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The difference growth and development of armyworm (*Spodoptera litura*) on five host plants

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Abstract. *Bayu MSYI, Krisnawati A. 2016. The difference growth and development of armyworm (*Spodoptera litura*) on five host plants. Nusantara Bioscience 8: 161-168. Spodoptera litura* is the important pest on soybean in Indonesia. The objective of this study was to determine the best feed that supports the development of *S. litura* and can be used for mass rearing of *S. litura*. This research was conducted in the Laboratory of Entomology, Indonesian Legume and Tuber Crops Research Institute on March-April 2014 using randomized complete design, five treatments, and 30 replicates. The treatments were *Glycine max*, *Jatropha curcas*, *Ricinus communis*, *Ipomoea aquatica*, and *Amaranthus viridis*. One leaf of each host plant was entered into test tube and was infested by one larva of *S. litura* 0 days after emergence. The result showed that feeds significantly affected the body size, survival rate, developmental time, reproduction, and longevity of *S. litura*. The longest and heaviest larvae were found on *I. aquatica*, 28.5 mm and 0.42 g respectively. The longest and heaviest pupae were found on *I. aquatica*, 19.3 mm, and 0.36 g respectively. The faster developmental time was found on I. *aquatica* (22.2 days) and *R. communis* (22.4 days). Furthermore, total egg masses produced by female were high on *I. aquatica* (11.6 egg masses). In conclusion, *I. aquatica* and *R. communis* leaves were found to be preferred for *S. litura* life which shown the best growth and development of this pest, so it can be used as feed for mass rearing of *S. litura*.

Keywords: development, growth, reproductive system, host plant, *Spodoptera litura*

INTRODUCTION

Spodoptera litura Fabricius (Lepidoptera: Noctuidae) is one of the most devastating pests of many economically important crop in tropical and subtropical country (Nathan and Kalaivani 2005; Baskar et al. 2012). This polyphagous pest is responsible for huge yield losses in cultivated crops and sometimes causes up to 100% in the field (Qin et al. 2004). In Indonesia, *S. litura* has important status and caused damage on soybean up to 80% (Marwoto and Suharsono 2008). *S. litura* attack leaves and also consume the pods that play an important role in the early reproductive phase thus have an impact on crop failure. Castor bean, physic nut, spinach, and water spinach are also known as host for *S. litura* (Murthy et al. 2007; Ahmad et al. 2013). A wide range of host plant is considered important for this species to survive better even in seasonal change.

The management of *S. litura* can be performed using chemical insecticides, resistant varieties, and transgenic plants (Souza et al. 2012; Bernardi et al. 2014). Various insecticides such as organophosphates, organochlorines, carbamates, and pyrethroids have been used for the management of *S. litura* (Huang and Han 2007; Ahmad and Arif 2007). However, this pest has developed multiple types of resistance due to the use of these chemical extensively, may likely contributing to the difficulties in controlling this pest in the field (Ahmad and Arif 2007; Ahmad et al. 2007; Ahmad et al. 2011; Abbas et al. 2012; Muthusamy et al. 2011). Integrated pest management needs to be implemented in order to reduce the use of chemical insecticides. One alternative is by combining a chemical control with technical cultures, such as crop rotation with non-host plants, the use of trap crop, and sanitary selective of host plants that allow the pest to develop (Baliadi and Tengkano 2008).

The information of life history parameters of *S. litura* on different host plant species will help to make efficient strategies to control this economic pest (Greenberg et al. 2001; Tisdale and Sappington 2001). Moreover, evaluation of the effectiveness and efficiency of control technology require the presence of the appropriate stage, quantity, and quality of insect test. Therefore, mass breeding technology using high quality of feed, easily to get, and affordable is needed in order to provide insect test described above.

Even though this pest eating of various crop, the differences in morphological and chemical substance between host plant may likely interfere with the biology and behavior of pest. Montezano et al. (2014) reported that the development of immature stage of *Spodoptera eridania* is influenced by the kind of host plant and artificial died. In addition, feeds also affect on the longevity, fertility, and reproductive capacity of parasitoids (Uckan and Ergin 2003). Therefore, the study on the influence of host plant on biology of insect is very important.

