Demographic study of the green leafhopper, *Empoasca decipiens* (Hemiptera: Cicadellidae) on four sugar beet cultivars

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ABSTRACT

The green leafhopper, *Empoasca decipiens* Paoli (Hemiptera: Cicadellidae) is one of pests of sugar beet, *Beta vulgaris* L. in Iran. In this research, life table, reproduction and population growth parameters of *E. decipiens* were studied on four sugar beet cultivars: Shirin, Rasool, PP8 and IC. The experiments were conducted in a growth chamber at temperature of $25\pm1^\circ$C, 50-60% RH and a photoperiod of 16:8 (L:D) h. The survival rate of individuals developed into adults from the initial cohort stage was estimated 0.78, 0.81, 0.78, and 0.76 on Shirin, Rasool, PP8 and IC, respectively. The life expectancy was 13.75, 14.89, 14.46 and 15.72 days, respectively at the first day of adult emergence. The highest gross and net fecundity rates were on IC and Shirin, respectively. Gross reproduction rate were 22.03, 20.07, 22.06 and 22.31 female per female per generation, on Shirin, Rasool, PP8 and IC, respectively. Intrinsic rate of increase (r_m) were 0.099 and 0.104 (day^{-1}) on Shirin and IC, respectively. The mean generation time (T), net reproduction rate (R_0), doubling time (DT) and finite rate of increase (λ) on these cultivars were estimated by Jackknife method: 29.14-31.75 days, 20.07-22.31 female per female per generation, 6.62-7.01 days, and 1.103-1.110 offspring per female per day, respectively. These results provide important information for demographic parameters of the green leafhopper on different sugar beet cultivars.

Key words: *Empoasca decipiens*, Life table, Reproduction, Population growth, Sugar beet cultivars.

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چکیده

زنجرک سبز، (Hem.: Cicadellidae) Paoli *Empoasca decipiens* یکی از آفـات چغنـدرقنـد
(Beta vulgaris L.) در ایران است. در این تحقیق، جدول زندگی، تولیدمثل و پارامترهای رشـد
جمعیت *E. decipiens* روی چهار رقم چغندرقند شامل شیرین، رسول، PP8 و IC مورد بررسـی
قرار گرفت. آزمایشات در اتاقک رشد تحـت دمـای ۲۵±۱ درجـه سلـسیوس، رطوبـت نـسبی
۶۰–۵۰ درصد و دوره نوری ۱۶ ساعت روشنایی و ۸ ساعت تاریکی انجام شد. نـسبت بقـا در
زمان ظهور حشرات کامل روی ارقام شیرین، رسول، PP8 و IC به ترتیب ۰/۷۸، ۰/۸۱، ۰/۷۸ و
۰/۷٦ تعیین شد. امید به زندگی حشرات کامل در اولین روز ظهور روی ارقام فوق بـه ترتیـب
۱۳/۷۵، ۱٤/۸۹، ۱٤/٤٦ و ۱۵/۷۲ روز بدست آمد. بیشترین میزان باروری ناخالص و خالص به
ترتیب روی IC و شیرین مشاهده شد. نرخ ناخالص تولیدمثل روی ارقام شـیرین، رسـول، PP8
و IC به ترتیب ۲۲/۰۳، ۲۰/۰۷، ۲۲/۰٦ و ۲۲/۳۱ نتاج ماده به ماده در هر نسل تعیین شـد. نـرخ
ذاتی افزایش جمعیت بین ۰/۰۹۹ تا ۰/۱۰٤ (day^{-1}) به ترتیب روی ارقام شیرین و IC متغیر بود.
پارامترهای رشد جمعیت روی ارقام مختلف چغندرقند به روش جک نایف برآورد شـد: طـول
هر نسل ۲۹/۱٤ تا ۳۱/۷۵ روز، نرخ تولید مثل خالص ۲۰/۰۷ تا ۲۲/۳۱ ماده به ماده در هر نسل،
مدت زمان دوبرابر شدن جمعیت ٦/٦۲ تا ۷/۰۱ روز و نرخ متناهی افزایش جمعیـت ۱/۱۰۳ تـا
۱/۱۱ نتاج ماده در هر ماده در هر روز. نتایج این تحقیق اطلاعات مهمی را در مورد پارامترهای
دموگرافیک زنجرک سبز روی ارقام مختلف چغندرقند فراهم نمود. این اطلاعات مـیتوانـد بـه
تشخیص و ردیابی آلودگی آفت، انتخاب و اصلاح نژاد ارقام کمک نماید*.

