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RESISTANCE AND SUSCEPTIBILITY OF SOME WHEAT CULTIVARS AND LINES TO GREENBUG, *SCHIZAPHIS GRAMINUM* RONDANI (HOMOPTERA: APHIDIDAE)

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Abstract

MOJAHED, S., J. RAZMJOU and A. GOLIZADEH, 2013. Resistance and susceptibility of some wheat cultivars and lines to greenbug, *Schizaphis graminum* Rondani (Homoptera: Aphididae). *Bulg. J. Agric. Sci.,* 19: 714-720

The greenbug, *Schizaphis graminum* Rondani (Homoptera: Aphididae) is one of the most important pests of cereal particularly wheat, and transmits plant disease viruses such as barley yellow dwarf virus (BYDV). In this study, resistance and susceptibility of 16 cultivars and 20 wheat lines to *S. graminum* was evaluated under laboratory conditions. First, the screening test was carried out at 25 ± 1˚C, 60 ± 5% RH and a photoperiod of 14:10 (L;D) in a growth chamber using a completely randomized design and then the biological characteristics of this pest were evaluated on three cultivars (namely Kouhdasht, Bezostaya, and Hirmand) and four lines (namely ERWYT 87-7, ERWYT 87-8, ERWYT87-15, and ERWYT87-16), that were selected in the screening test. The antibiosis test was based on the life table parameters. Results proved that the developmental time of immature stage ranged from 7 days on ERWYT 87-16 to 6.4 days on Kouhdasht. The lowest aphid fertility rate was obtained on ERWYT87-16 line (47.6 nymphs) comparing to the fertility yielded on Kouhdasht cultivar (66 nymphs) that was significantly higher. The highest and lowest r_m values were observed on Hirmand (0.369 nymphs/female/day) and ERWYT87-16 (0.312 nymphs/female/day), respectively. In addition, there were significant differences among the wheat cultivars and lines for all other parameters. The mean generation time(T), net reproductive rate (R_0), doubling time (DT) and the finite rate of increase (λ) on wheat cultivars and lines were 9.7-11.5 days, 28.2-61.6 nymphs/female, 1.9-2.1 days and 1.373-1.437 nymphs/female/day, respectively. As a result, our findings showed that the ERWYT 87-16 and ERWYT 87-7 lines were partially resistant against *S. graminum*, whereas Kouhdasht and Hirmand were relatively susceptible.

Key words: greenbug, *Schizaphis graminum,* wheat lines, plant resistance

Introduction

Aphids are major pests of the crops causing wheat yield loss in many parts of the world. Most of them because of parthenogenesis, viviparation and polymorphism have very high reproduction rate in the absence of natural enemies. These insects become mature in a short time, so they can significantly increase its population in less time (Carver, 1989). The ability of many species of aphids to modify their life cycles enables them adapt to changes of the environmental conditions (Dixon, 1985). Among aphids, the greenbug, *Schizaphis graminum* Rondani, causes severe damage to the crops, special Graminae family plants including oat, rice, sorghum, wheat, barley, and corn (Krober and Carl, 1991). *S. graminum* feeds on leaves, shrubs and the succulent trailing of plants and to obtain the greatest food inserts its stylets into the soft tissues of plants (Nouri and Rezvani, 1995). As well as, it is one of the main vectors of barley yellow dwarf virus (Murphy, 1959), sugarcane mosaic (Ingram, 1938) and maize dwarf mosaic viruses (Nault, 1969). This species is often found in association with other cereal aphids such as the Russian Wheat Aphid (RWA), bird cherry out aphid, corn leaf aphid and etc.. The feeding damage by *S. graminum* identifies need to check the resistance levels in wheat plant (Starks and Burton, 1977). Usage of the resistant varieties is considered as a part of the solution aphid's control. Mostly, resistant varieties to pests exacerbate the effects of biological agents and increase efficiency of natural enemies by reducing the physical ability and physiological status of the pests (Nematollahi and Ahmadi, 1999). Many features of the host plant,

