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Host Plant Selection Affects Biological Parameters in Armyworm, *Spodoptera litura* (Lepidoptera: Noctuidae)

Asad Abdullah, Muhammad Irfan Ullah*, Abu Bakar Muhammad Raza, Muhammad Arshad and Muhammad Afzal

Department of Entomology, University of Sargodha, 40100, Sargodha

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AA and MIU conceived and designed the study and wrote the manuscript. ABMR and MA analyzed the data and reviewed the literature. MA critically reviewed the manuscript and interpreted the results. This work is a part of PhD thesis of AA.

Key words
Armyworm, artificial diet, growth and development, host preference, host suitability

ABSTRACT

Armyworm, *Spodoptera litura* Fabricius (Lepidoptera; Noctuidae) is considered as one of the economically important insect pest in global agriculture. Suitability of host plants is critical for the efficient management of this economically important insect pest. We studied the effect of various host plants on the growth, development and fecundity of *S. litura*. The larvae of *S. litura* were offered leaves of cabbage, alfalfa, sesbania and, maize in comparison to artificial diet under laboratory conditions (32±05 ºC; 65±05 RH). The larval suitability was found maximum on cabbage followed by sesbania, alfalfa and minimum on maize. The larval length and weight were found higher on cabbage followed by alfalfa and sesbania. Similarly, the pupal development was minimum in respect to days on maize than others. The adults lived 11 days more on cabbage compared to other diets. Female life span was found higher than male on all diets provided. Adult emergence rate was high in cabbage (93.11%), followed by alfalfa (87.5%), sesbania (81.33%), and maize (68.44%). Fecundity was higher when fed on leaves of cabbage, alfalfa and sesbania as compared to maize and artificial diet. Number of eggs oviposited were highest on cabbage (2455.5 eggs) followed by alfalfa (1750.0 eggs) and lowest on maize (1055.6 eggs). More egg batches were found on alfalfa and sesbania. All of the biological parameters of *S. litura* included in the study were affected by the host plants.

INTRODUCTION

Armyworm, also known as common cutworm, *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) has achieved the significant position as a destructive insect pest in cotton growing areas of Pakistan (Saeed *et al*., 2010; Ahmad *et al*., 2007). It has a wide range of hosts from about 25 genera and 14 families including fodder crops, economically important cash crops, vegetables, weeds, various horticultural and ornamentals plants (Simpson *et al*., 2002; Raubenheimer and Simpson, 2003; Lee *et al*., 2003; Ahmad *et al*., 2013). This pest has a vigorous migratory ability (Fu *et al*., 2015) and is widely distributed throughout the tropical and temperate climatic conditions (Tenywa *et al*., 2018). This pest cause damage in the form of monstrous patches from one to another host plant, causing inconsiderable economic losses (Tuan *et al*., 2014; Zhang *et al*., 2006). *S. litura* damage the host plants by feeding leaves, brackets, newly emerged seedlings, tender shoots and fresh seed kernels (Yinghua *et al*., 2017).

Both species, *Spodoptera exigua,* Hübner (Lepidoptera: Noctuidae) and *S. litura* are economically to their high reproductive rate and heavy losses. Due to the absence of common hosts, *S. litura* may select the grasses for the reproduction and survival. Although it has been a sporadic pest of cotton in Pakistan for many years, it is becoming gradually a very important insect pest of various agricultural crops due Due to the absence of common hosts, *S. litura* may select the grasses for the reproduction and survival. Although it has been a sporadic pest of cotton in Pakistan for many years, it is becoming gradually a very important insect pest of fodder crops in recent years (Ahmad *et al*., 2008). The common cultivated fodder crops, mostly affected by the *S. litura* are corn, *Zea maize* L. (family: poaceae), alfalfa, *Medicago sativa* L. (family: fabaceae), barseem, *Trifolium alexandrinum* L. (family: fabaceae) (Khan *et al*., 2011; Ahmad *et al*., 2013). Alfalfa, being a perennial crop is mostly affected by the *S. litura* as alternate host (Kaur, 2012; Agrell *et al*., 2003).

