Taiwania 65(1): 95–99, **2020**
DOI: 10.6165/tai.2020.65.95

NOTE

Oviposition behaviour of *Scirpophaga incertulas* (Walker) (Lepidoptera: Pyralidae) on Sarawak rice landraces

Nur Najwa HAMSEIN[1,2], Freddy Kuok San YEO[1,*], Rahimah SALLEHUDDIN[2], Nur Karimah MOHAMAD[1], Felicia Fui KUEH-TAI[2], Nor Ain HUSSIN[1], Wan Nurainie Wan ISMAIL[1,*]

1. Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia.
2. Agriculture Research Centre, Semongok, 12th Mile, Kuching-Serian Road, P.O.Box 977, 93720 Kuching, Sarawak, Malaysia.
**Corresponding author's email: yksfreddy@unimas.my*

(Manuscript received 28 June 2019; Accepted 10 January 2020; Online published 20 January 2020)

ABSTRACT: The yellow rice stem borer, *Scirpophaga incertulas* (Walker) is an important pest of rice in Sarawak, Malaysian Borneo. For a better management of this pest, it is crucial to understand the oviposition behaviour of *S. incertulas* which is unknown for Sarawak rice landraces. This study observed several aspects of *S. incertulas* oviposition behaviour on Sarawak rice landraces in a net house experiment. Adult female stem borers were collected using light trap from the nearby rice field at night. A total of 180 females of *S. incertulas* were given access to six different rice landraces at three plant ages. The results indicated that rice plants at four-month old (heading to flowering) were strongly preferred for oviposition regardless of landraces. The vertical distribution of egg masses on plant were varied. Oviposition on leaf surfaces showed a clear preference on the abaxial leaf surface. To summarize, *S. incertulas* showed no oviposition preference to the six rice landraces tested in this study. The morphology of rice plants will affect the oviposition behaviour of *S. incertulas*.

KEY WORDS: Oviposition behaviour, rice stem borer, Malaysia, Sarawak rice landraces, *Scirpophaga incertulas*.

INTRODUCTION

Rice stem borer is one of the most serious pests that attacks rice plant worldwide. The infestation can occur from seedling to maturity stage. Litsinger *et al.* (1987) reported that rice stem borers have been most strongly associated with serious yield loss among other insect pests attacking rice due to their pervasiveness and type of injury. The crop losses due to rice stem borers varies in time and space. It has been reported that rice stem borers had caused 10% of rice yield reduction in Malaysia (Dale, 1994). While in Sarawak (in Malaysian Borneo), a statewide rice pests survey carried out from 2009 to 2011 in 166 rice fields showed that 11.4 % of rice damage in the fields were caused by rice stem borers (Gumbek and Hamsein, 2011). There are at least five species of Lepidopterous rice stem borers known to occur in Sarawak viz., *Scirpophaga incertulas* (Walker), *Scirpophaga innotata* (Walker), *Chilo suppressalis* (Walker), *Chilo auricillius* (Dudgeon) and *Sesamia inferens* (Walker) (Rothschild, 1971; Hamsein, 2011). Among these five rice stem borers, the yellow stem borer, *S. incertulas* is the most common and important pest of deepwater rice (Khan *et al*., 1991). The borer is also highly adapted to a wetland environment (Litsinger *et al*., 2009).

Most farmers depend on insecticides to control insect pests. The indiscriminate use of insecticides has led to many negative impacts on environment and human health (Ansari *et al*., 2014). In addition, heavy insecticide usage has also led to the development of insecticide resistant insect (Dar *et al*., 2006). For example, rice stem borers in Taiwan are developing resistance to different recommended insecticides (Cheng *et al*., 2010; Li *et al*., 2011). To reduce the dependency on chemical control, integrated pest management (IPM) programs are introduced. The IPM approach relies on the combination of biological, chemical and cultural control methods, and the use of insect resistant rice varieties (Heinrichs, 1994). To obtain insect resistant rice varieties, deploying resistance breeding program is needed.

