EVALUATION OF VARIOUS NATURAL DIETS FOR MASS REARING OF 
*Spodoptera frugiperda* J.E SMITH (LEPIDOPTERA: NOCTUIDAE)

Sempurna Ginting¹, Tri Sunardi¹, Chaincin Buana Sari¹, & Risky Hadi Wibowo²

¹ Plant Protection Department, Faculty of Agriculture, University of Bengkulu, Indonesia  
Jl. W.R Supratman, Kandang Limun Bengkulu 38371  
² Biology Department, Faculty of Mathematics and Natural Sciences, University of Bengkulu, Indonesia  
Jl. W.R Supratman, Kandang Limun Bengkulu 38371  
E-mail: sempurnaginting@unib.ac.id

Manuscript received: 2 November 2020. Revision accepted: 19 January 2021.

ABSTRACT

Evaluation of various natural diets for mass rearing of *Spodoptera frugiperda* J.E Smith (Lepidoptera: Noctuidae). *Spodoptera frugiperda* is one of the pests that attack corn in Indonesia. This study aimed to evaluate the most suitable diet for rearing of *S. frugiperda* from various natural diets. The study was conducted in vitro. The treatments were consisted of variation of *S. frugiperda* natural diets, such as maize leaf, green mustard leaf, water spinach, sweet potato leaf, sugar cane leaf, and soybeans leaf. The observed variables were life cycle period, pupa size, and pupa weight. The results showed that the shortest life cycle period was on corn leaves diet (40.92 days), and the longest was on sugarcane leaves (45.01 days). The longest size of pupa were *S. frugiperda* on mustard leaves diet (12.86 mm) and corn leaves (12.56 mm), The heaviest pupa weights were observed in *S. frugiperda* on mustard leaves diet (0.18 mg), and corn leaves (0.16 mg). Based on the data, it could be concluded that corn leaves were the most suitable type of diet for the growth and development of *S. frugiperda*.

Key words: corn, life cycle, pupa length, pupa weight, *S. frugiperda*

INTRODUCTION

*Spodoptera frugiperda* J.E Smith or Fall Armyworm (FAW) (Lepidoptera: Noctuidae) is an important pest of corn native from America (Kalyan et al., 2020). However, now it was widely spread in Indonesia and invaded corn production area in West Sumatra (West Pasaman District), West Java (Bandung City and Garut District), Lampung (East Lampung District and Central Lampung District), and Bengkulu (Seluma District, Merigi District and Bengkulu City) (Maharani et al., 2019; Trisyono et al., 2019; Ginting et al., 2020). The yield losses due to *S. frugiperda* was influenced by several aspects such as pest population, attack period, natural enemies, as well as plant resistance (Baudron et al., 2019). This pest caused damage on leaves, silk and cob of corn in the ranged of 25–50% and reducing the yield up to 58% (Chimweta et al., 2020).

Advance study on plant pest management had been encouraged development and improvement of mass rearing techniques for insects in the laboratory to support pest management programs. Insects mass rearing was performed to provide large number of insects in the laboratory that would be used for further studies. The reared insects could be widely used for investigating and resolving problems in some of field research such as effectiveness of natural enemies (parasitoids, predators and insect pathogens), resistance of Genetically Modified Organism (GMO) crops, genetic engineering, managing pest resistance, studying insect species, facilitating the introduction of a natural enemies, as well as efficacy of insecticides (Shalihah, 2015).

Recently, due to the serious problems caused by *S. frugiperda*, especially in corn production, the mass-rearing of *S. frugiperda* was very important to provide testing insects for learning management methods. Understanding of nutrition, genetics, reproduction, behavior, environment, and physiological aspects was needed in the mass rearing program. Insect mass rearing required suitable diet for growth. Types of diets could affect the insect development such as growth, reproduction, and morphological characteristics including body size and weight. There ware two types of diets that used for mass rearing program, the natural and artificial diet. Artificial diet was a diet made from various compositions of materials to replace the natural food, such as yeast and wheat germ (El-Shafie et al., 2013). Natural diet seem easier to be used. This kind of diet was available naturally in the field which could be found
easily (El-Shafie et al., 2013). The fitness of the Ostrinia furnacalis reared in the artificial diet were similar than those in the natural diet (corn kernel) (Rahayu et al., 2018).

