J. Crop Prot. 2013, 2 (1): 81-92

Does leaf pubescence of wheat affect host selection and life table parameters of *Sipha maydis* (Hemiptera: Aphididae)?

Samaneh Gholami Moghadam, Mojtaba Hosseini* and Mehdi Modares Awal

Department of Plant Protection, College of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran.

Abstract: The influence of leaf pubescence of three wheat cultivars (Pishtaz, Ghuds and Falat) on preference and biological parameters of *Sipha maydis* (Passerini) were investigated under greenhouse conditions (25 ± 2 °C, 70 ± 10% RH and 14: 10 h (L: D) photoperiod). The results showed that Pishtaz had a maximum density of trichomes compared to the other cultivars. In the preference test with whole plant, the number of aphids on Pishtaz was significantly greater than that on other cultivars at 48 hrs after infestation. Similarly, in the preference test with leaves, the numbers of attracted aphids per leaf was highest on Pishtaz. In the life table study, there was no significant difference of intrinsic rate of natural increase (r_m) among the three studied cultivars but it was highest on Pishtaz (0.187 /day). Aphids' net reproductive rate, doubling time, mean generation time and finite rate of increases did not show significant difference between the tested cultivars. According to our results, leaf surface pubescence of wheat is not an effective resistance mechanism against *S. maydis*.

Keywords: trichomes, *Sipha maydis*, plant resistance, wheat cultivars

Introduction

Many plant species have different defense mechanisms used for their protection against herbivores attack. These defenses consist of chemical (i.e. toxic compounds, digestibility-reduceres and other secondary metabolites) and physical defense such as tissue toughness, surface waxes and trichomes (Schoonhoven *et al.,* 2005). Trichomes are the first plant structures contacted by insects during the preliminary stages of host acceptance (Shufran *et al.,* 1997; Khan *et al.,* 2000), consequently, those are important physical barriers to oviposition of herbivore insects (Baur *et al.,* 1991; Handley *et al.,* 2005), movement (Ramalho *et al.,* 1984; Eisner *et al.,* 1998) and/or feeding (Eisner *et al.,* 1998; Lam and Pedigo, 2001). However, the effect of pubescence on herbivores may be positive or neutral. For instance, some herbivores are protected by trichomes from natural enemies and/or moisture loss (Woodman and Fernandes, 1991; Lovinger *et al.,* 2000). Several studies also have shown that dense pubescence correlated with higher rates of herbivore oviposition and feeding (McAuslane, 1996; Srinivasana and Uthamasa, 2005; Oriani and Vendramim, 2010).

Wheat, *Triticum aestivum* (L.) is the most produced food among the cereal crops in Iran and worldwide (FAO, 2008). Production of wheat is limited by various pests, e.g. aphids, such as *Diuraphis noxia* (Mordvilko), *Rhopalosiphum padi* (L.), *Schizaphis graminum* (Rondani), *Sitobion avenae* (F.) and *Sipha maydis* (Passerini) are the most important (Blackman and Eastop, 2006). Pesticides are generally used in the management of the wheat aphids, however, development of aphids' population resistance to chemical pesticides as well as their potential adverse impacts on the

Handling Editor: Dr. Ali Asghar Talebi

* **Corresponding author**, e-mail: m.hosseini@um.ac.ir
Received: 13 November 2012; Accepted: 12 February 2013

environment and human health have led to alternative control methods, such as the use of resistant wheat cultivars (Wilde *et al.,* 2001; Edwards *et al.,* 2008). In several cases, varying degrees of antibiosis and/or antixenosis in resistant wheat cultivars have been found to wheat aphids (Schotzko and Bosque-Perez, 2000; Lage *et al.,* 2003; Jyoti and Michaud, 2005). Although the presence of chemical compounds (i.e. phenolics (Eleftherianos *et al.,* 2006) and hydroxamic acids (Givovich and Niemeyer, 1995) are involved in wheat resistance to aphids such as *R. padi* and *S. avenae*, leaf pubescence also could be one of the resistance factors against various wheat aphids species (Roberts and Foster, 1983; Webster *et al.,* 1994). For example, resistant wheat cultivars against *D. noxia* had a significantly greater trichome density compared with the susceptible wheat cultivars (Bahlmann *et al.,* 2003).

Sipha maydis feeds broadly on numerous species over 30 genera of Gramineae (Blackman and Eastop, 2006) in which wheat and barley are the most preferred hosts (Corrales *et al.,* 2007). The aphid is widespread in Eastern Europe, the Middle East and central Asia, North and South Africa, and South America (El-Yamani and Hill, 1991; Blackman and Eastop, 2006; Corrales *et al.,* 2007). In Iran, *S. maydis* presents in wheat fields at the seedling and maturing stages of host plant that could severely damages wheat (Rassipour *et al.,* 1996; Sabzalian *et al.,* 2004). In addition, management of *S. maydis* through biological control is difficult because the common aphid parasitoids attacking the other wheat aphids do not prefer this aphid as a host (Rakhshani *et al.,* 2008). Thus, the use of resistant wheat cultivars can be an ideal management tactic to reduce the spread and incidence of the pest. To our knowledge, there is no published information on the resistance potential of wheat cultivars to *S. maydis*, particularly from the perspective of physical defense. The specific aims of the present study were: (1) to examine the variation of leaf pubescence in selected commercial Iranian wheat cultivars and (2) to assess the relationship of leaf pubescence of the wheat cultivars and biological traits of the barely aphid, *S. maydis*.

