RESEARCH ARTICLE

Life cycle, feeding preferences and control of *Sena* caterpillar (Fall Armyworm) (*Spodoptera frugiperda*)

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ABSTRACT

Fall Armyworm (FAW) (Spodoptera frugiperda) is an insect caterpillar which devastated the maize cultivations of Sri Lanka in 2018. Present study was undertaken to investigate the life cycle of the insect, feeding habit on selected crop plants and eco-friendly control measures for Sena caterpillar using different plant extracts. The results of feeding habit on selected crop plants showed that Sena caterpillar was able to feed and survive on Kathurumurunga (Sesbania grandiflora), rice (Oriza sativa), Guinea grass (Megathyrsus maximum), Buffalo grass (Axonopus compresses) and Guatemala grass (Tripsacum laxum) in the absence of maize. Being eco-friendly control measures for Sena caterpillar, 80% Margosa seed extract and; 80% Margosa leaf + 80% Ginger rhizome extract were found to be more promising. Life cycle of FAW consists of four stages; eggs, larva, pupa and moth. Mean duration of 33 d were taken by FAW to complete its life cycle, in which larval stage consisted of 18 d.

***Keywords**: Eco-friendly control measures, Fall Armyworm, maize, Margosa*

INTRODUCTION

Maize (*Zea maize*) remains as one of the most important crops in the tropics. Maize production of the world was estimated at 1,127 million tons in 2016 (FAOSTAT, 2020). In Sri Lanka also, maize cultivations are prominent, as there is high demand, especially to produce value added products. Thus, maize remains as a very important food crop in Sri Lankan context too.

Fall Armyworm (*Spodoptera frugiperda*) (FAW), which is locally known as *Sena* caterpillar, is an insect pest that belongs to *Spodoptera* genera in *Noctudae* family. FAW is native to tropical and subtropical regions of America. It is considered as a sporadic pest due to their migratory behavior and capable of migrating long distances over 500 km (300 miles) on prevailing winds. Moreover, they can also breed continuously in areas with suitable climates (Center for Agriculture and Bioscience International, 2019).

Of the Asian countries, Bangladesh, Myanmar, Sri Lanka and Thailand have reported the FAW incidences by December 2018 (Food and Agriculture Organization of Unites States, 2019). Incidence of FAW became the most common issue in Sri Lankan agriculture sector during the years of 2017 and

2018 particularly in the districts of Monaragala, Badulla, Ampara and Anuradhapura where many of maize cultivations were damaged by FAW. Furthermore, there was a risk and uncertainty whether this would become a threat to many other crops as well. Other field crops, which are mostly damaged by FAW, comprise of rice, soybean, sugarcane, tobacco, and wheat (Alfors and Kuhar, 2019).

Previous studies done in overseas for FAW infestations have revealed that biological, cultural, botanical, and chemical control measures have been used at varying levels of successes (Aseefa and Ayalew, 2019). Several botanical extracts taken from plants such as Ginger, Margosa, Lemon grass, Chick weed and high mallow have showed promising results in controlling the FAW (Phambala *et al*., 2020; Rioba and Stevenson, 2020). Generally, FAW feeds on plants of grass family. But, previous studies have shown that this pest can also feed on crops like cotton and soybean as well (Campos *et al*., 2012).

However, as this pest is not reported in Sri Lanka prior to year 2017, studies carried out on this pest's feeding habit, lifecycle and eco-friendly controls measures in Sri Lankan context are rare. With the emerging threat of FAW in past three years, finding eco-friendly control measures is of great importance to Sri Lanka. It is also important to investigate on possible threats of damaging other crops by this caterpillar. Observation of life cycle of this pest is important to check its life cycle duration and characteristics under tropical climes of Sri Lanka. Present study was therefore carried out to investigate three aspects namely, to investigate eco-friendly control measures for FAW found in maize cultivation in the Badulla district using locally available plant species, to study the life cycle of the *Sena* caterpillar and to assess the feeding habit and preferences of the caterpillar for various crop leaves and weeds as these lines of investigations conducted locally are lacking.

MATERIALS AND METHODS

Three different investigations were carried out to test different plant extracts as control measures of the caterpillar, to study the life cycle of FAW and to study the feeding habits of the caterpillar.