Information about the use growth and development of insect for this research parameter, information on the suitability of various natural diets for mass rearing of S. frugiperda had not been widely reported especially in Indonesia. This study was performed to determine an appropriate natural diet for mass rearing of S. frugiperda. Information obtained on this study would be very useful to improve achievement of mass rearing method of S. frugiperda to support successful the pest management.

**MATERIALS AND METHODS**

**Research Site.** Research was carried out from March to July 2020 at the Plant Protection Laboratory, Faculty of Agriculture, University of Bengkulu.

**Experimental Design.** This research was performed using a completely randomized design (CRD). Treatments used in this study were six kinds of leaves that were corn (Bonanza variety), water spinach leaves (Grand-2 variety), sugarcane leaves (Kidang Kencana Variety), sweet potato leaves (Kalasan variety), soybean leaves (Detam-1 variety) and mustard greens (Sawindo-3 variety). Each treatments consisted of five replications.

**Natural Diets Preparation.** The crops used for natural diets were cultivated in greenhouse of the Faculty of Agriculture, Bengkulu University. Each crops was planted in a polybag (30 cm in diameter). Soil which was mixed with chicken manure in a ratio of 2:1, respectively used as planting medium. Before being given to S. frugiperda larvae, the leaves were washed using running water and then air dried. The temperature and humidity at the time of the study were measured daily. Temperature was measured with a thermometer and humidity with a hygrometer.

**Rearing S. frugiperda.** Larvae of S. frugiperda were collected from Pekik Nyaring Village, Pondok Kelapa District, Bengkulu Tengah Regency. Larvae were taken from corn (NASA 29 variety by PT Samudera Artha Abadi) at the plants aged 3rd weeks after planting. The obtained larvae were brought to the Plant Protection Laboratory, Faculty of Agriculture, University of Bengkulu and to be used for mass rearing. The larvae were put in a plastic jar (6.5 cm in diameter and 4.5 cm in height) and feed with baby corn. When it reached pupa stage, the pupa was transferred into a plastic jar (18 cm in diameter and 30 cm in height) with sterile husks (sterilized by autoclaving). After pupa becomes imago then shifted to a plastic jar (35 cm in diameter and 50 cm in height) and covered with gauze. Each of plastic jars consists of a pair of adult. The forewings male generally have gray and brown shaded, with triangular white spots at the tip and near the center of the wing, but the females were less distinctly marked, ranging from a uniform grayish brown to a fine mottling of gray and brown. The hind wing were iridescent silver-white with a narrow dark border in both sexes. Adult was feed by 10% honey which was dropped to cotton and placed it at the bottom of the plastic jar using a plastic cup (6.5 cm in diameter and 4.5 cm in height). Female layed egg mass on the gauze that had been installed, and egg mass were then transferred to a new plastic jar (30 cm in length, 20 cm in width, and 5 cm in height) allowed to hatch. Larvae which were emerged at the equal time were used for testing insects. Each treatment consisted of 30 test insect larvae, diet replacement was carried out for two days so that the insects always got fresh diet. The room temperature during the study ranged from 23.10–28.8 °C. Insect maintenance was carried out until the third generation.

**Observation Variable.** Observation was conducted every day on the development of each stage of S. frugiperda using a magnifying glass and a stereo microscope (Olympus Japan). Observation was performed on the life cycle and reproductive potential, starting from the first instar to the stage where the insect spawn. Observation was also conducted on period required for pupa to be adult, time period each instar larvae, weight of the larvae (3rd–6th instars) and length of the pupa (Rahayu et al., 2018).

**Data Analysis.** Data were analyzed by ANOVA using the SPSS (Statistical Package for the Social Sciences) program 24 (Arifin, 2017), and followed by Duncan’s Multiple Range Test (DMRT) at 5% of significant level.

