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EFFECT OF DIFFERENT CONSTANT TEMPERATURES ON BIOLOGY OF *SCHIZAPHIS GRAMINUM* (RONDANI) (HEMIPTERA: APHIDIDAE) ON BARLEY, *HORDEUM VULGARE* L. (POACEAE) IN IRAN

Nastaran Tofangsazi[1], Katayoon Kheradmand[1], Shahram Shahrokhi[2], Ali A. Talebi[3]*

[1] Department of Entomology and Plant Pathology, College of Abouriahan, University of Tehran, P.O.Box 33955-159, Pakdasht, Iran
[2] Islamic Azad University, Miyaneh Branch, P.O.Box 22345-786, Miyaneh, Iran
[3] Department of Entomology, College of Agriculture, Tarbiat Modarres University P.O. Box 14115-336, Tehran, Iran

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Abstract: The temperature dependent biology of greenbug, *Schizaphis graminum* Rondani on Kavir barley cultivar was studied at seven constant temperatures including 10, 15, 19, 22, 26, 31, and 33±1°C, 70% relative humidity (RH), and a photoperiod of 16:8 (L:D) hours. The period of immature development ranged between 6.60 days at 26°C to 28.56 days at 10°C, respectively. All tested aphids failed to develop at 33°C. The calculated r_m and λ values were significantly the highest at 26°C and lowest at 10°C, respectively. The mean generation time and doubling time of *S. graminum* decreased linearly by increasing the temperature from 10 to 26°C. Additionally, the total number of offsprings per female was extremely low at 10 and 31°C, contrary to the highest and lowest values of life expectancy at 10°C (41.73 days) and 31°C (7.66 days), respectively. The results of the present study revealed that temperature had great effects on biology of *S. graminum*, which was never previously studied on barley in Iran.

Key words: demography, greenbug, *Schizaphis graminum*, Kavir variety, Iran

INTRODUCTION

The greenbug, *Schizaphis graminum* Rondani, is a cosmopolitan aphid distributed nearly worldwide (Lage *et al.* 2003). They are dominant cereal aphids that can infest winter and spring sown barley crops in Iran (Rezvani 2001). This species is able to attack cereals causing serious economical loss and direct and indirect damage (McCauley *et al.* 1990; Rezvani 2001). Their direct damage is caused by feeding, destroying plants, atrophying or stunting (Stone *et al.* 2000). The aphids inject toxic salivary enzymes into the plants, initiating the kill of seedling stage and reducing yields in older plants (Pendleton *et al.* 2009). Also, greenbug can transmit several important viruses, being the most effective vector of barley yellow dwarf virus in several varieties of *Hordeum vulgare* L. (Rezvani 2001).

The evaluated yield loss in grain crops are 20% in Iran annually and cause millions of dollars loss on small grains all around the world (Rezvani 2001; Pendleton *et al.* 2009).

Temperature is a factor influencing the developmental rate, survival and reproduction capacity of the pest. Also the host plant has an effective influence on its dynamics (Tofangsazi 2009). Studying temperature, host plant and humidity would help to control this important aphid.

Therefore, the goal of this study was to evaluate the effect of temperature on biology of the greenbug on barley cultivar (Kavir) in Isfahan (central part of Iran), a region with a moderate climate. The results of this study will be the basis to develop pest management program for barley fields in Iran.

MATERIALS AND METHODS

Rearing method

Seeds of Kavir barley cultivar were acquired from Karaj Cereal Research Department of the Iranian Research Institute of Plant Breeding and were sown in 15 cm plastic pots filled with standard mixed soil.

In March 2008, a colony of *S. graminum* was established on barley, *H. vulgare* L. cv. Kavir, in growth chamber from the aphids collected from Isfahan. A stock culture of the aphid was maintained at 22±1°C, 70% relative humidity, and a photoperiod of 16:8 (L:D) h. Regular infection of new host plant was performed to maintain the colony. Seedling stage was used in all experiments.

Development, survivorship and reproduction capacity

This research was carried out in a separate growth chamber at seven constant temperatures including 10, 15, 19, 22, 26, 31, and 33±1°C with a temperature control of ±1°C, 70% relative humidity (RH) and a photoperiod of 16:8 (L:D) h. Experiments at each tested temperature

*Corresponding address:
kkheradmand@ut.ac.ir

were started with 85 newly emerged nymphs (4 hours old), produced by apterous adults at 22°C. Every 24 h, females were checked for survivorship and ecdysis. Aphids were transferred by camel's-hair brush from discolored leaf disk to the fresh ones every 2–3 days, normally.

