BIOLOGY AND LIFE TABLE OF FALL ARMYWORM, *Spodoptera frugiperda* (J.E. SMITH) (LEPIDOPTERA: NOCTUIDAE) ON MAIZE AND RICE

Yani Maharani[1*], Dhita Puspitaningrum[1], Noor Istifadah[1], Syarif Hidayat[1] & Ade Ismail[2]
[1] Department of Plant Pests and Diseases,
Faculty of Agriculture,
Universitas Padjadjaran, West Java, Indonesia
[2] Department of Cultivation Agriculture,
Faculty of Agriculture,
Universitas Padjadjaran, West Java, Indonesia
*Corresponding author: *yani.maharani@unpad.ac.id*

ABSTRACT

The fall armyworm, *Spodoptera frugiperda* (J.E. Smith), is an invasive pest that causes heavy damage to maize in Indonesia and other countries. This is a polyphagous pest attacking more than 300 host plants species, especially on the Poaceae family, such as maize and rice. The biology and life table of *S. frugiperda* are important for predicting increases in field population and determining the appropriate timing and control techniques. This study was aimed to determine the development period, survival, reproduction, and life table of *S. frugiperda* on maize and rice. It was conducted in the laboratory under two treatments namely maize-fed larvae and rice-fed larvae, replicated three times, with a total number of 300 individuals observed. The results showed that the type of host plant significantly affected the biology and life table of *S. frugiperda*. The larvae of *S. frugiperda* that fed on maize had a larger body size than those fed on rice. The life table of *S. frugiperda* in both maize and rice was 32.24 and 37.90 days, respectively. Meanwhile, the female longevity at 25.7^{o}C from the egg until imagos death on maize and rice was 44.55 and 50.25 days, and 43.79 and 48.61 days for males, respectively. The fecundity was higher for maize-fed larvae at 261.88 eggs per female compared to rice-fed at 172.36 eggs per female. The intrinsic rate (r_m) was significantly different between the two hosts, with a higher rate of 0.209 individual per parent per day on maize-fed compared to the rice-fed larvae at 0.154 individual per parent per day. The maximum values of r_m alongside the net reproductive rate (R_o), the finite rate of increase (λ), the shortest mean generation time (T), and doubling time (DT) was also calculated, which indicated that maize was more favorable for the life of *S. frugiperda*. These findings are useful for predicting the development of *S. frugiperda* populations on both host plants and that they can be used as references to determine appropriate control.

Keywords: Development period, invasive pest, Poaceae, reproduction, survival

ABSTRAK

Ulat Ratus, *Spodoptera frugiperda* (J.E. Smith) merupakan perosak invasif yang menyebabkan kerosakan besar pada jagung di Indonesia dan negara lain. Perosak polifagus ini mempunyai lebih daripada 300 spesies tanaman perumah, terutama dari famili Poaceae seperti jagung dan padi. Biologi dan jadual hidup *S. frugiperda* adalah penting untuk meramalkan peningkatan populasi FAW di lapangan bagi menentukan teknik dan masa kawalan yang sesuai. Kajian ini bertujuan untuk menentukan tempoh perkembangan, kelangsungan hidup, pembiakan dan jadual hidup *S. frugiperda* yang memakan jagung dan padi. Kajian dilakukan di makmal, setiap dua rawatan iaitu larva yang diberi makan jagung dan larva yang diberi makan padi direplikasi tiga kali dengan jumlah individu yang diperhatikan adalah 300 individu. Hasil kajian menunjukkan jenis tanaman perumah mempengaruhi biologi dan jadual hidup *S. frugiperda*. Larva *S. frugiperda* yang memakan jagung mempunyai ukuran badan yang lebih besar dari yang memakan padi. Kitaran hidup *S. frugiperda* di dua tanaman (jagung dan padi) masing-masing adalah 32.24 dan 37.90 hari. Jangka hayat betina lebih panjang pada suhu 25.7°C dari telur sehingga betina mati ketika diberi makan jagung dan diberi makan padi pada masing-masing 44.55 dan 50.25 hari, dan 43.79 dan 48.61 hari untuk jantan. Fekunditi lebih tinggi untuk larva yang diberi makan jagung (261.88 telur per betina) berbanding dengan padi (172.36 telur per betina). Kadar intrinsik (r_m) jauh berbeza antara kedua-dua perumah, dengan kadar yang lebih tinggi (0.209 individu setiap pasangan setiap hari) pada makan jagung berbanding dengan makan padi (0.154 individu setiap pasangan setiap hari). Nilai maksimum r_m bersama dengan kadar pembiakan bersih (R_o) dan kadar kenaikan terhingga (λ), dan masa penjanaan min terpendek (T) dan masa penggandaan (DT) juga dikira, menunjukkan bahawa jagung adalah baik untuk kehidupan *S. frugiperda*. Hasil penemuan ini bermanfaat untuk menjangkakan perkembangan populasi *S. frugiperda* pada kedua tanaman perumah untuk dijadikan rujukan bagi menentukan pengendalian yang tepat.