**RESULTS AND DISCUSSION**

The results showed that all six kinds of natural diets had a significant effect on the life cycle period of S. frugiperda. The shortest life cycle period was observed in S. frugiperda on corn leaves diet (40.92 days) and the longest life cycle was observed in sugarcane leaves diet (45.01 days). None of the larvae which were fed by soybean leaves to develop into adult.
In this treatment, the development period from first instar to pupa was 46.68 days (Table 1). Sharanabasappa et al. (2018) reported that the period of larval stages fed by corn leaves (CP 818 hybrid) at a temperature of 26 ± 2 °C and a humidity of 75–80% was 14–19 days, pupa stage need 9–12 days, oviposition took 2–3 days, and the total life cycle period was 40.50 ± 4.88 days. The total life cycle of *S. frugiperda* which was fed with leaves and stalks of the corn of Pratap Makka-3 variety at a temperature of 25 ± 2 °C and humidity of 70–75% was 37.68 days consisted of 16.97 days for larval period, 8.96 days for pupa and 2.96 days for oviposition (Kalyan et al., 2020).

The life cycle of *S. frugiperda* observed in this study was longer than the results reported by Sharanabasappa et al. (2018) and Kalyan et al. (2020). This might cause by differences of natural diets, temperature as well as humidity. The temperature during the study was ranged from 23.10–28.8 °C with 70% humidity. FAO & CABI (2019) stated that the optimal temperature for larval development was 28 °C. At the optimum temperature, the life cycle period of *S. frugiperda* was faster than those in the lower temperatures. The period needed of the larvae to adult was an indicator wether it was fed by poor or good quality diets (da Silva et al., 2017). Generally, the development of insects depended on the quality of food consumed in the first few instars (Barros et al., 2010). In this study, we found that soybean leaves were not suitable for development of *S. frugiperda*. This was proved by longer larval period and its inability to reach the pupa stage while on soy bean leaves diet. Different plants will consisted of different nutrients which will influence its quality for diets of pest insects. The difference was caused by variation of its chemical compounds. Variations of chemical compounds were not only found between different plant species but also within a species due to differences in genotypes and environmental conditions (Behmer, 2009).

The result revealed that, each larvae which had different treatments showed different size and weight of pupa. The longest size of pupa was observed on mustard leaves diet (12.86 mm), followed by corn leaves (12.56 mm), water spinach leaves (11.08 mm), sweet potato leaves (10.83 mm), sugarcane leaves (10.83 mm), and the shortest pupa was found on soybean leaves diet (7.83 mm) (Table 2). Meanwhile, the heaviest pupa was found on mustard leaves diet (0.18 mg), followed by water spinach leaves (0.16 mg) and corn leaves (0.16 mg), sweet potato leaves (0.14 mg), sugarcane leaves (0.06 mg) and the lightest pupa was observed on soybean leaves (0.04 mg ) (Table 3).

The weight and length of the pupa resulted in this study were lighter and shorter than previous reports. Kalyan et al. (2020) reported that the length of pupa of *S. frugiperda* which was fed by leaves and stem of corn (Pratap Makka-3 variety) reached 15.7 ± 1.55 mm. Subiono (2020) stated that the weight of pupa which was previously fed by corn (Makmur variety) was 0.2342 ± 0.002 mg. Meanwhile, da Silva et al. (2017) reported that weight of the pupa which was formerly fed by corn (DKB390 variety) was 0.2343 ± 0.0027 mg. The difference length and weight of pupa was influenced by difference variety of corn which was consumed by larvae. A preferred diets with suitable nutritional substance would produce a heavier and longer weight than unsuitable diets. In the case of soybean leaves, since in the beginning the larvae were less developed, and resulted the lighter and shorter pupa. The nutritional substance of soybean leaves may unsuitable for *S. frugiperda*. Furthermore, soybean leaves contain phytoalexin, glyceollin and isoflavonoids which was toxic to herbivorous insects, making it an effective antifeedant for plants (Fischer et al., 1990). Secondary metabolites produced by plants would disturb nutrient regulation in insect herbivores (Behmer, 2009) which influence the growth, survival and reproduction (Piubelli et al., 2005; Fischer et al., 1990).

The corn leaves showed as the most suitable diet for *S. frugiperda*. This natural diet produced better growth and performance of larva and pupa compared to the other natural diets used in this study. Nagoshi et al. (2007) reported that *S. frugiperda* prefered corn and sorghum which were C4 plants, compared to C3 plants such as soybeans. This caused by the composition and nutritional adequacy of these plants (Barros et al., 2010). Insects would look for foods that had a balance of nutrients, including amino acids, carbohydrates, sterols, phospholipids, fatty acids, vitamins, minerals and water (Behmer, 2009).