All demographic experiments were done under the same laboratory condition as above. The number of offsprings produced by each aphid were counted and removed daily until the last female died. To prevent nutritional source deficiency, host plants were changed as necessary. These experiments were not done at 33°C because there was no nymphal survival.

Statistical analysis

Statistical analysis of all collected data was carried out using procedure of general linear models (GLM) of SAS statistical package (SAS Institute 1988). All life parameters are presented with its standard error using the jackknife method (Meyer *et al.* 1986; Maia *et al.* 2000). Differences between the values were detected by using One-Way ANOVA. If significant differences were observed, multiple comparison was made using least significant difference (LSD).

RESULTS

Immature development and mortality

The mean developmental time of *S. graminum* at seven constant temperatures are summarized in table 1. The period of immature development ranged from 6.60 days at 26°C to 28.56 days at 10°C for the combined nymph.

Longer average developmental period occurred at 31°C compared with the shortest developmental period that was recorded at 26°C. The first instar nymph was the longest stage of development within all other immature stages. Significant effect of temperature was observed at all tested temperatures. The lowest percentage of nymphal mortality was calculated (13%) at 19°C.

Aphid survival, life expectancy, longevity and fecundity

Longevity of *S. graminum* was highly affected by temperatures from 59.85±1.38–20.50±0.82 days at the lowest and highest extremes of tested temperatures (Table 2).

Table 1. Developmental time of *S. graminum* at seven constant temperatures (mean ±SE)

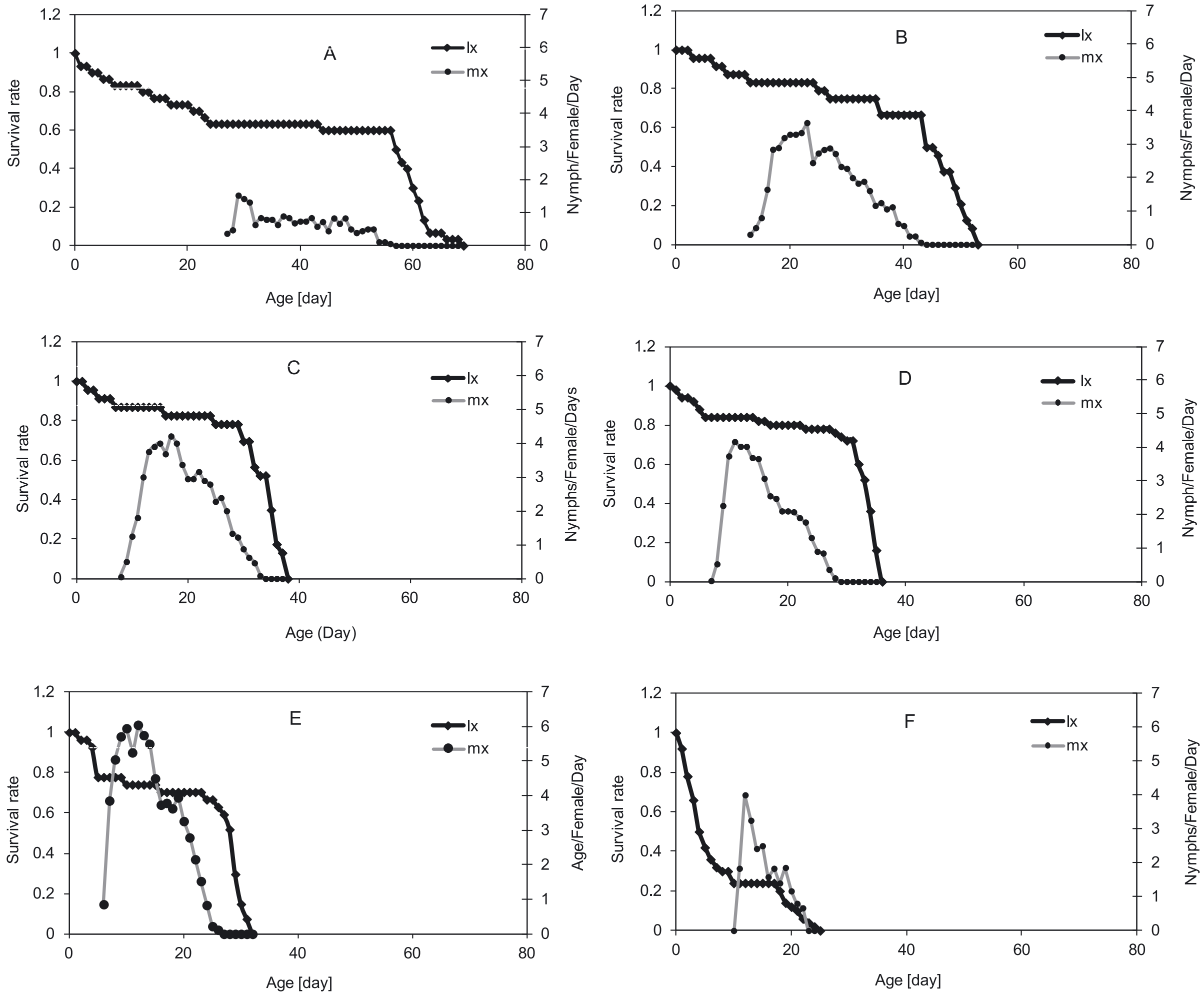
	Temperature [°C]						
	10	15	19	22	26	31	33
1st instar	7.61±0.12 a	4.86±0.07 b	3.67±0.08 c	2.63±0.06 d	2.16±0.05 e	3.90±0.11 c	–
2nd instar	7.21±0.15 a	3.57±0.12 b	2.45±0.07 c	2.05±0.07 d	1.56±0.06 e	3.50±0.13 b	–
3rd instar	6.85±0.14 a	3.13±0.08 b	2.07±0.11 c	2.04±0.08 c	1.50±0.06 d	2.83±0.21 b	–
4th instar	6.81±0.13 a	2.83±0.08 b	1.97±0.08 cd	1.76±0.06 d	1.31±0.05 e	2.36±0.15 c	–
Combined nymph	28.56±0.27 a	14.39±0.13 b	10.14±0.10 d	8.50±0.09 e	6.60±0.08 f	11.63±0.29 c	–
Nymphal mortality	37%	18%	13%	15%	23%	77%	–