واژههـای کلیـدی: *Empoasca decipiens*، جـدول زنـدگی، تولیـدمثل، رشـد جمعیـت، ارقـام
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Introduction

The green leafhopper, *E. decipiens* is an extremely polyphagous species and serious

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pest to a wide range of economically important crops in Iran (Naseri *et al.*, 2008). Previous studies showed that *E. decipiens* was the predominant leafhopper species on sugar beet (Ossiannilsson, 1981). Its main area of distribution is central and southern Europe, North Africa, the Middle East and Central Asia (Ossiannilson, 1981). Gunthardt (1971) failed to establish *E. decipiens* on vine, apple, willow trees, sugar beet, phaseolus beans and tomatoes. However, Vidano and Arzone (1983) recorded the presence of *E. decipiens* on vine and Schmidt and Rupp (1997) on tomatoes. In Egypt, *E. decipiens* and two other closely related leafhopper species are major pests in cotton (Hosny & El-Dessouki, 1969). Habib *et al.* (1972) studied the effect of temperature on *E. decipiens* reared on broad bean (*Vicia faba* L.) under field conditions in Egypt.

Different host plants are known to affect insect development, survivorship, reproduction and life table parameters (Kim & Lee, 2002). The effect of different host plants including broad beans, cucumber, tomato and sweet pepper was investigated on developmental time, longevity, fecundity and sex ratio of *E. decipiens* (Al-Moaalem *et al.*, 2005). In addition, the threshold temperature for development of the leafhopper is determined. Effect of temperature and host plants on the bionomics of *E. decipiens* was studied by Raupach *et al.* (2002), who noted that the longest and shortest time required for the nymphal development were on eggplant (*Solanum melongena* L.) and broad bean, respectively.

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). Maya-Hernandez *et al.* (2000) evaluated the population parameters of *Empoasca kraemeri* Ross and Moore on five bean (*Phaseolus* sp.) genotypes.

Demographic studies have several applications: analyzing population stability and structure; estimating extinction probabilities; predicting life history evolution; predicting outbreak in pest species; and examining the dynamics of colonizing or invading species (Vargas *et al*., 1997; Haghani *et al*., 2006). Demographic information may also be useful in constructing population models (Carey, 1993) and understanding interactions with other insect pests and natural enemies (Omer *et al*., 1996).

Fertility life tables are appropriate to study the dynamics of animal populations, especially arthropods, as an intermediate process for estimating parameters related to the population growth potential, also called demographic parameters (Maia *et al*., 2000). In spite

of the importance of *E. decipiens*, the demographic parameters of this pest have not been developed on different sugar beet cultivars. The goal of this research was to evaluate the demographic parameters of *E. decipiens* on four sugar beet cultivars to determine their susceptibility to the green leafhopper. This information could be extremely valuable for future development of IPM programs against *E. decipien*s.

Materials and Methods

Rearing method and experimental conditions

Four sugar beet cultivars seeds including Shirin, Rasool, PP8 and IC were obtained from the Karadj Plant and Seed Research Institute and were sown in suitable soil and compost mixture in 20 cm diameter plastic pots. Insects were originally collected from local sugar beet fields in Tehran, Iran in 2005. The green leafhoppers were reared on sugar beet (cultivar PP8) in a growth chamber at temperature of 25±1 ℃, 50-60% RH and a photoperiod of 16:8 (L:D) hours in cylindrical cages (40 cm high and 20 cm diameter) for two generations.. To reduce the effect of plant age on the leafhopper development and survivorship, the sugar beet cultivars used in the current experiments were in the stage of 10 to 15 leaves.