S. litura not only reduce the quality of various crops but also lower the quantity. *S. litura* damage the immature cobs of maize at milking stage by making galleries (Naz *et al*., 2003). Same trend is observed in cabbage flower due to which fungus develops and stunting in growth occurs (Bhatia and Gupta, 2003). This pest has 1-2 generations on sesbania and completely destroys the plant leaves (Ghaffar *et al*., 2002).

Number of studies have reported *S. litura* selection of various host plants and mode of damage under different

* Correspondingauthor:muhammad.irfanullah@uos.edu.pk
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environmental conditions in India (Christou *et al*., 2006; Xue *et al*., 2010), Pakistan (Ahmad *et al*., 2007; Chaudhry *et al*., 2017) and China (Kaur, 2012; Zhu *et al*., 2000, 2005; Qin *et al*., 2004), including other Asian countries. From the last many years, it is reported that this pest has established high immunity against the large groups of pesticides (Saleem *et al*., 2008; Nathan and Kalaivani, 2005; Sang *et al*., 2013) and also have minute range of susceptibility for the non-conventional growing crops (Wan *et al*., 2008). Due to the resistance, *S. litura* can survive from the area where application of pesticides carried out (Kaur *et al*., 2014).

In this study, we determined the oviposition preferences, development and survival of larval and pupal stages of *S. litura* on the different host plants (cabbage, alfalfa, sesbania and maize) to determine its host preferences.

MATERIALS AND METHODS

Test insects

Larvae of *S. litura* were collected from farmer fields from Muzaffargarh (29.5069° N, 70.8536° E) and Sargodha district (32.0740° N, 72.6861° E) and were brought into the laboratory of department of Entomology, University of Sargodha, Sargodha. Artificial diet was prepared from wheat germ based according to the method described by Sorour *et al*. (2011). The artificial diet contained 90 g of wheat flour, methyle-hydroxy benzoate (2g), streptomycin (0.25g), yeast (10g), vitamin C (2 capsule), wheat flour (90g), ascorbic acid (3g) and sorbic acid (3g). Flour was sterilized for 30 min before using. Diet was provided daily up to the pupation stage for the homogenous and less resistant population. Pupae were collected on the daily basis and kept in separate rearing cage for the adult emergence. Adults were released in separate rearing transparent cages (2x2 ft square) provided with moist cotton and honey solution (9:1%) to feed the adults. Towel paper strips were provided for egg laying. The strips having egg batches were replaced daily and eggs per batch were recorded under the microscope, (OPTIKA-SZM2, Italy). Standard rearing conditions of 27±2°C, 65±05% RH with 16:8 lights to dark ratio were followed (Ahmad *et al*., 2007; Arif *et al*., 2009; Gupta *et al*., 2005). The F_3 generation of reared culture of *S. litura* was used in this study.

Host plants

Four host plants were used in this study including common name jantar/sesban (*Sesbania sesban* (L.), lucern/alfalfa (*Medicago sativa* L.), maize (*Zea maize* L.) and cabbage (*Brassica oleracea* L.). These plant species were planted in research area at College of Agriculture, University of Sargodha, Sargodha. No pesticides were applied in the field. Fresh leaves of each host were collected to feed the *S. litura*. The leaves were first washed with distilled water and then dried at room temperature prior to feeding the larvae.

Development of S. litura

Newly hatched larvae were reared on artificial diet. Second instar larvae were used in the experiment. Larvae were starved for 24 h prior to experimentation. The experimental arena was a petri dish containing 1 larva/plate. There were three replications with 5 larvae in each replication. The data for larval length and weight were recorded daily using measuring scale and digital weight balance. After pupal formation, the pupal weight and length was recorded. Adult emergence ratio was also determined to check the effect of host plant.

Fecundity of S. litura

For each treatment, three pairs of adults were separated and released into clean cages separately. The towel paper was hanged to facilitate the egg laying, number of egg batches and total number of eggs were recorded daily. The honey solution was provided as discussed above.

Statistical analysis

One-way analysis of variance (ANOVA) was performed to test the significance of host plants on the developmental biology, and fecundity of *S. litura*, by keeping host plant as main factors. Means were separated by Tukey HSD all pairwise comparison test. All the analyses were performed using SPSS 20.0 software.

