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Original Article

Evaluation of different wheat varieties for resistance against aphid, *Schizaphis graminum* R. (Homoptera: Aphididae) under laboratory conditions

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Abstract

Aphid is a serious threat to wheat production in Pakistan. It causes direct and indirect damage by sucking the cell sap and transmitting fungal and viral diseases, respectively. Modalities of resistance (antixenosis, antibiosis, tolerance) along with seedling bulk test were deployed to elucidate resistance in nine varieties of wheat (Pak-81, Millat-08, Lassani-08, Fareed-06, Faisalabad- 08, Miraj-08, Aas-11, Sahar-06 and Blue Silver) against aphid, *Schizaphis graminum* R. under laboratory conditions. All experiments were laid out in completely randomized design and resistance/susceptibility of the varieties was categorized in the terms of differential damage rating of aphid to host plants. Seedling bulk test revealed seven varieties (Pak-81, Millat-08, Fareed-06, Miraj-08, Aas-11, Sahar-06 and Blue Silver) to be susceptible and two varieties (Faislabad-08 and Lasani-08) moderately resistant to aphid. In antixenosis test, Miraj-08 and Fareed-06 were the least and Millat-08 was highly preferred. On Aas-11, Miraj-08, Lassani-08, Pak-81, Fareed-06 and Sahar-06, aphids were the least fecund and on Faislabad-08 were highly fecund in antibiosis mechanism of resistance. In tolerant test, Sahar-06 and Millat-08 proved to be highly tolerant while Fareed-06, Faislabad-08 and Aas-11 were least tolerant. Pak-81, Lassani-08, Miraj-08 and Blue Silver were moderately tolerant. Based on the current investigation, Lasani-08 is recommended as resistant varieties against wheat aphid.

Keywords: Wheat varieties, Antixenosis, Antibiosis, Resistance, *Schizaphis graminum*

Introduction

Wheat (*Triticum aestivum* L.), as a major cereal crop occupies an important place in the economy of Pakistan. It is used as a staple food in the country (Govt. of Pakistan, 2014). In 100g, it has 326-335 calories, 4.3-5.3 mg niacin, 0.11-0.12 mg riboflavin, total carbohydrate 69.1-75.4 g, protein 9.4-14.0 g, fat 1.2-2.5 g, ash 1.7g, calcium36-46 mg, 354-400 mg phosphorus, 1.8-2.3 fiber, 3.0-4.3 mg iron, potassium 370-435 mg, thiamine 0.43-0.66 mg, and water 11.57-14.0 g (Ken, 2004).

The production of wheat is affected by both biotic and abiotic stresses. Abiotic factors including physical (temperature, rainfall, wind and drought) and chemical (salinity, pollution and pesticide) reduce the quality and quantity of the wheat. In biotic factors, insects are important that cause huge yield losses. There are six major and 12 minor pests attacking on wheat in Pakistan (Hashmi and Hassel, 1989; Akhtar and Parveen, 2002). The most serious threat to wheat crop

throughout the world is damage by the aphids (Yadev, 2003). This polyphagous pest attacks more than 60 plants species including sorghum, corn barley, and wheat. All higher altitude agricultural regions of the world such as UK, EU, North America and North East Asia are affected by aphids. Different species of aphids like *Sitobion miscanthi* (T.), *Schizaphis graminum* (R.), *Rhopalosiphum maidis* (F.), *S. avenae* (F.), *R. padi* (L.) and *Metopolophium dirhodum* (W.) attack on cereal crops in Pakistan (Inayatullah et al.,1993).

The green bug, *Schizaphis graminum* (Rondani), has been recognized as a major pest of small grains for over 150 years. There are about 40 recognized *Schizaphis* species worldwide with seven known from North America (Blackman and Eastop 2000). It reproduces without mating (i.e., parthenogenesis) in warm or mild climates. Nymphs are produced directly from the female in Florida. Green bugs pass through three instars directly into the adult stage (i.e., no pupal stage) in seven to nine days at temperatures of 60 to 80°F. The host range of green bug includes 70 graminaceous species (Michels, 1986).