Experiment 01: Evaluation of bio-efficacy of different plant extracts against *Sena* caterpillar

The first experiment was conducted at the Crop Protection Laboratory of Uva Wellassa University. Five different plant species; Margosa (*Azadirachta indica*), Wal Kapuru (*Artimisia vulgaris*), hot chili (*Capsicum chinense*) and Ginger (*Zingiber officinale*) were used to prepare plant extracts. Plant extracts were prepared using following plant parts: Margosa seeds and leaves, Walkapuru leaves, hot chili fruits, and Ginger rhizomes. Sufficient amount of each leaf material, Ginger rhizomes and hot chili fruits were separately ground for 30 s using a grinder. After grinding, 80 mL of extracts from each were taken by pressing the ground materials using a cheesecloth. To prepare 80% (v/v) extract, 20 mL of water was then added to each of the 80 mL of extracts (Plate 1). Margosa seeds were thoroughly soaked in 15 mL of water and ground using motor and pestle, followed by grinding after adding 5 mL of water. 80% Margosa leaves extract and 80% ginger rhizomes extract were mixed together (Table 1). Water was used as untreated control.

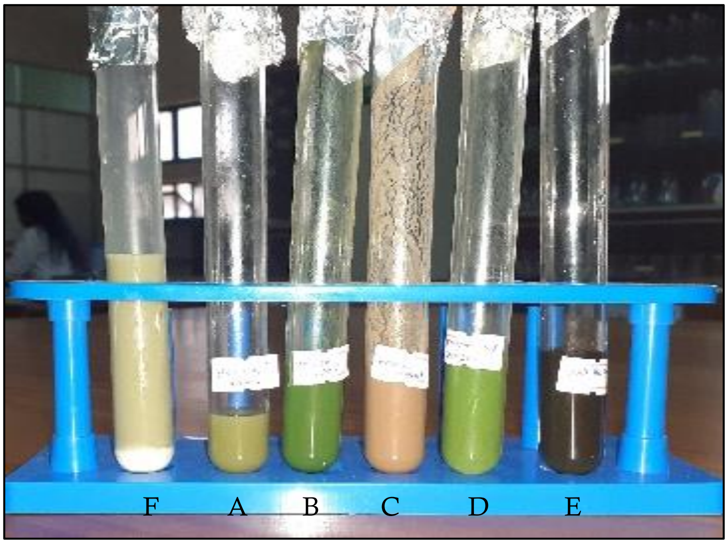

Plate 1: Margosa seed extract and different leaf extract (A: Hot chili fruit extract; B: Margosa leaf extract; C: Margosa seed extract; D: Margosa leaf + Ginger rhizome extract; E: Wal Kapuru leaf extract; F: Ginger rhizome extract).

Table 1: Different treatment combination.

Treatment	Treatment combination
T_1	80% (v/v) Margosa leaf extract
T_2	80% (v/v) Margosa seed extract
T_3	80% (v/v) Hot chili fruit extract
T_4	80% (v/v) Wal Kapuru leaf extract
T_5	80% (v/v) Margosa leaf + Ginger rhizome extract

About 50 *Sena* caterpillars were collected from five selected areas within Badulla and Monaragala districts and 30 caterpillars of same age and size were selected. In here, field selection was done very carefully so that the crop fields have not been contaminated by any pesticide particularly insecticides during previous years.

Then, caterpillars were placed in test tubes as at one caterpillar per one test tube. Each caterpillar in test tube was treated separately with drenching application of one selected extract of above to the caterpillar's body using a pipette. Each extract was freshly prepared daily to wet the body of caterpillar for four (04) consecutive days. Test tubes were arranged in a Complete Randomize Design (CRD) with five replicates.

As assessments, number of caterpillars responded to each treatment, number of dead caterpillars, number of sedated caterpillars and number of unaffected caterpillars after treatment were counted from each test tube daily for four (04) consecutive days. Data were analyzed using ANOVA with SAS statistical package. Count data were transformed before analysis, as necessary.

Experiment 02: Study on the life cycle of the insects

The study on the life cycle of insect was conducted at the Crop Protection Laboratory and at the University Agriculture Field. A sample of 50 *Sena* caterpillars and tender maize leaves were collected from a commercial maize field in Badulla and brought to the laboratory. The caterpillars were grouped according to their size and 10 caterpillars of the same size were selected and allowed to grow in a beaker covered with insect proof net. They were fed with maize leaves until they enter to pupae phase. To study the adult phase under field condition, five cubic feet (5'*5'*5') wooden cage was made and it was covered with an insect proof net. Then, the cage was placed within a block cultivated with maize crop encircling 10 maize plants inside it, at the University Agriculture Field (Plate 2). Laboratory bred moths were then brought and placed inside the cage until they become adult moths and allowed them to freely fly, mate and lay eggs. After oviposition by female moths, following data were collected: period of hatchery, time duration of larvae phase, pupae phase, moth phase and total duration of the life cycle. Data for whole life cycle of *Sena* caterpillar were analyzed.