Life table parameters

In order to determine the life table parameters, 20-mated female adults were selected from mass cultures and were placed on seedlings of different cultivars of sugar beet. After emergence of *E. decipiens* nymphs, for each cultivar of sugar beet, a cohort of 100 newly emerged nymphs (within 12 h) were individually transferred on detached sugar beet leaf disks in Petri dishes (20 cm diameter) and then transferred to a growth chamber. The lids of Petri dishes were covered with fine nylon mesh to facilitate ventilation. The petioles of detached leaves were inserted in water-soaked cotton to maintain freshness. A fine camel's hair brush was used for transferring younger nymphs to the Petri dishes. Fresh food material was provided as required, and observations were recorded daily for the mortality/survival of the nymphs in the same instar or moulting in next instar through adult emergence. Exuviae from moulting were used to discriminate the nymphal instars. This experiment was continued until death of all individual members of the cohort. Two important life table parameters (survivorship and life expectancy) were calculated by the following formula (Carey, 1993):

$$l_x = \frac{N_x}{N_o}$$

$$e_x = \frac{T_x}{l_x}$$

where x is unite of age, l_x is age-specific survival rate or the fraction of individuals of the initial cohort alive at age x, N_x is number alive at age x, N_0 is starting number of individuals in the cohort, e_x is life expectancy at age x, T_x is the number of time units lived by the cohort from age x until all individuals die: $T_x = \sum L_x$, L_x is the fraction of individuals alive during the interval between x and $x+1$.

Reproduction and population growth parameters

Twenty newly emerged adult females were collected from stock colony and introduced separately (with two males) into Petri dishes. In each cage, the number of eggs laid per female was recorded every day. The experiments were continued on each sugar beet cultivar up to the death of the last female.

The survival rate of immature and adult stages, daily fecundity, and sex ratio were used to construct $l_x m_x$ life tables from which demographic growth parameters were calculated. From the fertility and survivorship schedules, the following population growth parameters were calculated using formula suggested by Carey (1993): intrinsic rate of increase (r_m), mean generation time (T_c), finite rate of increase (λ), net reproduction rate (R_0) and doubling time (DT).

Statistical analysis

Demographic parameters, life table and fertility tables were estimated following the methods described by Carey (1993). Statistical analysis was carried out using Minitab 14.0 software (MINITAB, 2000). Differences in R_0, T_c, λ, DT and r_m values were tested for significance by estimating variances through the jackknife procedure (Meyer *et al.,* 1986, Maia *et al.,* 2000). The differences of reproduction and population parameters were compared using one-way analysis of variance (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 SPSS software (SPSS, 2004).

Results and Discussion

Life table parameters

The life expectancy, survival rate and age specific fecundity of *E. decipiens* on different sugar beet cultivars are shown in Fig. 1 and Fig. 2, respectively. The survival rate of

individuals developed into adults from the initial cohort stage was estimated 0.78, 0.78, 0.81 and 0.76 percent on Shirin, PP8, Rasool and IC, respectively. The lowest rate of survival was occurred at the age of 48, 48, 47 and 46 days, respectively. Age specific fecundity was similar on different cultivars and highest number of female eggs laid per female was observed on second day after adult emergence (Fig. 2). The life expectancy of *E. decipiens* was estimated 13.75, 14.46, 14.89 and 15.72 days, respectively at first day of adult emerge, which revealed maximum and minimum rates of this parameter on IC and Shirin, respectively. However, the longest and shortest life expectancy of pest was 38.86 and 36.25 days on Shirin and IC, respectively at the beginning of life (Fig. 1).

