J. Entomol. Res. Soc., 13(1): 91-101, 2011 *ISSN:1302-0250*

Comparative Life Table Parameters of the Beet Armyworm, *Spodoptera exigua* (Hübner) (Lepidoptera, Noctuidae) on Five Host Plants

Samira FARAHANI[1] Bahram NASERI[2] Ali Asghar TALEBI[1]

[1]Department of Entomology, Faculty of Agriculture, Tarbiat Modares University, Tehran, IRAN.

[2](Corresponding author) Department of Plant Protection, Faculty of Agriculture, University of Mohaghegh Ardabili, Ardabil, IRAN. phone: +98 9124010072, fax: +98 4515512204
e-mail: bnaseri@uma.ac.ir

ABSTRACT

The beet armyworm, *Spodoptera exigua* (Hübner) is an important cosmopolitan insect that attacks different plant species in Iran and many parts of the world. Life table parameters of *S. exigua* on different host plants including *Zea mays* (var. 704), *Gossypium hirsutum* (var. Varamin), *Brassica napus* (var. RGS), *Glycine max* (var. Sahar) and *Chenopodium album* were studied at 26 ± 1°C, 60 ± 5% RH and a photoperiod of 16:8 (L:D) h. The larval period, development time and life span of *S. exigua* were longest on *G. hirsutum* and shortest on *B. napus*. The longest pupal period was on *G. hirsutum* and the shortest one was on *G. max*. Among different host plants, fecundity (total number of eggs laid per female) of *S. exigua* was the highest (948.0 eggs) on *B. napus* and lowest (426.3 eggs) on *G. hirsutum*. The highest net reproductive rate (R0) was on *C. album* (377.11 female/female/generation), whereas the lowest one was on *G. hirsutum* (126.39 female/female/generation). The intrinsic rate of increase (rm) varied from 0.1707 to 0.2644, which was the highest on *B. napus* and lowest on *G. hirsutum*. Our results indicated that *G. hirsutum* was the most unsuitable host plant as compared to other hosts tested.

Key words: Population growth, life history, fecundity, plant resistance.

INTRODUCTION

The beet armyworm, *Spodoptera exigua* (Hübner) is a highly polyphagous insect pest, attacking more than 50 plant species from 10 plant families worldwide (Aarvik, 1981; Abdullah *et al*., 2000; Idris & Emelia, 2001). Many factors including adult immigration and emigration, quality and availability of different host plants, especially alternate hosts, and distribution and community composition of natural enemies contribute to fluctuations in *S. exigua* population (Tisdale & Sappington, 2001).

Knowledge of the life table parameters of *S. exigua* and understanding components of its fundamental life history on different host plant species will make progress in efficient strategies to control this economic pest (Greenberg *et al.*, 2001; Tisdale & Sappington, 2001). Among these, an important component will be an understanding of host suitability (Greenberg *et al.*, 2001). The role of different host plants especially limitation of food ingested is important in regulating insect populations (Umbanhowar & Hastings, 2002) as the performance of insects may be affected by variation in host plant (Awmack & Leather, 2002). Larval survival and development can be reduced on poor-quality hosts due to nutritional composition and/or secondary plant metabolites (Herms & Mattson, 1992; Slansky, 1992). Nutritional composition and secondary plant metabolites vary among different plants, plant parts and developmental stages (Nelson *et al.*, 1981; Brower *et al.*, 1982). Different host plants can also play an important role in population increase and outbreaks of polyphagous insect pests (Singh & Parihar, 1988).

The outbreak of *S. exigua* is not regular but develops quickly and since older larval instars are difficult to control with insecticides, early cautioning of population build up is necessary to effective intervention (Tisdale & Sappington, 2001; Idris & Emelia, 2001). It was reported that *S. exigua* larvae have developed resistant to nearly all pesticides used to its control (Ray *et al.*, 1996).

Population parameters are important in the measurement of population growth capacity of species under specified conditions. These parameters are also used as indices of population growth rates responding to selected conditions and as bioclimatic indices in assessing the potential of a pest population growth in a new area (Southwood & Henderson, 2000). The intrinsic rate of increase (rm) is a functional ecological parameter and to predict the potential of population growth of an animal under a given environmental condition (Andrewartha & Birch, 1954; Ricklefs & Miller, 2000;). The rm can be estimated from life table data under standardized laboratory conditions (Southwood & Henderson, 2000). A number of extrinsic and intrinsic factors have been shown to influence the rm value and related demographic parameters. These include temperature, geographical origin of insect and host plant species/cultivars (Gilbert & Raworth, 1996; Syed & Abro, 2003).

