Research Article

Evaluation of Pakistani Wheat against Aphid, *Schizaphis graminum* (Rondani) under Favourable Weather Conditions in Peshawar, Pakistan

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Abstract | Aphid is a serious pest of wheat crop which causes significant damage to wheat production in Pakistan. The present study was conducted to evaluate 125 Pakistani wheat varieties under high aphid infestation period from February to March, 2020 at experimental area of Nuclear Institute for Food and Agriculture (NIFA), Peshawar. Our study showed that seasonal mean population of aphid was found maximum on NIA Sarang (81.5 aphids per tiller) statistically higher than any other wheat variety while minimum mean aphid population (15.8 aphids per tiller) was recorded on Bathoor-08. Aphid resistance index values ranged widely among all 125 wheat varieties; 20 were moderately resistant having aphid population range 15 - 21. 41 varieties were lowly resistant having 22 - 31 aphids per tiller throughout the study. Similarly, 34 varieties showed a lowly susceptible response with 32 - 42 aphids per tiller and 16 varieties hosted 43 - 53 aphids per tiller on an average and graded as moderately susceptible. Moreover, 14 varieties were found highly susceptible having 54 - 82 aphids per tiller. Correlational analysis of *S. graminum* population with meteorological factors revealed that relative humidity (R.H) had significantly negative impact on aphid population. Whereas, temperature had significantly positive correlation with aphid population on NARC 2009 ($r = 0.58^{Min. Temp.}$, $r = 0.7^{Max. Temp.}$). The data of Pakistani wheat varieties with least population density of aphid would be helpful to make varietal selections for future breeding programs. Further, it is necessary to identify the resistant genes in these varieties that could be incorporated in future wheat cultivars.

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1. Introduction

Wheat (*Triticum aestivum* L.) is one of the major staple foods and most widely grown cereal crop throughout the world by serving food to more than one third population (Khan *et al*., 2011). Being a staple food of Pakistan, it plays vital role in enhancing country economy but still facing problem of low production/acre. In Pakistan, 8.7 million hectares area is under wheat cultivation with production of 24.2 million tons. It shares about 10.1 percent towards agriculture as well as 2.2 percent in GDP (Ahmed *et al*., 2015).

As many biotic and abiotic factors are responsible for this issue but arthropods are one of the major factors for declining yield in comparison to increasing demand of staple food. Wheat is attacked by number of insect pests such as wheat beetles, weevils (Coleoptera: Carabidae, Chrysomelidae, Curculionidae), cutworm, armyworm (Lepidoptera: Noctuidae), termites (Isoptera: Termitidae), thrips

(Thysanoptera: Phlaeothripidae, Thripidae), aphids (Hemiptera: Aphididae), Chinchbug (Hemiptera: Pentatomidae, Miridae, Lygaeidae), hessian fly (Diptera: Cecidomyiidae) and leafhopper (Hemiptera: Cicadellidae) (Miller and Pike, 2002; El-Wakeil and Volkmar, 2013).

Aphid species are reported as scary threat for different crops including wheat. It de-sap the plant by inserting their proboscis into plant parts that results in stunted growth of the plant (Akhtar and Khaliq, 2003). Moreover, it acts as vector of various plant viral and fungal diseases (Bukvayova *et al.*, 2006). These have become a notorious pest of wheat in Pakistan and responsible for huge yield losses (Riazuddin *et al.*, 2004; Aheer *et al.*, 2008; Javed et. al., 2014; Ahmad *et al.*, 2015). There are four aphid species namely *Rhopalosiphum padi* (L.), *Rhopalosiphum rufiabdominalis* (Sasaki), *Schizaphis graminum* (R.) and *Sitobian avenae* (F.) reported on wheat crop in Pakistan. However, *S. graminum* is serious pest of wheat crop in the country and responsible for 30 - 40% reduction in wheat production (Hashmi *et al.*, 1983; Singh, 1961; Kieckhefer and Gellner, 1992; Wains *et al.*, 2014; Ahmad *et al.*, 2015).

A thorough knowledge of the interaction between changing agro-ecological conditions and other effective factors on aphid density may not only mitigate the pest losses but also help to adopt timely preventive control measures (Aasman, 2001). To avoid ecological disruptions and public health issues caused by indiscriminate use of pesticides, exploration of host plant resistance is a necessary research theme for pest management in ecologically sound integrated pest management system. Host plant resistance is the most economical, efficient and reliable component of Integrated Pest Management (IPM) and plays vital role in managing crop pests and protecting natural enemies (Messina and Sorenson, 2001; Francis *et al.*, 2001).