Reproduction and population growth parameters

Reproduction parameters (mean±SE) of *E. decipiens* reared on four sugar beet cultivars are presented in Table 1. There were no significant differences in reproduction parameters of the leafhopper among four sugar beet cultivars. However, the highest gross fecundity and fertility rates were on IC (60.90 eggs) and lowest on Rasool (56.49 eggs). The net fecundity and fertility rates were higher on Shirin (42.04 eggs) and lower on PP8 (39.81 eggs) compared in other cultivars. Daily eggs per female were highest on Shirin and PP8 (4.18 and 4.18 eggs, respectively) and lowest on Rasool (3.79 eggs).

The population growth parameters of *E. decipiens* including intrinsic rate of increase (r_m), gross reproductive rate (*GRR*), net reproductive rate (R_0), mean generation time (T_c), finite rate of increase (λ) and doubling time (*DT*) are shown in Table 2. No significant differences were observed in population growth parameters of the leafhopper on different sugar beet cultivars, except for the mean generation time that significantly differed on four sugar beet cultivars (*P*<0.05). The gross reproductive rate varied from 31.18 to 37.06 female offspring per female per generation on Rasool and IC, respectively. The net reproductive rate was the highest on IC (22.31 females per female per generation) and lowest on Rasool (20.07 females per female per generation) as compared to the other sugar beet cultivars. The intrinsic rate of increase ranged from 0.099 to 0.104 female per female per day on Shirin and IC, respectively. Finite rate of increase was 1.10 days on all sugar beet cultivars. The longest time required for doubling of the leafhopper population was on Shirin (7.01 days), whereas the shortest one was on IC (6.62 days). The mean generation time was longer on Shirin (31.75 days) and shorter on Rasool (29.14 days) in comparison with other sugar beet cultivars. There were significant differences between mean generation times of *E. decipiencs* on four sugar beat cultivars.

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Table 1- Reproduction parameters (mean±SE) of *E. decipiens* reared on four sugar beet cultivars

Parameter	Cultivar				Unit
	Shirin	**Rasool**	**PP8**	**IC**	
Gross fecundity rate	57.56±2.05[a]	56.49±2.95[a]	60.55±1.93[a]	60.90±3.06[a]	eggs
Gross fertility rate	57.56±2.05[a]	56.49±2.95[a]	60.55±1.93[a]	60.90±3.06[a]	eggs
Net fecundity rate	42.04±2.72[a]	41.14±1.88[a]	39.81±1.82[a]	41.78±2.24[a]	eggs
Net fertility rate	42.04±2.72[a]	41.14±1.88[a]	39.81±1.82[a]	41.78±2.24[a]	eggs
Daily eggs per female	4.18±0.14[a]	3.79±0.19[a]	4.18±0.14[a]	3.87±0.19[a]	egg/female/day

The means followed by different letters in the rows are significantly different (P<0.05). Egg hatch rate was assumed to be 100%. Consequently, the obtained gross and net fertility and fecundity rates are equal.

Table 2- Population growth parameters (Mean±SE) of *Empoasca decipiens* reared on four sugar beet cultivars

Parameter	Cultivar				Unit
	Shirin	**Rasool**	**PP8**	**IC**	
Gross reproduction rate	34.84±1.06[a]	31.18±1.07[a]	36.69±1.05[a]	37.06±1.07[a]	Female offspring/ female/ generation
Net reproductive rate	22.03±1.08[a]	20.07±1.61[a]	22.06±1.54[a]	22.31±1.87[a]	Female offspring/ female/ generation
Intrinsic rate of increase	0.099±0.001[a]	0.103±0.002[a]	0.102±0.002[a]	0.104±0.002[a]	Day^{-1}
Finite rate of increase	1.10±0.001[a]	1.10±0.002[a]	1.10±0.002[a]	1.10±0.002[a]	Day^{-1}
Doubling time	7.01±0.08[a]	6.72±0.15[a]	6.77±0.13[a]	6.62±0.15[a]	Day
Generation time	31.75±0.1[a]	29.14±0.15[d]	30.26±0.15[b]	29.71±0.19[c]	Day