There were many previous studies evaluated about the host plant preference of *S. litura*, but not all of these studied the effect of the same host plant on biology parameter of *S. litura* (Shahout et al. 2011). In this study, we use *I. aquatica* leaves, the famous vegetable in

Indonesia and also was reported as host plant for *S. eridania* (Montezano et al. 2014). There has been no report about the developmental and reproduction of *S. litura* on this host plant. The objective of this study was to determine the best feed that supports the development of *S. litura* and can be used for mass rearing of *S. litura*.

MATERIALS AND METHODS

Collection of leaves

Leaves from five host plants namely *Glycine max* (L.) Merr (soybean), *Jatropha curcas* L. (physic nut), *Ricinus communis* L. (castor bean), *Ipomoea aquatica* Forsk. (water spinach), and *Amaranthus viridis* Linn (spinach) were used in this study. These plants were selected because they are primary host plant of *S. litura* in Indonesia. Soybean, *J. curcas*, and *R. communis* were collected from field in Indonesian Legume and Tuber Crops Research Institute (ILETRI), East Java. However, *I. aquatica* and *A. viridis* were purchased from traditional market in Malang, East Java.

Spodoptera litura rearing

Eggs and first instar larva of *S. litura* were originally collected from soybean field in ILETRI and were subsequently maintained on soybean leaves placed in glass petri dish (23 cm in diameter and 3 cm in depth). Soybean leaves were replaced daily as needed until larva reached pupa. Pupae were maintained in glass petri dish as mention above and were given soybean leaves in order to keep humidity inside the dish. After adult emerged, they were maintained in cage made from iron frame covered with white gauze (26 cm in diameter and 50 cm in high) for two days prior in order to ensure complete mating. Adults were fed with 10% honey solution through cotton layer and was hung on the top of cage. Adult then was transferred into nesting box (30 cm in diameter and 20 cm in high) and were fed with 10% honey solution through cotton layer in a small plastic dish (7 cm in diameter and 1 cm in depth). The entire surface of the box was covered with white paper and an additional folded paper to facilitate female laid egg. Egg masses produced by female were collected daily and the first instar larva from this generation was used as insect tested.

Immature development

This research was conducted in Laboratory of Entomology, ILETRI, Malang, East Java on March-April 2014. One leaf of each host plants were placed separately into test tube (1 cm in diameter and 18 cm in length). Newly hatched larvae obtained from the culture were transferred and maintained individually into these test tubes until they reached the fifth instar. Each host plant treatment had 30 larvae. The larvae were observed daily to record development time and mortality. Leaves were replaced on first three days after infestation (DAI) and continued daily until larvae completed their stage. Larva that successfully developed into a pupa was maintained individually in a plastic container (5 cm in diameter and 6 cm in depth). In order to maintain the humidity of the pupa, one soybean leaf was inserted into plastic container. The development stages were recorded daily until all individuals reached adulthood. We also observed the length and weight of larva at 3 and 8 DAI; weight of pre-pupa at 13 DAI; length, width, and weight of pupa, sex ratio of adult, and survival rate.

Reproduction and adult longevity

Newly emerged females obtained from the first experiment were used to assess reproduction and longevity. Females were maintained together with male in cage for two days to allow mated. After that, adult females were transferred individually into a nest (15 cm in diameter and 15 cm in depth), fed with 10% honey solution, and were maintained under the same method described above. We observed the first day of oviposition to determine preoviposition period. The females were observed daily to determine oviposition period, total number of egg masses/female, egg masses/female/day, post oviposition period, and adult longevity.

Statistical analysis

The life history parameters of *S. litura* were analyzed using one-way ANOVA (SPSS version 22). Means associated with host plants for each variable were separated using Turkey's HSD test when significant values were obtained. Proximate analysis of each host plant was obtained from previous study.

RESULTS AND DISCUSSION

Development of *S. litura*

The developmental period of *S. litura* was significantly affected by host plant tested ($p<0.05$) (Table 1). Larval duration was significantly decreased when the larva fed on *R. communis*, *I aquatica*, and *G. max* both on male and female which was 13.5-14.4 days. Larval duration of female did not differ significantly with the male on each host plant tested except larva that fed on *A. viridis*, where the larval duration of female was longer than larval duration of male. *S. litura* pupal duration was significantly long when the larva fed on *J. curcas* (13.4±0.20) days for female and (14.3±0.13) days for male. Moreover, the pupal duration was significantly shorter on female than male on each host plant tested.