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affects not only growth rate but also fecundity and survival of the insects (Price et al., 1980). The effect of host plant on aphids population growth characteristics have been studied by several researchers such as Lazar et al. (1995), Castro et al. (1999) and La Rossa et al. (2002) and etc. In addition, Razmjou et al. (2011) have investigated the effect of various wheat varieties on English grain aphid *Sitobion avenae* F. and Assad et al. (2004) have evaluated population growth of Russian wheat aphid *Diuraphis noxia* Mordvilko, on different wheat cultivars. Suitability of different cultivars of the host plant for the aphids and its effect on their population growth can be investigated by calculating biological parameters, particularly the intrinsic rate of increase (r_m). The r_m is the most important parameter of fertility table for determining changes of population growth in the fixed environmental and food conditions and any change in living conditions of the pests, which affect on this parameter (Southwood and Henderson, 2000). Generally, studies show that the use of resistant cultivars is very effective in protecting the crops from damage causing by this pest. This procedure has a better economic importance, ability to better integrate with other methods of control as well as lack destructive effects on the environment. Present study was to evaluate life table parameters, resistance, and susceptibility of wheat varieties and lines to improve IPM of wheat production.

Materials and Methods

Plant preparation

This study was conducted in the greenhouse and a laboratory of plant protection department, Faculty of Agriculture, University of Mohaghegh Ardabili, Iran. We employed 16 wheat cultivars and 20 wheat lines in this research (Figure 1). The seeds of tested plants were provided from Agriculture and Natural Resources of Moghan, Iran and planted for rearing aphid's colony and conducting the experiments. The plants were reared in conditions of 20-35˚C, 65 ± 10% R.H. and under the natural light in a greenhouse and then were kept in a laboratory growth chamber with 25 ± 1˚C, 60 ± 5% R.H. and photoperiod of 14: 10 h (L: D). The used aphids in the experiments were obtained from the aphid colony reared in the laboratory of plant protection department of Mohaghegh Ardabili University in July 2011. The experiments were performed at least after a month the breeding population of aphids on Hirmand cultivar. First, we performed screening test and used the selected plants with the highest and lowest aphid populations for follow-up experiments. The three wheat varieties namely Kouhdasht, Bezostaya, Hirmand, and four lines namely ERWYT87-7, ERWYT87-8, ERWYT87-15 and ERWYT87-16 selected in screening test were planted in 21-25 repetitions. Two randomly selected apterous aphids from the aphid colony were placed on the leaf of each plant of wheat cultivars and lines tested. After 24 hours, adult aphids and all nymphs except one nymph were removed and survival the remaining nymphs were recorded daily. This work continued until the maturity of the remaining nymphs. After the maturity of the aphids, the number of nymphs produced by each aphid, were recorded and then removed daily until the death of the last aphid. The obtained data from this experiment was used for estimating the survival and construction of fertility life table. All experiments were conducted in a randomized completely design.

Statistical analysis

Data from the screening test were the normal scores transformed in order to stabilize the variance analysis using the MINITAB ver. 16 statistical software (Minitab Inc. 1994). We evaluated developmental time and survival of the nymph stage, adult longevity and fecundity. The data of these parameters were analyzed by one way -ANOVA using SPSS ver. 16 (SPSS, Chicago, IL). When the mean value indicated significant differences among treatments, they were separated using Tukey's test at probability level of 0.05. Life table parameters including the intrinsic rate of natural increase (r_m), net reproductive rate (R_0), doubling time (DT), finite rate of increase (λ) and the mean generation time (T) were estimated by the jackknife method (Meyer et al., 1986; Carey, 1993 and Maia et al., 2000) using the SAS System version 9.1 (SAS Institute, 2000). Significance of differences between the mean values of the life table parameters was determined using Tukey's test.