Several researches have evaluated host plant influences on life history traits of *S. exigua* (Greenberg *et al*., 2001; Azidah & Sofian-Azirun, 2006; Saeed *et al*., 2009) or studied the effect of the insect feeding on population growth potential (Afify *et al*., 1970; East *et al*., 1989; Meade & Hare, 1991; Tisdale & Sappington, 2001). However, published information by above-mentioned researchers has been variable. Therefore, the objectives of the present study were to investigate the life table parameters of *S. exigua* reared on different host plants to determine whether various host plants have similar effects on these population parameters of *S. exigua.*

MATERIALS AND METHODS

Host plants

Seeds of the four host plants including *Zea mays* (L.) var. 704 (Poaceae); *Gossypium hirsutum* L. var. Varamin (Malvaceae); *Brassica napus* L. var. RGS (Brassicaceae) and *Glycine max* (L.) Merr. var. Sahar (Fabaceae) were acquired from the Plant and Seed Modification Research Institute of Karaj, Iran and were grown in the research field of Tarbiat Modares University in suburbs of Tehran, Iran. The weed species, *Chenopodium album* L. (Chenopodiaceae), which is commonly found in the fields was selected and used in the experiment. For this study, the leaves of five host plants were transferred to a growth chamber at 26 ± 1°C, 60 ± 5% RH and a photoperiod of 16:8 (L:D) h and used for feeding of different larval stages.

Insect colony

Originally, *S. exigua* specimens were collected from the beet fields located in the northwestern of Iran. Cultures were reared on each host plant for a whole generation (from eggs to adult emergence) in a growth chamber under given conditions to allow them to adapt to the new host plants, as the population was collected from the beet fields, and to remove maternal effects (Lacey, 1998). They were maintained inside a growth chamber at 26 ± 1°C, 60 ± 5% RH and a photoperiod of 16:8 (L:D) h.

Experiments

The same aged eggs (within 12 h) of *S. exigua* were taken from the adult moths, which had already been reared for a whole generation on each host plant using a small brush and placed in Petri dishes (8.5 cm. diameter and 3 cm. height) on a leaf of each host plant. The number of eggs used to start the experiment on host plants was 90, 100, 70, 100, and 70 eggs, respectively. The petioles of detached leaves were inserted in water-soaked cotton to maintain freshness. To facilitate aeration, lids of Petri dishes were covered with fine nylon mesh. After emergence of neonate larvae, they were transferred individually into plastic Petri dishes (8.5 cm. diameter and 3 cm. height) with a hole covered by a fine mesh net for aeration, containing the fresh leaves of different examined plants. Head capsules or exuviae from moulting larvae were used for discrimination of larval instars. The regular checking of Petri dishes were continued until all adults emerged or pupae died. The daily survival/mortality was recorded for all immature stages and ultimate instar larvae were kept in plastic containers (3 cm. diameter and 5 cm. height) for pupation. Larval and pupal periods were also recorded on different host plants.

The newly emerged adult females were transferred to separate cages (11 cm. diameter and 12 cm height) and one male added to each cage for mating. The host plant leaves were replaced with new ones every day and the number of eggs laid by individual females was recorded daily. For this purpose, the male and female moths were placed in a new cage, then all deposited eggs on a host plant leaf and inner walls of cage (as oviposition substrates) were counted daily. A small cotton wick soaked in 10% honey solution was placed in the cages to provide a source of carbohydrate for adult feeding. Daily monitoring continued until death of females. To obtain sex ratio on each host plant, deposited eggs that produced on the related host plants foliage were maintained until adult moths' emergence.

Data analysis

The data resulted from the effects of different host plants on development time, oviposition period, fecundity and adult longevity of *S. exigua* were subjected to the one-way analysis of variance (ANOVA) using the statistical software Minitab 15.

The population growth parameters were calculated using formulae suggested by Carey (1993): intrinsic rate of increase (rm), mean generation time (Tc), finite rate of increase (λ), net reproductive rate (R0) and doubling time (DT). All terminology and formulae for computing demographic parameters are consistent with Carey (1993). For example**,** the intrinsic rate of increase (rm) of *S. exigua* on different host plants was estimated using the following equation (Birch, 1948):

$$\sum_{x=\alpha}^{\beta} e^{-r_m x} l_x m_x = 1$$

The jackknife procedure was used to estimate the variance for rm and the other population parameters (Meye *et al.* 1986). It is based on repeated recalculation of the required estimator, missing out each sample in turn (Maia *et al.* 2000). Effect of host plant species on different parameters was analyzed using one-way ANOVA. If significant differences were detected, multiple comparisons were made using the Student-Newman-Keuls (SNK) ($P < 0.05$). Statistical analysis was carried out using Minitab 15.