Kata kunci: Tempoh perkembangan, perosak invasif, Poaceae, pembiakan, kelangsungan hidup

INTRODUCTION

The Fall Armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is a native insect pest of America, which has now spread to various countries worldwide (Baloch et al. 2020). This pest first entered Indonesia in 2019 in Pasaman (West Sumatra) (Nonci et al. 2019), and now spread throughout all maize crops in Indonesia, including Lampung, West Java, Bengkulu, East Kalimantan and South Sumatra (Ginting et al. 2020, 2021; Hutasoit et al. 2020; Maharani et al. 2019; Subiono 2020; Trisyono et al. 2019). It is polyphagous (infesting more than 300 host plants), reduces yields, and causes economic losses in cultivated plants up to 8.3-20.6 million tons annually (Shylesha et al. 2018), especially members of Poaceae. The main host of this pest is the Poaceae family, such as maize, rice, sugar cane, sorghum, and millet (Casmuz et al. 2010; Montezano et al. 2018), but its preference is maize over other crops (Suby et al. 2020). The damage to maize crops in Africa can reduce yields of up to 250-630 million U.S. dollars annually (Bateman et al. 2018). A similar scenario occurs on maize in Ghana and Zambia with 22-67% (Day et al. 2017), 32-47% in Ethiopia (Kumela et al. 2018), and 11.57% in Zimbabwe (Baudron et al. 2019).

Rice is the preferred host plant for *S. frugiperda* similar to other Poaceae plants (Lye & Smith 1988; Subiono 2020). Kalleshwaraswamy et al. (2019) stated that *S. frugiperda* also attacks rice in India. It should be noted that rice is a staple food for the people in Indonesia and other Asian countries. *S. frugiperda* is divided into two strains, i.e rice strain (R strain) and corn strain (C strain) (Nagoshi et al. 2012). The R strain is a pest that feeds on rice and various grasses (Poaceae), while the C strain feeds on corn, cotton, and sorghum. However, these two strains may share the same hosts (Kuate et al. 2019). Based on the morphological characters, both strains are identical and can only be differentiated genetically and by the main host's preference (Saldamando & Velez-Arango 2010).

In their growth and development, insects require adequate nutrition. The host plant is an important factor because the insect's life cycle depends on the suitability of the host. The nutritional content of suitable host plants will support the growth and development of these insects (Barros et al. 2010). Furthermore, the growth and development of an individual are represented by the life table. Since maize and rice are plants commonly attacked by S. *frugiperda*, it is necessary to determine the effect of both plants on the FAW's life. This study aims to measure some developmental biology parameters and balance the biological activity of *S. frugiperda* on both host plants namely maize and rice.

MATERIALS AND METHODS

Host Plant Preparation

The host plants used were maize (Talenta variety) and rice (Ciherang variety). Each type of plant is planted as many as 2 plants per polybag, the total number is 50 plants per kind of host plant. They were planted in polybags measuring 25x25 cm with a planting medium of soil mixture, compost, and husk charcoal with a ratio of 1: 1: 1. Both of these plants were prepared to obtain their leaves for use as feed during the research. Furthermore, the leaves of maize and rice given to feed the larva were the young leaves or plant shoots, 3 gr/larva. The age of the maize plant used as feed was 2 weeks after planting (WAP), while the rice plant was four weeks after planting (WAP).

Propagation of *Spodoptera frugiperda*

The larvae samples of *S. frugiperda* were collected from a maize field in Sumedang District, West Java Province, Indonesia. Each larva was reared in a plastic cup container measuring 4 cm high and 4 cm in diameter. They were fed with baby corn cut into lengths of 2 cm, and the feed was changed every two days. Furthermore, a pair of male and female imagos were placed in separate containers for copulation to occur and fed with 10% honey liquid. The imago rearing container had a diameter of 20 cm and a height of 30 cm. The eggs obtained from the results of copulation were used as research material. Meanwhile, the temperature of the maintenance room was around 25.7ºC with a relative humidity (RH) of 78% and a duration of photoperiodicity (Dark: Light) (12 hours: 12 hours). Meanwhile, the insects used in this research were second-generation (F2) insects.

Biology of *S. frugiperda*

Biological observations were carried out in the Laboratory of Entomology, Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Padjadjaran, Indonesia. The observations started from the egg phase until the imago died. The eggs used were in the same age batch, and each individual was placed in different containers according to their respective feed, i.e maize leaves, and rice leaves. The variables observed included (i) length of time required for development from egg to imago, (ii) age of eggs, age of larvae (instar I - VI), age of pupa, and longevity of imago, (iii) number of eggs laid, (iv) body length of larval instars, I-VI, (v) width of the head capsule of larvae instar I – VI. The supporting observations included daily laboratory temperature and humidity at 10.00 am. Observed each individual (total 300 individuals) using stereo microscope Olympus SZ61.

Life Table of *S. frugiperda*

A total of 150 eggs of the same age obtained from three brood stock were reared on maize and rice feeds, therefore the total eggs on both host plants were 300. Each egg was placed on a plastic container (diameter of 5 cm x height of 8 cm) and lined with tissue paper to ensure a consistent dry surface. The instar transition in the larval stage was characterized by the release of the old cuticle (exuviae). The number of live larvae and molting were observed and recorded daily until the adult stage.

The surviving male and female imago were kept in plastic cages (30 cm x 60 cm). One cage was filled with one pair, which were reared and given honey 10% (wt/vol) feed until the imago died. Reproductive observations were carried out daily on oviposition media paper. The eggs laid were taken every day and counted.

The data obtained were recorded in a table known as the Cohort Table, according to the study of population dynamics. Furthermore, the net reproductive rate (R_o) calculation was based solely on the female population, and it was assumed that sufficient males were available in the vicinity. The data required for the calculation included the age of *S. frugiperda* (x), age-specific survival rate (l_x), and age-specific fecundity (m_x). Age-specific fecundity involves the average number of *S. frugiperda* egg laid by the imago daily at age (x). The proportion of the number of eggs laid to all individuals (females) during the cohort generation was ($\sum l_x m_x$). Furthermore, age-specific survival rate and age-specific fecundity data can be described in a curve and life table. Based on the cohort table data, the calculation can be continued to determine other parameters. According to Birch (1948), the calculated life table parameters include:

(i) Gross reproduction rate (GRR) $=\Sigma$ mx;
(ii) Net reproduction rate (R_o) = Σ lxmx;
(iii) Intrinsic rate of increase (r_m) = ln (R_o) /T;
(iv) Average generation time (T) = Σ xlxmx /Σ lxmx;
(iv) Doubling time (DT) = ln (2)/r
(v) Finite rate of increase (λ) = exp (r_m).