Seasonal population dynamics of wheat aphid has been widely studied in Pakistan, but no data are available about the response of different Pakistani wheat varieties against *S. graminum* in Peshawar, Pakistan during favourable weather conditions. So, the objective of the present study deals with the evaluation of Pakistani wheat varieties against population dynamics of *S. graminum* under favourable weather conducive for high aphid population.

2. Materials and Methods

2.1 Experimental site

To determine the response of Pakistani wheat varieties against population dynamics of *S. graminum* in favourable weather conditions, the present study was carried out at experimental field area of Nuclear Institute for Food and Agriculture, Peshawar (34.0155° N and 71.7129° E) during the rabi period 2019–2020. A total of 125 wheat lines/ varieties were procured from National Wheat Improvement Program, National Agriculture Research Center (NARC) Islamabad and sown on December, 2019 by following the methodology of Zhou *et al.* (2011) with some modifications. In brief, each variety was laid out in randomized complete block design (RCBD) with three replications of each. Seeds were sown with each 0.5m long row length keeping 30 cm distance apart from other with the help of manual single line seed drill. The site chosen for this experiment hosting the wheat-fallow wheat cropping scheme. The experimental land was prepared by two deep ploughings and one planking. Fertilizer were used at rate of 120kg N/ha from urea and 90kg P/ha from DAP source for each experimental plot. First irrigation was applied at three weeks after seed sowing and subsequent irrigations were applied at different needful stages. No plant protection measures were taken throughout the study.

2.2 Aphid counting and resistance index

The method used for counting aphid population was; number of aphids/ tiller/ replication for each varieties at seven days interval from mid-February to mid-March, 2020. Evaluation of resistance in these lines/ varieties against *S. graminum* population was done by estimating the aphid resistance index (ARI) formula as:

$$\text{ARI} = \frac{\text{Average aphid density per plant of a certain variety}}{\text{Average aphid density per plant of all varieties}}$$

The aphid resistance index was indicated in 7 scales as shown in Table 1 (Painter, 1958). The data regarding aphid population were analysed statistically by using computer-based software "Statistix v8.1" (Miller and Miller, 2005) and computing the means by LSD test at $\alpha = 0.05$.

3. Results and Discussion

The data of 125 Pakistani wheat varieties evaluated against aphid infestation showed a lot of variability

for aphid population density observed on different dates. Results of the analysis depicts that highest mean aphid population (48.96 aphids per tiller) was recorded statistically on 02-03-2020 followed by aphid population on 24-02-2020, 09-03-2020 and 16-03-2020 ($P < 0.05$, Table 2).

Table 1: Rating scale used to determine wheat Aphid Resistance Indices (ARI).

Rating scale	Resistance index score	Resistance description
0	0	Immunity (I)
1	0.01-0.30	Highly Resistant (HR)
2	0.31-0.60	Moderately Resistant (MR)
3	0.61-0.90	Lowly Resistant (LR)
4	0.91-1.20	Lowly Susceptible (LS)
5	1.21-1.50	Moderately Susceptible (MS)
6	>1.50	Highly Susceptible (HS)

Table 2: Aphid (*S. graminum*) population on different dates in NIFA, Peshawar (2019-2020).

Dates	Mean+ S.E.	Homogenous groups
2-3-2020	48.96±0.89	A
24-2-2020	41.03±0.96	B
9-3-2020	35.99±1.19	C
16-3-2020	15.94±1.55	D
F	118.14	
P	0.0000	
LSD	3.59	

Full varietal data regarding mean aphid population per tiller is given in Figure 1. Maximum mean aphid population was recorded on NIA Sarang (81.5 aphids per tiller) and minimum was recorded on Bathoor-08 (15.8 aphids per tiller).

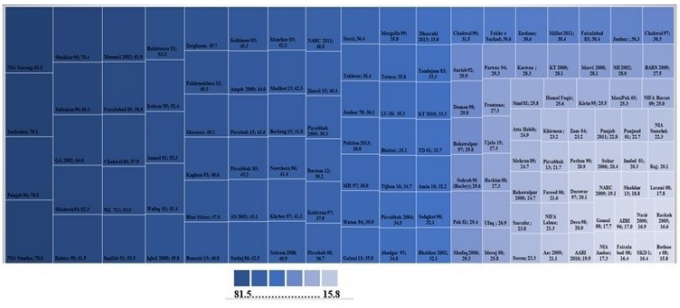

Figure 1: Mean aphid population on Pakistani wheat varieties sorting with largest to smallest values.