RESULTS

Development time, adult longevity and life span

The data of the development time of immature stages, adult longevity and life span of *S. exigua* reared on different host plants are given (Table 1). There was no variation in the incubation period of *S. exigua* on different host plants. Larval and pupal periods, development time of immature stages, and life span of *S. exigua* indicated significant differences among the host plants tested. The larval period, pupal period, development time and life span were longest on *G. hirsutum* ($P < 0.01$). However, the shortest larval period, development time of the immature stages and life span of this insect was on *B. napus* ($P < 0.01$). Furthermore, the shortest pupal period was on *B. napus* and *G. max* for males and females ($P < 0.01$).

Oviposition period and fecundity

Oviposition period and fecundity of *S. exigua* adults developed from the larvae fed on different host plants are shown in Table 2. The pre-oviposition period of *S. exigua* was significantly different among host plants tested ($P < 0.01$), but oviposition period and post-oviposition period were not significantly affected by different host plants. The longest pre-oviposition period was on *G. hirsutum* (4.15 days), whereas the shortest one was on *B. napus* (2.65 days).

The fecundity of *S. exigua* female (total number of eggs laid per female) is given in Table 2. Different host plants as larval food significantly influenced the total number of eggs produced per female ($P < 0.01$). The highest number of eggs laid was 948.0 eggs on *B. napus* and the lowest number of eggs was 426.3 eggs on *G. hirsutum*.

Population growth parameters

The population growth parameters of *S. exigua* on five host plants are given in Table 3. There were significant differences in the net reproductive rates (R0) of *S. exigua* on different host plants ($P < 0.01$). The highest R0 value was on *C. album*

Table 1. The mean (±SE) duration of development stages and adult longevity of *Spodoptera exigua* on different host plants under laboratory.

Stage	Host				
	C. album	*Z. mays*	*G. hirsutum*	*B. napus*	*G. max*
Incubation period (d)	3.00±0.00^{a}	3.00±0.00^{a}	3.00±0.00^{a}	3.00±0.00^{a}	3.00±0.00^{a}
Larval period (d)	12.53±0.13^{d}	14.91±0.17^{b}	15.50±0.15^{a}	11.98±0.14^{e}	13.10±0.17^{c}
Male	12.45±0.15^{bc}	15.00±0.25^{a}	15.58±0.24^{a}	11.87±0.22^{c}	12.74±0.25^{b}
Female	12.76±0.25^{b}	14.83±0.24^{b}	15.43±0.19^{a}	12.08±0.18^{b}	13.41±0.22^{b}
Pupal period (d)	7.00±0.62^{b}	7.02±0.13^{b}	8.70±0.11^{a}	6.69±0.09^{c}	6.66±0.08^{c}
Male	7.40±0.09^{bc}	7.54±0.18^{b}	9.11±0.13^{a}	7.00±0.13^{c}	7.00±0.11^{c}
Female	6.70±0.10^{b}	6.59±0.13^{b}	8.32±0.15^{a}	6.42±0.11^{b}	6.37±0.10^{b}
Development time (d)	22.64±0.17^{c}	24.93±0.22^{b}	27.22±0.20^{a}	21.63±0.16^{d}	22.76±0.18^{c}
Male	22.83±0.19^{c}	25.54±0.30^{b}	27.69±0.30^{a}	21.83±0.25^{d}	22.74±0.29^{c}
Female	22.45±0.28^{c}	24.41±0.29^{b}	26.79±0.25^{a}	21.46±0.20^{d}	22.78±0.24^{c}
Adult longevity (d)	13.47±0.42^{ab}	13.69±0.52^{a}	11.72±0.47^{b}	12.49±0.57^{ab}	12.37±0.42^{ab}
Male	12.83±0.65^{a}	12.25±0.08^{a}	10.58±0.59^{a}	12.04±1.04^{a}	11.59±0.52^{a}
Female	14.10±0.52^{a}	14.93±0.65^{a}	12.79±0.66^{a}	12.88±0.58^{a}	13.03±0.61^{a}
Life span (d)	36.33±0.44^{b}	38.42±0.53^{a}	38.94±0.45^{a}	34.12±0.56^{c}	35.15±0.41^{bc}
Male	35.87±0.67^{bc}	37.79±0.74^{ab}	38.31±0.65^{a}	33.87±0.95^{c}	34.33±0.55^{c}
Female	36.80±0.58^{b}	38.93±0.75^{a}	39.54±0.62^{a}	34.35±0.65^{c}	35.84±0.57^{bc}

The means followed by different letters in the same rows are significantly different ($P < 0.01$, SNK)

Table 2. The mean (±SE) pre- and post-oviposition and oviposition periods and fecundity of *Spodoptera exigua* on different host plants

