BIODIVERSITAS
Volume 24, Number 1, January 2023
Pages: 523-530

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d240161

The development of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) on several varieties of maize

NOVRI NELLY♥, HASMIANDY HAMID, EKA CHANDRA LINA, YUNISMAN, YAHERWANDI, YELSI DWI PUTRI

Departement Plant Protection, Faculty of Agriculture, Universitas Andalas. Kampus Unand Limau Manis, Padang 25163, West Sumatra, Indonesia. Tel.: +62-751-72701, Fax.: +62-751-72702 ♥email: novrinelly@agr.unand.ac.id

Manuscript received: 9 October 2022. Revision accepted: 23 January 2023.

Abstract. *Nelly N, Hamid H, Lina EC, Yunisman, Yaherwandi, Putri YD. 2023. The development of* Spodoptera frugiperda *(Lepidoptera: Noctuidae) on Several varieties of maize. Biodiversitas 24: 523-530.* Fall armyworm (FAW) or *Spodoptera frugiperda* (Lepidoptera: Noctuidae) is an invasive pest in Indonesia that cause damage to maize (*Zea mays*). Farmers for animal feed mainly cultivate several varieties of maize in West Sumatra, Indonesia. Therefore, it is necessary to test the resistance of maize varieties to fall armyworms planted by farmers. Therefore, this research aims to determine the resistance of several observed maize varieties based on their effects on the developmental time of *S. frugiperda*. The study was arranged in a Completely Randomized Design (CRD) with five treatments and five replications. The treatments for larvae feed consisted of five maize varieties: Sukmaraga, NK-212, Pioneer 21, Bonanza F1, and Secada F1. The development length from egg to adult and life parameters in the second generation were observed. Results of the study showed that the larval and pupal stages of *S. frugiperda* in the Sukmaraga variety had a longer development duration than the other four varieties, with the larval stage at 20.38 days and pupae at 11.26 days. In addition, the lowest pupae weight was found in the Sukmaraga variety. The maize varieties affect the length of the larval stage and the weight of the pupae and eggs produced. Based on these results, it can be concluded that Sukmaraga is a variety causing a more prolonged larval stage and lower pupae weight than other varieties. Furthermore, the eggs produced by the second-generation female *S. frugiperda* adult are fewer than in different varieties.

Keywords: Bioecology, fall armyworm, resistance, varieties

INTRODUCTION

The productivity of maize (*Zea mays*) in West Sumatra has fluctuated in the last three years, where 6.92 tons/ha was obtained in 2018, and in 2019, it decreased to 6.78 tons/ha, which later increased to 6.96 tons/ha in 2020 (BPS Sumbar 2020). Generally, maize productivity can be disrupted by several factors, such as pest attacks, which cause loss of maize yields and directly impact the community's economy. One pest like *Spodoptera frugiperda* (Lepidoptera; Noctuidae), that is to say, fifteen (15) generations per year (Tendeng et al. 2019). Previously, this pest has also been reported in other countries, such as India (Suby et al. 2020). A previous investigation has shown that maize armyworm, fall armyworm (FAW), or *S. frugiperda* 2019, have attacked this pest for the first time in West Pasaman Regency, West Sumatra (Nelly et al. 2021). *Spodoptera frugiperda* larvae attack and damage all parts of the plant, thereby reducing optimal productivity, as similarly reported in the Lampung area (Nonci et al. 2019).

Spodoptera frugiperda is an insect in tropical areas, including the United States, Argentina, and other continents (Goergen et al. 2016). It has many hosts, which are food crops from the Graminae group, such as maize, rice, wheat, sorghum, and sugarcane (Maharani et al. 2019). In Africa, *S. frugiperda* has been found in many host plants (Kuate et al. 2019). In Brazil, *S. frugiperda* is closely associated with grasses, maize, wheat, and oat and has a lower potential as a soybean or cotton feeder (da Silva et al. 2017). Meanwhile, tests on several types of plants, such as tomatoes, maize, and wheat, were also carried out. The results showed that fecundity was the greatest on maize and wheat but the smallest on tomatoes. In addition, the highest intrinsic rate of increase, finite speed of growth, net reproductive rate, and shortest mean generation duration on maize was recorded (Wang et al. 2020). Based on previous research (Nelly et al. 2021), the maize varieties used by farmers, such as Pioneer, Pertiwi, Bisi 18, and NK212, in the West Pasaman area were damaged by the attack of *S. frugiperda*.

Spodoptera frugiperda can attack all stages of maize plants, from vegetative to generative (Nelly 2022). Damage is often found on the leaves and growing points of plants, which can cause damage to the formation of plant shoots (Maharani et al. 2019). Nonci et al. (2019) stated that *S. frugiperda* larvae could cause severe damage, often leaving only leaf bones and broken stems of maize plants.