Aphids reduce the wheat yield either directly (35-40%) by sucking the plants cell sap or (20-80%) indirectly by transmitting fungal and viral diseases (Aslam et al., 2005). Both nymphs and adults suck the sap from stems and leaves and thus cause malnutrition in plants. Their damage results in curling, wilting, young shoot deformation, leaf twisting, stunting and early leaf drop of the crop (Ozder, 2002). They are directly concerned in dissemination of viruses in plants, like Barley Yellow Dwarf Virus (BYDW), and cause reduction in photosynthetic activity by depositing honey dew that induces sooty mould and premature leaf senescence (Akhtar and Khaliq, 2003). In Pakistan, aphids have been a serious pest on cereal crops (Zia et al., 1999). Farmers extensively use insecticides for control of insect pests (Rehman et al. 2013a, 2013b, 2014, 2016) which induce insect resistance, leave unwanted residues, and kill natural enemies (Dent, 2000). Host plant resistance which involves differential susceptibility to infestation of insect herbivores provides a good tool in reducing insecticide sprays. It is a simple and convenient method for insect pest control without any additional cost (Dent, 2000). The Hessian-fly, *Mayetiola destructor* (Say) resistant wheat provided a 9:1 return on investment of research in Morocco (Koul et al. 2004).

Appropriate understanding of mechanism for host plant resistance provides foundation for long-term resistance in the crop for sustainable management of insect pests. Keeping in view the significance of aphids associated with wheat in Pakistan, the present study aimed at to elucidate the three modalities of host plant resistance including antibiosis, anti-xenosis and tolerance in the wheat under the laboratory conditions (Hesler, 2005; Painter, 1951).

Material and Methods

The experiments were conducted during 2014 on nine wheat varieties *viz.*, Pak-81, Millat-08, Lassani-08, Fareed-06, Faisalabad-08, Miraj-08, Aas-11, Sahar-06 and Blue Silver. These varieties were obtained from Ayub Agriculture Research Institute (AARI), Faisalabad and Regional Agriculture Research Institute (RARI), Bahawalpur.

Culture of Aphids

Aphid (*S. graminum*) were collected from wheat at experimental area of Islamia University of Bahawalpur and reared in the laboratory of Department of Entomology University College of Agriculture and Environmental Sciences for use in different experiments. For rearing, a susceptible (Ahmad et al., 2015) wheat variety Faisalabad-08 (check variety) was sown in the pots. When the seedlings (Faislabad-08) were about 6-7 cm height, field collected aphids species were released on wheat seedlings. Aphids were reared under controlled conditions of 28 ± 2°C, RH 60 ± 5% and photoperiod of 16:8 hrs (L: D). Aphids were obtained in desired number to be used for the different experiments from these rearing pots

Seedling bulk test

In seedling bulk/flat test which involved comparing the seedling reactions of nine wheat varieties against *S. graminum* (Webster et al., 1987), a row of wheat variety (20 seeds) was sown in the soil mixture contained in a metal tray (51×35×9 cm) adjusting four to five rows. Fifty nymphs of aphids were released on each line when seedlings reached at a height of 5-7 cm. Damage rating (DR) was visually recorded with 0-9 damage rating scale in the terms of lodging on 12^{th} (DR_{1st}) and 15^{th} (DR_{2nd}) day after the start of aphid infestation (Inayatullah et al., 1993). The entries were classified as resistance (R) with DR of 2-3, moderately

resistance (MR) with DR of 4-6 and susceptible (S) with DR of 7-9.

Components of resistance

Antixenosis test

In antixenosis test, all nine wheat varieties were planted in earthen pot (30cm diameter) in a round pattern, 3 cm inwards from the border in completely randomized design (CRD) with five replications. When seedlings were about 5-8 cm in height, 50 adults were released in a circular paper (10 cm diameter) placed in the center of each pot. Seedlings in each pot were covered with round plastic cage (30 cm diameter and 35cm height) having ventilation holes on the sides and muslin cloth on the top. Aphids were allowed to settle on plants with free choice. Data on number of settled aphids on different varieties were recorded after 24, 48, 72 hours. One way ANOVA was used followed by LSD test to compare mean number of aphids on different varieties.