The evaluated 125 wheat varieties were divided into five groups based on aphid population (Figure 2). Aphid population ranged from 15-21 per tiller were recorded on 20 varieties, 41 varieties having 22-31 aphids per tiller throughout the study. Similarly, 32-42 aphids per tiller were recorded on 34 varieties while 16 varieties hosted 43-53 aphids per tiller on an average. Moreover, 54-82 aphids per tiller were found on 14 varieties.

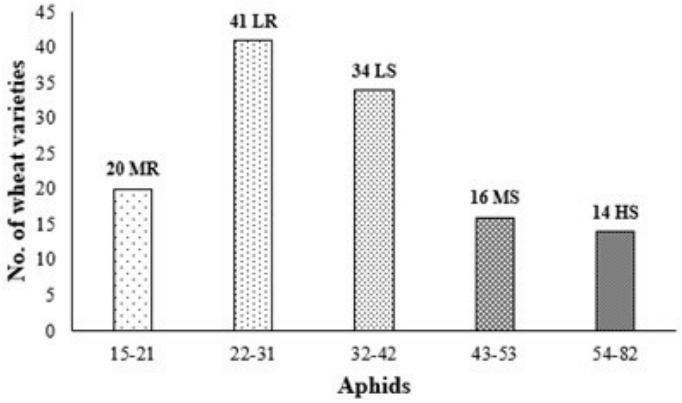

Figure 2: Varietal frequency with respect to aphid population.

The results for resistance evaluation to wheat aphid (*S. graminum*) in Feb-March, 2020 are presented in Table 3. There were 20 moderately resistant (MR) wheat varieties to aphid population, 41 showed lowly resistant (LR), 34 lowly susceptible (LS), 16 moderately susceptible (MS) and 14 highly susceptible (HS). The average percentage of wheat varieties according to ARI scale (Table 1) i.e. MR, LR, LS, MS and HS to aphid population were 16, 32.8, 27.2, 12.8 and 11.2% in entire Pakistani wheat varietal resources, respectively.

3.1 Correlation of aphid population with abiotic factors (Temp. and R.H) on wheat varieties

Aphid population observed on 43 wheat varieties correlates with the abiotic factors i.e. relative humidity (%) and temperature (°C) at NIFA, Peshawar (Table 4). Weather data was taken from meteorological section, NIFA Peshawar starting from February, 2020 to March, 2020. Aphid population on different wheat varieties (only shown in Table 4) showed significant and negative correlation with maximum relative humidity. Moreover, Bahawalpur 2000, Kirin 95, Lasani 08 and Mehran 89 also showed significant and negative correlation with minimum relative humidity. Similarly, $T_{max.}$ and T_{min}. showed significantly positive correlation with aphid population build-up on NARC 2009 while Auqab, 2000 and NIA Sunder showed significantly negative correlation with minimum temperature.

Table 3: Performance of Pakistani wheat varieties for aphid resistance.