The average length of *S. frugiperda* development at cooler temperatures lasts 60-90 days (Midega et al. 2018). Berger et al. (2008) reported that adult females would divert their energy to produce more eggs at high-temperature conditions. Insect development is influenced by temperature and other factors, such as the feed consumed by the larvae. Feeding with appropriate nutrition will make the development of insects more optimal (Altieri and Nicholls 2000). One variety's short life cycle indicated that this feed was a suitable host for *S. frugiperda* development.

Meanwhile, the varieties that interfere with the development of a pest can be said to be resistant. Wide varieties of maize have been released into the field and planted by farmers. Since maize is the primary host of *S. frugiperda*, there is a need to observe the most resistant varieties. This research aims to study the effect of maize varieties on the development of *S. frugiperda*.

MATERIAL AND METHODS

Research site

Insect observation and rearing were carried out in the Bioecology Laboratory, while the feed crops for the larvae included five maize varieties. Maize was grown in wirehouses at the Department of Plants Protection, Faculty of Agriculture, Andalas University, Padang, Indonesia.

The materials used were five varieties of maize commonly used by farmers (Sukmaraga, NK-212, Pioneer 21, Bonanza F1, and Secada F1), *Spodoptera frugiperda* larvae, soil, manure, one kg-sized polybag, label paper, honey, water, tissue, millimeter paper, rubber band, cotton, 50 mL plastic cup with a diameter of 4 cm and height of 3.5 cm, and 14 oz plastic cup with 6 cm diameter and 11 cm high. The tools used were a small brush, camera, microscope, ruler, scissors, and stationery.

Experimental design

This research used a completely randomized design (CRD) with five varieties as treatment, the feed source for *S. frugiperda* larvae, and five replications. The treatments were Sukmaraga, NK-212, Pioneer 21, Bonanza F1, and Secada F1.

Preparation of maize crops for *Spodoptera frugiperda* larvae feed

The planting medium used was soil and manure mixed with a ratio of 2:1 of 1 kg put in a polybag. Maize seeds are planted by mixing the ground with a depth of 2-5 cm. Subsequently, two maize seeds were planted per polybag and covered again with soil. Maize plants were buried every 15 days during the research to maintain feed availability. The plants used as feed are young leaves 3-4 weeks after planting. Plant maintenance is carried out by cleaning the surrounding weeds, watering plants to keep the soil moist, meeting water needs, and giving fertilizers to increase the nutrient content in the soil.

Spodoptera frugiperda larvae rearing

Spodoptera frugiperda larvae were obtained from maize plantations in Pauh District, Padang, West Sumatra Field. The larvae were taken using a brush, put in a plastic box, brought, and reared in the laboratory. Subsequently, the maize leaves were administered as feed by putting them in plastic cups (d: 4 cm and t: 3.5 cm). Larvae are reared until they become adults. The male and female adult forms were transferred into plastic boxes (d: 6 cm and t: 11 cm) and fed with honey at a concentration of 10% on cotton, which was placed on the lid of the plastic box. Adults reared until copulated and produced eggs maintained until they hatch into larvae in the first generation (F1). The test insects were first instar larvae from the second generation (F2).

Effect of larvae feed on the *Spodoptera frugiperda* development

A total of 10 1st instar larvae were fed according to treatment using five different varieties, which were kept in plastic boxes and labeled for each treatment. After entering the second instar larval stage, the larvae were transferred to a plastic cup with one larva/plastic cup. The maize leaves used the young leaves measuring 4x4 cm and are replaced daily to keep them fresh. The larvae were reared and observed every day until they formed pupae and adults. The male and female adults formed from pupae on same day were transferred to the cage box and fed with honey at a concentration of 10% cotton, which was placed on the cage lid. The male and female adults (1:1) were reared until they copulated to produce eggs. Subsequently, the eggs were kept until hatched, and the adult was observed until they died.

Effect of maize varieties as feed on the *Spodoptera frugiperda* development

Observations were made to determine the effect of maize varieties as larval feed on: (i) The stadia length of *S. frugiperda* larvae, which was observed daily after the eggs hatched into larvae. Furthermore, observations were made by calculating the development duration of the first to the sixth instar larvae; (ii) The length of the pupae stage, starting from the pupae formed to the adult; (iii) The live larvae formed was observed, and their development length was calculated until they became pupae. The percentage of successful pupae formed can be calculated using the formula:

$$P = \frac{Number\ of\ pupae\ formed}{Number\ of\ treatment\ larvae}\ x\ 100\%$$

(iv) Pupae weight (g) was observed by weighing the pupae formed on the first day using an analytical balance; (v) Adult Stadia Length (days) was calculated from the appearance of the adult until the adult dies; (vi) Percentage of Adult Appears (%). The success of the adult emerging from the pupae can be calculated using the formula:

$$P = \frac{number\ of\ adult\ offsprings}{number\ of\ treatment\ larvae}\ x\ 100\%$$

(vii) Sex ratio, the total male and female adults offsprings are calculated.

