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Research Article

Effect of different Solanaceous host plants on nutritional indices of *Spodoptera exigua* (Lepidoptera: Noctuidae)

Fariba Mehrkhou[1]*, Mahdieh Mousavi[1] and Ali Asghar Talebi[2]

1. Department of Plant Protection, Faculty of Agriculture, Urmia University, Urmia, Iran.
2. Department of Entomology, Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran.

Abstract: The beet armyworm *Spodoptera exigua* (Hübner) is a serious and economically important pest of solanaceous crops worldwide. The nutritional indices of this pest on three host plants including pepper *Capsicum frutescens*, eggplant *Solanum melongena* and tomato *Solanum lycopersicum* were determined under laboratory conditions at 26 ± 1 °C, 60 ± 5% RH and 16: 8 (L: D) h. The highest relative consumption rate (9.40 mg/mg/day) and approximate digestibility (95.20%) were recorded on eggplant. The relative growth rate (RGR) (0.08 mg/mg/day) was the highest on tomato. The efficiency of the conversion of ingested food (ECI) (1.66%) and efficiency of conversion of digested food (ECD) (2.22%) were significantly highest on pepper. Results showed that pepper was the most nutritionally suitable food and even small amount of this food could successfully support maximum RGR as evidenced by high value of ECI and ECD.

Keywords: nutritional indices, Solanaceae, *Spodoptera exigua*

Introduction

The beet armyworm, *Spodoptera exigua* (Hübner), originated from southern Asia (Wilson, 1932) and has been introduced to other regions since 19th century (Azidah and Sofian-Azirun, 2006a,b). It became an important insect pest with a worldwide distribution, a polyphagous species of vegetables and flowers, and a major pest of sugar beet, corn and alfalfa in Iran (Goudarzi and Fathipour, 2010; Farahani *et al*., 2011; Mehrkhou *et al*., 2012 a,b; 2013). Currently, this pest is occurring worldwide attacking over 170 plant species (Zhang *et al*., 2011). Zhang *et al*. (2011) reported that, the infestations have become increasingly serious by *S. exigua* in vegetable, field and flower crops, including all of the economically important members in the Brassicaceae (e.g., broccoli, cabbage, cauliflower, and turnips), Solanaceae (petunia, potato, chili, pepper, tomato, eggplant, and tobacco) and Fabaceae (beans, peas, peanuts, and soybeans). Larvae can also complete development on a number of common weeds such as lambsquarters, mullein, pigweed, purslane, Russian thistle, parthenium, and tidestromia (Wilson 1932; Smits *et al*., 1987; Capinera 2001).

Chemical control programs against this pest have been complicated by its propensity to develop insecticide resistance (Brewer *et al*., 1990). These drawbacks have increased interest in other control methods such as biological control and resistant cultivars of host plants. Therefore, the mentioned methods are useful

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* **Corresponding author**, e-mail: f.mehrkhou@urmia.ac.ir
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and desirable tools, in most pest management programs because they are compatible with natural enemies, human and the environment (Haseeb *et al*., 2004).

The quality and quantity of food consumed affect growth, development and reproduction of insects (Scriber and Slansky, 1981). Study on different aspects including biology, physiology and ecology of insect pests on different host plants is a way to recognize the host plant resistance to these herbivores. The rates of food ingestion, growth and utilization efficiency are important components of herbivores' performance. From a nutritional point of view, utilization efficiency reflects the quality of food consumed (Naseri *et al*., 2010; Baghery *et al*., 2013).

Due to the wide host range, many studies have focused on the biological demographic aspects of *S. exigua* on different host plants including beet varieties (Karimi *et al*., 2014; Mousavi *et al*., 2014) soybean varieties (Mehrkhou *et al*., 2012 a,b; 2013; Farahani *et al*., 2011) canola (Goudarzi and Fathipour, 2010), corn (Mardani Talaei *et al*., 2012), wheat, cabbage and pea (Shafqat *et al*., 2010), shallot, long bean, lady’s finger and chilli (Azidah and Sofian-Azirun, 2006 a,b), cotton, pepper, pigweed and sunflower (Greenberg *et al*., 2001). Whereas, there are no documents regarding the nutritional, utilization and consumption rates of *S. exigua* on solonaceous plants. Thus, the objectives of this study were to determine the food utilization on solonaceous host plants. Determining the nutritional indices of an insect is one of the useful tools for evaluating the host plant resistance mechanisms that could improve pest management programs.

