delta* Hawara-Batu**	IR-42** Bah-Butong** Cisadane** Hawara-Batu** Pandan-Wangi**
Relatively susceptible	Ariette* Cigalon* Lido*	Delta* Ariette* Onda*

* "French" varieties
** "Indonesian" varieties

In general, among 11 varieties, tests on their relative resistance against *S. cerealella*, IR-42, Cisadane and Bah-Butong, all "Indonesian" varieties, were classified as relatively resistant while Ariette a "French" variety was the most susceptible. The differences in climatic conditions and culture techniques during the production of the rices might have contributed to the physical or chemical characteristics of each varieties.

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RESISTANCE RELATIVE DE DIFFERENTES VARIETES DE RIZ A *SITOTROGA CEREALELLA* OLIV. (LEPIDOPTERA : GELECHIIDAE)

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RESUME

Nous avons étudié en laboratoire la résistance relative de variétés de riz au *Sitotroga cerealella* Oliv. Les variétés étudiées étaient : l'Ariette, le Cigalon, le Delta, le Lido, l'Onda, l'IR-42, le Cisadane, le Sirendah, l'Hawara-Batu, le Bah-Butong et le Pandan-Wangi. Les cinq premières ont été cultivées en France tandis que l'Indonésie fournissait les échantillons restants.

Nous avons utilisé du riz Paddy et du riz brun infesté par des oeufs de *S. cerealella*. L'expérience s'est déroulée en chambre climatisée à 25° C et 85 % RH. Les paramètres observés étaient le pourcentage de pénétration larvaire, le pourcentage de naissances d'adultes et le degré de sensibilité pris en tant que mesure de la résistance relative.

Les riz Paddy des variétés Cisadane, Bah-Butong, IR-42 et Delta se sont avérés résistants aux attaques du *S. cerealella* tandis que les variétés Cigalon, Ariette et Lido y sont sensibles. Après décorticage, de légères modifications ont été enregistrées. "Delta", par exemple, qui était résistant, est devenu sensible à *S. cerealella* ainsi qu'Ariette et Onda, tandis que IR-42 s'avérait être la variété la plus résistante avec Bah-Butong.

En conclusion, comparées aux variétés "françaises", mis à part Delta sous forme non décortiquée, les variétés indonésiennes se sont avérées relativement résistantes aux attaques de *S. cerealella*.