Sarawak rice landraces may possibly use as genetic resource for breeding rice with insect resistance. This suggestion is based on the observation on the agriculture practice of local farmers. In Sarawak, the local farmers usually cultivate a few varieties of rice in small scale and apply low level of pesticides and chemical fertilizers. By cultivating a few varieties, the production will suffer less disease and pest damage (Teo, 2007). Among the few varieties cultivated by a farmer, there might have presence of resistant (or tolerant) variety (ies) which reduces the damages impose by diseases and pests (Niks *et al*., 2011) especially during disease or pest outbreak. Unfortunately, study on the insect resistance of Sarawak rice landraces is limited.

In this study, antixenosis of Sarawak landraces towards *S. incertulas* was studied based on oviposition behaviour. Oviposition behaviour is one of the responses that can be evaluated for determining plant resistance (Saxena, 1989). Chemical compounds on the plant surface and the plant physical characteristics at the site of oviposition will influence the oviposition behaviour (Renwick and Chew, 1994). Although oviposition preference of *S. incertulas* on different rice varieties have been studied elsewhere (Heinrichs *et al*., 1985; Rustamani *et al*., 2002), there is no such information available for the rice landraces of Sarawak. In this study, oviposition behaviour of *S. incertulas* on Sarawak rice landraces was observed in a net house.

MATERIALS AND METHODS

A net house measuring 2.5 m × 4 m × 1.8 m was built near the irrigated rice field in Kampung Skuduk, Serian. Different rice landraces at different ages were grown in the net house. The experiment was a choice study, where *S. incertulas* were released into the net house and have access to all the plant materials. The experiments were conducted twice during rice planting season (February-March 2017 and February–March 2018), which were in wet seasons of both years. In the net house experiments, the design was in a randomized complete block design with three blocks.

Plant materials

In this study, long term rice landraces which take about 160–175 days to mature were used. Six Sarawak rice landraces (*Bajong, Selasih, Bario, Bubok, Biris* and *Nyamuk*) at three different ages (one-, two- and four-month-old) were selected. At the selected plant ages on different rice landraces, the estimated rice growth stages were early vegetative (one-month-old), mid vegetative (2-month-old; tillering to stem elongation) and mid to late reproductive (4-month-old; heading to flowering) stage, respectively (Rice Knowledge Bank, n.d.). The experiment were tested on three plant ages because different plant age has different susceptibility to *S. incertulas* (Viajante and Heinrichs, 1987). Planting were staggered in such that the different plant ages of rice were available at a single time point. The seeds of these landraces were provided by Agriculture Research Centre Semongok, Department of Agriculture Sarawak. The seeds were soaked in water before sowing and were raised on nursery trays containing sterilized soil mix (2:1:1, soil : peat moss : sand). Fourteen-day old rice seedlings were transplanted into pots (⌀ = 30 cm; 16 L) containing soil mixture of top soil:sand (2:1). Only one rice seedling was transplanted in each pot. Compound fertilizer $12N:12P_2O_5:17K_2O:2MgO$ +TE was applied at the rate of ≈2.4 g per pot at 14, 50 and 110 days after transplanting. No insecticide was applied to the plants throughout the experiment.

One pot of each rice landrace and age combination was randomly arranged inside each block for a total of 18 pots per block (6 rice landraces x 3 plant ages). The pots were arranged with 30 cm distance from each other in the net house.

Insects

The adult females of *S. incertulas* were collected from the nearby rice field at night. Light trap and white sheet were used to attract the adult females following the procedures of Upton and Mantle (2010). The trap was set up in rice field one hour before sunset and were used continuously for 3 hours (~1830-2130). The adult females landed on the white sheet of the light trap were collected individually by hand using clean vial. The adult females were then released into the net house.

The releasing points for the adult females were located at the center of every four pots of plants in each block. Each block consisted of 10 releasing points. Six adult females were released at every releasing point. In total, 180 adult females were released into the net house.

Data collection and statistical analysis

The number, position (adaxial, abaxial or leaf sheath) and vertical distribution (on plant) of egg masses were recorded three days after infestation. The adaxial and abaxial surface can be distinguished by the existence of the ridges on the leaf blade. The adaxial leaf surface has parallel veins which form many ridges, while the abaxial leaf surface has a protruding ridge on the midrib (Chang and Bardenas, 1965). The vertical distribution of egg masses was determined by dividing the plants into three equal heights segments *viz.* lower, middle and upper region. All egg masses found on the plants were photographed and collected. Leaf segments of individual egg mass were carefully cut off (Kamano and Sato, 1985; Saxena *et al*., 1990) and put inside individual test tube. Leaf segments were observed for five to seven days for any plant response (necrosis) induced by the egg masses of *S. incertulas*. The number of eggs per egg mass was also counted. The different data collected were analyzed using a two-way ANOVA.