Materials and Methods

Host plants

Three species of host plants including pepper (*Capsicum frutescens*), eggplant (*Solanum melongena*) and tomato (*Solanum lycopersicum*) were planted in a research field at Urmia University, West Azarbayjan, Iran, and were maintained insecticide-free. Selection of these host plants was based on their importance as most cultivated plants in different regions of Iran.

Insect culture

S. exigua larvae were collected originally from a sugar beet field in Maku, Iran, in 2013 (39° 18' N, 24° 20' E) and were subsequently reared on leaves of mentioned host plants for two generations before the experiment. Then, emerged adults were released in plastic containers (15 cm diameter and 19 cm height) for egg laying. During the oviposition period, adult moths were provided with 10% honey solution soaked in cotton balls. A piece of wax paper was set around the container for laying eggs.

Determination of food utilization

Fifty third instar larvae were isolated from stock culture, where reared on mentioned host plants. For this purpose, leaves and larvae were weighed and placed inside a plastic petri dish (diameter 16.5 cm, depth 7.5 cm), individually with a hole covered by fine mesh net for ventilation, the ends of the petioles were wrapped in moistened cotton to prevent desiccation. After 24 h., feces were removed from the unconsumed leaves and weighed again. Petri dishes were cleaned and new weighed leaves were supplied. The weights of the larvae were recorded daily before and after feeding until they finished feeding and reached the pre-pupal stage. Daily food consumption per larva was estimated by subtracting weight of remaining leaf tissue from weight of leaf provided and correcting for evaporation. The pupa, and adults from the larvae reared on each host plant were weighed as well. The weight of feces produced by the larvae fed on each host plant was recorded daily. To find the dry weights of the leaves, feces, and larvae, they were oven-dried (72 hours at 60 °C) then weighed. Nutritional indices were calculated on dry weight basis, as suggested by Waldbauer (1968) and Huang and Ho (1998) to calculate RCR (relative consumption rate), RGR (relative growth rate), AD (approximate digestibility), ECI (efficiency of conversion of ingested food) and ECD (efficiency of conversion of digested food) the following formulae were used:

$$RCR = I / I_W \times T \quad (1)$$
$$RGR = (F_W - I_W) / I_W \times T \quad (2)$$
$$ECI\ (\%) = B / I \times 100 \quad (3)$$
$$ECD\ (\%) = B / (I - F) \times 100 \quad (4)$$
$$AD\ (\%) = (I - F) / I \times 100 \quad (5)$$

where, I is the dry weight of food consumed, F is the dry weight of feces produced, I_w is the initial weight, F_w is the final weight, T is the duration of feeding period (days) and B is the insect dry weight gain. Petri dishes were held at 26 ± 1 °C, 60 ± 5% R. H. and a photoperiod of 16:8 (L: D) h.

Statistical analysis

Effect of different host plants on nutritional indices of *S. exigua* was analyzed by one-way analysis of variance (ANOVA). If significant differences were detected, multiple comparisons were made using Tukey's multiple range test ($P < 0.05$). Statistical analysis was carried out using SPSS ver.19 (SPSS, 2010). All data were checked for normality prior to statistical analysis.

Results

Larval and pupal weights

The larval dry weight, which reared on tomato (0.047 ± 0.001 mg/larva) was heaviest among host plants, followed pepper (0.037 ± 0.001 mg/larva), and eggplant (0.032 ± 0.001 mg/larva) ($F = 148.34$; df = 2, 118; $p < 0.01$). (Fig. 1, A). Pupal weights differed significantly depending on the host plants on which the larvae were fed ($F = 1.342$; df = 2, 42; $p < 0.01$). The heaviest pupal weights were observed on tomato (0.11 ± 0.03 mg/pupa), followed by pepper (0.06 ± 0.00 mg/pupa) and eggplant (0.05 ± 0.00 mg/pupa) (Fig. 1, B).

