Factors affecting survival and development of *Sitophilus oryzae* (L.) in rice grain pericarp layers

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Abstract

The role of rice grain pericarp layers on the development of *Sitophilus oryzae* (L.) was studied in laboratory conditions on eight rice varieties. Three types of grain were used for each variety: brown rice (dehusked paddy), brown rice kernel without embryo and polished rice. Egg-laying rate by the adults of *S. oryzae*, developmental time and F_1 production were checked either on grain or on artificial kernels reconstituted with the flour of the different types of grain. Incubation was performed at 25°C and 75% r.h.

It was found that the F_1 progeny production was the highest on brown rice for all varieties, and the lowest on polished rice. Developmental time was the shortest with brown rice. Based on radiographic control of hidden stages of development, it was observed that the highest rate of egg deposition occurred on brown rice and that the development of the first larval instar is greatly affected in polished rice kernels. On artificial kernels, it was shown that the pericarp layers are a nutritional 'growth factor' for *S. oryzae*.

Introduction

Rice is the most important staple food in Indonesia. During storage and distribution, it is often attacked by various storage insects. Among them is the rice weevil, *Sitophilus oryzae* (L.). The development of the larva inside the kernel may cause the loss of weight of about one-third of the kernel (Clement et al. 1988). In addition to the weight loss, various types of quality loss may also occur.

The results of studies related to the development of *S. oryzae* on rice kernels following different degrees of milling have been reported. Singh (1981), for example, found that the developmental period of the rice weevil on polished rice was significantly longer. At the same time, the productivity was also reduced. Similar results were also reported earlier by McGaughey (1974). From those studies, it was clear that the removal of the rice pericarp layers during milling may affect the development of rice weevil. However, the phenomenon was not clearly explained.

The present study was conducted to confirm those previous findings, and to gain further information on the development of rice weevil. In addition to the experiment on rice kernels, an experiment on oligidic media reconstituted as artificial kernels was also conducted.

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Materials

Rice grains

The study used eight varieties of Indonesian rice: IR-42, Cisadane, Sirendah, Hawara-batu, Bah-butong, Pandanwangi, Sukadane, and Sungai-rampah. Before the experiment, all samples were subjected to freezing temperature of −20°C in airtight plastic bags for more than one week to kill any insect present. The rice were then dehusked using laboratory husker to obtain whole brown rice.

For each variety, three types of kernel were prepared, namely whole brown rice, brown rice without embryo, and polished rice. Larvae of *Plodia interpunctella* were used to remove rice embryo.

Artificial grains

The artificial grains were prepared as follows. To a 10 g of solid material (9 g of polished rice flour and 1 g of gluten), 1 mL of glycerol were added. By adding water, little by little, a dough was obtained. From the dough small artificial grains were prepared manually. The artificial grains were then dried at 25°C and 50–60% r.h. overnight so that the moisture content was reduced to around 14–15 %. This was the base formula of the oligidic diet in this experiment. Other components may be substituted for the polished rice flour. In the present experiment, substitutes were rice bran flour at 0%, 10%, and 20%. In addition, artificial grain was also prepared from whole brown rice flour.

The test insect, *Sitophilus oryzae* (L.)

S. oryzae were obtained from laboratory culture maintained on soft wheat of Festival variety at 25°C and 70% r.h.. The 14 + 7 days old adult weevils were removed and given opportunity to mate by placing them on a thin layer of ground maize in closed plastic container in the dark. After a time mated couples were collected.

Methods

First experiment

Three replicates of 300 grains consisting of 100 grains of each of the three grain types were placed in plastic boxes (8.5 × 6.0 × 2.5 cm) provided with aerated lids. Ten pairs of *S. oryzae* were released and the females were allowed to oviposit for 7 days in a climate chamber. The parent weevils were then removed from the box and discarded.

The 300 grains were then separated according to each type and placed in three new boxes; for brown rice, brown rice without embryo, and polished rice. The boxes were returned to the chamber.

Two weeks later the grains in the boxes were radiographied according to the method of Fleurat-Lessard (1982) using

SIGMA 2060 X-ray unit at 20 kV and 6 mA for 30 seconds on Kodak Ready Pack M film. Hidden stages were observed and counted under binocular microscope.

Three weeks after the removal of the parent weevils, the emergence of the F_1 progenies was observed daily. The counting in each box was discontinued when there was no emergence for five consecutive days. The developmental period was calculated in days as the time between mid-oviposition period and the time when 50% of the F_1 progenies had emerged.

Second experiment

Three replicates of 100 artificial grains were placed in plastic box as in the first experiment. Ten pairs of *S. oryzae* were released and the females were allowed to oviposit for 7 days in chamber. The parent weevils were then removed from the box and discarded. The boxes were returned to the chamber until the emergence of all F_1 progenies. The observation of the F_1 progenies and the calculation of the developmental period was the same as in the first experiment.