Plate 2: The cage placed in the field to rear the moths under field conditions.

Experiment 03: Study on feeding preference of the caterpillar for the various crop and weeds

The study was conducted at the Crop Protection Laboratory of the university under controlled environment conditions. Leaves of six (06) plant species: Rice (*Oriza sativa*), Guatemala grass (*Tripsacum laxum*), Guinea grass (*Megathyrsus maximus*), Katurumurunga (*Sesbania grandiflora*), Common bean (*Phaseolus vulgaris*) and Buffalo grass (*Axonopus compresses*) were used as treatments to feed *Sena* caterpillar and tender maize leaves were used as the Control (Table 2). Ten (10) g of each leaf material was placed in each test tube and one caterpillar was inserted into each test tube and allowed to feed on given leaf material. The experiment was laid out in a Complete Randomized Design (CRD) with five (05) replicates.

Table 2: Different leaf materials used as treatments to feed the caterpillar.

Treatment	Treatment
T_1	Maize (Control) 10 g
T_2	Kathurumurunga 10 g
T_3	Rice 10 g
T_4	Guinea grass 10 g
T_5	Buffalo grass 10 g
T_6	Guatemala grass 10 g
T_7	Common Beans 10 g

Weight of the leaves eaten by each caterpillar was recorded for seven days. The mortality number was also counted from each test tube daily. Number of days taken for each caterpillar to become a pupa was also recorded. Data were analyzed for mean comparison using ANOVA with SAS statistical package.

RESULTS AND DISCUSSION

Evaluation of bio-efficacy of different plant extracts against Sena caterpiller

Figure 1 shows mortality rate of caterpillars as caused by different plant extracts. Results of similar kind of studies were not reported in the literature to compare the current results. However, field studies were carried out in several countries of the world to assess the effectiveness of chemical insecticides (Pitre, 1986). Environmental Protection Agency (EPA) in the United States has approved chemicals such as Carbaryl, trichlorfon, methyl and ethyl parathion, diazinon, and methomyl for FAW control in corn, sorghum, and pasturage. Study done in Auburn, Alabama, demonstrated FAW resistance to trichlorfon, diazinon, and methyl and ethyl parathion leaving methomyl as the only effective insecticide agains FAW. Compounds such as chloropyrifos, Larvin (thiodicarb) 5, and monocrotophos has also showed promising results agianst controlling FAW. But, the doses required to control FAW was higher than the doses required for other insects (Young, 1979). However, recent studies have shown that synthetic insecticides like Spinetoram, spinosad, and lambda-cyhalothrin, had caused more than 90% of larval mortility (Sisay *et al.*, 2019). But, use of higher doses of chemical insecticides contribute to the environmental pollution and disturb the balance of ecosystem (Aktar *et al.*, 2009). Thus, the importance of discovering eco-friendly control measures to control FAW is highlighted.

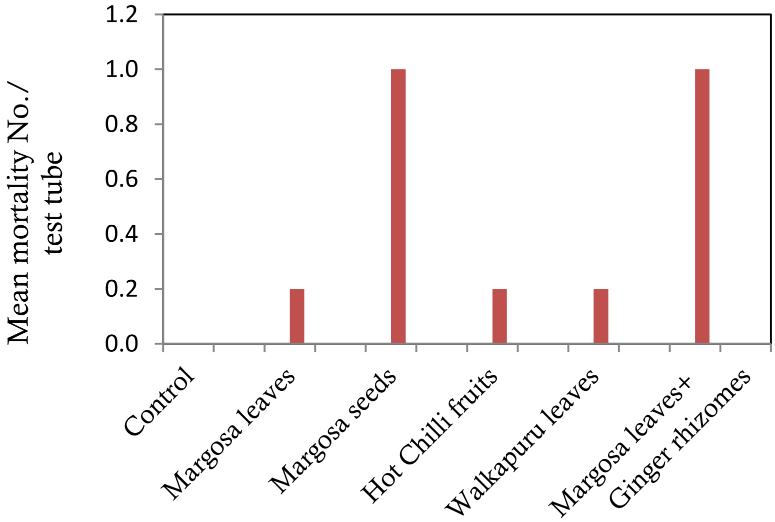

Figure 1: Mortality rate of caterpillars as caused by different plant extracts (Means that do not share the same letter are significantly different).