Parameter	Host				
	C. album	*Z. mays*	*G. hirsutum*	*B. napus*	*G. max*
Pre-oviposition period (d)	2.95±0.20^{b}	3.80±0.19^{a}	4.15±0.18^{a}	2.65±0.21^{b}	3.55±0.15^{a}
Oviposition period (d)	7.80±0.34^{a}	8.00±0.47^{a}	6.55±0.53^{a}	8.50±0.53^{a}	7.40±0.53^{a}
Post-oviposition period (d)	2.35±0.49^{a}	2.50±0.49^{a}	1.45±0.38^{a}	1.85±0.41^{a}	1.25±0.29^{a}
Fecundity (egg/female)	865.9±50.4^{a}	620.6±21.6^{b}	426.3±31.7^{c}	948.0±71.3^{a}	503.1±34.3^{bc}

The means followed by different letters in the same rows are significantly different ($P < 0.01$, SNK)

(377.11 female/female/generation), whereas the lowest value was on *G. hirsutum* (126.39 female/female/generation). The intrinsic rate of increase (rm) was also found to be significantly different on various host species ($P < 0.01$). The rm value ranged from 0.1707 to 0.2644, which was the highest on *B. napus* and lowest on *G. hirsutum*. The highest value of finite rate of increase (λ) was on *B. napus* (1.303 day -1). However, the lowest value was on *G. hirsutum* (1.186 day -1). The doubling time (DT) was also found to be significantly different on various host plants, which was the longest on *G. hirsutum* (4.059 days) and shortest on *B. napus* (2.621 days). The mean generation time (Tc) was significantly ($P < 0.01$) different on host plant species, which showed longest generation time on *G. hirsutum* (28.363 days) and shortest on *B. napus* (22.188 days) (Table 3).

Table 3. The mean population growth parameters (SE) of *Spodoptera exigua* on different host plants under laboratory.

Parameter	Unit	Host				
		C. album	*Z. mays*	*G. hirsutum*	*B. napus*	*G. max*
Net reproductive rate (R_o)	Female/Gen	377.113 (21.9) ^{a}	220.934 (7.37) ^{b}	126.385 (9.41) ^{c}	342.113 (25.5) ^{a}	160.927 (11.0) ^{c}
Intrinsic rate of increase (r_m)	1/day	0.24715 (0.0033) ^{b}	0.20781 (0.0021) ^{c}	0.17072 (0.0025) ^{d}	0.26439 (0.0039) ^{a}	0.20666 (0.0025) ^{c}
Finite rate of increase (λ)	1/day	1.280 (0.004) ^{b}	1.231 (0.003) ^{c}	1.186 (0.003) ^{d}	1.303 (0.005) ^{a}	1.230 (0.003) ^{c}
Doubling time (*DT*)	day	2.804 (0.037) ^{c}	3.335 (0.034) ^{b}	4.059 (0.059) ^{a}	2.621 (0.039) ^{d}	3.354 (0.041) ^{b}
Mean generation time (*T*)	day	24.867 (0.187) ^{d}	25.930 (0.166) ^{b}	28.363 (0.206) ^{a}	22.188 (0.238) ^{e}	24.598 (0.154) ^{c}

The means followed by different letters in the same rows are significantly different ($P < 0.01$, SNK). Data in the parenthesis are standard error of the means.

DISCUSSION

The role of host plants, especially food limitation, is an important factor in regulating insect populations (Umbanhowar & Hastings, 2002) as the life cycle characteristics of herbivores may be affected by variation in host plant traits (Awmack & Leather, 2002). For example, the life history parameters such as fecundity, longevity and survival may be influenced by the variation in host plant quality (Awmack &d Leather, 2002).

The present study demonstrated that the life table parameters of *S. exigua* were significantly differed on the five host plants tested. In regard to insect-plant interactions, it is useful to determine the effect of the different host plants/cultivars on the performance of herbivorous (Azidah & Sofian-Azirun, 2006; Saeed *et al.*, 2009).

Since there was no variation in egg incubation period (3.00 days) of *S. exigua* on five host plants tested, this indicated that host plant type did not affect normal egg hatch. Azidah and Sofian-Azirun (2006) & Sivapragasam and Syed (2001) also found the incubation period of *S. exigua* to be 3 days, but Afify *et al.* (1970) and Ahmed *et al.* (1997) stated that this parameter was between 2 to 3 days and 2.8 to 3.1 days, respectively.