*S. frugiperda* consisted of two genetically differentiated strains, the rice strain (R strain) and the corn strain (C strain) (Nagoshi & Meagher, 2004). The corn strains would prefer corn as their hosts and would not invade the rice. However, the R strain would also occupy corn when this plant were cultivated near to the rice field. Since the *S. frugiperda* used in this study was collected from the corn field and the most suitable diet was corn leaves, thus the pest insect may belong to the group of corn strains.

Physiological period was needed for an animal to complete developmental stages from beginning to end (life cycle) associated with the accumulation of...
Table 1. Life cycle (days) of *S. frugiperda* on various types of hosts (leaves) (n=30)

| Treatment       | Instar of larvae (Day ± SE) | Stage (day ±SE) | Life cycle |
|-----------------|-----------------------------|-----------------|------------|
|                 | 1  | 2  | 3  | 4  | 5  | 6  | Pupa | Image | Egg |          |
| Water spinach   | 4.71± | 5.40± | 3.52± | 3.25± | 3.83± | 3.32± | 9.09± | 5.71± | 4.62± | 43.45± |
|                 | 0.11 bc | 0.142 ab | 0.231 a | 0.264 b | 0.341 b | 0.303 b | 0.770 a | 0.552 a | 0.286 ab | 0.963 b |
| Mustard         | 5.40 ± | 4.23 ± | 3.51 ± | 3.20 ± | 3.73 ± | 3.51 ± | 9.02 ± | 6.61 ± | 4.14 ± | 43.35 ± |
|                 | 0.909 a | 0.161 cd | 0.136 a | 0.088 b | 0.273 b | 0.227 b | 0.821 a | 0.742 a | 0.261 ab | 0.541 b |
| Sweet potatoes  | 4.74 ± | 5.80 ± | 3.63 ± | 3.72 ± | 5.54 ± | 3.51 ± | 8.43 ± | 5.12 ± | 4.24 ± | 44.73 ± |
| Potatoes        | 0.091 bc | 0.350 a | 0.233 a | 0.243 b | 0.450 ab | 0.313 b | 0.772 ab | 0.623 a | 0.832 ab | 0.823 a |
| Soybean         | 5.32 ± | 5.44 ± | 4.45 ± | 6.13 ± | 10.13 ± | 8.10 ± | 7.14 ± |          |          |          |
|                 | 0.108 ab | 0.408 ab | 0.357 a | 0.548 a | 0.972 a | 0.731 a | 0.581 b |          |          |          |
| Sugar Cane      | 4.83 ± | 3.81 ± | 3.46 ± | 3.42 ± | 6.47 ± | 4.06 ± | 8.26 ± | 5.13 ± | 5.52 ± | 45.01 ± |
|                 | 0.112 bc | 0.281 d | ±0.314 a | 0.654 b | 0.614 ab | 0.352 b | 0.724 ab | 0.480 a | 0.230 a | 1.271 a |
| Corn            | 3.52 ± | 4.82 ± | 3.43 ± | 3.40 ± | 3.91 ± | 3.43 ± | 9.10 ± | 5.30 ± | 4.01 ± | 40.92 ± |
|                 | 0.118 c | 0.126 bc | 0.096 a | 0.091 b | 0.182 b | 0.153 b | 0.362 a | 0.551 a | 0.375 ab | 0.407 c |

The numbers followed by different letters in the same column were significantly different at DMRT 5%; SE= standard error; n= test insects.

Table 2. Larval and pupa body length (mm) of *S. frugiperda* on various types of hosts (leaves) (n=30)