Results

First experiment

Higher numbers of progeny were produced in whole brown rice than in brown rice without embryo, in all varieties except in IR-42. The number of progeny produced was significantly lower in polished rice. On Bah-butong variety no progeny emerged in all three boxes (Table 1). The results of the radiography show that the number of the hidden stages was highest in brown rice. In polished rice, the number of hidden stages was much lower (Table 2).

The absence of all or part of the pericarp layers, including the embryo, affected the developmental period of the weevils. For example, the mean developmental period of the weevils in brown rice without embryo was 36.24 days, which was almost one day longer than that in brown rice (Table 3). In polished rice, the mean developmental period was more than one week longer than that in brown rice.

Second experiment

The mean number of progeny of *S. oryzae* in artificial grains prepared from whole brown rice flour was 141.7. The developmental period was 39.50 days. The number of progeny was significantly reduced, to 61.3, in artificial grain prepared from polished rice flour. The developmental period was also prolonged, by almost four days, to 43.43 days.

Table 1. Number of progeny of *S. oryzae* in three types of grains of eight varieties of rice.

Variety	Brown rice	Brown rice without embryo	Polished rice
IR-42	69.3	75.3	5.3
Cisadane	94.3	83.6	1.7
Sirendah	93.7	76.7	16.0
Hawara-batu	98.3	83.7	8.0
Bah-butong	89.3	74.7	0
Pandan-wangi	94.7	78.3	4.7
Sukadane	80.0	74.7	0.7
Sungai-rampah	84.7	65.0	2.0
Means	88.0 a	76.5 b	4.8 c

Means followed by the same letter are not significantly different (Newman-Keuls test, p = 0.05)

Discussion

This study indicates that the role of pericarp layers, including the embryo, is very important to support the development of the rice weevil. During the oviposition period of 7 days, the female weevils were given free choice in which grain they would deposit their eggs. The data on the number of progeny produced in whole brown rice without embryo and polished rice suggested that the absence of the pericarp layers is detrimental to weevil development. The radiographic control suggests that the female weevils prefer whole brown rice kernels for oviposition. The results of the present study agree with the findings of McGaughey (1974) and Singh (1981). It is believed that for the development of first instar larva the pericarp layers are also indispensable.

The data obtained from the second experiment suggest that the rice grain pericarp layers are indeed important. When the artificial diet contains 10% rice bran flour, the number of progeny and the developmental period were immediately restored to better than that in artificial grains prepared from whole brown rice flour, which is considered as an ideal substrate for the optimum development of rice weevil. Rice bran, which constitutes the pericarp layers and the embryo,

Table 2. Developmental period (in days) of *S. oryzae* in three types of grains of eight varieties of rice.

Variety	Brown rice	Brown rice without embryo	Polished rice
IR-42	35.50	36.17	43.00
Cisadane	35.35	35.71	46.50
Sirendah	35.22	35.88	42.42
Hawara-batu	35.33	36.20	44.50
Bah-butong	35.50	35.63	-a
Pandan-wangi	35.46	36.45	47.89
Sukadane	35.95	36.90	49.50
Sungai-rampah	36.38	36.38	43.00
Means [b]	35.69 b	36.24 a	45.25

[a] No emergence of progeny observed
[b] Means followed by the same letter are not significantly different (Newman-Keuls test, p = 0.05)

Table 3. Number of hidden stages of *S. oryzae* in three types of grains of eight varieties of rice.

Variety	Brown rice	Brown rice without embryo	Polished rice
IR-42	82.0	81.3	9.0
Cisadane	107.0	92.7	6.7
Sirendah	101.0	79.3	20.0
Hawara-batu	108.7	97.0	15.3
Bah-butong	97.3	86.3	3.7
Pandan-wangi	107.3	89.0	7.7
Sukadane	88.0	80.0	5.7
Sungai-rampah	96.0	78.5	4.3
Means	98.4 a	85.5 b	9.1 c

Means followed by the same letter are not significantly different (Newman-Keuls test, p = 0.05)

Table 4. The effect of rice bran on the development of *S. oryzae* in artificial diet

Quantity of rice bran in the diet solid materials	Number of progeny	Developmental period
0%	61.3 b	43.43 a
10%	145.3 a	38.29 c
20%	149.3 a	39.58 b
Diet prepared from whole brown rice	141.7 a	39.50 b

Means followed by the same letter are not significantly different (Newman-Keuls test, $p = 0.05$)

played an important role in the development of *S. oryzae*. Hence, the pericarp layers of rice grain contain a 'growth factor' for the rice weevils *S. oryzae*.

Acknowledgment

The authors gratefully acknowledge the members of the Laboratory of Stored-product Insect, INRA Bordeaux, for various aides rendered to us during the course of the study.

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