Total developmental time from larva to adult of *S. litura* was short when larva fed on *I. aquatica*, but did not differ significantly with larva fed on *R. communis*. Based on the total developmental time of immature, females developed faster than males for *S. litura* fed on each host plant, except *J. curcas*. Total developmental time of female when larva fed on *I. aquatica* and *R. communis* was (22.2±0.22) and (22.4±0.17) days respectively. In addition, the development of female *S. litura* until they laid egg was short when larva fed on *R. communis* (23.7±0.17) days, but did not differ between larva fed on *I. aquatica* and *G. max*.

Immature survival rates from larva to adult of *S. litura* when the larva fed on *Glycine max* (96.7%) was higher

than immature survival when larva fed on other host plants (Figure 1). In contrast with the immature developmental that *S. litura* develop faster when the larva fed on *I. aquatica*, the survival rates of *S. litura* that fed on *I. aquatica* was low just about 50%.

Influence of different host plant on length and weight of larva *S. litura*

The results showed that the difference in feeds significantly affected the length and weight of larva *S. litura* at 3 and 8 DAI ($p<0.05$) (Table 2). The larval length at 3 DAI was high when they fed on *I. aquatica* (8.6±0.86) mm, but did not differ significantly with the larval length when they fed on *A. viridis* and *Glycine max*. At 8 DAI, larva fed on *I. aquatica* led to significantly longer (28.5±3.67) mm than larva fed on other host plants tested.

Larval weight recorded at 3 DAI was similar between host plants tested except larva fed on *J. curcas* which was only (2.3±0.99) mg, led to significantly lower than other four host plants. In addition, when larva fed on *I. aquatica*, the larval weight at 8 DAI was significantly increased to (422.5±89.07) mg, followed by larva fed on *R. communis*, *Glycine max*, and *A. viridis*. However, the larval weight decreased sharply when larva fed on *J. curcas* (9.6±6.09) mg.

Influence of different host plant on weight of prepupa, length, width, and weight of pupa

Weight of prepupa, length, width, and weight of pupa was significantly affected by host plant ($p<0.05$) (Table 3). Prepupal weight was significantly high when the larva fed on *I. aquatica* (381.8±24.96) mg, followed by pupa when larva fed on *R. communis* and *A. viridis* which was (366.3±31.96) mg and (355.5±33.93) mg respectively. However, prepupal weight was significantly decreased when larva fed on *J. curcas* (251.6±50.31) mg.

The body size of pupa including length, width, and weight was recorded one day after pupal emergence. *S. litura* that fed on *I. aquatica* during larval stage led to significantly high on pupal length, pupal width, and pupal weight which were 19.3±0.48 mm, 5.0±005 mm, and 359.1±25.43 mg, respectively. Pupal weight was significantly decreased when larva fed on *J. curcas* (223.0±12.08) mg.

Reproduction and adult longevity

Pre-oviposition period, oviposition period, post oviposition period, longevity of adult female, total egg masses/female, and daily egg masses production/female were significantly different between each host plant ($p<0.05$) (Table 4). Adult female of *S. litura* when larva fed on *I. aquatica* had a longer oviposition period (3.3±0.29) days than adult female when larva fed on *R. communis* and *Glycine max*. However, oviposition period of adult female when larva fed on *J. curcas* was short (1.4±0.2) days, did not differ with adult female when larva fed on *A. viridis* (1.6±0.24) days. The pre-oviposition and post-oviposition period on each treatment ranged from 1.4 to 3.1 days and 0.1 to 1.1 days, respectively.

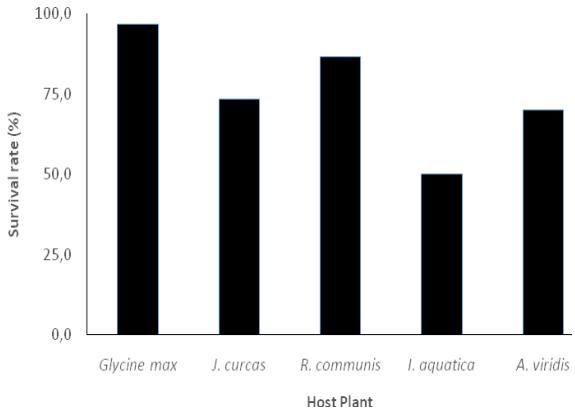

Figure 1. Survival rate of *S. litura* fed on five host plants during their development