The current research showed that the development time of *S. exigua*, which had been fed during the larval stage on different hosts was affected by the host plant species. This result is supported by Azidah & Sofian-Azirun (2006). The larval period (for male and female) was longest on *G. hirsutum* (15.50 days) and shortest on *B. napus* (11.29 days). According to the reports by East *et al.* (1989), Meade & Hare (1991) and Berdegue *et al.* (1998) the larval period of *S. exigua* was 39.3 days on cabbage at 25 °C, 13.7 to 18.5 days on celery depending upon cultivar at 26 °C, and 21.3 days on common weed (*Chenopodium murale* L.) at 28 °C, respectively. These variations might be due to either the variability of nutritional quality and quantity of the host plant species (Bernays & Chapman, 1994), differences in experimental conditions especially temperature or age differences within a plant (Wada, 1979), which increase the incidence of additional moults (Azidah & Sofian-Azirun, 2006).

There were five larval stages of *S. exigua* on all host plants tested. This situation has been previously reported by several researchers (Afify *et al.*, 1970; Anwar *et al.*, 1996; Sivapragasam & Syed, 2001). However, Afify *et al*. (1970) and Anwar *et al.* (1996) stated that occasionally there were six larval instars, and Ali & Gaylor (1992) reported that there were seven larval instars.

The pupal period was also affected by the larval host plant that it has been observed by Azidah & Sofian-Azirun (2006). However, it is not in consistency with the results of Berdegue *et al*. (1998) and Idris & Emelia (2001). These differences might be because of different host plants or different plant parts consumed by the larvae, which may be very different in primary and secondary biochemicals. The pupal period of *S. exigua* varied from 6.66 days on *G. max* to 8.70 days on *G. hirsutum*. According to the literature, pupal period of *S. exigua* was 7.5 days on celery (Berdegue *et al*., 1998) and 9.02 to 10.21 days on shallot and lady's finger, respectively (Azidah & Sofian-Azirun, 2006).

The development time of immature stages reared on each host plant species ranged from 21.63 days on *B. napus* to 27.22 days on *G. hirsutum*. Ali & Gaylor (1992) reported that *S. exigua* larvae had longer development time and required a greater number of stadia when reared on cotton, *G. hirsutum* compared with artificial diet or pigweed, *Amaranthus hybridus* L. (Amaranthaceae), a preferred wild host (Taylor, 1931).

Longer development time of *S. exigua* on *G. hirsutum* may allow longer windows of expedient for using natural enemies in biological control programs (Saeed *et al*., 2009). Based upon Greenberg *et al*. (2001), development time of *S. exigua* varied from 20.2 days on *A. retroflexus* to 26.6 days on pepper *Capsicum annuum* L. (Solanaceae). These findings are almost in agreement with our results on the development time of *S. exigua* reared on different host plants.

Adult male and female longevities of *S. exigua* fed on five host plants were not significantly different, which is not in agreement with the findings of some researchers (Azidah & Sofian-Azirun, 2006; Saeed *et al.,* 2009). Azidah & Sofian-Azirun (2006) noted that there was no difference in adult longevity reared on different host plants. However, there was a difference in the female and male longevity, where both adult females and males reared on lady's finger, and females on long beans lived longer than males reared on cabbage (Azidah & Sofian-Azirun, 2006).

Females reared as larvae on *B. napus* produced the highest number of eggs (948.0 eggs per female) as compared to the other hosts. The lowest number of oviposited eggs was recorded from females reared as larvae on *G. hirsutum* (426.3 eggs per female). The variation in *S. exigua* response has previously been shown to be attributed to the host plants and the conditions under which the plants were grown (Greenberg *et al.,* 2001)**.** Abdullah *et al.* (2000) reported that *S. exigua* produced 472.5 eggs on soybean leaf. Sethi *et al.* (2006) reported that fecundity of *S. exigua* on Valmaine and Tall Guzmaine cultivars of lettuce was 123.2 and 383.6 eggs, respectively. Differences between our study and the results of above-mentioned researchers might be as a resulted of host plant differences.

The population growth parameters of *S. exigua* vary considerably depending on various factors such as host plants and environmental conditions (Greenberg *et al*., 2001; Tisdale & Sappington, 2001). In the present study, the values of the intrinsic rate of increase (rm) of *S. exigua* varied from 0.1707 on *G. hirsutum* to 0.2644 on *B. napus*, suggesting the least suitability of the cotton as a host plant for population increase. It is known that cotton leaves contain chemicals, including volatile terpenoids that attract and/or deter herbivorous arthropods (Harborne, 1988). Gossypol has been shown to reduce *S. exigua* larval weights, increase the development time, and cause mortality (Bottger & Patana, 1966). Cotton plants with gossypol were less preferred as hosts to many herbivorous arthropods (Maxwell *et al*., 1965; Lukefahr & Martin, 1966). It is suggested that *S. exigua* larvae obtain a less diverse source of readily available (unbound) essential amino acids on cotton (because cotton leaves lack free leucine and sometimes free histidine and free phenylalanine) than pigweed, *A. hybridus* (Showler, 2001).