Data Analysis

All life table data were processed using the Jackknife method (Maharani et al. 2016) using Microsoft Excel 2019 software. The analysis of variance to ascertain the effect of the host plant on the development of *S. frugiperda* was carried out using the Independent Sample *T-Test* with the SPSS 25 (α: 95%).

RESULTS

Biology and Life Table

Spodoptera frugiperda has a holometabolic metamorphosis type. The development stage consists of eggs, larvae (6 instars), pupa, and imago. The life cycle of *S. frugiperda* lasts 32.24 days on maize and 37.90 days on rice (Table 1). These were significantly different (*P≤0.05*) according to the Independent Sample *T-Test*. Meanwhile, the length of larval stages, instars I-

VI also showed the same pattern, for example, the maize-fed larvae had a shorter lifespan than the rice-fed ones.

The first instar larvae were greenish-white and did not show the characteristics of *S. frugiperda*. The morphological characters of *S. frugiperda* started to appear on instar-III, which included an inverted Y shape on the head and four pinnacles in the last abdomen. The body length of maize-fed larvae was greater than in rice-fed larvae at all stages (Figure 1). The body of maize-fed larvae was longer than rice-fed and significantly different according to statistical tests (*P≤0.05)*. Furthermore, the width of the head capsule had no significant effect between the two types of feed given (Table 2).

Table 1. Duration of each stage of *S. frugiperda* in maize-fed and rice fed treatments

Stage		**Maize**	**Rice**	***T-Test***
Egg		2.66±0.57	3.00±0.00	0.411
Instar I		3.72±0.36	4.17±0.23	0.137
Instar II		2.86±0.21	3.08±0.05	0.159
Instar III		1.73±0.08	3.01±0.17	0.000*
Instar IV		1.99±0.03	2.11±0.16	0.347
Instar V		2.04±0.03	3.05±1.13	0.261
Instar VI		4.31±0.21	4.90±0.38	0.079
Instar I-VI		16.65±0.61	20.32±0.68	0.002*
Pupae		8.35±0.07	8.98±0.49	0.091
Imago	Female	16.89±0.55	18.94±1.50	0.091
	Male	16.13±1.02	16.71±0.93	0.511
Life cycle		32.24±0.06	37.90±0.43	0.002*

The mean value followed by (*) = significantly different *(P≤0.05)* based on the Independent Sample *T-Test* at the 95% confidence level.

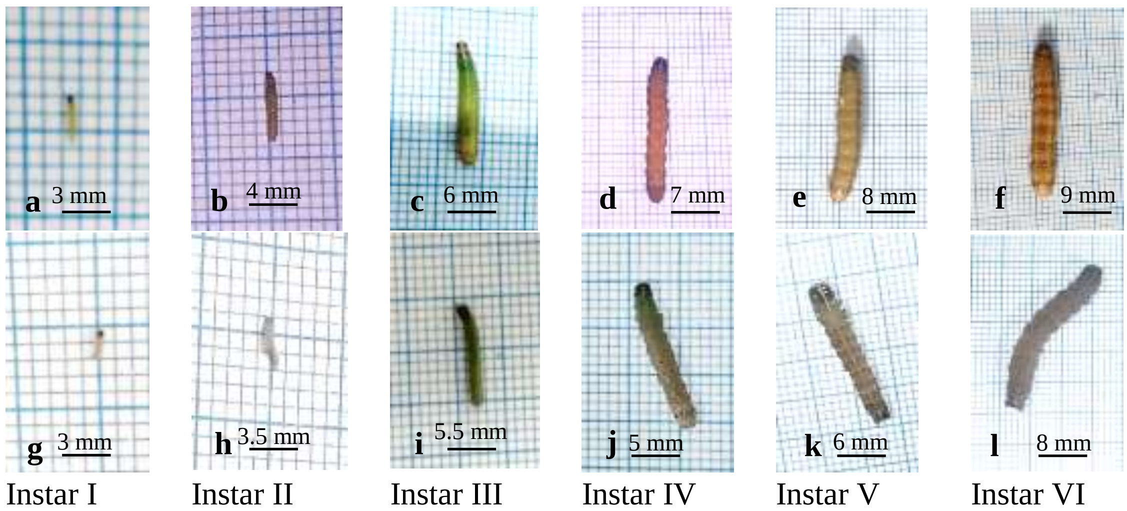

Figure 1. The body length of *S. frugiperda*. (a-f, instar I-VI) maize-fed larvae; (g-l, instar I-VI) rice-fed larvae

Table 2. Body length and head capsule width of *S. frugiperda* larvae for maize-fed and rice-fed (cm)

Larvae Stage	**Body Length**		***T-Test***	**Head Capsule Width**		***T-Test***
	Maize	**Rice**		**Maize**	**Rice**	
Instar 1	2.71±0.10	1.98±0.09	0.000*	0.34±0.05	0.33±0.09	0.660
Instar 2	4.50±0.74	3.15±0.39	0.000*	0.50±0.08	0.47±0.39	0.382
Instar 3	12.00±1.76	9.00±1.49	0.001*	1.10±0.09	1.07±1.49	0.458
Instar 4	19.60±0.84	15.90±0.88	0.000*	1.69±0.11	1.62±0.88	0.160
Instar 5	22.40±1.35	20.20±0.79	0.001*	2.00±0.00	1.97±0.79	0.193
Instar 6	28.60±2.12	25.40±2.80	0.010*	2.84±0.12	2.77±2.80	0.196

The mean value followed by (*) = significantly difference ($P \leq 0.05$) based on the Independent Sample *T-Test* at the 95% confidence level.