RESULTS

Rice landrace-plant age preference

A total of 89 egg masses were found deposited on the plants. When the adult females of *S. incetulas* were given a choice of six different rice landraces at three plant ages, the plant age had a significant effect on the oviposition of adult females (Table 1). The number of egg masses oviposited on four-month-old plants, were significantly higher than those of two-month-old and one-month-old. Plants at one-month-old had the least number of egg masses. There was no significant difference in the number of egg masses oviposited on the different landraces (Table 2). Mean number of eggs per plant also were significantly different between plant ages (Table 1) but no significant difference was found between rice landraces (Table 2). Plants at four-month-old received the highest number of eggs followed by plants at two-month-old. Plants at one-month-old received the fewest number of eggs.

Table 1. Mean number of egg masses and eggs per plant (± SD) laid at three different plant ages.

Plant age	Mean number of egg mass per plant	Mean number of eggs per plant
1 month	0.14 ± 0.35^{a}	11.53 ± 30.84^{a}
2 month	0.81 ± 1.01^{b}	48.19 ± 65.93^{b}
4 month	1.53 ± 1.40^{c}	86.63 ± 74.40^{c}

Means within the same column followed by the same letter are non-significantly different (p<0.05) based on Tukey HSD

Table 2. Mean number of egg masses and eggs per plant (± SD) laid on six different rice landraces.

Rice landraces	Mean number of egg mass per plant	Mean number of eggs per plant
Bajong	1.28 ± 1.56^{a}	76.61 ± 84.9^{a}
Selasih	0.61 ± 0.78^{a}	36.11 ± 54.35^{a}
Bario	1.11 ± 1.18^{a}	65.83 ± 74.23^{a}
Bubok	0.67 ± 0.76^{a}	39.22 ± 42.70^{a}
Biris	0.78 ± 1.56^{a}	44.72 ± 84.15^{a}
Nyamuk	0.50 ± 0.70^{a}	30.22 ± 43.73^{a}

Means within the same column followed by the same letter are non-significantly different (p<0.05) based on Tukey HSD

Vertical distribution of egg masses

The egg masses vertical distribution showed differences among plant regions. *S. incertulas* exhibited a clear preference on depositing eggs on the upper region of plant when compared with the lower region regardless of rice landraces and plant ages (Table 3).

Table 3. Mean number of egg masses per plant (± SD) at different location (lower, middle, or upper region of plant) regardless of rice landraces and plant ages.

Plant region	Mean number of egg mass per plant
Lower	0.11 ± 0.34^{a}
Middle	0.28 ± 0.56^{ab}
Upper	0.44 ± 0.85^{b}

Means within the same column followed by the same letters are not significantly different (p< 0.05) based on Tukey HSD.

Leaf surface of preference for oviposition

Regardless of rice landraces and plant ages, mean number of egg masses deposited by *S. incertulas* were varied between the different observed leaf surfaces. Significantly higher numbers of egg masses were laid on the abaxial leaf surface (Table 4). There was no significant difference between the numbers of egg masses on the adaxial leaf surface and leaf sheath surface. The observation on the plant response to *S. incertulas* eggs deposition showed no necrosis symptom around or underneath the eggs. All eggs were still attached on the plant surface.

Table 4. Mean number of egg masses per plant (± SD) for the oviposition preference on leaf surfaces regardless of rice landraces and plant ages.

Leaf surface	Mean number of egg mass per plant
Adaxial	0.24 ± 0.53^{a}
Abaxial	0.48 ± 0.83^{b}
Leaf sheath	0.10 ± 0.30^{a}

Means within the same column followed by the same letters are not significantly different (p < 0.05) based on Tukey HSD.