Food consumption and utilization

The food consumption and utilization rates of larvae varied considerably among the three host plants ($F = 30.42$; df = 2, 118; $P < 0.01$). The highest and lowest food consumption was obtained on eggplant (572.45 ± 30.47 mg / larva) and pepper (367.30±8.57mg), respectively (Fig. 1, C). The fecal rate produced by larvae was the highest on pepper (88.30 ± 4.30 mg / larva) followed by tomato (33.43 ± 0.71 mg / larva), and eggplant (23.47 ± 1.33 mg / larva) ($F = 172.86$; df = 2, 118; $P < 0.01$) (Fig. 1, D). The relative consumption rates were highest on eggplant (9.40 ± 0.24 mg/mg/day), followed by tomato (6.00 ± 0.10 mg/mg/day), pepper (4.06 ± 0.12 mg/mg/day) ($F = 261.94$; df = 2, 118; $P < 0.01$) (Fig. 1, E). The relative growth rate on tomato (0.08 ± 0.00 mg/mg/day), was the highest, while the larvae that fed on pepper (0.06 ± 0.00 mg/mg/day) and eggplant (0.06 ± 0.00 mg/mg/day) showed similar growth rate ($F = 6.20$; df = 2, 118; $P < 0.01$) (Fig. 1, F). The efficiency of conversion of ingested food was highest on pepper (1.66 ± 0.06%), followed by tomato (1.35 ± 0.03%) and lowest on eggplant (0.74 ± 0.04%) ($F = 101.37$; df = 2, 118; $p < 0.01$) (Fig. 2, A). The efficiency of conversion of digested food was higher when the larvae fed on pepper (2.22 ± 0.07%) than on other two host plants ($F = 157.60$; df = 2,118; $P < 0.01$) (Fig. 2, B). The approximate digestibility of larvae on three host plants differed significantly ($F = 173.90$; df = 2, 118; $P < 0.01$) and was higher on eggplant (95.20 ± 0.41%) and tomato (93.00 ± 0.20%) than on pepper (75.27 ± 1.34%) (Fig. 2, C).

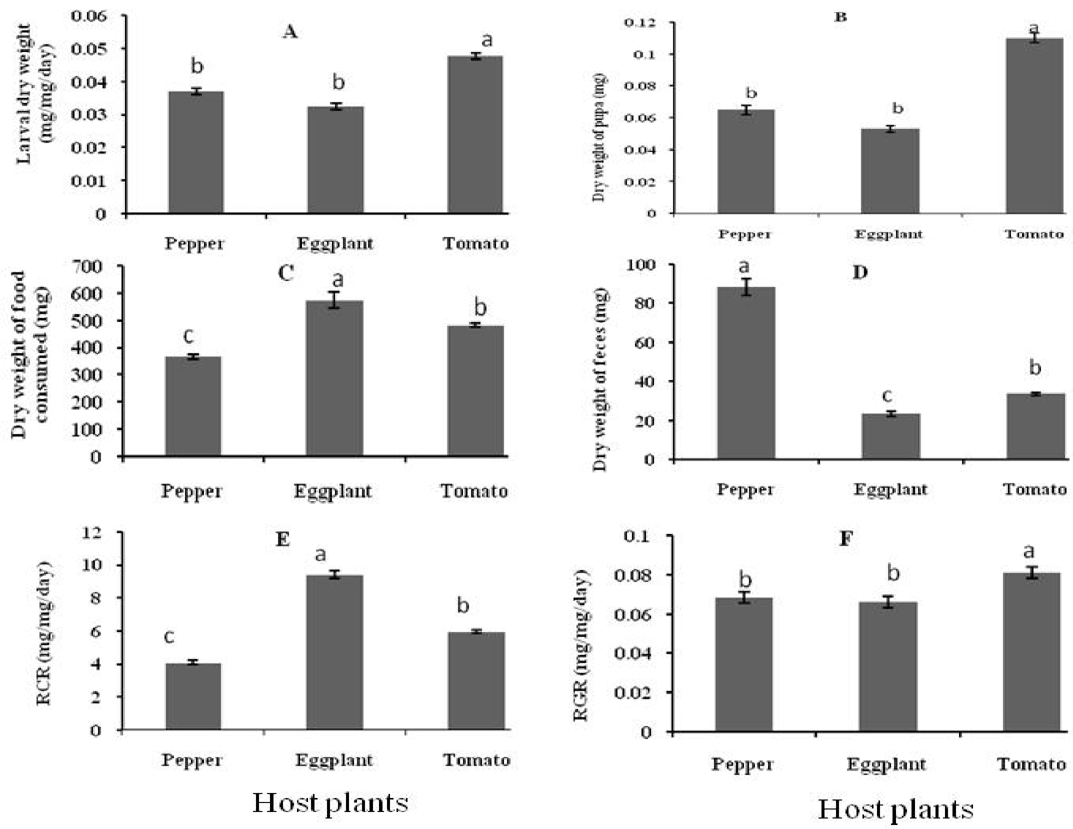
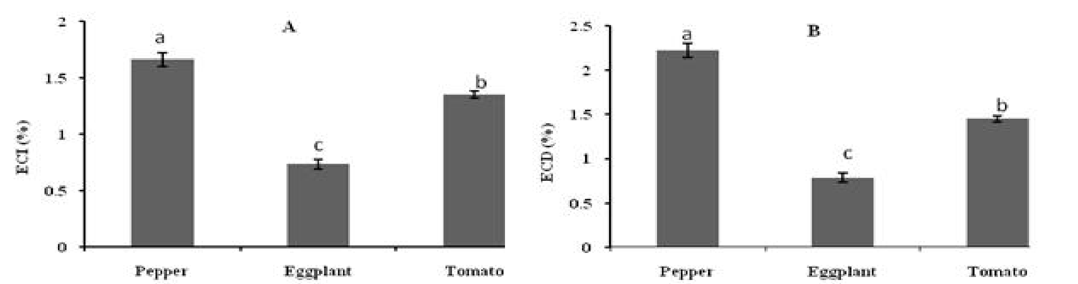