| Treatment       | Instar (mm ± SE) | Pupa (mm ± SE) |
|-----------------|------------------|----------------|
|                 | 1   | 2   | 3   | 4   | 5   | 6   |        |          |
| Water spinach   | 2.40± | 0.761 a | 5.33± | 0.202 b | 13.18± | 0.943 ab | 18.23± | 1.410 a | 22.24± | 1.871 a | 10.69± | 1.105 a | 11.08± | 0.973 a |
| Mustard         | 2.56± | 0.103 a | 6.20± | 0.193 ab | 12.23± | 0.401 bc | 17.73± | 0.782 a | 23.23± | 1.350 a | 13.21± | 1.803 a | 12.86± | 1.121 a |
| Sweet potato    | 2.38± | 0.071 a | 4.52± | 0.273 b | 11.18± | 0.774 c  | 14.92± | 1.041 b | 19.83± | 1.472 b | 11.06± | 1.102 a | 10.83± | 0.980 a |
| Soybean         | 2.25± | 0.052 a | 5.01± | 0.378 b | 8.97± | 0.780 d  | 10.87± | 1.012 c | 11.60± | 1.103 c | 10.45± | 0.920 b | 7.83± | 2.491 b |
| Sugar Cane      | 2.40± | 0.082 a | 4.06± | 0.362 b | 12.62± | 1.165 ab | 15.64± | 1.410 b | 18.64± | 1.726 b | 12.01± | 1.203 a | 10.83± | 0.912 a |
| Corn            | 2.48± | 0.091 a | 7.38± | 1.310 a | 13.76± | 0.382 a  | 17.79± | 1.682 a | 21.60± | 0.501 ab | 13.13± | 0.406 a | 12.56± | 0.530 a |

The numbers followed by different letters in the same column were significantly different at DMRT 5%; SE= standard error; n= test insects.
temperature over time (Meyer, 2003). The shorter of duration from the development process, more eggs insects would be produced, which would encourage an increase in population. This was occurred when the increase was in ambient temperature and in its optimum tolerance range. If the increase in environmental temperature more than the limit temperature, the development of insects would be decreased. This was also occurred at low temperature. The development of insects would decrease at low temperatures to the limit of their temperature tolerance. If it exceed the lowest temperature limit of its tolerance temperature range, insect development would stop and would start again when the temperature increases (Niswati, 2015).

Knowledge of physiological period had an important value in effective pest control. Effective pest control strategies could be developed and implemented by studying the growth and development patterns of these pests. For example, knowledge of the egg or larval phase was very important to estimate the time for insecticide application. In addition, by knowing the preferred feed or host of this pest, we could break the chain of development of their life cycle in the field.

CONCLUSION

The best diets that supported the growth and development of *S. frugiperda* were corn leaves and mustard leaves. In the other hand, the diets that did not support the growth and development of *S. frugiperda* was soybean leaves.

ACKNOWLEDGMENTS

The author would like to acknowledge to the research grant for Unggulan PNBP UNIB in 2020 with Contract Number 1995/UN30.15/PG/2020 and farmers who own corn gardens in Pekik Nyaring Village had allowed researchers to take insect pest of corn for this research.

REFERENCES

Arifin J. 2017. *SPSS 24 untuk Penelitian dan Skripsi*.
 PT Elex Media Komputindo, Jakarta.

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.

Baudron F, Zaman-Allah MA, 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 Prot.* 120: 141–150.

Behmer ST. 2009. Insect herbivore nutrient regulation. *Annu. Rev. Entomol.* 54: 165–187.

Chimweta M, Nyakudya IW, Jimu L, & Mashingaidze AB. 2020. Fall armyworm (*Spodoptera frugiperda* [J.E. Smith]) damage in maize: management options for flood-recession cropping smallholder farmers. *Int. J. Pest Manage.* 66(2): 142–154.

da Silva DM, Bueno ADF, Andrade K, Stecca CDS, Neves PMOJ, & Oliveira MCND. 2017. Biology and nutrition of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) fed on different food sources. *Sci. Agrí.* 74(1): 18–31.

| Treatment       | Instar (mg ± SE) | Pupa (mg ± SE) |
|-----------------|-----------------|----------------|
|                 | 3               | 4              | 5              | 6              | 3             |
| Water spinach   | 0.08 ± 0.041 a  | 0.16 ± 0.016 a | 0.16 ± 0.014 b | 0.15 ± 0.020 ab| 0.16 ± 0.059 ab|
| Mustard         | 0.08 ± 0.073 a  | 0.15 ± 0.014 ab| 0.18 ± 0.020 a | 0.16 ± 0.014 a | 0.18 ± 0.018 a|
| Sweet potato    | 0.07 ± 0.013 b  | 0.12 ± 0.010 b | 0.14 ± 0.197 c | 0.12 ± 0.011 b | 0.14 ± 0.057 b|
| Soybean         | 0.05 ± 0.011 d  | 0.06 ± 0.019 c | 0.06 ± 0.018 d | 0.09 ± 0.014 b | 0.04 ± 0.041 d|
| Sugarcane       | 0.06 ± 0.048 c  | 0.07 ± 0.029 c | 0.12 ± 0.011 cd| 0.10 ± 0.012 bc| 0.06 ± 0.085 c|
| Corn            | 0.08 ± 0.035 a  | 0.12 ± 0.052 b | 0.18 ± 0.010 a | 0.16 ± 0.048 a | 0.16 ± 0.062 ab|