Life parameters of *Spodoptera frugiperda* with different maize varieties

The life parameters of *S. frugiperda* were observed for the next generation (F3 from initial rearing or F2 after treatment), starting from the adult form, laying eggs until hatching. (i) Preoviposition duration was counted from the female adult that app to produce the first egg; (ii) The oviposition duration was calculated from when the female adult laid the first egg until the last; (iii) The postoviposition duration was calculated from the last day the female adult

laid eggs until the adult died; (iv) The number of eggs and groups were counted for each female adult that produced eggs; (v) The length of the egg stage was calculated from the time the eggs were laid until they were hatched into the first instar larvae; (vi) The percentage of larvae that emerge from hatching eggs can be calculated using the formula:

$$P = \frac{Number\ of\ larvae\ appearing}{Number\ of\ eggs\ laid}\ x\ 100\%$$

Data analysis

Data were analyzed using analysis of variance, and if the treatment showed significance, then they were continued by testing the mean value with the LSD test at a 5% significance level using the Statistics 8.0 (Statistics for Windows) program.

RESULTS AND DISCUSSION

Effect of maize varieties as larval feed on the *Spodoptera frugiperda* development

Spodoptera frugiperda larvae fed with different varieties of maize showed different development times (P: 0.000). From Figure 1, it can be concluded that Sukmaraga is a variety that causes longer larval stadia than other varieties.

The length of larval stadia on the Sukmaraga variety was 20.38 days. That is significantly different from Bonanza F1, Secada F1, Pioneer 21, and NK-212 varieties, which were 18.20, 18.48, 18.58, and 18.44 days, respectively. Meanwhile, the shortest length of larval stadia is larvae fed with Bonanza 11 variety. Feeding larvae with different varieties of maize also causes differences in the development of each instar, as shown in Figure 2.

The first instar larval stage took longer for the Pioneer 21 variety, which was 2.88 days compared to others. The development of second-instar larvae in all varieties showed almost the same stadia length ranging from 2.48-2.66 days. The average length of the third instar *of S. frugiperda* larvae fed Sukmaraga was shorter than the others, only 0.42 days. Third, instar larvae fed Pionier 21, Secada F1, NK212, and Bonanza F1 for an average of 2 days. The length of the fourth instar larval stage on the Sukmaraga variety was 3.44 days longer than the other. Similarly, the fifth instar stadia duration was longer for the Sukmaraga variety than other varieties, which was 3.32 days. Sufficient length development also occurred in all treatments' fifth and sixth instars. The Pioneer 21, Secada F1, NK-212, and Bonanza F1 varieties showed a duration that was not significantly different from all these varieties. Furthermore, the late larvae or sixth instar will molt to complete the larval stage and turn into the pre-pupae stage. Pupae are formed after the pre-pupae stage is complete and molt in the late sixth instar larvae, as shown in Figure 3.

The pre-pupae is the larval stage, where there is no longer any feeding activity, and the larval size begins to shrink, as presented in Figure 3a. The pupae of *S. frugiperda* are oval and glossy brown, as exhibited in Figure 3B. The length of the pre-pupae and pupae stages is shown in Table 1. However, pupae from larvae fed with different varieties of maize showed no significant difference (P: 0.764) for pre-pupae. However, the length of the pupae stage was significantly different in all maize varieties (P: 0.000).

The pre-pupae stage with a long duration occurred in Secada F1 varieties for 2.24 days, followed by 2.18, 2.16, 2.14, and 2.10 days in Sukmaraga varieties, Bonanza F1, NK-212, and Pioneer 21, respectively. In the pupal stage, the difference in maize varieties affected the length of pupae development. Moreover, the pupae stage with a long duration occurred in the Sukmaraga variety, 11.26 days, significantly different from the Pioneer 21 variety for 10.16 days. These two varieties were significantly different from the Bonanza F1 (9.26 days), Secada F1 (8.76 days), and NK-212 (9.34 days).

The percentage of *S. frugiperda* pupae formation is shown in Figure 4. The results showed that maize varieties did not significantly affect the percentage of pupae formed (P: 0.430). In NK-212 and Sukmaraga varieties, the rate of pupae formed reached 100%, which is not significantly different from that of Bonanza F1 98%, Pioneer 21 98%, and Secada F1 96%. The difference in the percentage of pupae formed is due to death at the larval stage.