Figure 1 Larval dry weight (A), pupal dry weight (B), consumed food (C), produced feces (D), relative consumption rate (E) and relative growth rate (F) of whole larval instars of *Spodoptera exigua* on different host plants.



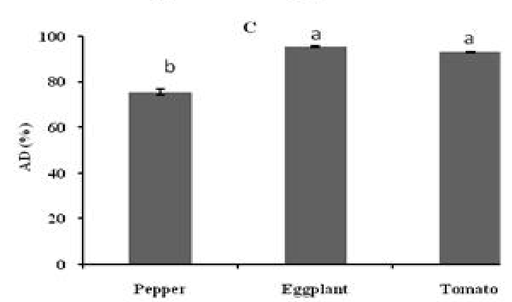


Figure 2 Efficiency of conversion of ingested food (A), efficiency of conversion of digested food (B) and approximate digestibility (C) of whole larval (third to fifth) instars of *Spodoptera exigua* on different host plants.

Discussion

There are several documents on biological aspects of *S. exigua* on different host plants. Whereas, no studies are available regarding the nutritional performance of *S. exigua* on mentioned host plants.

The data clearly show that larval and pupal dry weights as well as nutritional indices were affected when tomato, pepper or eggplant was offered as the food plant. The direct comparison of these data can be difficult; it could be due to the fact that, the different host plants interfering in these studies. The pupal dry weights in this study were 0.05 to 0.11 mg, which were not generally within a wide range such as soybean varieties, which was varied from 73 to 88.10 mg (Farahani *et al*., 2011), One possible reason for this variation could be due to the experimental conditions.

The developmental time of insects is one of the important factors for determining the suitability of host plants, (Naseri *et al*., 2010). Previously, Mehrkhou (2014) studied the developmental time of *S. exigua* on pepper, eggplant and tomato mentioned host plants. Mehrkhou showed that the larvae fed on eggplant had the longest larval (21.76 d), pupal (12.35 d) and total developmental time (36.18 d), whereas, the shortest larval (13.21 d), pupal (7.21 d) and total developmental time (24.42 d), occurred on tomato.

This study was undertaken to investigate the effects of different Solanaceous host plants on nutritional indices of beet army-worm determining the suitability or unsuitability of the examined host plants to this pest.