RESULTS

Overall, larval development was significantly affected by the host plants (P<0.05) and was longest on cabbage (8.86 days) followed by alfalfa (8.00 days) and shortest on maize (7.00 days). Maximum larval length was found on cabbage (3.74 cm), followed by alfalfa (3.54 cm) and minimum on maize (2.93 cm). In case of larval weight, similar trend was found. However, the pupal development was also affected significantly (P<0.05) by hosts. Pupal developmental period was longest on artificial diet (17.00 days), followed by maize (13.66 days) and the shortest on cabbage (9.66 days). Pupal length was also significantly different (P<0.001) by host and was longer 2.05 cm on cabbage, followed by 1.93 cm on artificial diet and shortest 1.34 cm on maize. Pupal weight was significantly different by host and was found heaviest (0.089 g) in cabbage treatment and was the lightest (0.034 g) on maize (Table I).

Table I.- Effect of host plants on larvae and pupal development of *Spodoptera litura.*

	Larval development			Pupal development		
Diets	Length (cm)	Weight (g)	Period (No. of days)	Length (cm)	Weight (g)	Period (No. of days)
Cabbage	3.74±0.11a	0.69±0.03a	8.86±0.35a	2.05±0.06a	0.089±0.01a	9.66±0.37d
Alfalfa	3.54±0.18ab	0.61±0.04ab	8.00±0.37ab	1.83±0.05b	0.067±0.00b	11.26±0.40cd
Sesbania	3.48±0.08ab	0.54±0.03bc	7.46±0.32ab	1.61±0.05bc	0.065±0.00b	11.66±0.37c
Maize	2.93±0.24b	0.42±0.02cd	7.00±0.39b	1.34±0.11c	0.034±0.00c	13.66±0.49b
Artificial	3.11±0.15ab	0.33±0.02d	7.4±0.40b	1.93±0.42a	0.036±0.00c	17.00±0.60a
F-value	3.921	23.603	3.811	15.801	526	37.703
P-value	<0.05	<0.001	<0.05	<0.001	<0.05	*<0.05*

The means±SE in the same column followed by same letters are not significantly different at $P > 0.05$.

Number of egg masses and total eggs oviposited by *S. litura* females on host plants differed significantly (egg masses: F = 174.0; df = 4, 74; P < 0.001; total eggs: F = 348.0; df = 4, 74; P < 0.001). *S. litura* oviposited greater and almost the similar number of egg masses (21-22.6) on alfalfa and sesbania compared to other treatments. The lowest number of egg masses (9.3) were found on maize. However, the total number of eggs laid by three females were found greater on cabbage (7366.7) followed by 5250.0 on alfalfa and the lowest 2316.0 on artificial diet (Fig. 1).

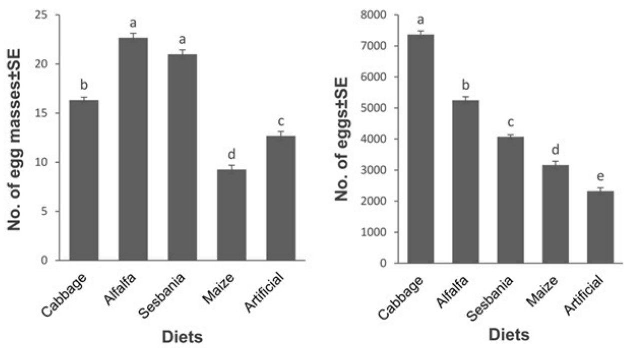

Fig. 1. Egg masses and total eggs per three females *Spodoptera litura* on four host plants in comparison to artificial diet, same letters over the five bars in each figure indicates that the means are not significantly different at $P > 0.05$.

Adult emergence rate was also significantly affected (F = 28.41 and P > 0.001) by host plants and was maximum on cabbage (93.11%±6.73) followed by alfalfa (87.5%±4.61). While minimum adult emergence percentage 68.44%±2.59 was found on maize (Fig. 2).