Material and methods

Plant rearing

Three common local cultivars of wheat, *Triticum aestivum* L., namely Pishtaz, Ghuds and Falat were selected for further investigation under controlled conditions. Seeds of these cultivars were prepared from Agricultural Research Center of Mashhad, Iran and were sown on pots (17 cm diameter, and 15 cm depth) composing of 2.5 Kg sand and clay (Kumari coir, Singapore) combination (at the ratio 2: 1) as a growing medium. Plants were irrigated routinely and reared at 26 °C day/ 23°C night, 70 ± 10% RH and a photoperiod of 14L: 10D.

Insect rearing

A clone of the *S. maydis* was started from a single individual from a culture maintained at the College of Agriculture, Ferdowsi University of Mashhad, reared on *Hordeum vulgare* cv. Kavir, at 25 ± 1 °C, 70 ± 10% RH and a photoperiod of 14L: 10D.

Assessment of trichomes density

1- *Scanning electron microscopy (SEM).* Leaf upper surfaces (1 mm × 1 mm) of the second fully expanded leaf from each wheat cultivar, at the five expanded-leaf stage, were fixed in glutaraldehyde (4% v/v, in phosphate buffer 0.2 M, pH 7) at 4°C for 24 hrs, then thoroughly rinsed in fresh phosphate buffer and dehydrated through an acetone series (25%, 50%, 75%, and 100% v/v) for 15 minutes at each concentration. Samples were mounted on SEM tubes and coated with a thin layer of gold. A LEO 1450VP SEM operating at 30 KV was used.

2- *Light microscopy*. Five leaf sections (1 mm × 1 mm) of the second fully expanded leaf from each cultivar (totally 15 samples) were cleared of chlorophyll by placing them in a 1:1 (v/v) chloral hydrate-phenol solution for 6 hrs. at 45°C, followed samples were washed four times in distilled water for three min each time. Samples from each cultivar were mounted adaxial side up on microscopic slides. The numbers of trichomes was determined with light microscope using the 10 × objective and 10 × ocular lenses. The data were analyzed using one-way ANOVA in SAS v. 8.2 (SAS Institute 2000). If significant differences were detected (P ≤ 0.05), Fisher's LSD test was used.

Preference tests

Choice preference test with whole plants

Seedlings of three wheat cultivars (one from each cultivar) were randomly planted in a circular pattern in 30-cm pot, 4 cm from the rim and 10 cm apart each other in ten replicating. When plants were at the five expanded leaf-stages, 30 apterous *S. maydis* adults were placed on the soil at the center of each pot. Adult aphids per plant were counted after 24 and 48 hrs. and test plants were discarded. Aphid numbers were analyzed for effects of cultivars using one-way ANOVA. When significant effects were observed, means were separated using Fisher's LSD test (P ≤ 0.05).

Choice preference test with leaves

The test was performed according to Martin and Fereres (2003). Briefly, the bottoms of Petri dishes (diameter 20 cm) were covered with agar (1%) (Krips *et al.,* 1999) and surface of agar lined with filter paper. At the edge of the paper, six pieces (8 × 40 mm) were cut out around the center of the dish and two leaf-disks from the second fully expanded leaf of each cultivar, at the five expanded-leaf stage, were placed alternately. Ten Petri dishes were prepared (i.e. 10 plants and 20 leaf disks for each wheat cultivar). Then, 20 apterous *S. maydis* adults, starved for three hours, were released at the center of each Petri dish. The dishes were then transferred to a growth chamber at 25 ± 1 °C, 70 ± 10% RH and 14: 10 h (L: D) photoperiod. The number of aphids located on each disk was counted at 1, 2, 3, 4, 6, 12, 24 and 48 hrs. after the aphids were released. The number of aphids per disk (n = 20 disks for each cultivar) was compared statistically with non-parametric Kruskal-Wallis test using Minitab v. 14.2 (Minitab Inc. State College PA USA).

Life table study

When the plants were at the five expanded leaf-stages, at least 35 female aphids were placed individually on the surface of the second fully expanded leaves in each cultivar (30 plants per cultivar). A ventilated clip cage (1.5 × 3 cm) encaged each individual aphid. Twenty-four hours later the initial adult aphids and produced nymphs except one were removed (n = 30). This single aphid was allowed to develop to adulthood. All aphids were examined daily for the onset of reproduction and every other day thereafter. The number of young produced by each aphid (age-specific fecundity) was recorded for the remainder of its life. The plants and aphids were maintained in a climate chamber at 25 ± 1°C, 70 ± 10% RH and 14: 10 h (L: D) photoperiod.

To construct the age specific fertility life table, age specific survival rate (l_x) and average aphids progeny in x age class (m_x) were obtained. Based on these data, the intrinsic rate of natural increase (r_m, per day) was calculated by iteratively solving the equation (Birch, 1948): $\sum l_x m_x e^{-r_m x} = 1$

Where x is the age of the aphid in days, r_m is the intrinsic rate of natural increase, l_x is the age-specific survival, and m_x is the age-specific number of female offspring.

Other parameters of fertility life table including net reproduction rate ($R_0 = \Sigma\, l_x m_x$), generation time ($T = (\ln R_0) / r_m$), population doubling time ($DT = (\ln 2) / r_m$) as well as finite rate of increase ($\lambda = e^{r_m}$) were likewise computed (Carey, 1993).

To find differences in R_0, T, DT, λ and r_m values, jackknife method (Meyer *et al.,* 1986; Maia *et al.,* 2000) were used for producing pseudovalues. To assess the impact of varied trichome density, aphid performance parameters were subjected to One-way ANOVA.

Results

Assessment of trichome density

Scanning electron micrographs of the upper surface of second fully expanded leaves from each of cultivars are shown in Figure 1. The trichomes of three wheat cultivars were unicellular and nonglandular.