Adult female longevity was significantly long when larva fed on *I. aquatica* 5.8 days followed by adult female when fed on *R. communis*, *A. viridis*, *Glycine max*, and *J. curcas* with an average 4.8; 4.8; 4.5; and 4.4 days respectively. The total egg masses per female during their life (fecundity) was higher on female when the larva fed on *I. aquatica* (11.6 egg masses) than that when larva fed on other host plant species. The fecundity was decreased sharply when larva fed on *J. curcas* which only 3 egg masses. In addition, the highest average daily egg masses production of female *S. litura* was found when larva fed on *I. aquatica* (3.8 egg masses), but did not differ significantly with the female when larva fed on *R. communis* (3.6 egg masses). Larva that fed on *J. curcas* had low daily egg production which only 2.2 egg masses.

Discussion

The results from this present study revealed the effect of different host plant on the growth and development of *S. litura*. Generally, shorter developmental times, higher reproduction rates, and low mortality of insects on a host indicate greater suitability of a host plant (Awmack and Leather 2002). Larva *S. litura* developed fast when they fed on *I. aquatica*, *R communis*, and *Glycine max*. The developmental time of larva when they fed on *Glycine max* was shorter than developmental time of larva fed on the same host plant reported in previous study which was 17.09 days (Shahout et al. 2011). In addition, Favetti et al. (2015) reported that the developmental time of larva from the genus *Spodoptera* (*S. eridania*) fed on soybean cultivar FMT Tabarana and Monsoy 8757 was 15.9 days and 18.5 days respectively, longer than larval duration in this present study. Shahout et al. (2011) recorded that the larval duration of *S. litura*, when fed on *Ipomoea batatas*, was 15.82 days. In this present study, larval duration when they fed on *I. aquatica* was shorter than larval duration that fed on *I. batatas*. Even both of these host plant is the same in genus, but they are different in species and may have different nutrition value. According to Adepoju and Adejumo (2015), *I. batatas* contain only 69.80% of moisture, 0.46% of crude protein, and 26.84% of carbohydrate. This value was lower than those found in *I.*

aquatica which was 78% of moisture and 3% of crude protein (Doka et al. 2014), and also 42.18% of carbohydrate (Igwenyi et al. 2011). Furthermore, Shahout et al. (2011) also reported the larval duration of *S. litura* fed on cowpea which was 19.55 days. Our result showed that larval duration was shorter in all host plant tested except *J. curcas* leaves than that on previous study.

Pupal duration of *S. litura* was similar when larva fed on *I. aquatica*, *R. communis*, *Glycine max*, and *A. viridis*, ranged from 7.9-8.1 days for female and 10.1-10.3 days for male. This result on pupal duration was little similar with previous study reported by Shahout et al. (2011) where pupal duration was about 8.43 days when larva fed on soybean. Favetti et al. (2015) also revealed that pupal duration of *S. litura* when larva fed on soybean cultivar ranged from 10.5-11.2 days for female and 11.2-11.8 days for male, indicated longer than pupal duration in this present study. It can be indicated that *I. aquatica* was more preferred by *S. litura* for their feed.

Table 1. Developmental time (days ± SE) from larva to adult of *S. litura* maintained in five host plants

Treatment	N[1)]		n[2)]	Larva	Pupa	Larva-Adult	Larva-Egg
Glycine max	29/30	♀	14	14.4 ± 0.13 c (14-15)	8.1 ± 0.10 c (8-9)	22.5 ± 0.14 cd (22-23)	24.4 ± 0.17 c (23-25)
		♂	15	14.1 ± 0.07 c (14-15)	10.2 ± 0.11 b (10-11)	24.3 ± 0.12 b (24-25)	-
J. curcas	22/30	♀	7	24.4 ± 0.37 a (23-26)	13.4 ± 0.20 a (13-14)	37.9 ± 0.46 a (36-39)	40.6 ± 0.37 a (39-42)
		♂	15	25.0 ± 0.17 a (24-26)	14.3 ± 0.13 a (14-15)	39.3 ± 0.23 a (38-41)	-
R. communis	26/30	♀	14	14.1 ± 0.18 c (13-15)	8.2 ± 0.11 c (8-9)	22.4 ± 0.17 d (22-24)	23.7 ± 0.19 c (23-25)
		♂	12	13.5 ± 0.15 c (13-14)	10.1 ± 0.15 b (9-11)	23.6 ± 0.19 b (23-25)	-
I. aquatica	15/30	♀	9	14.0 ± 0.00 c (14-14)	8.2 ± 0.22 c (8-10)	22.2 ± 0.22 d (22-24)	23.7 ± 0.24 c (23-25)
		♂	6	14.0 ± 0.00 c (14-14)	10.2 ± 0.17 b (10-11)	24.2 ± 0.17 b (24-25)	-
A. viridis	21/30	♀	9	15.7 ± 0.33 b (15-17)	7.9 ± 0.11 c (7-8)	23.6 ± 0.29 bc (23-25)	26.7 ± 0.37 b (25-28)
		♂	12	14.1 ± 0.36 c (13-17)	10.3 ± 0.14 b (10-11)	24.4 ± 0.47 b (23-28)	-
F				336.942	234.622	499.125	437.664
df				9, 103	9, 103	9, 103	4, 48
P				p < 0.000	p < 0.000	p < 0.000	p < 0.000