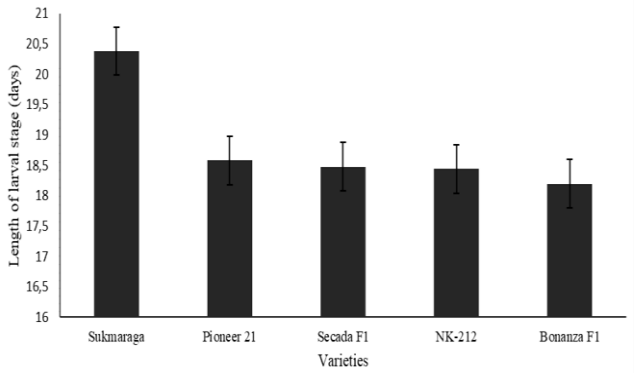

Figure 1. Larval stages of *Spodoptera frugiperda*-fed maize with different varieties

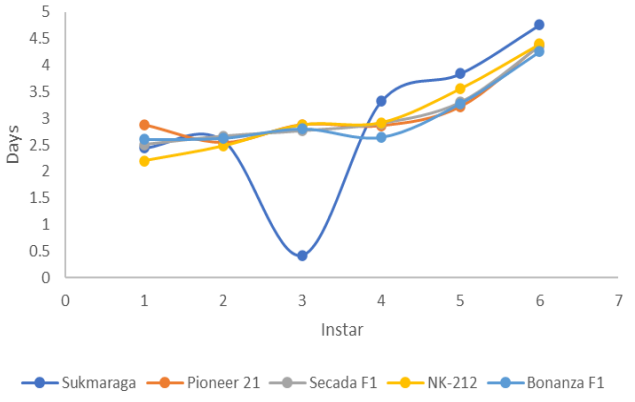

Figure 2. The duration of instar development of *Spodoptera frugiperda* larvae with different varieties of maize feed

The results showed that the use of maize varieties as larval feed affected the pupae weight of *S. frugiperda* (P: 0.007), as shown in Table 2. The pupae weight of Sukmaraga maize was significantly different from that of Bonanza F1, NK-212, and Pioneer 21 varieties, except for the Secada F1 variety. Pupae weight on the Bonanza F1, NK-212, and Pioneer 21 varieties was 0.11g, the Sukmaraga variety was 0.09g, and the Secada F1 variety was 0.10g.

The percentage of *S. frugiperda* adults that appeared, as shown in Figure 5, was not significantly different (P: 0.430). Figure 5 shows the average percentage of adults that appeared in different maize varieties, namely Sukmaraga 100%, Pioneer 21 98%, Bonanza F1 98%, Secada F1 96%, and NK-212 100%. Based on the percentage of male and female adult emergence, as shown in Table 5, the adult that emerged from larvae fed was not significantly different between varieties.

The male adult percentage in each maize variety that appeared in the Sukmaraga and the Secada F1 varieties was 58% and 34%. However, the rate of female adults that appeared in the Secada F1 variety (62%) was relatively higher than the other four varieties. That showed more female adults than males in Bonanza F1, Secada F1, and NK-212 varieties.

Table 1. Average pre-pupae and pupae stages of *Spodoptera frugiperda* in five maize varieties

Varieties	Stadia duration (days) ± sd	
	Pre-pupae	Pupae
Sukmaraga	2.18 ± 0.19	11.26 ± 0.34a
Pioneer 21	2.10 ± 0.15	10.16 ± 0.73b
Bonanza F1	2.16 ± 0.18	9.26 ± 0.83c
Secada F1	2.24 ± 0.16	8.76 ± 0.61c
NK-212	2.14 ± 0.15	9.34 ± 0.29c

Note: numbers followed by the same lowercase letter on the same line, not significantly different based on the results of the LSD test at the 5% level

Table 2. Average pupae weight of *Spodoptera frugiperda* in five maize varieties

Varieties	Average pupae weight (g) ± SD	
Bonanza F1	0.11 ± 0.00	a
NK-212	0.11 ± 0.00	a
Pioneer 21	0.11 ± 0.00	a
Secada F1	0.10 ± 0.04	ab
Sukmaraga	0.09 ± 0.00	b

Note: numbers followed by the same lowercase letter on the same line, not significantly different based on the results of the LSD test at the 5% level

A B

Figure 3. *Spodoptera frugiperda* developmental stage: A. pre-pupae stage, B. pupae

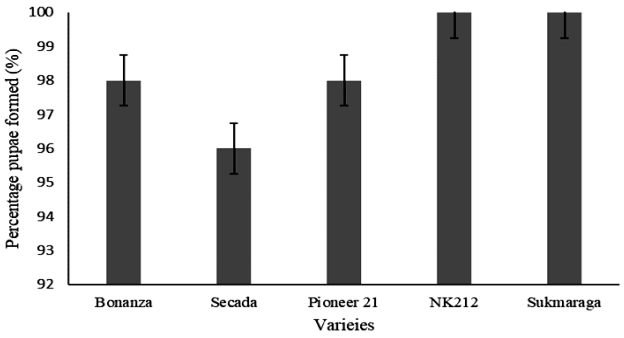

Figure 4. The average percentage of pupae formed in five maize varieties

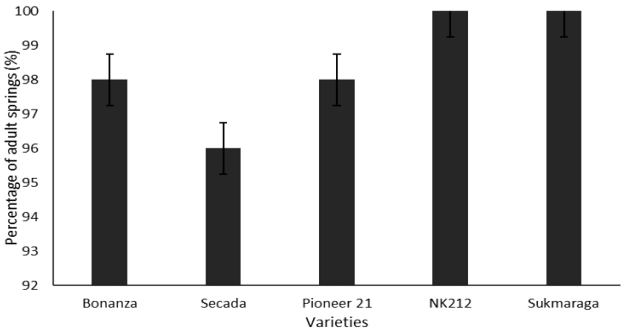

Figure 5. The average percentage of adults appearing in five maize varieties

Table 5. Average percentage, and number of male and female adult comparison of *Spodoptera frugiperda* in five maize varieties