The numbers followed by different letters in the same column were significantly different at DMRT 5%; SE= standard error; n= test insects.
El-Shafie HAF, Faleiro JR, Abo El-Saad MM, & Aleid SM. 2013. A meridic diet for laboratory rearing of red palm weevil, Rhynchophorus ferrugineus (Coleoptera: Curculionidae). Sci. Res. Assays. 8(39): 1924–1932.

FAO & CABI. 2019. Community-Based Fall Armyworm (Spodoptera frugiperda) Monitoring, Early Warning and Management. Training of Trainers Manual. The Food & Agriculture Organization of the United Nations and CAB International.

Fischer DC, Kogan M, & Paxton J. 1990. Effect of glyceollin, a soybean phytoalexin, on feeding by three phytophagous beetles (Coleoptera: Coccinellidae and Chrysomelidae): dose versus response. Environ. Entomol. 19(5): 1278–1282.

Ginting S, Zarkani A, Wibowo RH, & Sipriyadi. 2020. New invasive pest, Spodoptera frugiperda (J.E. Smith) (Lepidoptera: Noctuidae) attacking corn in Bengkulu, Indonesia. Serangga. 25(1): 104–115.

Kalyan D, Mahla MK, Babu RS, Kalyan RK, & Swathi P. 2020. Biological parameters of Spodoptera frugiperda (J.E. Smith) (Lepidoptera: Noctuidae) under laboratory conditions. Int. J. Curr. Microbiol. App. Sci. 9(5): 2972–2979.

Maharani Y, Dewi VK, Puspasari LT, Rizkie L, Hidayat Y, & Danar 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. J. Cropsaver. 2(1): 38–46.

Meyer JR. 2003. The Concept of Physiological Time. General Entomology. NC State University.

Nagoshi RN, Adameczyk JJ, Meagher, Gore J, & Jackson RL. 2007. Using stable isotope analysis to examine fall armyworm (Lepidoptera: Noctuidae) host strains in a cotton habitat. J. Econ. Entomol. 100(5): 1569–1576.

Niswati Z. 2015. Pengaruh suhu terhadap pertumbuhan dan perkembangan ulat grayak Spodoptera litura F. (Lepidoptera: Noctuidae) pada kubis (Brassica oleracea var. capitata L.). Skripsi. Universitas Jember. Jember.

Piubelli GC, Hoffmann-Campo CB, Moscardi F, Miyakubo SH, & de Oliveira MCN. 2005. Are chemical compounds important for soybean resistance to Anticarsia gemmatalis? J. Chem. Ecol. 31(7): 1509–1525.

Rahayu T, Trisyono YA, & Witjaksono. 2018. Fitness of Asian corn borer, Ostrinia furnacalis (Lepidoptera: Crambidae) reared in an artificial diet. J. Asia Pac. Entomol. 21(3): 823–828.

Shalihah A. 2015. Pengaruh tiga jenis pakan terhadap biologi perkembangan Ostrinia furnacalis Guenée (Lepidoptera: Crambidae). Skripsi. Institut Pertanian Bogor. Bogor.

Sharanabasappa, Kalleshwaraswamy CM, Maruthi MS, & Pavithra HB. 2018. Biology of invasive fall army worm Spodoptera frugiperda (J.E. Smith) (Lepidoptera: Noctuidae) on maize. Indian J. Entomol. 80(3): 540–543.

Subiono T. 2020. Preferensi Spodoptera frugiperda (Lepidoptera: Noctuidae) pada beberapa sumber pakan. J. Agroekoteknologi Tropika Lembab. 2(2): 130–134.

Trisyono YA, Suputa, Aryuwandari VEB, Hartaman M, & 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.