The number of trichomes per mm^2 was as Falat (14.4 ± 0.7) < Ghuds (23.6 ± 1.02) < Pishtaz (41.6 ± 1.43) which was significantly different between cultivars (One-way ANOVA, $F_{2, 42} = 156.04$; $P < 0.01$).

a
b
c

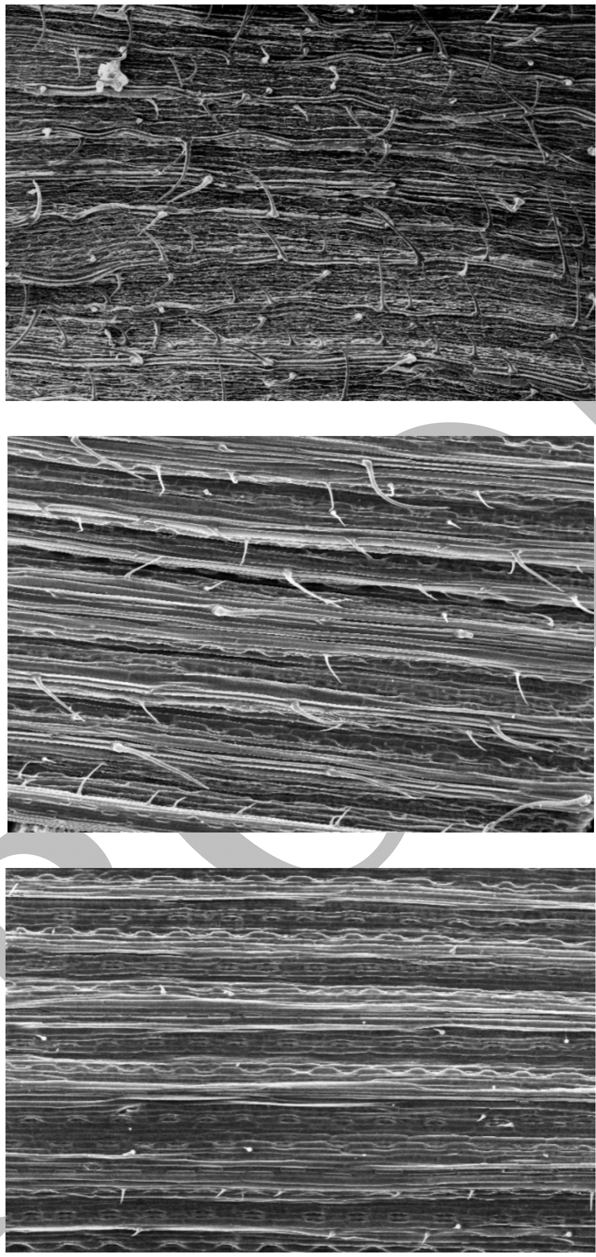

Figure 1 SEM micrographs showing the upper surface of second fully expanded leaves from three wheat cultivars a, Pishtaz; b, Ghuds; and c, Falat.

Preference tests

Choice preference test with whole plants

Up to 24 hrs. after release, the number of aphids per plant was not significantly different among cultivars (Figure 2a, One-way ANOVA, $F_{2,27} = 2.51$; $P = 0.1$). However, for longer assessment time, 48 hrs. after release, the number of aphids per plant varied significantly among cultivars (One-way ANOVA, $F_{2, 27} = 5.31$; $P = 0.01$). Significantly more number of aphids preferred Pishtaz cultivar than Falat and Ghuds (Figure 2a).

In addition, the linear regression analysis demonstrated a significant positive relationship between the number of aphids for various cultivars and trichome density 48 h after initiation of test (Figure 2b, $Y = 5.91 + 0.076 X$, $P < 0.05$, $R^2 = 0.35$).

Choice preference test with leaves

The results clearly indicate that, from the beginning of the experiment onwards, Pishtaz leaf disks were significantly more preferred than Ghuds or Falat ones (Table 1). However, in all assessment times, there was no significant difference between the numbers of aphids chose the leaf disks of Ghuds and those chose the leaf disks of Falat (Table 1).

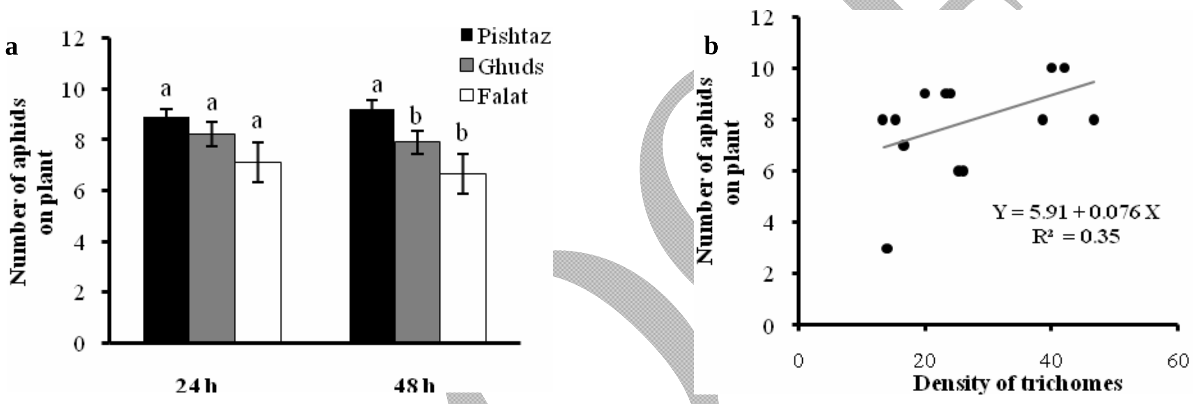

Figure 2 (a) Number of adult aphids (Mean ± SE) present on each wheat cultivar 24 and 48 h after release in preference test with whole plant; different letters indicate significant differences between cultivars ($P < 0.01$, LSD after one-way ANOVA), and (b) Relationship between the number of aphids present on plants and trichome density of wheat cultivars 48 h after initiation of test ($P < 0.05$, $R^2 = 0.35$), (n = 10).