Varieties	Percentage of adult		Total of adult		Sex ratio
	Male	Female	Male	Female	
Sukmaraga	58.00 ± 14.83	42.00 ± 14.83	5.8	4.2	1.4:1
Pioneer 21	54.00 ± 20.73	44.00 ± 16.73	5.4	4.4	1.2:1
Bonanza F1	40.00 ± 15.81	58.00 ± 14.83	4.0	5.8	1:1.5
Secada F1	34.00 ± 20.73	62.00 ± 20.49	3.4	6.2	1:1.8
NK 212	44.00 ± 20.73	56.00 ± 20.73	4.4	5.6	1:1.2

The morphology of male and female adults can be distinguished from the pattern of their wings. The male adult has wings with many patterns, such as white on the wing tips and brown, as shown in Figure 4a, while the female adult has a plain and grayish brown wing pattern, as presented in Figure 4b. Meanwhile, the form of *S. frugiperda* adult is illustrated in Figure 6.

The lifespan of a male adult is shorter than a female adult due to the difference in maize varieties as a source of feed for larvae. The shortest lifespan of male adults occurred in the Bonanza F1 variety, which was 5.02 days and was significantly different from Pioneer 21 with 6.72 days, followed by NK-212 and Sukmaraga with 6.83 days and 6.89 days, respectively, except the Secada F1 variety (6.12 days). The treatment of maize varieties on the lifespan of the female adult was not significantly different. Female adult, which has a longer duration of 9.50 days, was found in the Sukmaraga variety, as shown in Table 6.

Life parameters of *Spodoptera frugiperda* adult with different varieties

Preoviposition, oviposition, and post oviposition

The female adult undergoes a duration of preoviposition, oviposition, and postoviposition after copulation. Different maize varieties' effects on larvae feed caused preoviposition and oviposition duration to show significantly different results (P: 0.000). However, the postoviposition duration showed no significant difference in each maize variety (P: 0.187).

Table 7 shows that the longer preoviposition duration that occurred in the Pioneer 21 variety (4.20 days) was not significantly different from the Secada F1 variety (3.60 days) and Sukmaraga variety (3.80 days). However, it was significantly different with Bonanza F1 and NK-212, which were 2.80 and 2.60 days, respectively. The longest oviposition duration occurred in the NK-212 variety (6.40 days), and the shortest was 4.60 days, which occurred in the Pioneer 21 variety. The postoviposition duration in females was not significantly different in all treatments. The average postoviposition duration that occurs ranges from 2.20 to 3.80 days.

A **B**

Figure 6. Adult *Spodoptera frugipeda*; A. Male adult; B. Female adult

Table 6. The average lifespan of *Spodoptera frugiperda* adult is derived from larvae fed on different varieties of maize

Varieties	The lifespan of an adult (days) ±SD	
	Male	Female
Sukmaraga	6.89 ± 1.49a	9.50 ± 2.25a
Pioneer 21	6.72 ± 1.29a	8.27 ± 0.71a
NK-212	6.83 ± 1.30a	9.29 ± 1.01a
Secada F1	6.12 ± 0.87ab	7.95 ± 0.47a
Bonanza F1	5.02 ± 0.33b	8.40 ± 0.75a

Note: numbers followed by the same lowercase letter on the same line, not significantly different based on the results of the LSD test at the 5% level

Table 7. Average preoviposition duration, oviposition, and post-oviposition of female *Spodoptera frugiperda* adults on five different maize varieties

Varieties	Duration (days) ±sd		
	Preoviposition	Oviposition	Post oviposition
Pioneer 21	4.20 ± 1.48a	4.60 ± 1.34b	2.20 ± 1.30a
NK-212	2.60 ± 0.89b	6.40 ± 1.51a	2.20 ± 1.30a
Bonanza F1	2.80 ± 0.83b	5.20 ± 1.48ab	2.40 ± 1.14a
Secada F1	3.60 ± 0.89ab	4.80 ± 1.30ab	3.40 ± 1.14a
Sukmaraga	3.80 ± 0.83ab	5.80 ± 0.44ab	3.80 ± 1.48a

Note: numbers followed by the same lowercase letter on the same line, not significantly different based on the results of the LSD test at the 5% level

Number of eggs produced by female *Spodoptera frugiperda*

During oviposition, the female adult produces eggs which are laid in groups. The eggs are round, yellowish-green, and laid in groups by the female adult. The observations of whole egg groups laid by one female adult on the Pioneer variety showed that it was not significantly different from the Bonanza F1 variety but varied from the Secada F1, NK-212, and Sukmaraga varieties. The average number of egg groups in the Pioneer 21 variety was 15.40, followed by 12.60, 11.20, 10.60, and 11.00 in Bonanza F1, Secada F1, NK-212, and Sukmaraga varieties, as shown in Figure 6.