Results

Screening test

Significant differences were observed among the wheat cultivars and lines in the mean number of greenbug aphids on day 14 after infestation ($F = 3.44$; $df = 35,108$; $P > 0.01$). It was highest on Kouhdasht and Hirmand, while ERWYT87-16 and ERWYT87-7 presented the lowest average number of aphids per plant, and Bezostaya, ERWYT 87-8 and ERWYT 87-15 exhibited intermediate status (data not shown). The 16 wheat cultivars and 20 lines examined were classified into groups with respect to the mean number of aphids on each cultivar and line at day 14. The dendrogram of these cultivars and lines is shown in Figure 1.

Developmental time and nymph survival

The developmental time of viviparous apterae was significantly different among wheat cultivars and lines tested

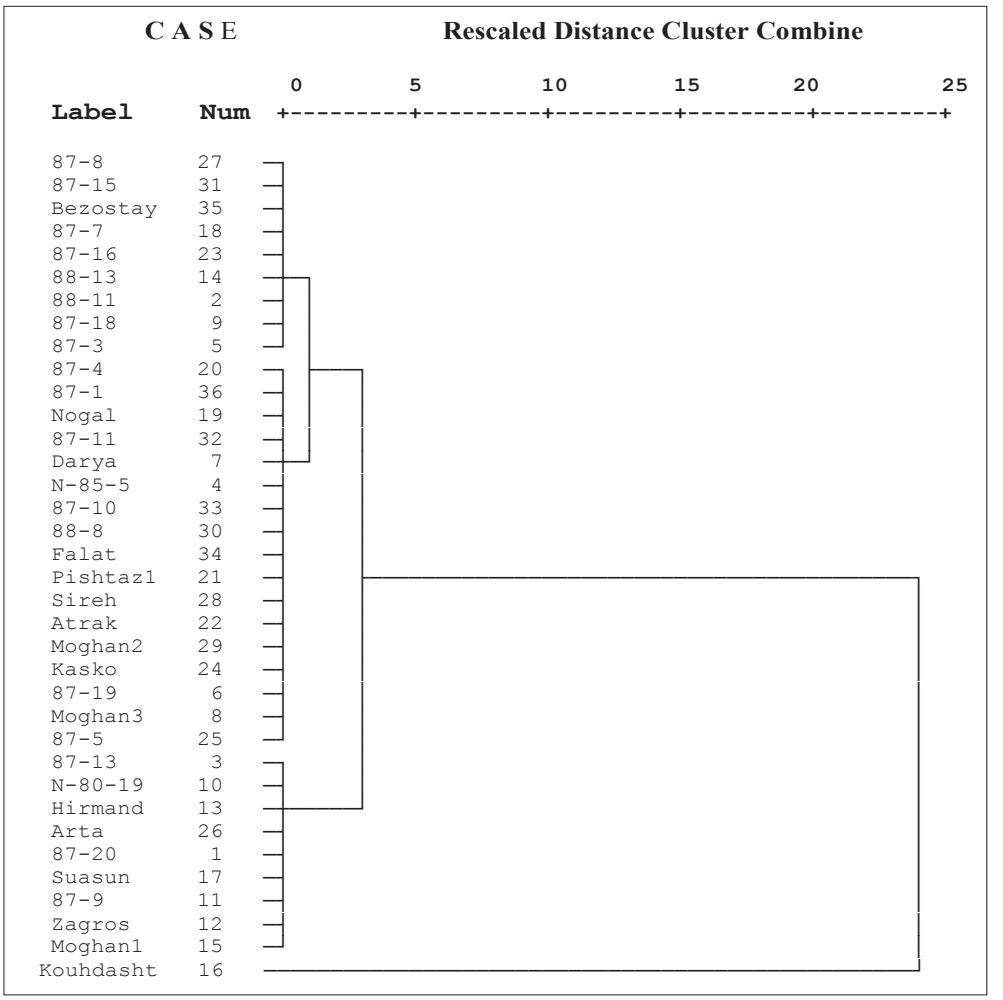

Fig. 1. Dendrogram of 16 wheat cultivars and 20 lines with respect to the mean number of *Schizaphis graminum* on day 14 after infestation using Wards method

(F = 4.333; df = 6,160; P > 0.01). On ERWYT 87-16, aphids were generally found to have the longest developmental time, while the shortest times were on Kouhdasht (Table 1). The percentage of nymphal survival ranged from 50 to 89% on ERWYT87-16 and Kouhdasht, respectively.