Survivorship and Fecundity of *S. frugiperda*

The daily observations showed that the length of life or the ability to survive *S. frugiperda* from egg to imago were significantly different in each plant. The lifespan of female *S. frugiperda* on maize was 5.7 days shorter than in rice, and the male individual of *S. frugiperda* on maize was also shorter, 4.82 days compared to rice (Table 3). The sex ratio of *S. frugiperda* in maize between females and males was 1.03:1, while in rice, the sex ratio between females and males was 1.04:1. These results showed that the type of feed does not affect the pattern of formation of the sex ratio.

Tabel 1. Longevity, fecundity, and sex ratio of *S. frugiperda* on maize and rice

Parameters		**Maize**	**Rice**	*T-Test*
Longevity	Female	44.55±0.59	50.25±1.04	0.001*
	Male	43.79±0.99	48.61±0.55	0.002*
Fecundity		261.88±14.47	172.36±17.06	0.002*
Sex Ratio (Female : Male)		1.03:1	1.04:1	

The mean value followed by (*) = significantly different ($P \leq 0.05$) based on the Independent Sample *T-Test* at the 95% confidence level

The survival ability of *S. frugiperda* in rice was lower than in maize. Figure 2 showed that the mortality of *S. frugiperda* in maize started from the 6th day of rearing with a survival rate of 99% and tended to decrease until the 46th day until all individuals died. Based on the survival curve of *S. frugiperda* rice-fed, the death started on day 5 to day 52 (Figure 3). From the two survival curves obtained, *S. frugiperda* was included in the type I survival ship curve. This is because the highest mortality occurred when the individual became older, with few deaths at the beginning.

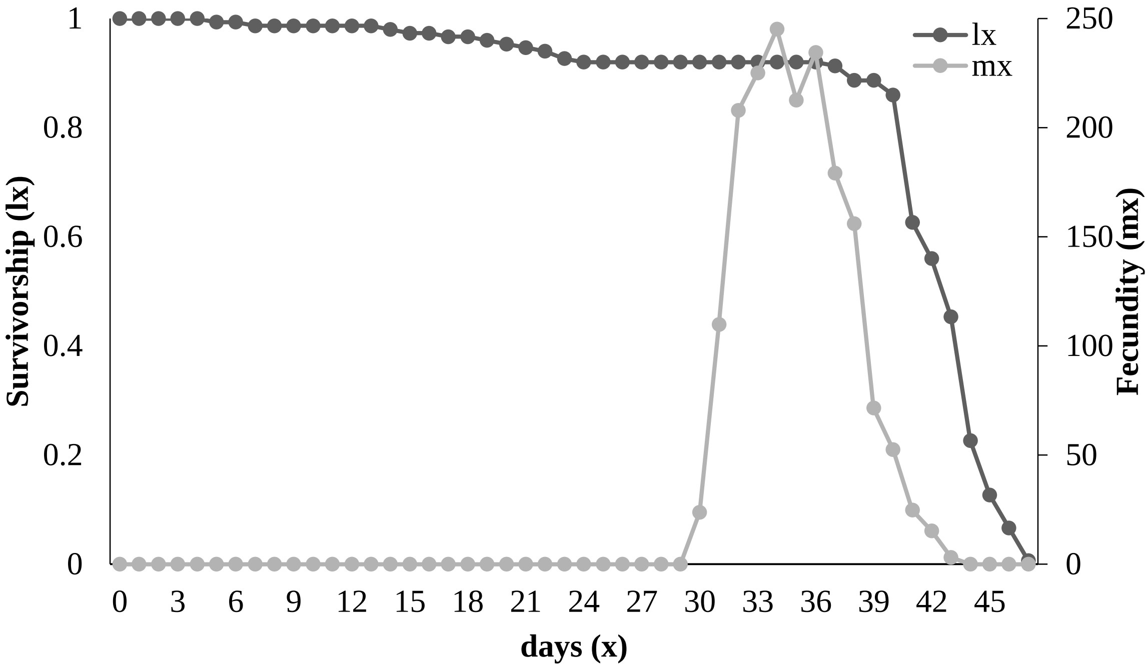

Figure 2. Survivorship (lx) and fecundity (mx) of *S. frugiperda* fed on maize plants