The means followed by different letters in the rows are significantly different (P<0.05).
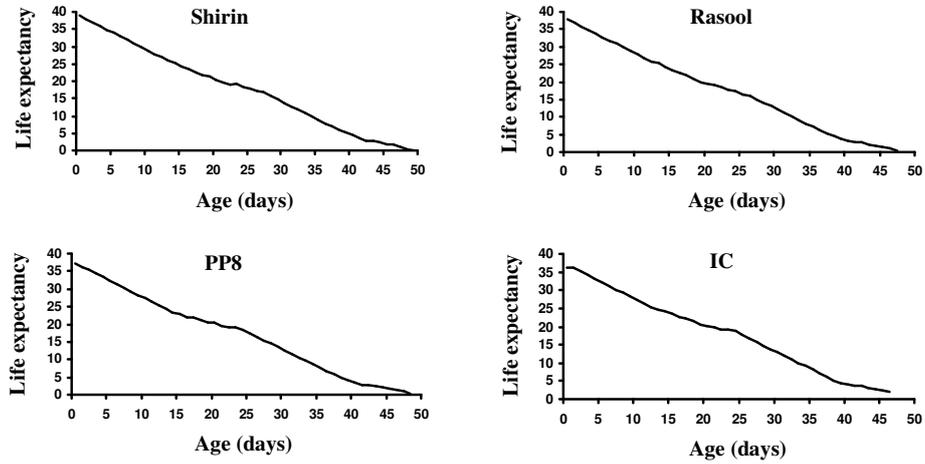
Fig. 1- Life expecpancy (e_x) of *Empoasca decipiens* reared on four sugar beet cultivars
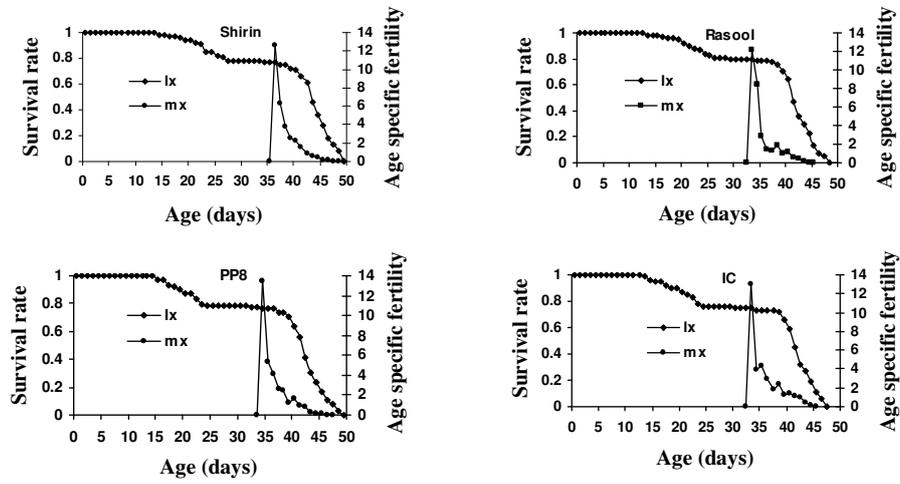
Fig. 2- Survival rate (l_x) and Age specific fecundity (m_x) of
Empoasca decipiens reared on four sugar beet cultivars

Understanding the demographic parameters of pest is essential to develop an integrated pest management strategy. These parameters provide population growth rate of an insect pest in the current and next generations (Frel *et al*., 2003). Morgan *et al.* (2001) have declared that in developing forecasting models, it is necessary to investigate the bionomics of indigenous populations, in order to avoid erroneous data resulting from adaptation to disparate ecoclimatic conditions.