Table 1 Number of adult aphids (Mean ± SE) located on leaf-disks of each wheat cultivar at different assessment in preference test with leaves (n = 10).

Assessment Time	Wheat cultivars			H *
	Pishtaz	Ghuds	Falat	
1 h	6.2 ± 0.5 a**	3.9 ± 0.8 b	3.1 ± 0.8 b	7.94
2 h	6.4 ± 0.9 a	3.1 ± 0.6 b	2.1 ± 0.5 b	11.7
3 h	6.4 ± 0.9 a	3.3 ± 0.7 b	2.4 ± 0.6 b	10.1
4 h	7.5 ± 1 a	3.3 ± 0.7 b	2.5 ± 0.5 b	11.39
6 h	7.8 ± 1.1 a	3.4 ± 0.6 b	2.7 ± 0.5 b	12.1
12 h	7.6 ± 1.2 a	3.1 ± 0.6 b	2.8 ± 0.4 b	10.1
24 h	7.5 ± 0.1 a	3.4 ± 0.8 b	3 ± 0.4 b	12.5
48 h	7.6 ± 1.1 a	3 ± 0.9 b	2.9 ± 0.5 b	11.8

* Kruskal-Wallis H-test

** Means followed by the different lowercase letter in a row are significantly different ($P < 0.01$, Bonferroni correction after Kruskal-Wallis)

Life table study

Nymph developmental time and survivorship

Total pre-oviposition period (mean number of days from birth to first reproduction) of *S. maydis* was not significantly different among the tested cultivars (One-way ANOVA, $F_{2, 87} = 0.54$; $P = 0.57$). Although shortest developmental time was observed on Ghuds, it was not significantly shorter than that on other cultivars (Table 2). The lowest nymph survival rate (l_x) was obtained on Falat (96%) and the highest nymph survival rate was observed on Ghuds and Pishtaz (99% and 100%, respectively, Figure 3).

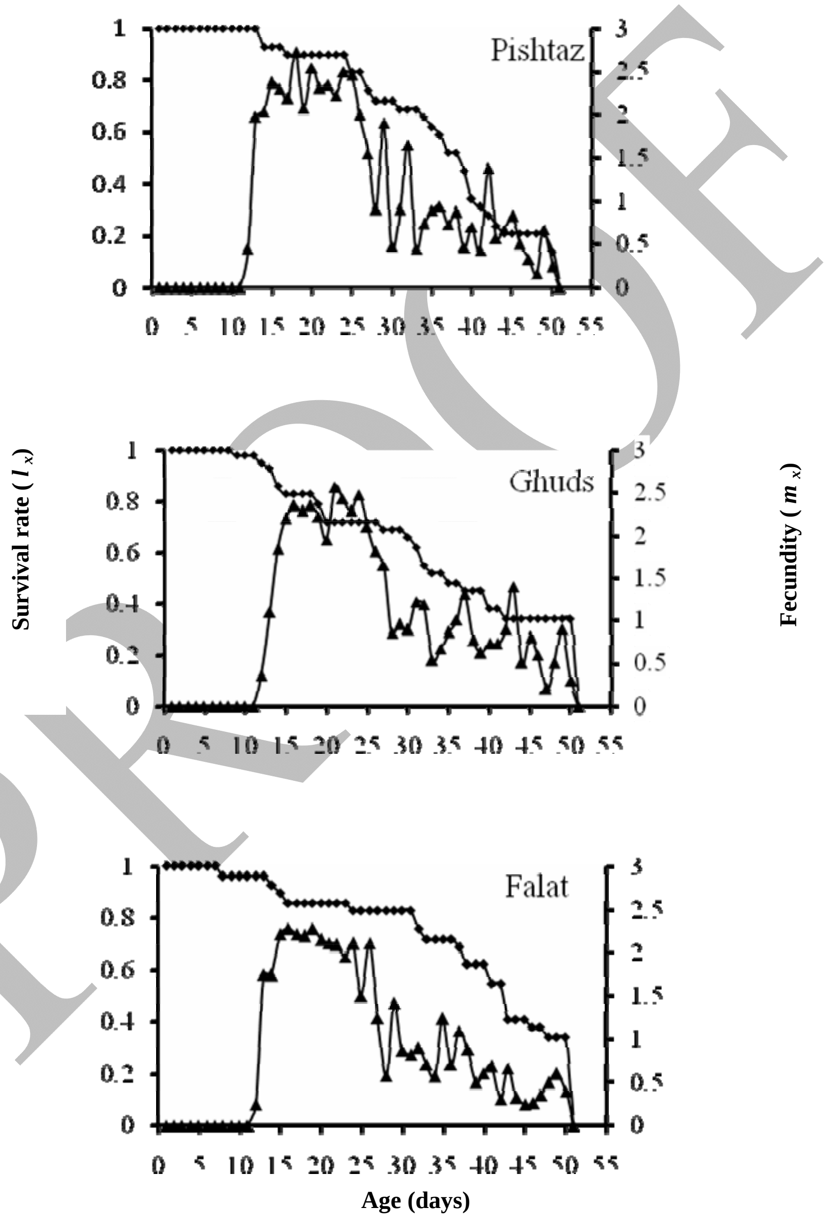

Figure 3 Survival rate (l_x) and fecundity (m_x) of *Sipha maydis* on three wheat cultivars at the greenhouse conditions.