There was a significant difference in male (F=26.1 and P>0.00) and female (F=12.1 and P>0.00) adult life span feeding on different host plants. Female adults lived more days compared to male feeding on hosts. However, the adult life span was more; 10±0.29 days for female and 8.80±0.34 days for male followed by alfalfa and sesbania when were fed on cabbage leaves compared to other hosts. The shortest period of both male (4.6±0.31 days) and female (6.6±0.42 days) adults were observed when they fed on maize (Fig. 3). The host suitability was found maximum on cabbage, Alfaalfa and least on artificial diet (Fig. 4).

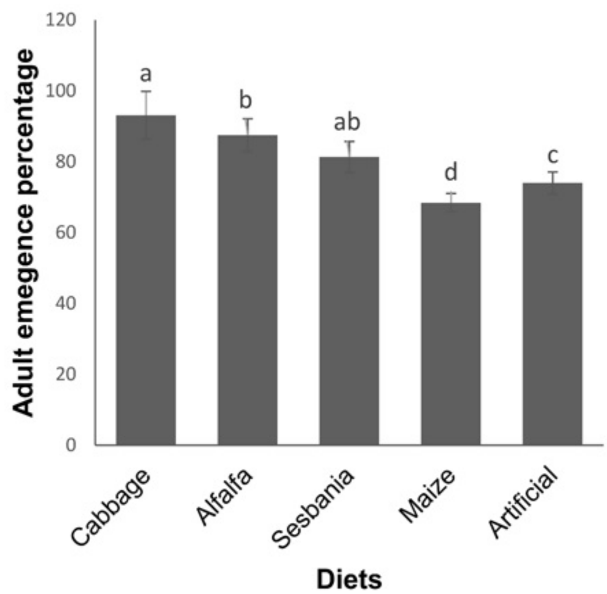

Fig. 2. Percentage adult emergence of *Spodoptera litura* on host plants in comparison to artificial diet, same letters over the bars indicates that the means are not significantly different at $P > 0.05$.

DISCUSSION

The current study results show that larval food directly affects the pupal size and weight and duration as well adult life span on all four host plants. The results are in line to Xue *et al*. (2010) and Ahmad *et al*. (2013), they reported that the food directly affects the larval and pupal developmental period along with length and weight of larvae and pupae. Their findings depicted that during the larval feeding activity, specific storage proteins play an important role in fecundity and metamorphosis of insects. Few work has been reported that focused on the process of protein storage at larval and pupal stages (Telang *et al*., 2002). Our results showed that S. litura preferred the cabbage, lucern (alfalfa) and jantar (sesbania) leaves in comparison to maize and artificial diet, these results supported by Wakil *et al*. (2011) and Maung (2016). Current study results are in line with Zhu *et al*. (2000); Chen *et al*. (2002), Seema *et al*. (2004) and Courdon *et al*. (2002) they stated that due to the variation in nutritional values, larval weight and developmental period may differ. Differences in pupal survival, adult sex ratio, longevity, and fecundity may also be affected by temperature and other environmental conditions (Zhu *et al*., 2000; Chen *et al*., 2002; Seema *et al*., 2004).

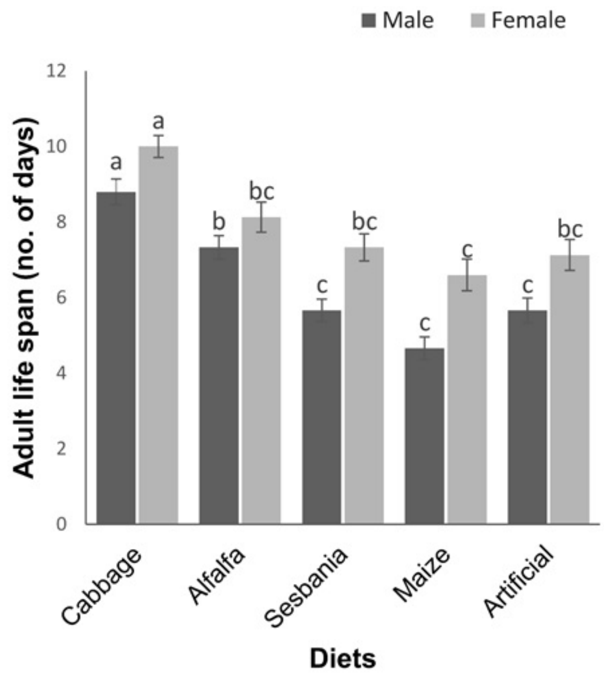

Fig. 3. Adult *S. litura* life span on host plants in comparison to artificial diet, same letters over the bars for each color indicates that the means are not significantly different at *P > 0.05*.