The number of eggs produced by one female was not significantly different for each treatment. The average number of eggs produced by one female adult on maize varieties are Pioneer 21 (623.00), Bonanza F1 (516.40), Secada F1 (512.20), NK-212 (579.20), and Sukmaraga (457.40). That indicates that egg-laying by female adults was not affected by different maize varieties, as illustrated in Figure 9.

During oviposition, the female adult can produce a different number of eggs each day. In the Sukmaraga variety, although the larval stadia duration is long compared to other varieties, the adults are reversed. As a result, the number of eggs produced is less on average, with 457.4 eggs/1 female compared to Pioneer 21, NK-212, Bonanza F1, and Secada F1.

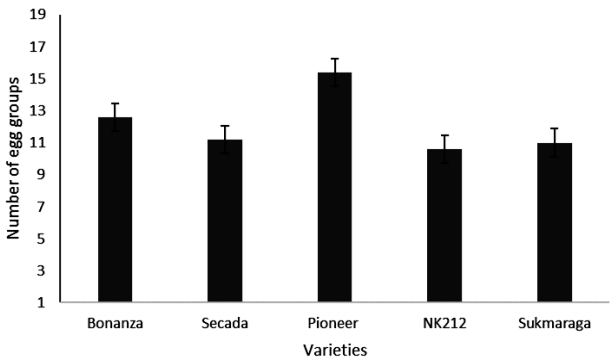

Figure 8. Average egg groups of one female *Spodoptera frugiperda* on five maize varieties

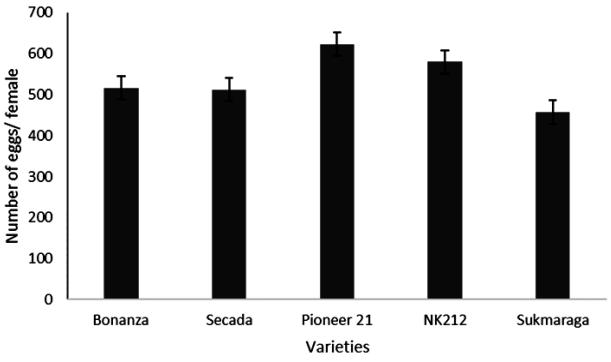

Figure 9. Average eggs of one female *Spodoptera frugiperda* in five maize varieties

Discussion

The development of the larval stages of *S. frugiperda* in 5 varieties showed that the Sukmaraga variety was longer compared to other varieties. That indicated that the larval development on the Sukmaraga variety is longer than that of the Pioneer 21, Bonanza F1, Secada F1, and NK-212 varieties. The average larval stadia duration is 20.38 days, while it is only 18 days in other varieties. The length of the third instar stadia in the Sukmaraga variety was much shorter and was the most active feeding stage in insects of the order Lepidoptera. It is suspected that plants' morphological and nutritional conditions as feed will affect insects' food consumption.

According to Maharani et al. (2019), maize is the main host plant of *S. frugiperda* that attack sweet hybrid varieties and ordinary hybrids. The nutritional content of each variety causes a difference in the developmental duration of this larval stage. Based on the description of varieties, Sukmaraga has a light green leaf compared to the other four varieties, which are dark green. Plants with dark green leaves contain more chlorophyll than plants with light green. That showed that the nutritional content of the Sukmaraga variety is less than other varieties, which causes the development of *S. frugiperda* larvae to be longer.

The content and amount of nutrients in feed are very influential in the growth and development of insect pests. In the order Lepidoptera, this is very real because those who carry out feeding activities are mainly during the larval stage (Nelly et al. 2021). According to Hidayanti and Asri (2019), the nutritional content of maize plants, such as protein and carbohydrates, can affect the growth and development process of armyworms (Mubarakkan et al. 2012) stated that the protein content in hybrid varieties of maize is, on average, 11.61%. Furthermore, the protein content contained in the Sukmaraga variety ranged from 8-10%. That showed that the Sukmaraga variety has a low protein content; therefore, the larvae development of *S. frugiperda* is slower than other varieties.

The short duration of larval development indicated that the variety was highly favored by *S. frugiperda*. Varieties favored by insects can indicate susceptibility to these varieties. That indicated that the Sukamaraga variety is more resistant and can reduce the attack rate of *S. frugiperda* compared to other varieties. According to (De La Rosa-Cancino et al. 2016), *S. frugiperda* showed more interest in the Pioneer variety because it developed faster than the Tuxpen, a maize variety in China. Ginting et al. (2020) also reported that the leaves of maize plants show suitable feed for the development of *S. frugiperda*, and good feed quality will affect the duration of larval development.