Table 2 Life-table parameters (Mean ± SE) of *Sipha maydis* on three cultivars of wheat in the life table test (n = 30).

Parameters	**Wheat cultivars**		
Adult longevity	**Pishtaz**	**Ghuds**	**Falat**
Total nymph produced per adult aphid	23.36 ± 2.11 **	25.83 ± 2.43 a	22.33 ± 2.75 a
Nymph development time	38.43 ± 3.51 a	36.83 ± 3.56 a	30.06 ± 2.13 a
r_m*	10.66 ± 0.09 a	10.13 ± 0.52 a	10.42 ± 0.38 a
R_0	0.187 ± 0.004 a	0.179 ± 0.005 a	0.170 ± 0.003 a
λ	38.04 ± 2.42 a	37.26 ± 3.68 a	30.85 ± 2.11 a
T	1.22 ± 0.09 a	1.19 ± 0.17 a	1.17 ± 0.12 a
DT	19.45 ± 0.45 a	20.18 ± 0.38 a	20.07 ± 0.33 a
Adult longevity	3.71 ± 0.11 a	3.91 ± 0.27 a	3.98 ± 0.14 a

*r_m, intrinsic rate of increase; R_0, net reproduction rate; *λ*, finite rate of increase; *T*, mean generation time (days); *DT*, doubling time (days)

**Means followed by the same lowercase letter in a row are not significantly different (P < 0.01, LSD)

Aphid adult longevity and reproductive ability

No significant difference was found in longevity of adult aphids among wheat cultivars (Table 2, One-way ANOVA, $F_{2,87} = 0.37$; $P = 0.66$). Similar results was observed for total number of offsprings per female aphid among the examined cultivars (One-way ANOVA, $F_{2, 87} = 0.98$; $P = 0.39$). The total number of offspring per female was the lowest on Falat but it was not significantly lower than that on other cultivars (Table 2). The number of offspring per female per day also showed no significant differences (One-way ANOVA, $F_{2, 87} = 0.18$; $P = 0.82$, Figure 3).

Life table parameter

Age specific life table parameters of *S. maydis* on three wheat cultivars are presented in Table 2.

No significant differences were observed for net reproductive rate (R_0) (One-way ANOVA, $F_{2, 87} = 1.31$; $P = 0.27$); mean generation times (*T*) (One-way ANOVA, $F_{2, 87} = 0.13$; $P = 0.88$); doubling time (*DT*) (One-way ANOVA, $F_{2, 87} = 0.53$; $P = 0.58$) and finite rate of increase (λ) (One-way ANOVA, $F_{2, 87} = 0.35$; $P = 0.71$) of aphids among wheat cultivars. The intrinsic rate of natural increase (r_m) values of the aphids, in three studied cultivars (Pishtaz, Ghuds and Falat) were 0.187, 0.179 and 0.170/day, respectively. Statistical analysis showed that there was no significant difference in calculated r_m on wheat cultivars (One-way ANOVA, $F_{2, 87} = 0.45$; $P = 0.6$).

Discussion

This study demonstrates considerable variability in the density of trichomes on the leaf surfaces of three wheat cultivars. The number of trichomes per mm^2 of leaf ranged from 14.4 ± 0.7 on Falat to 41.6 ± 1.43 on Pishtaz. This finding is in accordance with that of Webster *et al.* (1994) who reported that 13.5 ± 3.8 to 53.3 ± 3.7 trichomes per mm^2 on the leaves of wheat lines and cultivars including PI 452264, PI 452262, CI9321, PI 452265, PI 452263, Downy, Abe and Fletcher. In addition, a range of trichome numbers per mm^2 on the leaves of wheat varieties reported by Hoxie *et al.* (1975) is compatible with our results.

Sipha maydis preference response to changing trichome density differed on the wheat cultivars. Contrary to expectation, aphid preference was positively correlated with trichome density, and hairy-leaf cultivar (Pishtaz) was significantly more selected by aphids in the preference experiments. This is in agreement with the results reported by other authors for the preference of greenbug aphid, *S. graminum* on the pubescent wheat cultivars (Starks and Merkl, 1977). Similarly, Harvey *et al.* (1990) found that the landing efficiency of *Eriophyes tuliae* Keifer (Acari: Eriophyidae) positively increased on hairy-leaf cultivars of wheat. However, in contrast to our finding, there is a considerable evidence to suggest that attraction and establishment of some wheat pests negatively influenced by pubescent wheat cultivars (Roberts and Foster, 1983; Webster *et al.,* 1994). Therefore, probably less host acceptance of *S. maydis* on hairless-leaf wheat cultivar in the present study attributed to the other morphological factors (e.g. quantity of epicuticular wax on leaf surface), (Weibel and Starks, 1986) and/or deterrent chemical profiles in tested cultivars (e.g. dihydroxyphenols) (Leszczynski *et al.,* 1995) which should be investigated further.

In the current study, the results of life table experiment revealed that the biological parameters of *S. maydis* were not significantly different between the wheat cultivars. The aphids reared on Pishtaz had longer duration of juvenile stage (10.7 days) than that on other cultivars. A range of data obtained here on the nymph developmental time of *S. maydis* on wheat cultivars (10.1-10.7 days) were slightly higher than the value previously reported on barely, *H. vulgare* cv. Pampa, (9.4) by Ricci and Kahan, (2005).