Longevity and fecundity

There were significant differences in the adult longevity of *S. graminum* reared on the wheat cultivars and lines examined (F = 15.756; df = 6,160; P > 0.01; Table 1). The fecundity of *S. graminum* differed significantly among the wheat cultivars and lines tested (F = 6.277; df = 6,160; P > 0.01). *S. graminum* produced fewer progeny on ERWYT87-16 compared with Kouhdasht (Table 1). The mean number of nymphs per female per day of *S. graminum* was no significant differences on the wheat cultivars and lines examined (F = 0.680; df = 6,162; P = 0.666). In addition, the reproductive period of *S. graminum* was significantly affected on the wheat cultivars and lines (F = 5.099, df = 6, 160; P > 0.01; Table 1).

Life table parameters

The intrinsic rate of natural increase (r_m) values of the apterous aphids indicated significant differences (F = 6.958; df = 6, 160; P > 0.01) among the wheat cultivars and lines examined. The r_m values of *S. graminum* were found highest on Hirmand, whereas lowest values were attained when the aphids were reared on ERWYT 87-16 (Table 2). In addition, significant variation in the net reproductive rate (R_0) values of *S. graminum* was observed among the cultivars and lines of wheat (F = 31.181; df = 6, 160; P > 0.01). The aphids reared on Kouhdasht had the largest R_0 value and ERWYT87-16 had the lowest R_0 values (Table 2). The T values of viviparous apterae

Table 1
Developmental times, reproductive periods, mean numbers of nymphs per aphid per day, adult longevity, and the mean numbers of nymphs per female of *Schizaphis graminum* on wheat cultivars and lines at 25˚C

Wheat cultivars and lines	Parameters (mean ± SE)[a]					
	Developmental time, days	Nymph survival, %	Reproductive period, days	Mean number of nymphs/aphid/day	Adult longevity, days	Fecundity
ERWYT 87-7	6.8 ± 0.09ab	55	1.08bc±14.9	3.2 ± 0.1a	1.1cd±19.6	1.3bc±50.1
ERWYT 87-8	6.7 ± 0.08abc	71	0.92abc±17.1	3.4 ± 0.1a	1.08bc±23.1	3.1abc±54.9
ERWYT 87-15	6.7 ± 0.08abc	68	1.04abc ±16.3	3.4 ± 0.2a	0.81bcd±21.5	2.6bc±52.3
ERWYT 87-16	7.0 ± 0.12a	50	0.98c±13.6	3.2 ± 0.2a	1.03d±18.7	2.43c±47.6
Bezostaya	6.7 ± 0.08abc	62	1.09abc±16.7	3.4 ± 0.1a	0.94bc±23.4	3.16abc ±55
Kouhdasht	6.4 ± 0.11c	89	0.8a±19.5	3.7 ± 0.1a	0.84a±28.8	2.35a±66
Hirmand	6.5 ± 0.10bc	85	1.14ab±18	3.4 ± 0.2a	0.88b±25.2	4.02ab±59.4

[a]For each parameter, the differences between wheat cultivars and lines were determined by the Tukey's test.
Within columns, means followed by the same letters are not significantly different (P>0.05).

Table 2
Life table parameters of *Schizaphis graminum* reared on wheat cultivars and lines