For developmental time, difference among temperatures was determined by LSD tests. Means with the same letters in each row are not significantly different ($p \geq 0.05$)
SE – standard error

Table 2. Longevity and total number of offspring per female of *S. graminum* at six constant temperatures

Temperature [°C]	Longevity	Total No. of nymphs/female
10	59.85±1.38 a	18.25±0.79 c
15	45.50±1.82 b	50.00±2.85 b
19	32.60±1.20 c	56.50±2.69 b
22	32.29±0.68 c	50.09±1.32 b
26	27.57±1.51 d	70.19±3.60 a
31	20.50±0.82 e	21.80±3.07 c

Means with the same letters in each column are not significantly different ($p = 0.001$)



lx – survival rate; mx – number of nymph laid by females per day

Fig 1. Age-specific fecundity and survivorship for *S. graminum* reared at (A) 10°C, (B) 15°C, (C) 19°C, (D) 22°C, (E) 26°C, and (F) 31°C on barley (Kavir variety)

Table 3. Population growth parameters of *S. graminum* at six constant temperatures

Temperature [°C]	Parameters (mean ±SE)				
	R_0	r_m	generation Time	doubling time	λ
10	11.56±0.46 d	0.07±0.00 f	32.24±0.29 a	9.16 ±0.13 a	1.07±0.00 d
15	39.46±2.58 c	0.17±0.02 d	21.31±0.47 b	3.88±0.08 c	1.19±0.00 c
19	47.77±1.67 b	0.23±0.00c	16.17±0.43 c	2.81±0.07 d	1.27±0.00 b
22	42.81±1.25 bc	0.27±0.00 b	13.69±0.15 d	2.54±0.02 d	1.31±0.00 b
26	55.42±1.58 a	0.33±0.00 a	11.79±0.19 e	2.05±0.03 e	1.40±0.00 a
31	4.86±0.72 e	0.11±0.00 e	12.90±0.29 de	6.15±0.26 b	1.18±0.04 c