The higher intrinsic rate of increase on *B. napus* was due to the faster development of immature stages (shorter generation time), higher survivorship and higher fecundity rates. High value of rm indicates the susceptibility of a host plant to insect feeding, while a low value indicates that the host plant species is resistant to the pest. The increase in growth rate, shorter development time, and higher fecundity point out that increased feeding and/or higher assimilation rate, both of which may be the result of an increased titer of digestive enzymes (Woods, 1999).

Our results revealed that the highest value of net reproductive rate of *S. exigua* was on *C. album* (377.11) and lowest one was on *G. hirsutum* (126.39). However, this value on *C. album* had not significant difference with the values obtained on *B. napus* (342.11). Greenberg *et al*. (2001) reported that net reproductive rate of *S. exigua* ranged from 139.3 to 596.0 on cabbage *Brassica oleracea capitata* L. (Brassicaceae) and *A. retroflexus*, respectively. Therefore, according to our results the net reproductive rate of *S. exigua* on *G. hirsutum* was almost similar to that reported by Greenberg *et al*. (2001) on cabbage. The greatest mean generation time (T) was on *G. hirsutum* (28.36 days) and the shortest was on *B. napus* (22.19 days). Greenberg *et al*. (2001) have reported the shortest mean generation time of *S. exigua* on *A. retroflexus* (24.2 days) and longest on cabbage (31.6 days). However, our data for mean generation time of *S. exigua* on *C. album* (24.87 days) and *G. max* (24.60 days) was nearly similar to the estimates reported by Greenberg *et al*. (2001) on *A. retroflexus* (24.2 days). The longer mean generation time of *S. exigua* on *G. hirsutum* revealed that the mean time required for a newborn female to replace herself by R0-fold was longer on this host species as compared to the other host plant species. Because of the highest intrinsic rate of increase of *S. exigua* on *B. napus*, the shortest time period required for doubling the initial population was observed on this host plant. Doubling time ranged from 2.62 days on *B. napus* to 4.06 days on *G. hirsutum*. Greenberg *et al.* (2001) have noted that the doubling time of *S. exigua* varied from 2.62 days on *A. retroflexus* to 4.44 days on cabbage. However, our data for doubling time of *S. exigua* on *B. napus* (2.62 days) and *G. hirsutum* (4.06 days) were similar to their estimates on *A. retroflexus* (2.62 days) and pepper, *C. annuum* (4.00 days), respectively. Possible reasons for some inconsistency of our data with the results of above-mentioned researchers are likely caused by variations in experimental conditions, physiological differences depending on the type of the host plant species, genetic differences as a result of laboratory rearing or variation in strains of *S. exigua* .

Understanding the variations in host plants and food quality among different host plants could have useful implications for the management of insect pests including *S. exigua* (Greenberg *et al.,* 2001; Saeed *et al.,* 2009). In conclusion, our findings will help to perceive the performance of *S. exigua* and could help in its management and control. Perhaps of the most practical significance is the fact that *S. exigua* larval development times differ depending on host plant, an occurrence also demonstrated by Palumbo *et al.* (1999) in their study on the influence of host plant on the development of *S. exigua*. Therefore, future studies should focus on testing a wider range of host plant species for the development of *S. exigua* and, also, assessing of the chemical components of the host plant species would help to better understand the mechanism of host suitability. Additional study will be required to determine the biochemical basis of multiple-insect resistance in the host plants tested especially in cotton cultivars. Knowledge of the mechanism of resistance will doubtlessly help in the development of cotton cultivars with improved pest resistance and may result in reduced insecticide use.

ACKNOWLEDGEMENTS

This research was partly supported by a grant from the Center of Excellence for Integrated Pests and Diseases Management of Oil Crops of Iran, which is greatly appreciated.

REFERENCES

Aarvik, L., 1981, The migrant moth *Spodoptera exigua* (Hübner) (Lepidoptera, Noctuidae) recorded in Norway. *Fauna Norveg*, 28: 90-92.

Abdullah, M. D., Sarnthoy, O., Chaeychomsri, S., 2000, Comparative study of artificial diet and soybean leaves on growth, development and fecundity of beet armyworm, *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae). *National Science*, 34: 339-344.

Afify, A. M., El-Kady, M. H., Zaki, F. N., 1970, Biological studies on *Spodoptera (Laphygma) exigua* Hbn. in Egypt, with record of five larval parasites. *Journal of Applied Entomology*, 66: 362-368.

Ali, A., Gaylor, M. J., 1992, Effects of temperature and larval diet on development of the beet armyworm (Lepidoptera: Noctuidae). *Environmental Entomology*, 21: 780-786.