Antibiosis test

In antibiosis test, a seedling of each wheat variety was gown in the centre of a pot (7 cm diameter) in CRD with five replications. At a height of 5-6 cm, one aphid adult was released on each seedling variety in the pot covered with plastic cage (6 cm diameter and 30 cm in height) having muslin cloth on top and ventilation holes on two sides and were allowed to grow until matured and started reproduction parthenogenetically. Numbers of nymphs reproduced daily were counted and then removed from each seedling until aphids stopped reproducing and died. Data were recorded for 12 days continuously, pooled and statistically analyzed with ANOVA. The means were separated for significance difference by using LSD test. The varieties were categorized specifically for the current experiments as least preferred for fecundity (LF) having least numbers of nymphs (0.0-1.1), per seedling moderately preferred for fecundity (MF) having moderate numbers of nymphs (1.2-1.3) produced per seedling and highly preferred for fecundity (HF) having highest numbers of nymphs (1.4-2.0) produced per seedling (Akhtar et al., 2013).

Tolerance test

In tolerance test, nine varieties (two seeds of each variety) of wheat were sown in a pot (7 cm diameter) having standard soil mixture. The experiment was replicated five times in five pots. On reaching at maturity (height of 5-6 cm), seedlings of each variety were thinned to one plant of each variety per pot. Five aphid adults were released on each seedling and each pot was covered with plastic cage of 6 cm diameter and 30 cm in height having muslin cloth on top with having ventilation holes on sides. The population of five adults on each variety was maintained daily by adding or removing aphids. After 10 days of release, data were recorded on visual damage rating (DR) scale of 1-9 based on lodging of seedlings to classify varieties as highly tolerant (HT) with the DR of 1-3, moderately tolerant (MT) with the DR of 4-6 and least tolerant (LT) with DR of 7-9 (Inayatullah et al., 1993). Experiment was designed in a completely randomized design (CRD) and data were recoded for two days according to pre-standardized method by Akhtar et al., (2013). The data were analyzed statistically by using Minitab-16 with completely randomized design and means were compared by LSD test.

Results and Discussion

Seedling bulk test

Results of the seedling bulk test showed that two varieties Faisalabad-08 and Lasani-08 had damage rating of 6 while other seven varieties Pak-81, Millat-08, Fareed-06, Miraj-08, Aas-11, Sahar-06 and Blue Silver had damage rating 7-9 (Table 1). None of the varieties showed the complete resistance against the wheat aphid. According to the nature of resistance varieties Lasani-.08 and Faislabad-08 were moderately resistant (MR) and remaining seven varieties were susceptible. Akhtar et al. (2010) also used of the same technique for evaluation of resistant wheat lines/varieties against *R. padi* under laboratory conditions and found that five varieties were resistant, thirteen were moderately resistant and two were susceptible. Akhter and Mujahid (2006) evaluated the resistance in the 16 NUWT (rainfed) wheat cultivars against *S. graminum.* Four varieties; KT 2000, BARS-I, MA W-1 and FASILABAD were resistant with damage rating of 3 and twelve were moderately resistant. In the present investigation, Faislabad-08 as a moderately resistant is deviant from observations of Ahmad et al. (2015) who reported it as a susceptible cultivar against *S. graminum* in Punjab Pakistan. Factors responsible for variation in this susceptibility of Faislabad-08 should be more investigated for obvious elucidation.

Antixenosis test

In antixenosis test, Miraj-08 and Fareed-06 were the most unsupportive varieties and had lowest mean aphid population 2.4 ± 0.35 and 2.5 ± 0.27, respectively. Ass-11, Lassani-08, Blue Silver, Sahar-06, Faislabad-08 and Pak-81 had the mean aphid population 3.4 ± 0.59, 4.3 ± 0.59, 4.9 ± 0.54, 5.3 ± 0.86, 5.5 ± 0.43 and 6.0 ± 1.22 respectively in ascending order. Millat-08 with the highest mean (6.6 ± 0.86) aphid populations, scored least in suitability for cultivation (Table 2). Present study is similar with work of Akhter and Mujahid (2006) who reported a differential varietal preference of *S. graminum* on different wheat cultivars in Pakistan.