Dai et al. (2020) stated that the ability to develop *S. frugiperda* in sweet maize was higher than that of glutinous maize (waxy maize). That is because sweet maize leaves contain major nutrients such as starch, protein, vitamin C, fat, amino acids, and higher fiber than glutinous leaves.

The difference between the five maize varieties can also affect the weight of the pupae. The lowest pupae weight was found in Sukmaraga maize due to the ability of larvae to consume feed, where this variety had less nutritional content; therefore, the weight produced would also be low. Barros et al. (2010) also reported that the growth and development of insects depend on the preferred feed with the nutritional content of the host plant suitable for insects. A previous study by (Wang et al. 2020) showed a positive relationship between the weight of the female pupae and the number of eggs produced. The observations of heavier pupae show that more eggs are produced. Subsequently, high pupae weights were found in Bonanza F1, NK-212, and Pioneer 21 varieties, and adults from heavier pupae also had more eggs. Adults that emerged from pupae from Bonanza F1, NK-212, and Pioneer 21 varieties produced more eggs than Secada F1 and Sukmaraga varieties.

Based on the observations on the pupae stage duration, it was discovered that there are differences in each variety used, where the long stage occurred in the Sukmaraga variety. That happened due to differences in feed content consumed during the larval stage, affecting the pupae's development duration. CABI (2019) stated that the time of the pupae stage ranges from 8 to 9 days in summer and reaches 20 to 30 days in winter. Moreover, female adults lived longer than males because they experienced preoviposition, oviposition, and postoviposition. Female adults at high-temperature conditions will divert energy to produce more eggs, while at low temperatures, they will collect energy to form body structures. Hutasoit et al. (2020) stated oviposition duration of female adults would affect the total eggs produced, and the short oviposition duration has fewer eggs. However, in this study, a short oviposition

duration occurred in the Pioneer 21 variety, but the total eggs produced were more than in the other varieties.

The number of female adults formed was higher in the Secada F1, Bonanza F1, and NK-212 varieties than in the Pioneer 21 and Sukmaraga varieties. The ratio of females formed, which is higher than males, will produce a larger population in the subsequent offspring. The female adult undergoes a period of oviposition to produce eggs, which can be up to 1000 eggs in her lifetime (Wang et al. 2020). From the observation, the number of eggs produced in the Sukmaraga variety was less than in the other varieties. The difference in the variety of larval feed used only affected the larvae and pupae development of *S. frugiperda*. According to Hutasoit et al. (2020), the female adult of *S. frugiperda* produces many eggs at the beginning of the adult after copulation, which shows a fluctuating number during life until the adult dies.

The observations made on the developmental duration of the *S. frugiperda* egg stage showed no effect on the duration for eggs to hatch into first instar larvae. That indicated that the nutritional content of each variety does not affect the egg hatched. It only affects the larvae and pupae development; therefore, the eggs were hatched on days 2 and 3. According to (Capinera 2002), the egg stage of *S. frugiperda* is only 2 to 3 days in summer. The percentage of successful larvae that emerged from the eggs in each variety showed that the eggs could develop into larvae, although not all the eggs formed would hatch. The average number of eggs that successfully become larvae is only 50%.

The maize varieties affect the length of the larval stage and the weight of the pupae and eggs produced. Based on these results, it can be concluded that Sukmaraga is a variety causing a longer larval stage and lower pupae weight than other varieties. Furthermore, the eggs produced by the second-generation female *S. frugiperda* adult are fewer than in other varieties.

ACKNOWLEDGMENTS

Acknowledgments to the Rector through the chairman of LPPM Andalas University, Padang, Indonesia who has funded this research through research grants for Professorship Research in 2022 on behalf of Novri Nelly (No. T/13/UN.16.17/PP/Pangan-PDU-KRP1GB-Unand/2022).

REFERENCES

Altieri MA, Nicholls CI. 2000. Agroecology and the Search for a Truly Sustainable Agriculture (1st Edition). University of California, Berkeley.

Barros EM, Torres JB, Ruberson JR, Oliveira MD. 2010. Development of *Spodoptera frugiperda* on different hosts and damage to reproductive structures in cotton. Entomol Exp Appl 137 (3): 237-245. DOI: 10.1111/j.1570-7458.2010.01058.x.

BPS Sumbar. 2020. West Sumatra Statistics. Badan Pusat Statistik, Sumatera Barat. [Indonesia]

CABI. 2019. Community-Based Fall Armyworm Monitoring, Early Warning, and Management: Training of Trainers Manual. http://www.fao.org/3/ca2924en/CA2924EN.pdf.

Capinera JL. 2002. Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Insecta: Lepidoptera: Noctuidae). Edis 2002 (7): 1-6. DOI: 10.32473/edis-in255-2000.

da Silva DM, Bueno AF, Andrade K, Stecca CS, Neves PMOJ, de Oliveira MCN. 2017. Biology and nutrition of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) fed on different food sources. Scientia Agricola 74 (1): 18-31. DOI: 10.1590/1678-992x-2015-0160.