Means with the same letters in each row are not significantly different by LSD test

R_0 – net reproduction rate; r_m – intrinsic rate of increase; λ – finite rate of increase

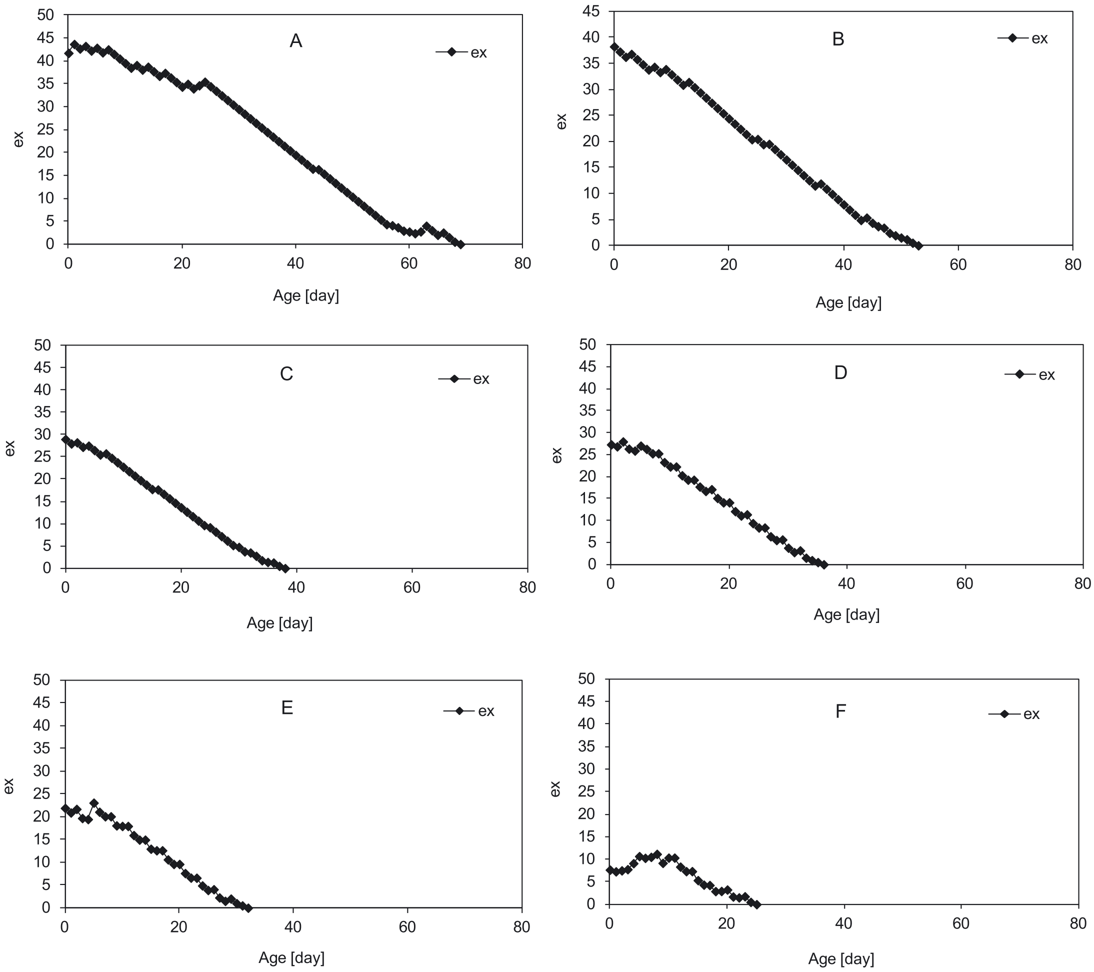


Fig. 2. Life expectancy of *S. graminum* reared at (A) 10°C, (B) 15°C, (C) 19°C, (D) 22°C, (E) 26°C, and (F) 31°C on barley (Kavir variety); ex – life expectancy

The total number of offspring per female was high, between 19 to 26°C but it was extremely low at high and low temperatures extremes (Table 2).