Note: Numbers with the same letter in the same column are not significantly different (Tukey's HSD test, p < 0.05). 1) Number of adult survival/Initial number of larvae. 2) Number of individual tested

Table 2. Mean (± SD) length and weight of larva *S. litura* in five host plants

Host plant	Length of larva (mm)		Weight of larva (mg)	
	3 DAI	8 DAI	3 DAI	8 DAI
Glycine max	8.2 ± 0.73 a (7-9)	25.1 ± 2.09 b (22-30)	10.8 ± 1.65 a (8-14)	267.5 ± 52.89 b (179-400)
J. curcas	4.8 ± 0.96 c (3-7)	8.2 ± 1.60 c (6-11)	2.3 ± 0.99 b (1-4)	9.6 ± 6.09 c (1-23)
R. communis	7.4 ± 1.43 b (4-9)	26.0 ± 2.34 b (22-30)	9.8 ± 3.06 a (5-15)	277.2 ± 52.08 b (217-445)
I. aquatica	8.6 ± 0.86 a (7-10)	28.5 ± 3.67 a (16-32)	10.2 ± 2.66 a (2-15)	422.5 ± 89.07 a (210-579)
A. viridis	8.4 ± 0.0.76 a (7-10)	25.1 ± 3.54 b (17-31)	11.2 ± 2.99 a (8-14)	265.9 ± 74.10 b (124-381)
F	75.69	251.265	71.051	168.155
df	4, 145	4, 140	4, 145	4, 140
p	p < 0.000	p < 0.000	p < 0.000	p < 0.000

Note: Numbers with the same letter in the same column are not significantly different (Tukey's HSD test, p < 0.05)

Table 3. Mean (± SD) Weight of prepupa, length, width, and weight of pupa *S. litura* in five host plants

Host plant	Weight of prepupa (mg)	Length of pupa (mm)	Width of pupa (mm)	Weight of pupa (mg)
Glycine max	345.9 ± 30.16 b (296-434)	18.9 ± 0.74 ab (18-20)	4.9 ± 0.30 a (4.0-5.2)	323.1 ± 29.84 bc (258-404)
J. curcas	251.6 ± 50.31 c (170-333)	14.8 ± 1.10 c (13-16)	4.0 ± 0.21 b (3.5-4.5)	223.0 ± 12.08 d (198-250)
R. communis	366.3 ± 31.96 ab (260-415)	18.9 ± 0.80 ab (17-20)	4.9 ± 0.23 a (4.0-5.0)	338.2 ± 23.29 b (299-389)
I. aquatica	381.8 ± 24.96 a (296-434)	19.3 ± 0.48 a (18-20)	5.0 ± 0.05 a (5.0-5.2)	359.1 ± 25.43 a (304-400)
A. viridis	355.5 ± 33.93 ab (294-437)	18.3 ± 0.97 b (18-20)	4.9 ± 0.26 a (4.0-5.0)	304.6 ± 32.32 c (243-363)
F	56.605	118.967	86.759	105.274
df	4, 134	4, 121	4, 121	4, 121
p	$p < 0.000$	$p < 0.000$	$p < 0.000$	$p < 0.000$

Note: Numbers with the same letter in the same column are not significantly different (Tukey's HSD test, $p < 0.05$)

Table 4. Mean duration (days ± SE) of adult, longevity, and oviposition rates (mean ± SE) of *S. litura* in five host plants