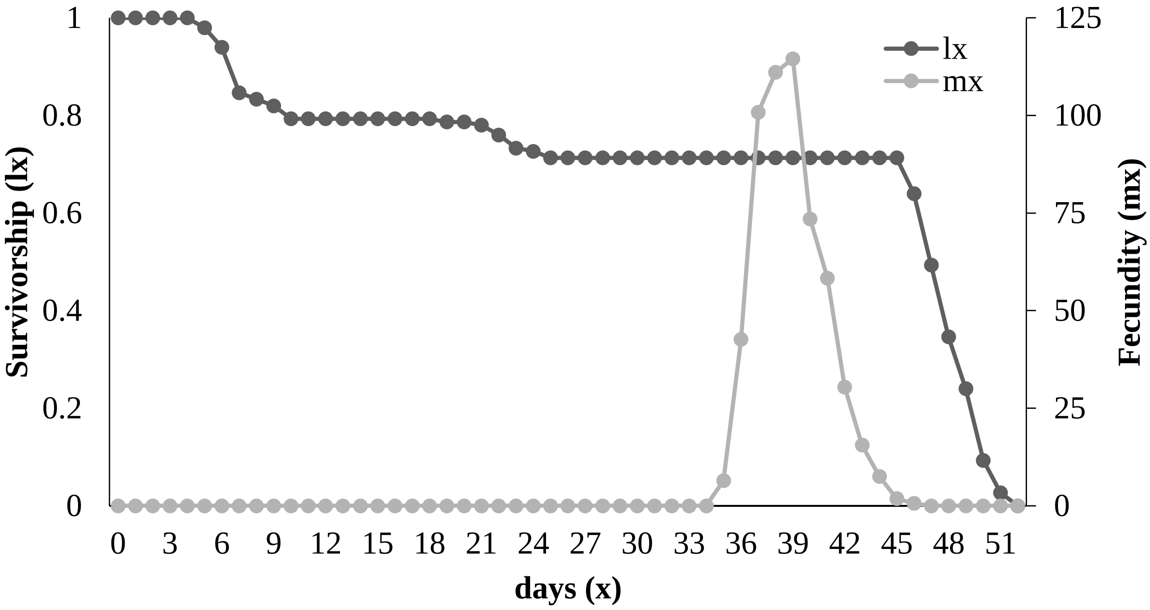

Figure 3. Survivorship (lx) and fecundity (mx) of *S. frugiperda* fed on rice plants

The females of *S. frugiperda*, which were maize-fed, produced more eggs with a faster laying time, and the duration of egg production was longer than that of *S. fugiperda* rice-fed. For maize-fed females, egg-laying started on the 30^{th} – 43^{rd} day. The average female fecundity reached a maximum point on day 34, with 245.23 eggs laid. On the survival ability of *S. frugiperda* on rice-fed females, the egg-laying started from day 35 to day 46. The population began to reduce on day 6, and the highest fecundity peak of *S. frugiperda* for rice-fed females occurred on day 39, with an average of 114.56 eggs laid on that day.

Life Table

Knowing the values of the life table parameters of a population is one of the first steps in studying the development of an insect population. These parameters include the gross reproduction rate (GRR), net reproduction rate (R_o), intrinsic growth rate (r_m), limited growth rate (λ), average generation period (T), and multiplication capacity (DT). The life table containing information on *S. frugiperda* in maize and rice are shown in Table 4.

Table 4. Life table parameters of *S. frugiperda* for Maize-fed and rice-fed treatments

Life Table Parameters	Maize	Rice	Unit	*T-Test*
GRR	1791.47±180.22	563.35±129.96	Individual/Generation	0.001*
Ro	1599.02±127.92	398.87±73.03	Individual/female/Generation	0.000*
r_m	0.209±0.003	0.154±0.004	Offspring/female/Generation	0.000*
T	35.276±0.64	39.363±0.41	Days	0.001*
DT	3.31±0.04	4.51±0.11	Days	0.000*
λ	1.23±0.003	1.17±0.004	Days	0,000*

The mean value followed by (*) = significantly difference (P≤0.05) based on the Independent Sample *T-Test* at the 95% confidence level

The life table parameter values varied depending on the type of host plant. The net reproduction rate (R_o) and intrinsic rate increase (r_m) of *S. frugiperda* reared on maize were significantly higher compared to the ones reared on rice (*P≤0.05*). The same pattern was shown by the difference in the value of the limited growth rate (λ) between the two plant hosts. However, the different patterns in the generation time (T) and doubling time (DT) parameters in maize had a shorter time, specifically 35.276 days and 3.3, and were significantly different (*P≤0.05*) compared to rice.

DISCUSSION

Spodoptera frugiperda lives on both host plants, i.e. maize, and rice. This agrees with Hay-Roe et al. (2016) which observed that *S. frugiperda* infested corn, rice, sorghum, and various types of grass and caused damage to these host plants. The life cycle of *S. frugiperda* was significantly shorter on maize plants compared to rice (Table 1). The nutrition in a plant is a primary factor that regulates the growth, reproduction, and diversity of an insect. Other factors that influence the duration of insect development include the shape and density of trichomes on leaves (Schoonhoven et al. 2005). An unsuitable level of feed quality will result in less fertile insects and longer development. The growth process of the larval stage is influenced by the amount of protein present in the feed. This protein will be used for body system formation to enable larvae to reach the final instar stage more quickly with a perfect and fertile shape (Savopoulou-soultoni et al. 1994). Silva et al. (2017), showed that *S. frugiperda* fed with corn feed had a shorter development stage than other feeds. This was also observed by Hutasoit et al. (2020), which showed that maize was an appropriate feed for the growth and development of *S. frugiperda*. The protein content in maize is about 9.5% higher than rice which is only about 7.1% (Sugiyono et al. 2004). Furthermore, this is supported by other data that *S. frugiperda* generally attacks maize crops in various countries (Cock et al. 2017; Goergen et al. 2016; Sharanabasappa et al. 2018; Sidana et al. 2018).

Proper nutrition enhances insect growth and development. Insects with appropriate and sufficient nutrition produce a fit body such as a long body, a short life cycle, and many eggs produced. From Table 2, *S. frugiperda* that fed on maize reached the final instar stage faster and had a longer body length than rice-fed because maize has higher protein. Kataria (2014), stated that the protein, fat, and fiber content in corn is higher than in rice and these nutrients are required to produce energy.

Environmental conditions play an important role in the development of insects. The existence and population of S. *frugiperda* larvae in the field are strongly influenced by environmental conditions such as temperature, humidity, and rainfall (Anandhi et al. 2020). The life cycle of *S. frugiperda* in summer is shorter (30 days) and longer in spring and winter (60 days) (Kondidie 2011). Furthermore, temperature and humidity during this study were highly supportive of the development of *S. frugiperda*. The average temperature was 25.75^{o}C with a humidity of 78%. This temperature is included in the category of optimum temperature for insect development, therefore the *S. frugiperda* cycle obtained was about 30 days (Murúa & Virla 2004).