Greenbug survivorship decreased rapidly in the beginning of the lifespan at 31°C however; the highest percentage of mortality occurred in 4th nymphal stage. Contrary at our other experiments, this decreasing trend was observed at the end of life span (Fig. 1). The highest value of fecundity at 10°C was 1.52 nymphs per female per day. Also this value at 26°C was 6.05 nymphs per female per day (Fig. 1). The lowest value of life expectancy was reported at 31°C (7.66 days) (Fig. 2).

Population growth parameters

The intrinsic rate of increase for *S. graminum* was significantly affected by tested temperatures (Table 3). The optimum temperature for increasing population density of this aphid was at 26°C that is conclusion of the significant highest values of r_m, R_0 and λ. However, the lowest value of doubling time and mean generation time occurred at this temperature. Estimated R_0 values were different at all tested temperatures, and was significantly the lowest at 31°C. The mean generation time and doubling time decreased by increasing temperature from 10 to 26°C and then were increased at 31°C.

DISCUSSION

The results of the present study revealed that temperature has great effects on biology of *S. graminum*, which has never been previously studied on barley in Iran. The period of immature development decreased significantly with increasing temperature from 10 to 26°C. Similar data was reported for *Toxoptera aurantii* (Boyer de Fonscolombe) by Wang and Tsai (2001) when fed on orange jessamine but when comparing their reported values they were slightly lower at temperature 10–26°C (7.9–11.9 days).

All tested aphids failed to develop at 33°C, therefore we considered this temperature as the lethal temperature. That is close to 30°C for *Sitobion avenae* F and *Metopolophium dirhodum* Walker when fed on durum wheat (Asin and Pons 2001).

Additionally, according to the collected data we can estimate that the most suitable temperature for immature development can be 26°C which was different from 28.5, 26.5 and 24.5°C calculated for *Rhopalosiphum padi* L., *S. avenae* and *M. dirhodum*, respectively by Asin and Pons (2001) using non-linear models.

The aphid's mortality was considerably high at two extremes of tested temperatures in our investigation. That is in accordance with what was reported by Zamani *et al.* (2006) for *Aphis gossypii* Glover when cucumber was served as food source. In contrary, low temperatures such as 10 and 15°C had an adverse effect on aphid longevity and prolonged the time required to complete their life span. Therefore, their longevity was higher than 16.4–30.1 days reported by Nuessly *et al.* (2008) for the same species reared on several varieties of *Paspalum vaginatum* Swartz at temperature range of 18–25°C.

Our data indicated that the total number of offspring per female ranged between 18.25–70.19 nymphs per female. These values didn't confirm the data published by Webster and Porter (2000) for biotype E of the greenbug reared for resistance wheat entries (GRS 1201 and Largo) (36.29, 26.20).

Survivorship and aphid fecundity were obviously dependent on age and temperature. According to the figures, the upper tested temperature had deleterious effect on both parameters and the lower tested temperature declined the aphid's fecundity.

The life expectancy of the 1-day-old nymphs was decreasing by increasing the temperature from 10 to 31°C. The estimated life expectancy for *A. gossypii* on cotton cultivars was ranged between 14–16 days that was much lower than 7.66–41.73 days for the first day old nymphs calculated in our experiments (Razmjoo *et al.* 2006).

The r_m, R_0 and λ values reached their maximum peak at 26°C that can be the result of significantly shorter developmental time and upper m_x values. In all tested temperatures estimated intrinsic rate of increase and net reproductive rate was greater than for the same species reared on synthetic hexapolid wheat and several varieties of *S. paspalum* (0.01–0.198) (12.3–40.4) respectively (Lage *et al.* 2003; Nuessly *et al.* 2008). The calculated λ values were almost similar to those estimated for *A. gossypii* at 10 to 30°C (1.06–1.52). Furthermore the mean generation time and doubling time were significantly lower for *A. gossypii* at 10°C. These results confirmed our findings at the same temperature (Zamani *et al.* 2006). Regarding to all estimated population growth parameters optimal temperature seem to be between 22–26°C.

The differences measured in our findings are likely associated with ecotypical differentiation in aphid species, host plants, ecoclimatic and experimental conditions (Morgan *et al.* 2001).

To conclude basing on our data the greenbug has the potential to increase its population size in spring and winter barley crops during the growing season at moderate climate areas of Iran specially in our experimental region, Isfahan. Additionally, the aphids have the potential to fit a wide range of temperatures that can increase its chance to damage barley fields.

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