Host plant	n[1)]	Pre-oviposition	Oviposition period	Post oviposition	Longevity of female	Total eggs/female	Egg/female/ day
Glycine max	14	1.9 ± 0.10 b (1-2)	2.1 ± 0.21 ab (1-3)	0.5 ± 0.23 ab (0-3)	4.5 ± 0.31 b (2-7)	6.0 ± 0.49 bc (4-10)	3.0 ± 0.27 ab (1.7-5)
J. curcas	7	2.7 ± 0.18 a (2-3)	1.4 ± 0.2 b (1-2)	0.3 ± 0.18 b (0-1)	4.4 ± 0.3 b (4-6)	3.0 ± 0.38 d (2-4)	2.2 ± 0.31 b (1.5-4)
R. communis	14	1.4 ± 0.13 b (1-2)	2.4 ± 0.29 ab (1-4)	1.1 ± 0.16 a (0-2)	4.8 ± 0.32 ab (3-7)	8.0 ± 0.90 ab (3-14)	3.6 ± 0.31 a (2-5.5)
I. aquatica	9	1.6 ± 0.18 b (1-2)	3.3 ± 0.29 a (2-4)	0.9 ± 0.31 ab (0-3)	5.8 ± 0.22 a (5-7)	11.6 ± 0.87 a (7-16)	3.8 ± 0.54 a (1.8-6.5)
A. viridis	9	3.1 ± 0.26 a (2-5)	1.6 ± 0.24 b (1-3)	0.1 ± 0.11 b (0-1)	4.8 ± 0.22 ab (4-6)	4.3 ± 0.75 cd (2-8)	2.8 ± 0.29 ab (2-4)
F		17.403	6.164	4.872	2.650	15.706	3.011
df		4, 48	4, 48	4, 48	4, 48	4, 48	4, 48
p		$p < 0.000$	$p < 0.000$	$p < 0.002$	$p < 0.044$	$p < 0.000$	$p < 0.027$

Note: Numbers with the same letter in the same column are not significantly different (Tukey's HSD test, $p < 0.05$). 1)Number of female tested

In this study, total developmental time of female *S. litura* was shorter when larva fed on *I. aquatica* and *R. communis* than total developmental time when larva fed on other three host plants which required 22.2 and 22.4 days respectively. The difference of developmental time of *S. litura* between each host plant tested in this study and also with the previous study indicated that host plant species plays an important role in regulating insect development. Pannizi and Parra (2009) mentioned that phytophagous insects require nutritional from their food in order to develop normally into the adult stage thus the ingestion in the early stage is very important. Moreover, the quality of food is referred to be one of the possible factors affecting the duration of immature development (Esperk et al. 2007). Food quality is determined by defenses, toughness, secondary metabolites, nutrients (protein, lipid, carbohydrates, ash, and crude fiber), water, and nitrogen. Kursar et al. (2006) mentioned that the growth of Lepidoptera was slower when they fed on leaves with higher amount of crude fiber and less protein.

In addition, some secondary metabolites and proteins produce toxic, repellent, and anti-nutritional that either kill or retard the development of the herbivores (Hanley et al. 2007; War et al. 2011). According to Samira et al. (2011), the differences in developmental time might be due to the different of host plants consumed by the larva, which may likely different also in primary and secondary metabolites. The developmental time of immature stage when larva fed on *J. curcas* was longer than other host plants. This may be related to the higher value of secondary metabolites that contain in the *J. curcas* leaf which can inhibit the growth of larva. According to Devanand and Rani (2008), an extract of *J. curcas* caused high antifeedant activity and toxicity against *S. litura*. Moreover, *J. curcas* produced a toxic that effect on *Sitophilus zeamais*. This toxicity was attributed by toxic compounds (phorbol esters) which are commonly found in plants of the family *Euphorbiaceae*, primarily in the genus *Jatropha*. Phorbol esters concentration may vary according to the genetic characteristics of the plant (Devappa et al. 2013).

