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

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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 on *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 3th 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 plactic 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 ^{o}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 (3th–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 ligtest 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 larvae 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	Imago	Egg	
Water spinach	4.71 ± 0.11 bc	5.40 ± 0.142 ab	3.52 ± 0.231 a	3.25 ± 0.264 b	3.83 ± 0.341 b	3.32 ± 0.303 b	9.09 ± 0.770 a	5.71 ± 0.552 a	4.62 ± 0.286 ab	43.45 ± 0.963 b
Mustard	5.40 ± 0.909 a	4.23 ± 0.161 cd	3.51 ± 0.136 a	3.20 ± 0.088 b	3.73 ± 0.273 b	3.51 ± 0.227 b	9.02 ± 0.821 a	6.61 ± 0.742 a	4.14 ± 0,261 ab	43.35 ± 0.541 b
Sweet Potatoes	4.74 ± 0.091 bc	5.80 ± 0.350 a	3.63 ± 0.233 a	3.72 ± 0.243 b	5.54 ± 0.450 ab	3.51 ± 0.313 b	8.43 ± 0.772 ab	5.12 ± 0.623 a	4.24 ± 0.832 ab	44.73 ± 0.823 a
Soybean	5.32 ± 0.108 ab	5.44 ± 0.408 ab	4.45 ± 0.357 a	6.13 ± 0.548 a	10.13 ± 0.972 a	8.10 ± 0.731 a	7.14 ± 0.581 b	-	-	-
Sugar Cane	4.85 ± 0.132 bc	3.81 ± 0.281 d	3.46 ±0.314 a	3.42 ± 0.654 b	6.47 ± 0.614 ab	4.06 ± 0.352 b	8.26 ± 0.724 ab	5.13 ± 0.480 a	5.52 ± 0.230 a	45.01 ± 1.271 a
Corn	3.52 ± 0.118 c	4.82 ± 0.126 bc	3.43 ± 0.096 a	3.40 ± 0.091 b	3.91 ± 0.182 b	3.43 ± 0.153 b	9.10 ± 0.362 a	5.30 ± 0.551 a	4.01 ± 0.375 ab	40.92 ± 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 a ± 1.105 a	11.08 ± 0.973 a
Mustard	2.56 ± 0.103 a	6.20 ± 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
Sugarcane	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.

Table 3. Larval and pupa weight (mg) of *S. frugiperda* on various types of hosts (leaves) (n=30)

Treatment	Instar (mg ± SE)				Pupa (mg ± SE)
	3	4	5	6	
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.

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 occured 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.

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