The age-specific fecundity (m_x) showed the number of female eggs produced by the female parent on x-day, and was calculated after considering the sex ratio. Figures 2 and 3 showed the number of eggs laid per day by *S. frugiperda* on maize-fed and rice-fed. The difference in mortality rates of *S. frugiperda* in the two types of feed given may have been influenced by nutrition. The quality of plant nutrition affects life span and insect reproduction (Awmack & Leather 2002; Pinto et al. 2019). *Spodoptera litura* showed different responses to growth, development, and eggs produced on five types of host plants. Water spinach (*Ipomoea aquatica*) and castor bean (*Ricinus communis*) are the most suitable hosts for *S. litura* (Bayu & Krisnawati 2016).

The R_o value for *S. frugiperda* fed on maize was higher than that fed on rice, which was ±1599.02 and ±398.87 individuals per parent per generation for each host plant. According to Maharani et al. (2016) and Hidayat et al (2019), high R_o and GRR values indicate the suitability of an insect population towards its host plant. The highest R_o value was found in maize and significantly different from the R_o value in rice. Therefore, it was concluded that *S. frugiperda* was more suitable in maize than in rice. Temperature and food crops influence fecundity through their influence on pupal weight and the adult body size of *Streblote panda* (Calvo & Molina 2005). The balance of the sex ratio between male and female imago also determined the number of eggs produced because it influenced the mating process. In this study the *S. frugiperda* sex ratio was 1.03:1 (female: male) for FAW fed on maize and 1.04:1 rice-fed.

The intrinsic rate of increase (r_m) involves the increase in population in a constant environment and unlimited resources. The intrinsic rate of increase is a statistic composite that has taken into account various biological parameters such as developmental period, personality, lifespan, survival, and sex ratio (Carey 1993). Accordingly, the intrinsic rate of increase can be used to compare the potential increase in pest populations on various host plants. The higher the r_m value in a host plant, the higher the potential for increasing the pest population on the host plant (Maharani et al. 2016).

The value of the intrinsic rate of increase (r_m) in *S. frugiperda* in maize was 0.209 individuals per female per day. This was higher and significantly different from the r_m value of *S. frugiperda* in rice at 0.154 individuals per female per day. The value of intrinsic growth rate changes with a higher and wide distribution when environmental conditions such as climate are supported (Zacarias 2020). Some types of Armyworms show a comparable or slightly higher intrinsic growth rate. For example, the intrinsic rate of increase of *S. frugiperda* in maize

0.22 (Hutasoit et al. 2020), *S. exigua* 0.207 (Farahani et al. 2011), *S. exigua* 0.131, 0.137, 0.136, and 0.102 (Mardani-Talaei et al. 2016), *S. litura* 0.18, 0.13, and 0.15 (Tuan et al. 2014). Meanwhile, the value of the limited growth rate (λ) in *S. frugiperda* fed with maize was 1.23 days and higher than those fed with rice, which was 1.17 days. The high value of multiplying capability may cause a decrease in environmental resources, thereby affecting the intrinsic rate of increase (r_m) (Zacarias 2020).

The mean generation period (T) is the average time taken from when the eggs are laid until the female imago produces half of its offspring (Carey 1993). The species of a population with a lower T value will experience faster growth compared to population species with a high T value (Subagyo 2014). Furthermore, the mean generation of *S. frugiperda* at 25.75°C that fed on maize and rice were ±35.276 and ±39.363 days, respectively. The time required for *S. frugiperda* to produce half of its offspring for maize-fed was shorter compared to rice-fed. The shortest time required for *S. frugiperda* to multiply (D.T.) was found in maize, namely 3.31 days, and the longest in rice, namely 4.51 days. These differences occurred due to variations in the physical and chemical factors of the leaves of each host plant tested (Maharani et al 2016). The smaller T and D.T. values indicated that the insects will reproduce and multiply faster.

CONCLUSION

The differences in the type of host plant affected several parameters. The maize-fed *S. frugiperda* had an egg stage and a shorter larval development period compared to the rice-fed. The body size of the maize-fed larvae was larger. In the biological balance parameters such as intrinsic rate of increase (r_m), net reproduction rate (R_o), and finite rate of increase (λ), they were higher in maize compared to rice with successive values of 0.209 individuals/female/day; 1599.02 individuals/female/generations and 1.23 days. Meanwhile, the average generation time (T) and the double period (DT) in maize were significantly shorter than rice, respectively i.e 35.28 days and 3.31 days. The results showed that between the two types of plants tested, maize was the most suitable host for the development and growth of *S. frugiperda*. Therefore, with the support of other environmental factors, FAW population increases considerably faster in maize than in rice cultivation.

ACKNOWLEDGEMENT

The author acknowledges the financial grant internal research Nomor: 1427/UN6.3.1/LT/2020, from Universitas Padjadjaran, Bandung, West Java, Indonesia.

REFERENCES

Anandhi, S., Saminathan, V.R., Yasodha, P., Roseleen, S.S.J., Sharavanan, P.T., & Rajanbabu, V. 2020. Correlation of fall armyworm *Spodoptera frugiperda* (J.E. Smith) with weather parameters in maize ecosystem. *International Journal of Current Microbiology and Applied Sciences* 9(8): 1213-1218.

Awmack, C.S., & Leather, S.R. 2002. Host plant quality and fecundity in herbivorous insect. *Annual Review of Entomology* 47: 817–844.

Baloch, M.N, Fan, J., Haseeb, M., & Zhang, R. 2020. Mapping potential distribution of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in Central Asia. *Insects* 11(3): 1–10.