Survival rate of *S. litura* during their development was more than 50% in all host plant tested. The highest survival rate was found when larva fed on soybean (96.7%) and the lowest survival rate was found on *I. aquatica* (50%). This

may likely due to *I. aquatica* leaf contain a lot of water thus effect on the *S. litura* activity. *I. aquatica* showed moisture content 78% (Doka et al. 2014), higher than moisture content on soybean (63.06%) (Ponnusha et al. 2011). Many larvae dead during the experiment because the humidity inside test tube was high and their faces mixed with water produced from the leaf. The same trend was found on *A. viridis* which the leaf contains a lot of water as compared with *R. communis* and *Glycine max*. In order to minimize the number of dead larvae, it is better to maintain the condition inside test tube by putting tissue paper to absorb the water.

Our result showed that body size of larva up to 8 DAI was higher when they fed on *I. aquatica* which was 28.5 mm in length and 422.5 mg in weight. However, the body size of larva was decreased sharply when they fed on *J. curcas*. The difference in body size of larva was affected by host plant which may have differences in quality and nutritional. In addition, the body size of pupal *S. litura* when larva fed on *I. aquatica* led to significantly higher than that when larva fed on other four host plants which were 19.3 mm in length, 5 mm in width, and 359.1 mg in weight. The pupal weight when larva fed on *R. communis* was also high (338.2 mg). Shahout et al. (2011) reported the pupal weight of *S. litura* was 279.8 mg when larva fed on cabbage, 160.9 mg when larva fed on cowpea, and 186.6 mg when larva fed on soybean. Favetti et al. (2015) recorded pupal weight when larva fed on different soybean cultivar which ranged from 172.3-250.9 mg. Our result showed that pupal weight when larva fed on soybean was 323.1 mg, higher than that on previous study. The differences in body size of *S. litura* reported here and the previous study was affected by different host plant, different cultivar (Souza et al. 2012), and may likely be affected by environmental condition. According to Xue et al. (2010), host plant on which larva was fed significantly affected the pupal size. Moreover, the pupal size differed significantly between female and males when larva fed on same host plant or different host plant.

Host plant fed by larval *S. litura* has an effect to the biological attributes of the adult female. In this study, there was a decrease in the pre-oviposition period and an increase in daily and total egg masses produced per female when larva fed on *I. aquatica* and *R. communis* leaves. In contrast, there was an increase in pre-oviposition period to 2.7 days and reduced in daily and total egg masses produced by female which was 2.2 and 3.0 egg masses respectively when larva fed on *J. curcas* leaves. Pre-oviposition period of female when larva fed on *I. aquatica* and *R. communis* leaves was 1.6 and 1.4 days respectively. Daily and total egg masses produce by female when larva fed on *I. aquatica* was 3.8 and 11.6 egg masses respectively, when larva fed on *R. communis* was 3.6 and 8.0 egg masses respectively. This finding was shorter than previous study reported by Cabezas et al. (2013) that pre-oviposition period of other species of *Spodoptera* i.e. *S. cosmioides* was 3.4 days when larva fed on *R. communis* and 6.8 days when larva fed on *J. curcas.* The differences in biological attribute related to the differences in the number of food consumed during larval stage. It also may likely due to the differences in insect species used and the environmental condition in these both experiments.

Longevity of female *S. litura* was high when larva fed on *I. aquatica* (5.8 days), slightly higher than longevity of female when larva fed on *A. viridis* and *R. communis*. In contrast, the longevity of female was decreased when larva fed on *J. curcas* and did not differ from those fed on *Glycine max* which was 4.4 and 4.5 days. A slight difference in the longevity of female among the host plant tested due to the stage consumed feed was larva. The deficiency in nutritional because of different host plant quality might be only occurred in larval stage. However, after adult emerged, female fed on honey solution thus they might compensate for the deficiency of nutritional (Cabezas et al. 2013). According to Milano et al. (2010), the use of carbohydrates in the adult stage is important key to increase longevity and it is common for species of Lepidoptera. In addition, adult insect often depends on supplemental nutritional sources such as sugars, proteins, carbohydrates, and lipids to maximize their life expectancy and reproductive capacity. These resources can be obtained from animal secretions or plant exudates, including honeydew (Harvey et al. 2012). Salmah et al. (2012) reported that longevity of *Apanteles metesae*, parasitoid of oil palm bagworm was longer when fed on 50% honey solution than fed on pure honey. It indicates that honey solution is better to be used as feed for maintaining adult insect. Furthermore, the longevity of female *S. litura* may likely be affected by such hormone namely juvenile hormones (JHs) or juvenile hormone analog (JHA/ pyriproxyfen). According to Xu et al. (2015), JHs and JHA play an important role in the reproductive systems of female insects. High amount of JHs and JHA progressively decreased life span and oviposition period of *S. litura*. High value of secondary metabolites contain in *J. curcas* leaves such as tannin, saponin, and phenol might have an impact on the lower value of female longevity as compared with the longevity of female that fed on *I. aquatica* during larval stage.