Margosa seeds alone and Margosa leaf + Ginger rhizome extracts are thus found to be more promising in killing of *Sena* caterpillar.

Study on the life cycle of the insect

Observations were made throughout the life cycle of the insect starting with caterpillar stage of FAW. Four distinct stages of the life cycle namely egg, larvae stage, pupae stage and adult (moth) stage were observed.

Eggs had been laid underside of leaves as egg masses. Reynolds *et al.* (2014) reported that up to 1000 eggs in a mass were laid by the female moth. A significant color variation in egg masses could be seen throughout the egg stage, *i.e.*, the color of eggs was white and also, eggs were covered with cotton like structure (Plate 3). After one (01) day, eggs became greenish color. When the egg reached its hatching time, the egg color changed to black (Plate 4). The duration of the egg stage would be around two to three days. These results were in agreement with Capinera, (1999).

Plate 3: Egg masses laid underside of the maize leaf.

Plate 4: Colour variations in egg masses.

With hatching of eggs, larvae were emerged. Emerged caterpillars dispersed on the leaf surface (Plate 5). At this stage, caterpillars were highly active and mobile.

Plate 5: Young caterpillars dispersing just after hatching.

During the larval phase, six (06) instars having different body sizes could be observed. Center for Agriculture and Bioscience International (2019) and Sharababasappa *et al*. (2018) have also shown the same results of FAW having six instars. Field observations of FAW showed that instars of four, five and six prey on instars one, two and three of FAW caterpillars.

A light-colored upside down "Y" mark could be observed in dark brownish color face of mature caterpillars (Plate 6). After caterpillars reached its maximum weight and length, during next few days, the weight and length started to reduce gradually and then caterpillars produced an oval shaped cover which is about 1.5 cm in length and reddish brown in color turning into pupae. The duration of the larval stage varied between 14-22 days. This is in agreement with the findings of 14-22 days of larval state as reported in Latin America (Food and Agriculture Organization of United States, 2017).

Plate 6: Fall armyworm with a dark head having a pale, upside-down Y-shape on the front.

A significant color range from brown to dull red was observed in different pupae (Plate 7).

Plate 7: Different phases from larvae to pupae.

Mean duration of pupae stage of FAW lasted for 8 days. Food and Agriculture Organization of United States (2017) also reported that in Latin America, the pupae stage lasted around 8-30 d. However, in the current study number of days for pupae stage did not exceed 12 d. At the end of pupae stage, it gave birth to the adult, FAW moth. The forewings of male moth were marked with light brown and grey color spots (Plate 8-a). Female had light colored forewings (Plate 8-b). Female moth laid eggs underside of the leaf. Mean duration of the moth phase lasted for five (05) days. Capinera (1999) reported that the average number of days of adult moth is around 10 d, and it can be ranged between 07 to 21 d. However, the shorter moth life in the current study may be attributed to the limited space and food sources, the adult moth had during the experiment.

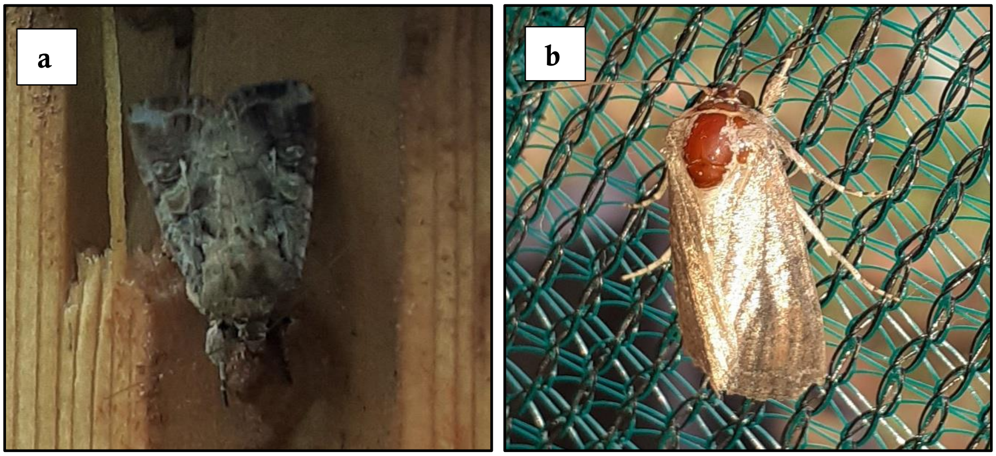

Plate 8: (a) FAW male moth; (b) FAW female moth.