Barros, E., Torres, J.B., Ruberson, J.R. & Oliveira, M.D. 2010. Development of *Spodoptera frugiperda* on different hosts and damage to reproductive structures in cotton. *Entomologia Experimentalis et Applicata* 137: 237-245.

Bateman, M.L, Day, R.K., Luke, B., Edgington, S., Kuhlmann, U., Cock, M.J.W. 2018. Assessment of potential biopesticide options for managing fall armyworm (*Spodoptera frugiperda*) in Africa. *Journal of Applied Entomology* 142: 805–819.

Baudron, F., Zaman-Allah, M.A., Chaipa, I., Chari, N., & Chinwada, P. 2019. Understanding the factors influencing fall armyworm (*Spodoptera frugiperda* J.E. Smith) damage in African smallholder maize fields and quantifying its impact on yield. A case study in Eastern Zimbabwe. *Crop Protection* 120: 141–150.

Bayu, M.S.Y.I., & Krisnawati, A. 2016. The difference growth and development of armyworm (*Spodoptera litura*) on Five Host Plants. *Nusantara Bioscience* 8(2): 161-168.

Birch, L.C. 1948. The intrinsic rate of natural increase of an insect population. *Journal of Animal Ecology* 17(1): 15-26.

Calvo, D. & Molina, M. 2005. Fecundity–body size relationship and other reproductive aspects of *Streblote panda* (Lepidoptera: Lasiocampidae). *Annals of The Entomological Society of America* 98(2): 191-196.

Carey JR. 1993. *Applied Demography for Biologists with Special Emphasis on Insects*. Oxford: Oxford University Press.

Casmuz, A., Juarez, M.L., Socıas, M.G., Murua, M.G., Prieto, S., Medina, S. 2010. Review of the host plants of fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae). *Revista de la Sociedad Entomológica Argentina* 69 (3-4): 209–231.

Cock, M.J.W, Beseh, P.K., Buddie, A.G., Cafa, G, & Crozier, J. 2017. Molecular methods to detect *Spodoptera frugiperda* in Ghana, and implications for monitoring the spread of invasive species in developing countries. *Scientific Report* 7(4103): 1-10.

Day, R., Abrahams, P., Bateman, M., Beale, T., Clottey, V. …..et al. 2017. Fall armyworm: Impacts and implications for Africa. *Outlooks Pest Management* 28(5): 196–201.

Farahani S, Naseri, B. & Talebi, A.S. 2011. Comparative life table parameters of the beet armyworm, *Spodoptera exigua* (Hubner) (Lepidoptera, Noctuidae) on five host plants. *Journal of the Entomological Research Society* 13(1): 91-101.

Ginting, S., Zarkani, A., Wibowo, R.H. & Sipriyadi, 2020. New invasive pest, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) attacking corn in Bengkulu, Indonesia. *Serangga* 25(1): 105–117.

Ginting, S., Zarkani, A., Wibowo, R.H. & Sipriyadi, 2021. Corrigendum, New invasive pest, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) attacking corn in Bengkulu, Indonesia. *Serangga* 26(1): 110-112.

Hay-Roe, M.M., Meagher, R.L., Nagoshi, R.N. & Newman, Y. 2016. Distributional patterns of fall armyworm parasitoids in a cornfield and a pasture field in Florida. *Biological Control* 96: 48-56.

Hidayat, P., Harleni., Maharani, Y. & Triwidodo, H. 2019. Biology and demography statistic aphids *Rhopalosiphum rufiabdominale* (Sasaki) and *Tetraneura nigriabdominalis* (Sasaki) (Hemiptera: Aphididae) in rice roots. *Jurnal Entomologi Indonesia* 16(3): 180-186.

Hutasoit, R.T., Kalqutny, S.H. & Widiarta, I.N. 2020. Spatial distribution pattern, bionomic, and demographic parameters of a new invasive species of armyworm *Spodoptera frugiperda* (Lepidoptera; Noctuidae) in maize of South Sumatra, Indonesia. *Biodiversitas* 21(8): 3576–3582.

Goergen G, Kumar, P.L., Sankung, S.B., Togola, A. & Tamo, M. 2016. First report of outbreaks of the fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in West and Central Africa. *Plos One* 11(10): 1-9.

Kalleshwaraswamy, C.M., Asokan, R., Mahadevaswamy, H. M. & Sharanabasappa. 2019. First record of invasive fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on rice (*Oryza sativa*) from India. *Journal of Entomology and Zoology Studies* 7(3): 332–337.

Kataria, R. 2014. Proximate nutritional evaluation of maize and ice gluten free cereal. *IOSR Journal of Nursing and Health Science* 3(2): 1-6.

Kondidie, D.B. 2011. Genetic variability and gene flow of the fall army worm *Spodoptera frugiperda* (J.E. Smith) in the Western Hemisphere and susceptibility to insecticides. Dissertation, University of Nebraska-Lincoln, Lincoln, Nebraska.

Kuate, F.A., Hanna, R., Doumtsop Fotio, A.R.P., Abang, A.F. & Nanga, S.N. 2019. Correction: *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) in Cameroon: Case study on its distribution, damage, pesticide use, genetic differentiation and host plants. *Plos One* 14(6): 1–18.

Kumela, T., Simiyu J., Sisay, B., Likhayo, P., Mendesil, E., Gohole, L. & Tefera, T. 2018. Farmers' knowledge, perceptions, and management practices of the new invasive pest, fall armyworm (*Spodoptera frugiperda*) in Ethiopia and Kenya. *International Journal of Pest Management* 65(1): 1–9.

Lye, B.H. & Smith, C.M. 1988. Evaluation of rice cultivars for antibiosis and tolerance resistance to fall armyworm (Lepidoptera: Noctuidae). *The Florida Entomology* 71(3): 254-261.