Total fecundity (number of offspring per female) of *S. maydis* was the lowest on Falat in the present study (30.1). The values of this parameter on Falat was lower than that for *S. maydis* reared on barely (37.1) (Ricci and Kahan, 2005) and wheat (cv. Pishtaz) (44.82) (Tazerouni and Talebi, 2012). However, total fecundity of *S. maydis* on Pishtaz and Ghuds (38.5 and 36.8, respectively) were very close to that estimated for this aphid on barely (Ricci and Kahan 2005).

The r_m value of *S. maydis* estimated in this study ranged from 0.170 on Falat to 0.187 on Pishtaz. These values were lower than that calculated for this aphid on barley (0.198) (Ricci and Kahan, 2005). The higher r_m of *S. maydis* found here on Pishtaz (hairy-leaf cultivar) is contrary to expectation that enhanced trichome density on the leaf surfaces of wheat should result in decreased aphid performance. Nevertheless, positive correlations between trichome densities and herbivore fitness have been demonstrated in other plant-herbivore systems (Flint and Parks, 1990, Srinivasana and Uthamasa, 2005; Horgan *et al.,* 2007). The reasons why hairy leaf cultivar caused the higher performance of aphids in our study remains unknown. However, when insect herbivore overcome trichome defenses of host plant, particularly in relative to antixenosis resistance, the trichomes may increased herbivore fitness by either protection against UV radiation and water stress (Ehleringer, 1984; Butter and Vir, 1989).

Interestingly, the r_m value of *S. maydis* on Falat (the cultivar with the lowest trichome density) was relatively lower than that on the other tested cultivars. Although we did not investigate the reasons for this occurrence, some authors, e.g. Thackray *et al.,* (1990), found that some defensive metabolites, such as hydroxamic acids, caused low performance of aphids on wheat. It has also been revealed that either the level of amino acids or nitrogen in the phloem sap of wheat can affect the life table parameters of wheat aphids (Kazemi and Van Emden, 1992; Telang *et al.,* 1999).

In conclusion, based on the lack of significant differences among the life table parameters of *S. maydis* on tested cultivars, leaf pubescence density is probably not playing a role in plant defense against this aphid in these cultivars. However, it is important to consider that performance indices such as r_m are merely a comparative figure estimated under optimum condition which is likely different from field conditions. Thus, it is necessary to assess *S. maydis* population growth rate and associated yield losses on tested cultivars in the field where several biotic and abiotic components of environment interact simultaneously. Moreover, since plant morphological characteristics could influence the efficiency and behavior of natural enemies, further studies are planned to investigate the potential of using these cultivars integrating with biocontrol agents, especially for the dominant native predatory bug, *Orius albidipennis* (Reuter) (Hemiptera: Anthocoridae), in IPM of *S. maydis*.

Acknowledgement

Ferdowsi University of Mashhad (Iran) and Iranian National Institute of Elites grant (No. 5/3521) to MH funded this research.

References

Bahlmann, L., Govender, P. and Botha A. M. 2003. Leaf epicuticular wax ultrastructure and trichome presence on Russian wheat aphid (*Diuraphis noxia*) resistant and susceptible leaves. African Entomology, 11: 59-64.

Baur, R., Binder, S. and Benz G. 1991. Nonglandular leaf trichomes as short-term inducible defense of the gray Aader, *Alnus incana* (L), against the chrysomelid beetle, *Agelastica alni* L. Oecologia, 87: 219-226.

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

Blackman, R. L. and Eastop, V. F. 2006. Aphids on the world's herbaceous plants and shrubs. Chichester, Wiley.

Butter, N. S. and Vir, B. K. 1989. Morphological basis of resistance in cotton to the whitefly *Bemisia tabaci*. Phytoparasitica, 17: 251-261.

Carey, J. R. 1993. Applied demography for biologists, with special emphasis on insects. New York, Oxford University Press.

Corrales, C., Castro, A. M., Ricci, M. and Dixon, A. F. G. 2007. *Sipha maydis*: Distribution and host range of a new aphid pest of winter cereals in argentina. Journal of Economic Entomology, 100: 1781-1788.

Edwards, O. R., Franzmann, B., Thackray, D. and Micic, S. 2008. Insecticide resistance and implications for future aphid management in Australian grains and pastures: a review. Australian Journal of Experimental Agriculture, 48: 1523-1530.

Ehleringer, J. 1984. Ecology and ecophysiology of leaf pubescence in North American desert plants, In: Rodriguez, E., Healey, P. L. and Mehta, I. (Eds), Biology and chemistry of plant trichomes. Plenum Press, New York, pp. 113-132.

Eisner, T., Eisner, M., Hoebeke, E. R. 1998. When defense backfires: Detrimental effect of a plant's protective trichomes on an insect beneficial to the plant. Proceedings of the National Academy of Sciences, 95: 4410-4414.

Eleftherianos, I., Vamvatsikos, P., Ward, D. and Gravanis, F. 2006. Changes in the levels of plant total phenols and free amino acids induced by two cereal aphids and effects on aphid fecundity. Journal of Applied Entomology, 130: 15-19.

El-Yamani, M. and, Hill, J. H. 1991. Aphid vectors of barley yellow dwarf virus in West-Central Morocco. Journal of Phytopathology, 133: 105-11.

FAO (2008). FAO Statistical Databases. Food and Agricultural Organization (FAO). http://www.faostat.fao.org. Accessed 19 April 2011.