Sr. No.	Genotype	Rating	Status	Sr. No.	Genotype	Rating	Status	Sr. No.	Genotype	Rating	Status
1	Bathoor 08	0.44	MR	43	BARS 2009	0.78	LR	85	Rustam 12	1.11	LS
2	Faisalabad 08	0.46	MR	44	SH 2002	0.79	LR	86	Pirsabbak 2005	1.11	LS
3	SKD 1	0.46	MR	45	Marvi 2000	0.79	LR	87	Zincol 15	1.14	LS
4	Raskoh 2005	0.47	MR	46	KT 2000	0.79	LR	88	NARC 2011	1.15	LS
5	Nasir 2000	0.48	MR	47	Karwan	0.80	LR	89	Saleem 2000	1.16	LS
6	AZRI 96	0.48	MR	48	Parwaz 94	0.83	LR	90	Khyber 87	1.17	LS
7	NIA Ambar	0.49	MR	49	Shafaq 2006	0.83	LR	91	Nowshera 96	1.17	LS
8	Gomal 08	0.50	MR	50	Pak 81	0.83	LR	92	Borlaug 15	1.18	LS
9	Lasani 08	0.50	MR	51	Sohrab 96 (Barley)	0.84	LR	93	Shalkot 13	1.19	LS
10	Shahkar 13	0.53	MR	52	Bahawalpur 97	0.84	LR	94	Manthar 03	1.20	LS
11	NARC 2009	0.54	MR	53	Daman 98	0.84	LR	95	Sutlaj 86	1.20	LS
12	AARI 2010	0.56	MR	54	Sariab 92	0.85	LR	96	AS 2002	1.22	MS
13	Dera 98	0.57	MR	55	Chakwal 97	0.86	LR	97	Pirsabbak 85	1.22	MS
14	Darawar 97	0.57	MR	56	Janbaz	0.86	LR	98	Pirsabak 15	1.23	MS
15	Raj	0.57	MR	57	Faisalabad 83	0.86	LR	99	Auqab 2000	1.24	MS
16	Imdad 01	0.57	MR	58	Millat 2011	0.86	LR	100	Kohinoor 83	1.28	MS
17	Sehar 2006	0.58	MR	59	Zardana	0.86	LR	101	Banazir 13	1.32	MS
18	Pasban 90	0.59	MR	60	Fakhr e Sarhad	0.86	LR	102	Blue Silver	1.35	MS
19	Aas 2009	0.60	MR	61	Chakwal 90	0.89	LR	103	Kaghan 93	1.37	MS
20	NIFA Lalma	0.60	MR	62	Bhakkar 2002	0.91	LS	104	Morocco	1.39	MS
21	Fareed 06	0.61	LR	63	Sohghat 90	0.91	LS	105	Pakhtunkhwa 15	1.39	MS
22	Pirsabbak 13	0.61	LR	64	Amin 10	0.91	LS	106	Zarghoon	1.40	MS
23	NIA Sunehri	0.63	LR	65	TD 01	0.92	LS	107	Iqbal 2000	1.41	MS
24	Panjnad 01	0.64	LR	66	Tandojam 83	0.94	LS	108	Wafaq 01	1.45	MS
25	Punjab 2011	0.65	LR	67	KT 2010	0.94	LS	109	Anmol 91	1.48	MS
26	Zam 04	0.65	LR	68	Dharrabi 2013	0.96	LS	110	Kohsar 95	1.48	MS
27	Khirman	0.65	LR	69	Abadgar 93	0.96	LS	111	Bakhtawar 92	1.50	MS
28	Seren	0.66	LR	70	Pirsabbak 2004	0.97	LS	112	Inqilab 91	1.51	HS
29	Sarsabz	0.67	LR	71	Tijban 10	0.98	LS	113	WL 711	1.51	HS
30	Bahawalpur 2000	0.70	LR	72	Bhittai	0.99	LS	114	Chakwal 86	1.64	HS
31	Mehran 89	0.70	LR	73	LU-26	1.00	LS	115	Faisalabad 85	1.64	HS
32	Atta Habib	0.70	LR	74	Tatara	1.01	LS	116	Moomal 2002	1.72	HS
33	NIFA Barsat 09	0.71	LR	75	Margalla 99	1.01	LS	117	Rohtas 90	1.75	HS
34	MaxiPak 65	0.71	LR	76	Galaxi 13	1.01	LS	118	Shaheen 94	1.76	HS
35	Kirin 95	0.72	LR	77	Watan 94	1.01	LS	119	GA 2002	1.81	HS
36	Hamal Faqir	0.72	LR	78	MH 97	1.02	LS	120	Suleman 96	1.87	HS
37	Sind 81	0.73	LR	79	Pakitan 2013	1.02	LS	121	Shahkar 95	1.99	HS
38	Meraj 08	0.73	LR	80	Jauhar 78	1.02	LS	122	Punjab 96	2.20	HS
39	Ufaq	0.76	LR	81	Takbeer	1.03	LS	123	NIA Sunder	2.20	HS
40	Hashim 08	0.77	LR	82	Sassi	1.03	LS	124	Zarlashta	2.23	HS
41	Ujala 15	0.77	LR	83	Pirsabak 08	1.04	LS	125	NIA Sarang	2.30	HS
42	Frontana	0.77	LR	84	Kohistan 97	1.07	LS				

Aphids are soft bodied insect pests of wheat that deliberately depend on biotic and abiotic environmental factors. The seasonal fluctuation in their population density is determined by growth rate and duration of the time period for which aphid population can grow (Honek and Martinkova, 2004).