Andrewartha, H. G., Birch, L. C., 1954, *The Distribution and Abundance of Animals,* University of Chicago Press. 782.

Anwar, M., Shafique, M., Taufique, M., 1996, Biology and mass rearing of Lucerne caterpillar, *Spodoptera exigua* (Hbn.) on artificial diet. *Proceedings of the Pakistan Congress of Zoology*, 16: 207-212.

Awmack, C. S., Leather, S. R., 2002, Host plant quality and fecundity in herbivorous insects. *Annual Review of Entomology*, 47: 817-844.

Azidah, A. A., Sofian-Azirun, M., 2006, Life history of *Spodoptera exigua* (Lepidoptera: Noctuidae) on various host plants. *Bulletin of Entomological Research*, 96: 613-618.

Berdegue, M., Reitz, S. R., Trumble, J. T., 1998, Host plant selection and development in *Spodoptera exigua*: do mother and offspring know best? *Entomologia Experimentalis et Applicata*, 89: 57-64.

Bernays, E. A., Chapman, R. F., 1994, Host-Plant Selection By Phytophagous Insects, *Chapman and Hall*, New York, 312**.**

Birch, L. C., 1948, The intrinsic rate of natural increase of an insect population. *Journal of Animal Ecology*, 17: 15-26.

Bottger, G. T., Patana, R., 1966, Growth, development, and survival of certain Lepidoptera fed gossypol in the diet. *Journal of Economic Entomology*, 59: 1166-1168.

Brower, L. P., Seiber, J. N., Nelson, C. J., Tuskes, P., Lynch, S. P., 1982, Plant determined variation in the cardenolide content, thin layer chromatography profiles, and emetic potency of monarch butterflies, *Danaus plexippus* reared on milkweed, *Asclepias eriocarpa* in California. *Journal of Chemical Ecology*, 8: 579-633.

Carey, J. R., 1993, *Applied Demography For Biologists With Special Emphasis on Insec*, Oxford University Press, UK, 211.

East, D. A., Edelson, J. V., Cartwright, B., 1989, Relative cabbage consumption by the cabbage looper (Lepidoptera: Noctuidae), beet armyworm (Lepidoptera: Noctuidae), and diamondback moth (Lepidoptera: Plutellidae). *Journal of Economic Entomology*, 82: 1367-1369.

Gilbert, N., Raworth, D. A., 1996, Insect and temperature, a general theory. *Canadian Entomologist*, 128: 1-13.

Greenberg, S. M., Sappington, T. W., Legaspi, B. C., Liu, T. X., Setamou, M., 2001, Feeding and life history of *Spodoptera exigua* (Lepidoptera: Noctuidae) on different host plants. *Annals of the Entomological Society of America*, 94: 566-575.

Harborne, J. B., 1988, *Introduction to Ecological Biochemistry*, 3rd ed. Academic Press, New York.

Herms, D. A., Mattson, W. J., 1992, The dilemma of plants: to grow or to defend. *Quarterly Review of Biology*, 67: 283-335.

Idris, A. B., Emelia, O., 2001, Development and feeding behaviour of *Spodoptera exigua* (Lepidoptera: Noctuidae) on different food plants. *Journal of Biological Science,* 1: 1161-1164.

Khalid Ahmed, M., Mohammed, G., Venkataiah, M., Rao, N. H. P., 1997, Biologty and bionomics of cutworm *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae) on chillies. *Vegetables Science*, 24: 61-63.

Lacey, E. P. 1998, *What Is An Adaptive Environmentally Induced Parental Effect?. In: Mousseau, T. A., Fox, C. W. (Eds.). Maternal Effects as Adaptations*. Oxford University Press, New York, USA. 54-66.

Lukefahr, M. J., Martin, D. F,. 1966, Cotton-plant pigments as a source of resistance in the bollworm and tobacco budworm. *Journal of Economic Entomology*, 59: 176-179.

Maia, A. H. N., Luiz, A. J. B., Campanhola, C., 2000, Statistical influence on associated fertility life table parameters using jackknife technique, computational aspects. *Journal of Economic Entomology*, 93: 511-518.

Maxwell, F. G., Lafever, H. N., Jenkins, J. N., 1965, Blister beetles on glandless cotton. *Journal of Economic Entomology*, 58: 792-793.

Meade, T., Hare, J. D., 1991., Differential performance of beet armyworm and cabbage looper (Lepidoptera: Noctuidae) larvae on selected *Apium graveolens* cultivars. *Environmental Entomology*, 20: 1636-1644.

Meyer, J. S., Ingersoll, C. G., McDonald, L. L., Boyce, M. S., 1986, Estimating uncertainly in population growth rates: jackknife vs. bootstrap techniques. *Ecology*, 67: 1156-1166.