Dai QX, Li ZY, Tian YJ, Zhang ZF, Wang L, Lu YY, Li Y, Chen Z. 2020. Effects of different corn varieties on development and reproduction of *Spodoptera frugiperda*. Ying Yong Sheng Tai Xue Bao 31 (10): 3273-3281.

De La Rosa-Cancino W, Rojas JC, Cruz-Lopez L, Castillo A, Malo EA. 2016. Attraction, feeding preference, and performance of *Spodoptera frugiperda* larvae (Lepidoptera: Noctuidae) reared on two varieties of maize. Environ Entomol 45 (2): 384-389. DOI: 10.1093/ee/nvv229.

Ginting S, Nadrawati N, Zarkani A, Sumarni T. 2020. Natural incidence of entomophatogenic fungus *Nomuraea rileyi* on *Spodoptera frugiperda* infesting corn in Bengkulu. Jurnal Hama Penyakit Tumbuhan Tropika 20 (2): 85-91. DOI: 10.23960/j.hptt.22085-91.

Goergen G, Kumar PL, Sankung SB, Togola A, Tamò 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. DOI: 10.1371/journal.pone.0165632.

Hutasoit RT, Kalqutny SH, Widiarta IN. 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. DOI: 10.13057/biodiv/d210821.

Kuate AF, Hanna R, Fotio DARP, Abang AF, Nanga SN, Ngatat S, Tindo M, Masso C, Ndema R, Suh C, Fiaboe KKM. 2019. *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) in Cameroon: A case study on its distribution, damage, pesticide use, genetic differentiation, and host plants. Plos One 14 (4): 1-12. DOI: 10.1371/journal.pone.0215749.

Maharani Y, Dewi VK, Puspasari LT, Rizkie L, Hidayat Y, Dono D. 2019. Cases of fall army worm *Spodoptera frugiperda* J. E. Smith (Lepidoptera: Noctuidae) attack on maize in Bandung, Garut and Sumedang District, West Java. Cropsaver-J Plant Prot 2 (1): 38. DOI: 10.24198/cropsaver.v2i1.23013.

Midega CAO, Pittchar JO, Pickett JA, Hailu GW, Khan ZR. 2018. A climate-adapted push-pull system effectively controls fall armyworm, *Spodoptera frugiperda* (J E Smith), in maize in East Africa. Crop Prot 105: 10-15. DOI: 10.1016/j.cropro.2017.11.003.

Mubarakkan M, Taufik M, Brata B. 2012. Produktivitas dan mutu jagung hibrida pengembangan dari jagung lokal pada kondisi input rendah sebagai sumber bahan pakan ternak ayam. Naturalis: Jurnal Penelitian Pengelolaan Sumber Daya Alam Lingkungan 1 (1): 67-75. DOI: 10.31186/naturalis.1.1.5928. [Indonesia]

Nelly N. 2022. Hama Utama Pada Tanaman Jagung dan Eksplorasi Beberapa Teknik Pengendalian. Nas Media Pustaka, Makassar.

Nelly N, Hamid H, Lina EC, Yunisman. 2021. The use of several maize varieties by farmers and the infestation of *Spodoptera frugiperda* (Noctuidae: Lepidoptera). IOP Conf Ser Earth Environ Sci 662 (1): 012020. DOI: 10.1088/1755-1315/662/1/012020.

Nonci N, Kalgutny, Hary A, Mirsam H, Muis A, Azrai M, Aqil M. 2019. Pengenalan Fall Armyworm (S*podoptera frugiperda* J.E. Smith) Hama Baru pada Tanaman Jagung di Indonesia. Badan Penelitian dan Pengembangan Pertanian Balai Penelitian Tanaman Serealia, Maros. [Indonesia]

Suby SB, Soujanya PL, Yadava P, Patil J, Subaharan K, Prasad GS, Babu KS, Jat SL, Yathish KR, Vadassery J, Kalia VK, Bakthavatsalam N, Shekhar JC, Rakshit S. 2020. Invasion of fall armyworm (S*podoptera frugiperda*) in India: Nature, distribution, management and potential impact. Curr Sci 119 (1): 44-51. DOI: 10.18520/cs/v119/i1/44-51.

Tendeng E, Labou B, Diatte M, Djiba A, Diarra K. 2019. The fall armyworm *Spodoptera frugiperda* (J.E. Smith), a new pest of maize in Africa: Biology and first native natural enemies detected. Intl J Biol Chem Sci 13 (2): 1011. DOI: 10.4314/ijbcs.v13i2.35.

Wang W, He P, Zhang Y, Liu T, Jing X, Zhang S. 2020. The population growth of *Spodoptera frugiperda* on six cash crop species and implications for its occurrence and damage potential in china. Insects 11 (9): 1-14. DOI: 10.3390/insects11090639.