Efficiency ingested food fed on different host plants varied considerably by *S. exigua* larvae (Mehrkhou *et al*., 2013) and by other insects in general (Scriber and Slansky 1981). In conclusion, based on nutritional requirements of *S. exigua*, the three host plants were ranked as pepper > tomato > eggplant in suitability. Nutritional indices of overall third to fifth larval instars indicated that, pepper was the most nutritionally rich food and even small amount of this food could successfully support maximum relative growth rate (RGR*)* as evidenced by high values of ECI and ECD. Variation in the nutritional indices of the pest on different host plants could be due to the plant shape, color, toughness, age, and origin (Jermy, 1984; Bernays and Chapman, 1994; Mayhew 1997; Nomikou *et al*., 2003; Hull-Sanders *et al*. 2007; Peres-Contreras *et al*. 2008), as well as plant quality, either reflected by a difference in nutrients required by the pest or differences in the level of secondary biochemicals (Naseri *et al*., 2010). Analysis of nutritional indices can lead to the understanding of the behavioral and physiological basis of an insect's response to host plants (Lazarevic and Peric-Mataruga 2003).

The results based on nutritional indices, confirmed our previous study, showing that, the eggplant was the least suitable plant for *S. exigua*. By combining the data from the earlier study with the current research, it could be designated a comprehensive scheme for an integrated pest management of *S. exigua* on mentioned host plants.

It is suggested that future studies focus on demographic parameters, enzyme activities and assessment of the chemical components of the host plants to elucidate the mechanism of host suitability.

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تأثیر میزبان‌های مختلف گیاهی بادمجانیان روی شاخص‌های تغذیه‌ای کرم برگ‌خوار چغندر
Spodoptera exigua (Lepidoptera: Noctuidae)

فریبا مهرخو[1*]، مهدیه موسوی [1] و علی‌اصغر طالبی[2]

۱- گروه گیاهپزشکی، دانشکده کشاورزی، دانشگاه ارومیه، ارومیه، ایران.
۲- گروه حشره‌شناسی کشاورزی، دانشکده کشاورزی، دانشگاه تربیت مدرس، تهران، ایران.
* پست الکترونیکی نویسنده مسئول مکاتبه: f.mehrkhou@urmia.ac.ir
دریافت: ۲ مرداد ۱۳۹۳؛ پذیرش: ۲۰ بهمن ۱۳۹۳

چکیده: کرم برگ‌خوار چغندر *Spodoptera exigua* یکی از آفات مخرب محصولات تیره بادمجانیان در جهان است. در این مطالعه، شاخص‌های تغذیه‌ای لاروهای کرم برگ‌خوار چغندر روی سه میزبان گیاهی فلفل، گوجه‌فرنگی و بادمجان در دمای ۱ ± ۲۶ درجه سلسیوس، رطوبت نسبی ۵ ± ۶۰ درصد و دوره نوری ۱۶ ساعت روشنایی و ۸ ساعت تاریکی مورد مطالعه قرار گرفت. بیشترین میزان نرخ مصرف نسبی و قابلیت هضم‌شوندگی لاروهای کرم برگ‌خوار چغندر روی بادمجان به‌ترتیب ۹/۴۰ میلی‌گرم/میلی‌گرم/روز و ۹۵/۲۰ درصد به‌دست آمد. بیش‌ترین نرخ رشد نسبی روی گوجه‌فرنگی ۰/۰۸ میلی‌گرم/میلی‌گرم/روز به‌دست آمد. بالاترین میزان کارایی غذای خورده شده و کارایی تبدیل غذای هضم شده به‌ترتیب ۱/۶۶ و ۲/۲۲ درصد روی فلفل مشاهده شد. این نتایج نشان داد که اگرچه، لاروهای کرم برگ‌خوار چغندر کم‌ترین میزان تغذیه را از فلفل داشتند ولی همین مقدار کم نیز توانسته باعث افزایش نرخ رشد نسبی، کارایی تبدیل غذای خورده شده و کارایی تبدیل غذای هضم شده شود.

واژگان کلیدی: شاخص‌های تغذیه‌ای، بادمجانیان، کرم برگ‌خوار چغندر