Flint, H. M. and Parks, N. J. 1990. Infestation of germplasm lines and cultivars of cotton in Arizona by whitefly nymphs (Homoptera: Aleyrodidae). Journal of Entomological Science, 25: 2223-2229.

Givovich, A. and Niemeyer, H. M. 1995. Comparison of the effect of hydroxamic acids from wheat on five species of cereal aphids. Entomologia Experimentalis et Applicata, 74: 115-119.

Handley, R., Ekbom, B. and Agren, J. 2005. Variation in trichome density and resistance against a specialist insect herbivore in natural populations of *Arabidopsis thaliana*. Ecological Entomology, 30: 284-292.

Harvey, T. L., Martin, T. J. and Seifers, D. L. 1990. Wheat curl mite and wheat streak mosaic in moderate trichome density wheat cultivars. Crop Science, 30: 534-536.

Horgan, F. G., Quiring, D. T., Lagnaoui, A. and Pelletier, Y. 2007. Variable responses of tuber moth to the leaf trichomes of wild potatoes. Entomologia Experimentalis et Applicata, 125: 1-12.

Hoxie, R. P., Wellso, S. G., Webster, J. A. 1975. Cereal leaf beetle response to wheat trichome length and density. Environmental Entomology, 4: 365-370.

Jyoti, J. L. and Michaud, J. P. 2005. Comparative biology of a novel strain of russian wheat aphid (Homoptera : Aphididae) on three wheat cultivars. Journal of Economic Entomology, 98: 1032-1039.

Kazemi, M. H. and van Emden, H. F. 1992. Partial antibiosis to *Rhopalosiphum padi* in wheat and some phytochemical correlations. Annals of Applied Biology, 121: 1-9.

Khan, M. M., Kundu, R. and Alam, M. Z. 2000. Impact of trichome density on the infestation of *Aphis gossypii* Glover and incidence of virus disease in ashgourd *Benincasa hispida* (Thunb.). International Journal of Pest Management, 46: 201-204.

Krips, O. E., Willems, P. E. L., Gols, R., Posthumus, M. A. and Dicke, M. 1999. The response of *Phytoseiulus persimilis* to spider mite-induced volatiles from gerbera: Influence of starvation and experience. Journal of Chemical Ecology, 25: 2623-2641.

Lage, J., Skovmand, B. and Andersen, S. B. 2003. Characterization of greenbug (Homoptera : Aphididae) resistance in synthetic hexaploid wheats. Journal of Economic Entomology: 96: 1922-1928.

Lam, W. K. F. and Pedigo, L. P. 2001. Effect of trichome density on soybean pod feeding by adult bean leaf beetles (Coleoptera : Chrysomelidae). Journal of Economic Entomology, 94: 1459-1463.

Leszczynski, B., Tjallingii, W. F., Dixon, A. F. G. and Swiderski, R. 1995. Effect of methoxyphenols on grain aphid feeding behavior. Entomologia Experimentalis et Applicata, 76: 157-162.

Lovinger, A., Liewehr, D. and Lamp, W. O. 2000. Glandular trichomes on alfalfa impede searching behavior of the potato leafhopper parasitoid. Biological Control, 18: 187–192.

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

Martin, B. and Fereres, A. 2003. Evaluation of a choice-test method to assess resistance of melon to *Aphis gossypii* Glover (Homoptera, Aphididae) by comparison with conventional antibiosis and antixenosis trials. Applied Entomology and Zoology, 38: 405-411.

McAuslane, H. J. 1996. Influence of leaf pubescence on ovipositional preference of *Bemisia argentifolii* (Homoptera: Aleyrodidae) on soybean. Environmental Entomology, 25: 834-841.

Meyer, J. S, Igersoll, C. G., MacDonald, L. L. and Boyce, M. S. 1986. Estimating uncertainty in population growth rates: jackknife vs. bootstrap techniques. Ecology, 67: 1156-1166.

Oriani, M. A. D. G. and Vendramim, J. D. 2010. Influence of trichomes on attractiveness and ovipositional preference of *Bemisia tabaci* (Genn.) B Biotype (Hemiptera: Aleyrodidae) on tomato Genotypes. Neotropical Entomology, 39: 1002-1007.

Rakhshani, E., Tomanovic, Z., Stary, P., Talebi, A. A., Kavallieratos, N. G., Zamani, A. A. and Stamenkovi, S. 2008. Distribution and diversity of wheat aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) in Iran. European Journal of Entomology, 105: 863-870.

Ramalho, F. S., Parrott, W. L., Jenkins, J. N. and McCarty, J. C. 1984. Effects of cotton leaf trichomes on the mobility of newly hatched tobacco budworms (Lepidoptera: Noctuidae). Journal of Economic Entomology, 77: 619-621.

Rassipour, A., Radjabi, G. and Esmaili, M. 1996. Part II – Country reports. Sun pests and their control in the near east. http://www.fao.org. Accessed 5 May 2011.

Ricci, M., Kahan, A. E. 2005. Biological and population aspect of *Sipha maydis* (Passerini) and *Schizaphis graminum* (Rondani) on barley. Revista de la Facultad de Ciencias Agrarias, 37: 25-32.

Roberts, J., Foster, J. E. 1983. Effect of leaf pubescence in wheat on the bird cherry oat aphid (Homoptera: Aphidae). Journal of Economical Entomology, 76: 1320-1322.

Sabzalian, M. R., Hatami, B. and Mirlohi, A. 2004. Mealybug, *Phenococcus solani*, and barley aphid, *Sipha maydis*, response to endophyte infected tall and meadow fescues. Entomologia Experimental et Applicata, 113: 205-209.

SAS Institute. 2000. SAS / STAT User's Guide, Version 8.2. SAS. Institute, Cary, NC, USA.