DISCUSSION

Based on the net house experiments, *S. incertulas* did not show any specific preference to any of the Sarawak rice landraces which suggest the absence of antixenosis defense mechanism among the rice landraces. The six Sarawak rice landraces may not have chemical compounds on plant surface or released (volatile compounds) which are toxic and will repel or deter insect pest (Renwick and Chew, 1994; Moraes *et al*., 2001; Kessler and Baldwin, 2001). The oviposited eggs of *S. incertulas* did not induce any necrotic symptom underneath or around the egg mass. Besides that, all eggs collected in this study were well attached to the plant surface until the larvae emerged. No formation of neoplastic tissue that can loosen the interface between eggs and plant surface were observed. Presumably, no chemical cues are released by rice plants to hinder the development of *S. incertulas*' eggs. The different landraces tested in this study may not have antibiosis defense mechanism in response to egg deposition (Hilker and Fatouros, 2015).

Although *S. incertulas* showed no preference towards the rice landraces used in this study, *S. incertulas* still showed some preference behaviour when ovipositing their eggs on rice plant. One of the factors affecting the behaviour is plant age. The adult females of *S. incertulas* showed preference to oviposit on plants of four-month-old. This finding is consistent with Reay-Jones *et al*. (2007) who studied the oviposition behaviour of other stem borer species, *Chilo polychrysa* and *Eoreuma loftini*. This is probably because of the height of the older plants as compared to the younger plants. This suggestion is according to Hosseini *et al*. (2011) and Baloch *et al*. (2004), who reported a positive correlation between plant height and number of egg mass in their study on stem borer *Chilo suppresalis* and *S. incertulas*, respectively. Baloch *et al*. (2004) speculated that plant with high stature is easier to be identified by flying moths, making it preferable for the moths to rest and oviposit. Further study is needed to determine how plant stature play a role in attracting the adult female of *S. incertulas* for oviposition.

Similar to the height factor, female moths of *S. incertulas* seems to prefer to oviposit on the upper region of a plant rather than the lower region. The observation on the vertical distribution of egg masses on plants reviewed that higher number of egg masses were found on the upper region of plant. This behaviour of *S. incertulas* is similar to rice stem borer, *Diatraea saccharalis* (Hamm *et al*., 2012) as well as cotton leaf worm, *Alabama argillacea* Hubner (Fernandes *et al*., 2007). This preference behaviour may be due to the presence of new leaves on the upper part of a plant which favors the young larvae development (Steinbauer *et al*., 1998; Fernandes *et al*., 2007). As observed by Satpathi *et al*., (2012), it was observed that most of the larvae remained at the top most internodes, which may be due to the soft and palatable plant tissue.

Another factor affecting the ovipositing behaviour of *S. incertulas* is leaf surface. In this study, the number of egg masses found on abaxial surface was significantly higher than adaxial surface. This could be due to the morphological differences between abaxial and adaxial surfaces. One of the possible explanations is the difference in trichome numbers between abaxial and adaxial surfaces. Tabari *et al*. (2016) observed that the trichome numbers is higher on the adaxial surface of the rice cultivars used. The author reported a negative correlation between the trichome numbers and the number of egg masses on adaxial surface. Contrarily, Shahjahan (2002) reported that *S. incertulas* preferred to oviposit on the adaxial surface of their rice cultivars. This may suggest that there are variations between rice varieties for the trichome numbers on leaf surfaces. Further study is needed to document the leaf trichome of the rice landraces used in this study. The contrary observation may also suggest behavioral differences between biotypes of *S. incertulas* in Pakistan (Shahjahan, 2002) and Sarawak. Theoretically, oviposition on the abaxial would be the preference for survival purpose of *S. incertulas*. This is because, deposition of eggs on adaxial will increase the chances of exposure to predators, parasitoids and insecticides (Hamm *et al*., 2012).

CONCLUSION

The oviposition behaviour of *S. incertulas* observed in this study was influenced by rice plant age regardless of landraces. Taller plants seemed to be more attractive for *S. incertulas*. This study also showed that *S. incertulas* preferred the middle to upper region of plant and the abaxial leaf surface for oviposition. These information may facilitate surveillance on rice stem borer for a more time efficient field assessment of egg masses and effective chemical control that focused on the plant mid region upwards and abaxial leaf surface of the plant.

ACKNOWLEDGMENTS

This study was funded by Universiti Malaysia Sarawak Small Grant Scheme F07/(S171)/1273/2015(08). The authors would like to thank the staffs of Entomology section, Agriculture Research Centre Semongok, for the assistance rendered during the study period. Thanks also extended to Mr Gek Konen from Kampung Skuduk for the permission given to use his land to set up the net house in this study.

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