Larva *S. litura* fed on *J. curcas* completed their developmental slowly and showed low size in their body as compared with larva that fed on other host plants tested here. Moreover, larva fed on *J. curcas* showed low reproductive capability. This might be due to the nutrient content and also secondary metabolites contained in *J. curcas* leaf which can inhibit the growth and development of *S. litura*. According to Agbaire and Emoyan (2012), *J. curcas* contains only 3.96% carbohydrates and 6.32% protein. This value was lower than those contain on *R. communis* which was 21.1% and 16.2%, respectively (Dastagir et al. 2013). The carbohydrate contains on *I. aquatica* was 42.18%, higher than these both host plant. Carbohydrates also play an important role in living organisms. Insects need carbohydrate, protein, and fiber sufficiently in order to grow and develop. Carbohydrate can be oxidized to yield energy, their polymers play as energy storage molecules and their derivatives are found in a number of biological molecules including coenzymes and the nucleic acids (Hasan et al. 2011). According to Gall and Behmer (2014), insects show better performance when they

have access to foods containing protein and digestible carbohydrate in the right ratio and at high concentrations.

Kind of secondary metabolites contained in *J. curcas* are phenolic, flavonoid, isoflavonoid, tannins, saponin, and alkaloid (Harry-Asobara et al. 2014). Phenolic increases the leaf toughness that reduces the feeding by herbivores. Phenolic also decreases the nutritional content of the leaf which gives negative affects to the insect growth and development (Bhonwong et al. 2009; Johnson et al. 2009). In addition, flavonoids and isoflavonoids influence the behavior, growth, and development of insects. Flavonoids are known as feeding deterrents against *Spodoptera exempta* and *Spodoptera littoralis* (Simmonds 2003; War et al. 2012). Barbehenn and Peter-Constabel (2011) reported that the other secondary metabolites namely tannins have a strong deleterious effect on phytophagous insects. Tannins affect insect growth and development by binding to the proteins, reducing nutrient absorption, and cause midgut lesions. According to Harry-Asobara et al. (2014), *J. curcas* leaves contain 0.18% flavonoid, 0.48% saponin, 0.46% tannin, and 31.42% HCN. Higher value of HCN of this leaf also indicated their high toxicity level. On the other hand, phenolic content in *I. aquatica* leaves was 0.016 mg/g and flavonoid content was 0,03mg/g, indicated lower toxicity than *J. curcas* (Umar et al. 2015).

Another study related to chemical substance was reported by Devanand and Rani (2008) that acetone extracts of *J. curcas* plants possess toxic with significant antifeedant effects and could be a potential crop protectant against *S. litura*. In addition, when larva fed on *A. viridis*, the developmental time was significantly longer and reproduction capacity was significantly lower than that when larva fed on *I. aquatica* and *R. communis* but higher than that when larva fed on *J. curcas*. It might be due to the presence of chemical substance in *A. viridis* that inhibited the development of *S. litura*. However, *S. litura* can develop faster, showed high body size during immature stage, and the female has high reproduction capability when they fed on *I. aquatica* and *R. communis* during larval stages. *I. aquatica* and *R. communis* might have such chemical substance that supports their growth and development. Further research about the chemical compound contained in *I. aquatica*, *R. communis*, and *A. viridis* is required. This result suggesting that the best feed for mass rearing of *S. litura* in laboratory is *I. aquatica* and *R. communis*. Both of these are available throughout the year and affordable. The results also implying the role of host plant in regulating *S. litura* population or mass rearing in order to provide the qualified insect by choosing the best leaves as their feed. This can support the successfulness of the evaluation of pest control technology. Furthermore, it also suggests that the presence of both host plants in field need to be considered in order to avoid pest infesting and pest outbreak.

In summary, host plant plays an important role in regulating *S. litura* population and mass rearing. The best feed for mass rearing of *S. litura* in laboratory is *I. aquatica* and *R. communis* which showed the best growth and development of this insect. Both of these host plants are available throughout the year and affordable. The presence of both host plants in field needs to be considered in order to avoid plant pest infesting species.

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