Cultivars and lines	Parameters (mean ± SE)[a]				
	Net reproductive rate, R_0	Intrinsic rate of increase, r_m	Mean generation time, T	Doubling time, DT	Finite rate of increase, λ
ERWYT 87-7	2.04cd±31.8	0.324 ± 0.008c	0.2ab±10.1	0.04a±2.1	0.008b±1.373
ERWYT 87-8	2.33b±41.4	0.007abc±0.340	0.3a±11.5	0.05a±2.1	0.011b±1.382
ERWYT 87-15	1.89bc±38.3	0.008abc±0.339	0.3ab±10.7	0.05ab±2	0.012ab±1.401
ERWYT 87-16	1.41d±28.2	0.005c±0.312	9.7 ± 0.2b	0.04ab±2	0.011ab±1.407
Bezostaya	2.47b±43.1	0.006bc±0.334	0.3a±11.2	0.04ab±2	0.009ab±1.396
Kouhdasht	2.19a±61.6	0.007ab±0.363	0.2a±11.3	0.03b±1.9	0.01a±1.437
Hirmand	2.11a±59.4	0.008a±0.369	0.2a±11.2	0.03b ±1.9	0.01a ±1.43

[a]For each parameter, the differences between wheat cultivars and lines were determined by the Tukey's test.
Within columns, means followed by the same letters are not significantly different (P>0.05).

adults demonstrated significant differences (F = 3.818; df = 6, 160; P > 0.01) among the wheat cultivars and lines tested (Figure 2). The DT values of *S. graminum* showed significant differences (F = 5.430; df= 6.160; P > 0.01). They were longer on ERWYT 87-7 and ERWYT 87-8 than on the others. Furthermore, the λ values of viviparous apterae were significantly lower on ERWYT87-7 and the largest on Hirmand (F = 5.624; df = 6, 160; P > 0.01; Table 2).

Discussion

In the present study, our screening experiment exhibited significant differences among the cultivars and lines tested with respect to the average number of aphids reared on the plants. The highest numbers of aphids were seen on Kouhdasht and Hirmand, while the lowest average numbers of aphids were on ERWYT 87-16 and ERWYT87-7. However, average numbers of aphids were intermediate on Bezostaya, ERWYT 87-8 and ERWYT 87-15. Under the laboratory conditions used, performance of *S. graminum* on different cultivars and lines was similar for mean number of nymphs per female per day, but differed significantly for other traits such as the nymph developmental time of immature aphids, the fecundity, adult longevity, and mean reproduction periods. The r_m values of *S. graminum*, which provide a good index of insect population growth (Razmjou and Golizadeh, 2010), ranged from 0.312 to 0.369 nymphs/female/day on ERWYT 87-16 and Hirmand, respectively. The high performance of the aphids on Kouhdasht and Hirmand mostly results from the longest adult longevity, lowest developmental time and the highest number of nymphs produced on these cultivars. Conversely, the poor performance of *S. graminum* on ERWYT 87-16 and ERWYT 87-7 lines is correlated with the lowest fecundity, the longest developmental time, and the lowest adult longevity. Najafi (2012) obtained the highest and lowest r_m values for *S. graminum* on N 88-11 (r_m = 0.321) and N 88 19