The survival rate of individuals developed into adults from the initial cohort stage ranged from 0.76 to 0.81 percent on IC and Rasool, respectively. Survival rate of *Cicadulina bipunctata* (Melicher) (Homoptera: Cicadellidae) reared on corn was 50.0% at 25.3ºC (Tokuda *et al.,* 2004). The life expectancy of *E. decipiens* on different sugar beet cultivars varied from 13.75 to 15.72 days at first day of adult appearance, which revealed highest and lowest rates of this parameter on IC and Shirin, respectively. The results of Maya-Hernandez *et al.* (2000) studies indicated that life expectancy of *E. kraemeri* adult on five bean genotypes including DOR-207, EMP-40, BAT-1636, BAT-58-2 and Negro Jamapa was 19.04, 21.29, 22.29, 21.17 and 22.2 days, respectively. Variation in the survival rate and life expectancy of *E. decipiens* on different soybean varieties could be result of differences in plant quality, either reflected in difference in nutrients required by pest or differences at the levels of secondary compounds

In our experiments, the net fecundity and fertility rates ranged from 39.81 eggs on PP8 to 42.04 eggs on Shirin. Net fecundity rate of *C. bipunctata* was 291.5 eggs at 25.3ºC (Tokuda *et al.,* 2004), for *Recilia dorsalis* (Motschulsky) (Homoptera: Cicadellidae) reared on rice was 39.6 eggs (Matsumoto, 1988) and for *Homalodisca coagulate* (Say) was 194 eggs on cowpea (Setamou & Jones, 2005).

The net reproductive rate (R_0) of the leafhopper was 20.07 female per female per generation on Rasool. This result agrees with the findings of Maya-Hernandez *et al* (2000) for *E. kraemeri* reared on Negro Jamapa (bean genotype). Tokuda & Matsumura (2004) have reported that net reproductive rate of *C. bipunctata* was 75.9 female per female per generation. There was not any significant difference in intrinsic rate of increase of the leafhopper fed on different sugar beet cultivars, suggesting that the type of the host plant had not significant effect on this parameter. The intrinsic rate of increase ranged from 0.0988 to 0.1040 female per female per day on Shirin and IC, respectively. The value of this parameter on IC similar to those reported by Tokuda and Matsumura (2004) for *C. bipunctata* reared on corn at 25.3ºC. Maya-Hernandez *et al* (2000) have noted that the r_m value of *E. kraemeri* on

five bean genotypes including DOR-204, EMP-40, BAT-1636, BAT-58-2 and Negro Jamapa was 0.055, 0.084, 0.090 and 0.120 (day^{-1}), respectively. This disagreement may be due to differences in the examined insect species and physiological differences depending on type of host plant.

As can be observed in table 2, the finite rate of increase (λ) of *E. decipiens* was 1.10 days on all sugar beet cultivars. Based upon Setamou & Jones (2005), finite rate of increase of *H. coagulates* on cowpea was 1.045 days. The doubling time of the leafhopper population (6.62 to 7.01 days on IC and Shirin, respectively) were lower that reported for *H. coagulate* on cowpea (15.6 days) by Setamou & Jones (2005).

The mean generation time (T_c) was significantly longer on Shirin (31.75 days) and shorter on Rasool (29.14 days) than the other sugar beet cultivars. The results of this parameter on Rasool were the same as those reported by Maya-Hernandez *et al* (2000) for *E. kraemeri* fed on Negro Jamapa (bean genotype). The mean generation time of *C. bipunctata* reared on corn was 44.4 days at 25.3ºC (Tokuda & Matsumura, 2004).

In conclusion it should be noted that, the life history parameters of *E. decipiens* were not significantly different on various sugar beet cultivars. Therefore, it may be useful to consider a wide range of sugar beet varieties for evaluation of demographic parameters of *E. decipiens* and assessment of biological control agents in integrated pest management (IPM) program of sugar beet.

Acknowledgements

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