Schoonhoven, L. M., Van loon, J. J. A. and Dicke, M. 2005. Insect plant biology book. Oxford University Press, Oxford.

Schotzko, D. J. and Bosque-Perez, N. A. 2000. Seasonal dynamics of cereal aphids on Russian wheat aphid (Homoptera: Aphididae) susceptible and resistant wheats. Journal of Economic Entomology, 93: 975-981.

Shufran, R. A, Wilde, G. E. and Sloderbeck, P. E. 1997. Response of three greenbug (Homoptera: Aphididae) strains to five organophosphorous and two carbamate insecticides. Journal of Economic Entomology, 90: 283-286.

Srinivasana, R. and Uthamasa, S. 2005. Trichome density and antibiosis affect resistance of tomato to fruitborer and whitefly under laboratory conditions. Journal of Vegetable Science, 11: 3-17.

Starks, K. J., Merkl, O. G. 1977. Low level resistance in wheat to greenbug. Journal of Economic Entomology, 70: 305-306.

Stoetzel, M. B. 1987. Information on and identification of *Diuraphis noxia* (Homoptera: Aphididae) and other aphid species colonizing leaves of wheat and barley in the United States. Journal of Economic Entomology, 80: 696-704.

Tazerouni, Z. and Talebi, A. A. 2012. Biological characteristics of *Sipha maydis* (Hem.: Aphididae) on wheat at different constant temperatures. Proceedings of the 20th Iranian Plant Protection congress, Shiraz, Iran, p. 643.

Telang, A., Sandstrom, J., Dyreson, E., Moran, N. A. 1999. Feeding damage by *Diuraphis noxia* results in a nutritionally enhanced phloem diet. Entomologia Experimental et Applicata, 91: 403-412.

Thackray, D. J., Wratten, S. D., Edwards, P. J. and Niemeyer, H. M. 1990. Resistance to the aphids *Sitobion avenae* and *Rhopalosiphom padi* in Gramineae in relation to hydroxamic acid levels. Annals of Applied Biology, 116: 573-582.

Webster, J. A., Inayatullah, C., Hamissou, M. and Mirkes, K. A. 1994. Leaf pubescence effects in wheat on yellow sugarcane aphids and greenbugs (Homoptera: Aphididae). Journal of Economic Entomology, 87: 231-240.

Weibel, D. E., Starks, K. J. 1986. Greenbug nonpreference for bloomless sorghum. Crop Science, 26: 1151–1153.

Wilde, G. E., Shufran, R. A., Kindler, S. D., Brooks, H. L. and Sloderbeck, P. E. 2001. Distribution and abundance of insecticide resistant greenbugs (Homoptera: Aphididae) and validation of a bioassay to assess resistance. Jornal of Economic Entomology, 94: 547-551

Woodman, R. L., Fernandes, G. W. 1991. Differential mechanical defense - Herbivory, Evapotranspiration, and Leaf-Hairs. Oikos, 60: 11-19.

آیا انبوهی تریکوم برگ گندم بر انتخاب میزبان و آماره های جدول زیستی شته‌ی *Sipha maydis* (Hemiptera: Aphididae) تأثیر دارد؟

سمانه غلامی مقدم[1]، مجتبی حسینی[1*] و مهدی مدرس اول[1]

۱- گروه گیاه‌پزشکی، دانشکده کشاورزی، دانشگاه فردوسی مشهد، مشهد، ایران

* پست الکترونیکی نویسنده مسئول مکاتبه: m.hosseini@um.ac.ir

دریافت: ۲۳ آبان ۱۳۹۱؛ پذیرش: ۲۴ بهمن ۱۳۹۱

چکیده: تأثیر انبوهی تریکوم برگ بر مقاومت سه رقم گندم پیشتاز، قدس و فلات نسبت به شته‌ی Sipha maydis در مرحله‌ی پنج برگی گندم و تحت شرایط گلخانه‌ای (دمای ۲ ± ۲۵ درجه‌ی سلسیوس، رطوبت نسبی ۱۰ ± ۷۰ درصد و دوره‌ی روشنایی به تاریکی ۱۴:۱۰) مورد بررسی قرار گرفت. نتایج نشان داد که رقم پیشتاز نسبت به دیگر ارقام دارای انبوهی تریکوم بیش‌تر بود. در آزمون رجحان انتخابی با گیاه کامل، تعداد شته‌ها ۴۸ ساعت پس از شروع آزمون روی رقم پیشتاز به‌طور معنی‌دار بیش‌تر از دو رقم دیگر بود. به‌طور مشابه، در آزمون رجحان انتخابی دیسک برگی، تعداد شته-های جذب شده به برگ رقم پیشتاز بیش‌تر بود. مطالعه‌ی پارامترهای جدول زیست-باروری نشان داد که نرخ ذاتی افزایش جمعیت (r_m) شته جو بین ارقام مورد مطالعه تفاوت معنی‌دار نداشت. اما مقدار (r_m) شته جو روی رقم پیشتاز بیش ترین بود (۰/۱۸۷ / روز). نرخ خالص تولیدمثل، زمان دو برابر شدن جمعیت، متوسط طول یک نسل و نرخ متناهی افزایش جمعیت شته بین ارقام تفاوت معنی‌دار نشان نداد. بر اساس نتایج به‌دست آمده، انبوهی تریکوم برگ در ارقام گندم مورد مطالعه عامل مؤثری در مقاومت نسبت به شته‌ی S. maydis نبود.

واژگان کلیدی: تریکوم، Sipha maydi ، مقاومت گیاه، ارقام گندم