Maharani, Y., Rauf, A., Sartiami, D. & Anwar, R. 2016. Biology and life table of papaya mealybug *Paracoccus marginatus* Williams & Granara de Willink (Hemiptera: Pseudococcidae) on three host plant species. *Jurnal HPT Tropika* 16(1): 1-9.

Maharani, Y., Dewi, V.K., Puspasari, L.T., Rizkie, L., Hidayat, Y. & Dono, D. 2019. Cases of fall armyworm *Spodoptera frugiperda* J. E. Smith (Lepidoptera: Noctuidae) attack on maize in Bandung, Garut and Sumedang District, West Java. *Cropsaver* 2(1): 38–46.

Mardani-Talaei, M., Nouri-Ganbalani, G., Naseri, B., Hassanpour, M., Mottaghinia, L. & Mansouri, S.M. 2016. Comparative life table parameters of the *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae) on corn hybrids under laboratory conditions. *Journal of Entomological Society of Iran* 35(4): 17-27.

Montezano, D.G., Specht, A. & Sosa-Gomez, D.R. 2018. Host plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas. *African Entomology* 26(2): 286–300.

Murúa, G. & Virla, E. 2004. Population parameters of *Spodoptera frugiperda* (Smith) (Lep.: Noctuidae) fed on corn and two predominant grasess in Tucuman (Argentina). *Acta Zoologica Mexicana* 20(1): 199-210.

Nagoshi, R.N., Meagher, R.L. & Hay-Roe, M. 2012. Inferring the annual migration patterns of fall armyworm (Lepidoptera: Noctuidae) in the United States from mitochondrial haplotypes. *Ecology and Evolution* 2(7): 1458–1467.

Nonci, N., Kalqutny, S.H., Mirsam, H., Muis, A., Azrai, M. & Aqil, M. 2019. *Pengenalan Fall Armyworm (Spodoptera frugiperda J.E. Smith) Hama Baru pada Tanaman Jagung di Indonesia*. Maros, Indonesia: Balai Penelitian Tanaman Serealia.

Pinto, J.R.L., Torres, A.F., Truzi, C.C., Vieira, N.F., Vacari, A.M. & De Bortoli, S.A. 2019. Artificial corn-based diet for rearing *Spodoptera frugiperda* (Lepidoptera: Noctuidae). *Journal of Insect Science* 19(4): 1–8.

Saldamando, C.I. & Velez-Arango, A.M. 2010. Host plant association and genetic differentiation of corn and rice strains of *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) in Colombia. *Neotropical Entomology* 39(6): 921-929.

Savopoulou-soultoni, M., Stavridis, D.G., Vassillou, A., Stafilidis, J.E. & Irakiidis, J. 1994. *Response of Lobesia botrana (Lepidoptera: Tortricidae) to Levels of Sugar and Protein in Artificial Diets.* Thessalonik Greece: Aristotelian University of Thessalonik.

Schoonhoven, L.M., van Loon, J.J.A. & Dicke, M. 2005. *Insect Plant Biology*. United Kingdom: Oxford University Press.

Sharanabasappa., Kalleshwaraswamy, C.M., Maruthi, M.S. & Pavithra, H.B. 2018. Biology of invasive fall armyworm *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on maize. *Indian Journal of Entomology* 80(3): 540-543.

Shylesha, A.N., Jalali, S.K., Gupta, A., Varshney, R. & Venkatesan, T. 2018. Studies on new invasive pest *Spodoptera frugiperda* (Smith, J. E.) (Lepidoptera: Noctuidae) and its natural enemies. *Journal of Biological Control* 32(3): 145–151.

Sidana, J., Singh, B. & Sharma, O.P. 2018. Occurrence of the new invasive pest, fall armyworm, *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae), in the maize fields of Karnataka, India. *Current Science* 115 (4): 621-623.

Silva D.M., Bueno, A.F., Andrade, K., Stecca, S.C., et al. 2017. Biology and nutrition of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) fed on different food sources. *Scientia Agricola* 74(1): 18-31.

Subagyo, V.N.O. & Hidayat, P. 2014. Life table of the silverleaf whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) on chili pepper and goatweed at temperatures 25°C and 29°C. *Jurnal Entomologi Indonesia* 11(1): 11-18.

Subiono, T. 2020. Preferences of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in several feed sources. *Jurnal Agroekoteknologi Tropika Lembab* 2(2): 130–134.

Suby, S.B., Soujanya, P.L., Yadava, P., Patil, J., Subaharan, K., Prasad, G.S. et al. 2020. Invasion of fall armyworm (*Spodoptera frugiperda*) in India: Nature, distribution, management and potential impact. *Current Science* 119(1): 44-51.

Sugiyono, T., Soewarno, Soekarto, Purwiyatno, H. & Agus, S. 2004. Kajian optimasi teknologi pengolahan beras jagung instan. *Jurnal Teknologi Industri Pangan* 15: 119–128.

Trisyono, Y.A, Suputa, V.E.B., Aryuwandari, M., Hartaman & Jumari. 2019. Occurrence of heavy infestation by the fall armyworm *Spodoptera frugiperda*, a new alien invasive pest, in corn in Lampung Indonesia. *JPTI* 23(1): 156–160.

Tuan, S.J., Lee, C.C. & Chi, H. 2014. Population and damage projection of *Spodoptera litura* (F.) on peanuts (*Arachis hypogaea* L.) under different conditions using the age stage, two-sex life table. *Pest Management Science* 70: 805-813.

Zacarias, D.A. 2020. Global bioclimatic suitability for the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae), and potential co-occurrence with major host crops under climate change scenarios. *Springer Nature* 161: 555–566.