Nelson, C. J., Seiber, J. N., Brower, L. P., 1981, Seasonal and intraplant variation of cardenolide content in California milkweed, *Asclepias eriocarpa*, and implications for plant defense. *Journal of Chemical Ecology*, 7: 981-1010.

Palumbo, J. C., Reyes, F., Amaya, A., Ledesma, L., Cary, L., 1999, Development and consumption rates for lepidopterous larvae as influenced by host-plant and temperature. 10 pp. University of Arizona College of Agriculture 1999 Vegetable Report. http://ag.arizona.edu/pubs/crops/ az, 1143.

Portillo, H. E., Pitre, H. N., Meckenstock, D. H., Andrews, K. L., 1998, Performance of a lepidopteran pest complex (Langosta) (Lepidoptera: Noctuidae) on sorghum, maize, and noncrop vegetation in Honduras. *Environmental Entomology,* 27: 70-79.

Ray, H., Fichs, T., Benedict, J., Parker, R., Sparks, S., Norman, J., Leser, J., Knutson, A., Minzenmayer, R., Frisbie, R., 1996, Management Guidelines For the Beet Armyworm on Cotton, *Texas Agricultural Experiment Station*.

Ricklefs, R. E., Miller, G. L., 2000, *Ecology, 3rd ed. Freeman and Company, New York.*

Saeed, S., Sayyed, A. H., Ahmad, I., 2009, Effect of host plants on life-history traits of *Spodoptera exigua* (Lepidoptera: Noctuidae). *Journal of Pest Science,* 83: 165-172.

Sethi, A., Mcauslane, H. J., Nagata, R. T., Nuessl, G. S., 2006, Host plant resistance in Romaine lettuce affects feeding behavior and biology of Trichoplusia ni and *Spodoptera exigua* (Lepidoptera: Noctuidae). *Journal of Economic Entomology*, 99: 2156-2163

Showler, A. T., 2001, *Spodoptera exigua* oviposition and larval feeding preferences for pigweed, *Amaranthus hybridus*, over squaring cotton, *Gossypium hirsutum*, and comparison of free amino acids in each host plant. *Journal of Chemical Ecology*, 27: 2013-2028.

Singh, O. P., Parihar, S. B. B., 1988, Effect of different hosts on the development of *Heliothis armigera*. *Bulletin of Entomological Research*, 29: 2168-2172.

Sivapragasam, A., Syed, A. R., 2001, The genus Spodoptera with emphasis on the ecology and natural enemies of the beet armyworm, *Spodoptera exigua* Hübner in Malaysia. *Malaysian Plant Protection Society Newsletter*. October, 6-7.

Slansky, F. Jr., 1992, Allelochemical-nutrient Interactions In Herbivore Nutritional *Ecology*. In: Rosenthal, G. A., Berenbaum, M. R., (Eds.). Herbivores: Their Interaction with Secondary Plant Metabolites. Academic, New York. 135-174.

Southwood, T. R. E., Henderson, P. A., 2000, *Ecological Methods*, 3rd ed. Blackwell Science, Oxford.

Syed, T. S., Abro, G. H., 2003, Effect of brassica vegetable hosts on biology and life table parameters of *Plutella xylostella* under laboratory conditions. Pakistan Journal of Biological Science, 6: 1891-1896.

Taylor, J. S., 1931, Notes on the biology and *Laphygma exempta* Walk., and *L. exigua* Hübn. (Lepidoptera: Noctuidae). *Bulletin of Entomological Research*, 22: 209-210.

Tisdale, R. A., Sappington, T. W., 2001, Realized and potential fecundity, egg fertility, and longevity of laboratory-reared female beet armyworm (Lepidoptera: Noctuidae) under different adult diet regimes. *Annals of the Entomological Society of America*, 94: 415-419.

Umbanhowar, J., Hastings, A., 2002, The impact of resource limitation and the phenology of parasitoid attack on the duration of insect herbivore outbreaks. *Theoretical Population Biology*, 62: 259-269.

Vanderzant, E. S., 1958, The amino acid requirements of the pink bollworm. *Journal of Economic Entomology*, 51: 309-311.

Wada, T., 1979, Influence of the temperature and the growing stages of the rice plant on the number of larval instars in the rice leaf roller, *Cnaphalocrocis medinalis* Guenee. *Japanese Journal of Applied Entomology and Zoology*, 23: 178-182.

Woods, H. A., 1999, Patterns and mechanisms of growth of fifth instar *Manduca sexta* caterpillars following exposure to low- or high-protein food during early instars. *Physiological and Biochemical Zoology*, 72: 445-454.

Received: December 12, 2010 Accepted: January 28, 2011