Figure 2 gives details on mean duration of different stages of the life cycle.

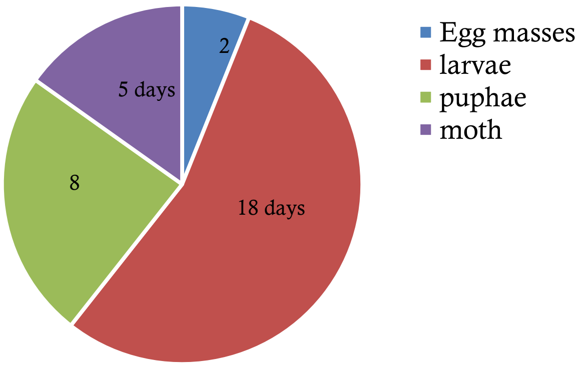

Figure 2: Mean Duration of Different Stages of the Life Cycle.

Evaluation of Bio-efficacy of different plant extracts against *Sena* caterpillar

There was a significant difference in weight between leaves of different plant species, eaten by *Sena* caterpillar (P<0.05). The highest weight of 5.8 g of maize leaves (control) and the lowest weight of 2 g of bean leaves were eaten by caterpillar. As illustrated in the Figure 3, there was a significant difference in weight between maize leaves and bean leaves eaten by caterpillar. However, there was no significant (P>0.05) difference between leaf weights of Kathurumurunga, rice, Guinea grass, Buffalo grass and Guatemala grass when compared to that of maize. This indicates that the *Sena* caterpillar can feed on Guinea grass, Buffalo grass, Guatemala grass, Kathurumurunga and rice leaves in similar capacity to maize leaves.

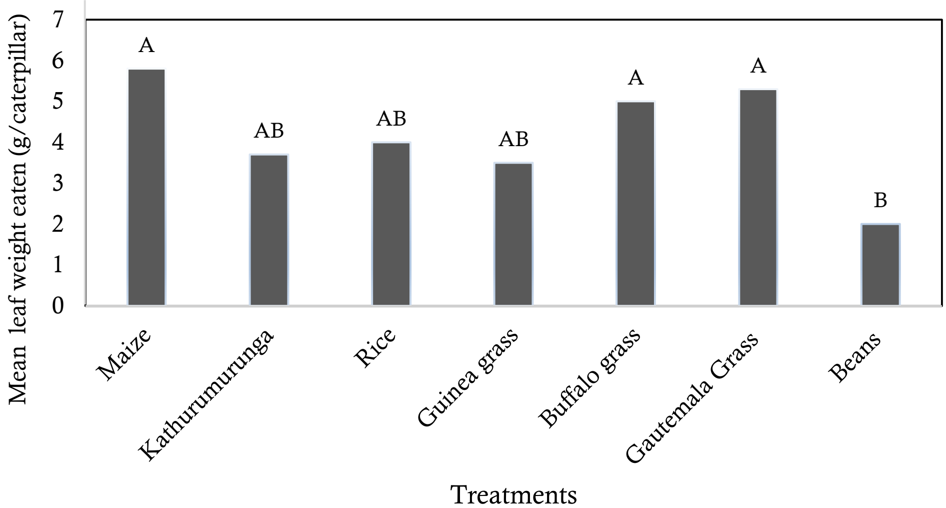

Figure 3: The mean weight of leaf materials eaten by a caterpillar (Means that do not share the same letter are significantly different).

CONCLUSIONS

Margosa seed 80% extract and combination of Margosa leaf and Ginger rhizome 80% extracts were found to be more promising eco-friendly control measures for *Sena* caterpillar in maize cultivation. As *Sena* caterpillar also feeds on Kathurumurunga, rice, Guinea grass, Buffalo grass and Guatemala grass, in the absence of maize, there is a risk of these plants becoming alternative host of the FAW. Mean duration of 33 d were taken by FAW to complete its life cycle, in which egg, larvae, pupae and adult (moth) stages consisted of 2, 18, 8 and 5 d, respectively.

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