Antibiosis test

Result showed (Table 3) that out of nine varieties six viz., Ass-11, Miraj-08, Lassani-08, Pak-81, Fareed-06 and Sahar-06 had low mean aphid population 0.7 ± 0.05, 0.7 ± 0.10, 0.9 ± 0.09, 1.0 ± 0.07, 1.1 ± 0.15 and 1.1 ± 0.15 aphids/seedling respectively in ascending order. While two varieties Millat-08 and Blue Silver had mean aphid population of 1.3 ± 0.14 and 1.3 ± 0.20, respectively and only one wheat variety Faislabad-08 had maximum mean aphid population of 1.9 ± 0.23 aphids /seedling. According to nature of resistance aphids were least fecund on six varieties, moderately fecund on two varieties i.e. Millat-08 and Blue Silver and highly fecund on only one variety. For cultivar fitness and aphid management under related environmental situations local studies on biology of aphids on different cultivars are essential to give information (Razmjou et al., 2006). So as to stay away from unacceptable data resulting from adaptation to different eco-climatic situations it is also required to examine the bionomics of local populations for the development of forecasting models (Morgan et al., 2001). The similar study were done by Akhtar et al., (2010) evaluated the fecundity of *R. padi* on different wheat varieties. Least fecundity of *R. padi* was observed on the varieties Diamond and Wafaq and moderate fecundity was observed on seven varieties/lines like 99B2278, Inqlab-91, SD-66, Margalla-99, V00183, SARC-5 and RWM-9313. High fecundity was noted on V00125.

Tolerance test

Results showed no significant difference (P> 0.05) among the varieties (Table 4). Two varieties (Millat-08 and Sahar-06) were highly tolerant against aphid. Pak-81, Lassani-08, Miraj-08 and Blue Silver were moderately tolerant with mean DR of 4.4 ± 0.92, 4.5 ± 1.00, 4.7 ± 1.01 and 4.8 ± 0.80, respectively in ascending order. On the other hand least tolerant varieties were Fareed-06, AAS-11 and Faislabad-08 with mean DR of 5.0 ± 0.95, 5.5 ± 1.01 and 5.6 ± 0.99 respectively against wheat aphids. Likewise Puterka et al. (1982) defined a damage rating of 3 or less as resistant, and for susceptible were 4 or more based upon a 6- point scale. Akhtar et al., (2013) also studied the tolerance by the same method and reported that TD-1, NARC-2009 and Sussui were highly tolerant varieties.

Table 1: Nature of resistance based on seedling bulk test in wheat varieties against *S. graminum*

Sr. No.	Varieties	Damage Rating (DR)		Nature of Resistance
		DR_{1st}	DR_{2nd}	
1	Pak-81	6	8	S
2	Millat-08	7	9	S
3	Lassani-08	4	6	MR
4	Fareed-06	8	9	S
5	Faisalabad- 08	4	6	MR
6	Miraj-08	6	9	S
7	Aas-11	7	8	S
8	Sahar-06	6	9	S
9	Blue Silver	5	7	S

R= Resistant varieties MR= moderately resistant S= Susceptible

Table 2: Antixenosis (Free Choice test) of wheat varieties against *S. graminum*

Sr. No.	Varieties	Mean numbers of aphids (adults)[a]			
		24 h	48 h	72 h	Overall mean ± SE
1	Pak-81	3.2ab	6.2ab	8.6a	6.0 ± 1.22ab
2	Millat-08	4.2ab	7.6a	8a	6.6 ± 0.86a
3	Lassani-08	3ab	3.2ab	6.6a	4.3 ± 0.59bcd
4	Fareed-06	2.6ab	2.4b	2.4a	2.5 ± 0.27d
5	Faisalabad-08	5a	5.4	6.2a	5.5 ± 0.43ab
6	Miraj-08	1.4b	2.0ab	3.8c	2.4 ± 0.35d
7	Aas-11	1.6b	4.0ab	4.6a	3.4 ± 0.59cd
8	Sahar-06	3.2ab	5.8ab	7a	5.3 ± 0.86ab
9	Blue Silver	3ab	5.0ab	6.8a	4.9 ± 0.54abc