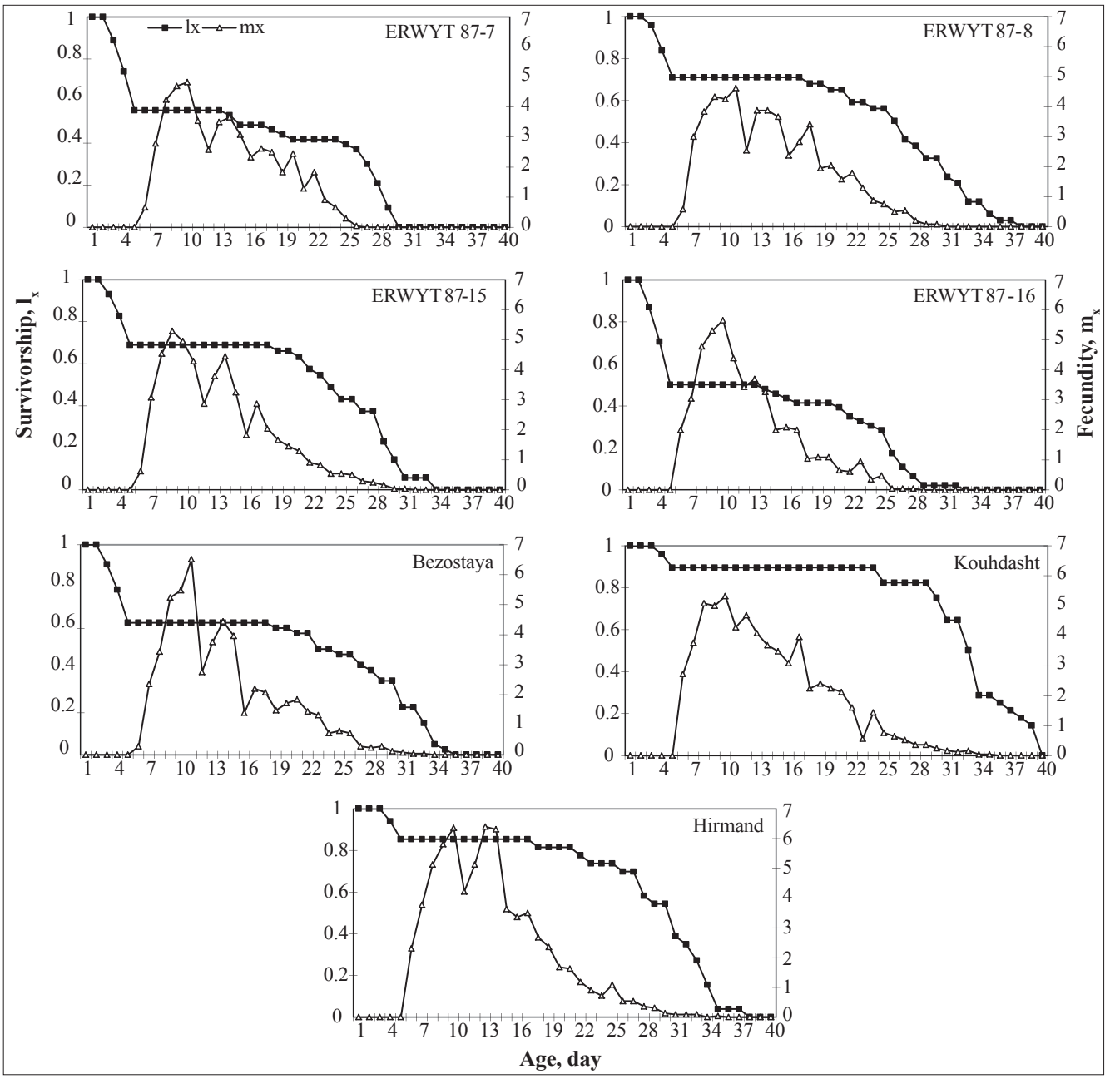

Fig. 2. Age-specific survival (l_x) and fecundity rate (m_x) of *Schizaphis graminum* reared on wheat cultivars and lines at 25°C

(r_m = 0.251) among the various wheat lines tested. In addition, according to Fattaholhoseini et al. (2010) the r_m values of this aphid ranged from 0.276 to 0.312 nymphs/female/day. There are several reports about the effects of various host plants on the biology and life table parameters of aphids (Tsai and Wang, 2001; Li et al., 2004; Razmjou et al., 2006, 2009 and references therein). The findings of some reports have shown that plant secondary compounds are involved in plant resistance to aphids (Gianoli et al., 1996). Thackray et al. (1990) indicated that some phytochemicals, such as DIMBOA interfere in the resistance levels of wheat to aphids through antibiosis and feeding avoidance. In addition, hydroxamic acids appear to be natural defensive agents against insects (Escobar and Niemeyer, 1993).

Conclusions

Our results showed clearly that Kouhdasht and Hirmand cultivars were the most suitable hosts and the ERWYT 87-16 and ERWYT 87-7 lines were the worst for development of greenbug among cultivars and lines examined. The low quality of plants can execute as a defense mechanism against herbivorous insects (Legrand and Barbosa, 2000). Therefore, host plant quality affects the fecundity of herbivorous insects at both individual and population scale (Awmack and Leather, 2002). Identification of resistant wheat lines to aphids would be helpful to develop an integrated pest management program.

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