Similarly, the adult emergence ratio was higher on cabbage leaves than other diets and the adult life span was also higher in this treatment. The results about female longevity and the number of eggs laid is also in accordance to Mabrouk *et al*. (2001) and El-Awady *et al*. (2009) who reported that *S. litura* laid maximum number of eggs feeding on cabbage leaves. Selection of the suitable host plants for feeding help the insects to maintain the population up to several generations and multiplication (Lee *et al*., 2003). The information about the host plants for insect pest development led to the useful implementation for the integrated pest management (IPM) tool (Greenberg *et al*., 2001; Saeed *et al*., 2009; Rezapanah *et al*., 2008). To understand the insect behavior and for the management tools this basic nutritional ecology can enhance our appreciation of insects' adaptation to new food resources. The destruction ability of *S. litura* for host plants represented by the fitness of the pest (Tuan *et al*., 2015). The fitness can be determined with the help of pest life table, because life table provides complete and inclusive exposure about the pest developmental stage, reproduction of new progeny and its existence (Jha *et al*., 2012). Integrated pest management program can be established by the life tables as an important ecology-based implementing tool (Tuan *et al*., 2014; Ahmad *et al*., 2018). Under the different laboratory circumstances for the life history facts, *S. litura* was reared on diverse host plant materials reported by Xue *et al*. (2010) and Shahout *et al*. (2011). To understand the effect of host plants diversity on the ecosystem of pest is very essential for the population management strategies (Greenberg *et al*., 2001).

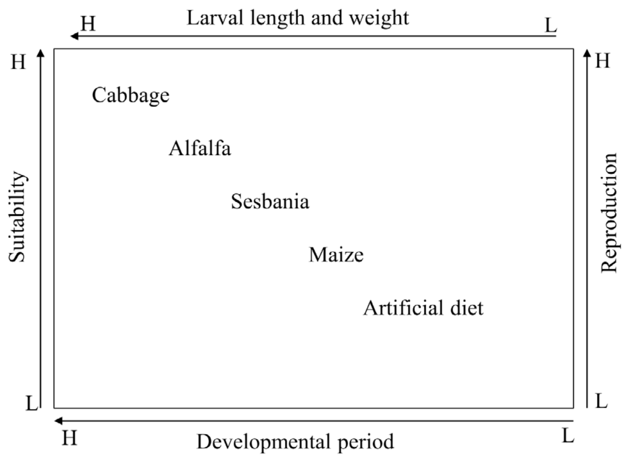

Fig. 4. The relationship between fitness indicators of the *S. litua* and suitability of the host plant→change trend of fitness indicators of *S. litura*→change trend of host suitability from unsuitable to suitable, L= low and H=high.

Cabbage crop is a potentially good candidate trap crop for oviposition by the *S. litura*. However, the effectiveness of trap crops depends on the relative attractiveness of the plant species (Badenes-Perez *et al*., 2004), the proportion of the field occupied by the trap crop (Banks and Ekbom, 1999), duration of the trapping effect (Cook *et al*., 2007), insect migratory and host-finding behaviors (Shelton and Badenes-Perez, 2006), and the relative planting times of trap crops. Trap crops at the field edge can prevent the pest from reaching the crop (Rea *et al*., 2002). The use of trap cropping in agriculture is not well established because this approach is more knowledge-intensive than is pesticide use. However, in least developed countries, pesticides can represent an unacceptable extra cost (Khan *et al*., 2001; Gurr *et al*., 2017) and generally lead to many environmental problems.

The results of our study will be helpful to determine the population dynamics and preferences for various biological parameters in different host regimes and ultimately will aid in developing the suitable management practices for the control of this notorious pest.

CONCLUSION

These findings of this study will be useful in understanding the biology of *S. litura* that could be utilized in various management protocols including integrated pest management (IPM)

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Conflict of interest

The authors declare no conflict of interest.

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