[a] Means within a column followed by the same letter are not significantly different at P < 0.05 by LSD

Table 3: Nature of resistance based on antibiosis test of wheat varieties against *S. graminum*

Sr. No.	Varieties	Mean numbers of aphids after different days													
		1	2	3	4	5	6	7	8	9	10	11	12	Overall mean ±SE[a]	Nature of resistance
1	Pak-81	1.2	1.0	0.6	1.2	0.8	1.4	1.0	0.8	0.8	0.6	1.2	1.0	1.0 ± 0.07a	LF
2	Millat-08	1.8	2.2	1.6	1.4	1.0	0.8	0.8	1.2	2.0	0.8	1.4	0.8	1.3±0.14ab	MF
3	Lassani-08	1.4	0.4	1.0	1.4	1.0	1.2	0.6	0.8	0.8	0.8	0.8	0.6	0.9 ± 0.09b	LF
4	Fareed-06	1.0	2.0	1.4	1.2	1.4	1.2	0.8	0.6	2.2	0.6	0.6	0.6	1.1 ± 0.15b	LF
5	Faisalabad- 08	2.4	1.8	2.6	2.6	1.4	2.4	3.2	1.6	2.2	0.6	1.0	0.8	1.9 ± 0.23a	HF
6	Miraj-08	0.6	0.8	2.0	0.8	0.8	0.2	0.4	0.6	0.6	0.6	0.2	0.6	0.7 ± 0.10b	LF
7	Aas-11	0.4	0.8	0.8	0.8	0.6	0.8	1.0	0.6	0.4	0.8	0.4	0.6	0.7 ± 0.05b	LF
8	Sahar-06	0.8	2.0	1.4	2.2	1.4	1.0	0.8	0.8	0.8	0.8	0.6	0.8	1.1 ± 0.15b	LF
9	Blue Silver	0.4	1.0	1.2	0.6	1.2	0.8	1.6	1.6	1.6	1.0	3.2	1.0	1.3 ± 0.20ab	MF

Mean within a column followed by the same letter are not significantly different at P < 0.05 by LSD
LF= Least fecundity, MF= Moderate fecundity, HF= High fecundity
[a] Mean of 12 days

Table 4: Nature of resistance based on tolerance test of wheat varieties against *S. graminum*

Sr. No.	Varieties	Mean numbers of aphids after different days			Nature of resistance
		D_{1st}	D_{2nd}	Overall mean ± SE[a]	
1	Pak-81	3.4	5.4	4.4 ± 0.92a	MT
2	Millat-08	1.4	4.0	2.7 ± 0.53a	HT
3	Lassani-08	3.6	5.4	4.5 ± 1.00a	MT
4	Fareed-06	4.2	5.8	5.0 ± 0.95a	MT
5	Faisalabad- 08	4.6	6.6	5.6 ± 0.99a	MT
6	Miraj-08	4.0	5.4	4.7 ± 1.01a	MT
7	Aas-11	4.6	6.4	5.5 ± 1.01a	MT
8	Sahar-06	1.0	3.8	2.4 ± 0.54a	HT
9	Blue Silver	3.8	5.8	4.8 ± 0.80a	MT

Mean within a column followed by the same letter are not significantly different at P < 0.05 by LSD
LT= Least tolerant, MT = Moderately tolerant, HT= Highly tolerant
[a]Mean of 1st and 2nd days

Conclusion

We conclude that out of nine varieties tested in mechanisms of resistance and seedling bulk test, Lasani-08 was resistant against the aphids. It is recommended to further evaluate this variety for its resistance against aphids under field conditions as a potential candidate for less aphid infestation. Use of this variety can reduce the yield losses and can also be the economical method to manage *S. graminum* damage in wheat crops.

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