Current study was conducted first time in which a huge number of Pakistani wheat varieties were subjected to screening against *S. graminum* aphid during peak population time as compared to previous studies which were conducted on a small scale (Iqbal *et al*., 2008).

As expected, aphid population was relatively higher during the reported period of screening due to prevailing favourable abiotic factors (temperature and humidity), as it is already known that the aphid population are significantly affected by the abiotic factors (Aheer *et al*., 2008; Wains *et al*., 2010a). As far as the *S. graminum* population dynamics is concerned during the experiment, according to previous studies the aphid population increases gradually from 19th Jan. to 19th Feb. every year and later on, decreases (Ahmad and Nasir, 2001) but during the current study maximum population was observed in first week of March. It is because of different climatic zones of Punjab and Khyber Pakhtunkhwa (KPK) while wheat was at its maximum tillering stage which is favourable for rapid *S. graminum* reproduction.

Aphid population varied significantly on 125 wheat varieties observed on different dates (Table 2, $P < 0.05$). NIA Sarang was the most preferred wheat variety by *S. graminum* and Bathoor-08 was least preferred. Our results are very similar with Ali *et al*. (2015), Singh *et al*. (2001), Parvez and Ali (1999) and Ciepiela (1993) who concluded significant variations among different wheat varieties in response to aphid infestations. However, varieties of wheat studied were different to our present studies.

Significant variation in *S. graminum* population was recorded during different observation dates (24-02-2020 to 16-03-2020) that could be due to favourable abiotic factors e.g., temperature and relative humidity or nourishing crop stage. Significantly higher population of *S. graminum* were observed on 2-3-2020 than those of 24-2-2020, 9-3-2020 and 16-3-2020. These results are in line with the findings of Ahmad *et al*. (2015). Most probably it is due to the favourable weather factors or crop growth stage during first week of March as compared to other days when aphid population is reduced possibly due to adverse environmental factors beyond favourable range.

The data regarding various abiotic factors for the year 2020 was taken (Only data of corresponding dates with mean *S. graminum* populations shown in Table 2). However, analysis is based on correlation of *S. graminum* populations data with corresponding temperature and relative humidity data. This weather data was taken for an estimation of the correlated response of abiotic factors with *S. graminum* population density. Maximum and minimum temperature displayed a non-significant correlation with population of *S. graminum* except Auqab, 2000; NARC, 2009 and NIA Sunder whereas, relative humidity exerted a negative and significant role except Auqab, 2000; NARC, 2009 (Table 4). These findings

are contrary to results of Ahmad and Nasir (2001). The weather data of temperature showed in the month of March average minimum temperature as 7.8°C and maximum temperature of 23.3°C, were the most favourable meteorological conditions for build up the aphid population beyond the economic threshold level except average monthly relative humidity of 67 % which had negative effect on wheat. The minimum temperature 13.7°C, maximum temperature 30.3°C and relative humidity 45.3% were the most conducive conditions for aphid population growth (Ahmad and Nasir, 2001)) while Singh *et al.* (2001) documented that aphid population decreased with winter showers.

Table 4: Correlation between abiotic factors and aphid population observed on different wheat varieties.

Wheat Genotype	Weather factors				Wheat Genotype	Weather factors			
	Max. Temp.	Min. Temp.	Max. R.H.	Min. R.H.		Max. Temp.	Min. Temp.	Max. R.H.	Min. R.H.
AZRI 96	-0.06	-0.23	-0.59*	-0.11	LU-26	-0.05	-0.14	-0.71**	-0.25
Abadgar 93	-0.03	-0.11	-0.70**	-0.45	Lasani 08	0.42	0.38	-0.65*	-0.66*
Amin 10	-0.06	-0.01	-0.94**	-0.47	Marvi 2000	0.19	0.17	-0.71**	-0.51
Auqab 2000	-0.41	-0.57*	-0.45	0.24	Mehran 89	0.04	0.14	-0.87**	-0.57*
Bahawalpur 2000	0.07	0.17	-0.89**	-0.6*	Millat 2011	-0.34	-0.48	-0.69**	0.03
Banazir 13	-0.14	-0.08	-0.93**	-0.41	Morrocco	0	0.11	-0.69**	-0.45
Bhittai	-0.33	-0.48	-0.70**	0.03	NARC 2009	0.7**	0.58*	-0.02	-0.5
Chakwal 86	0.01	-0.1	-0.70**	-0.28	NARC 2011	-0.35	-0.45	-0.6*	0.06
Dera 98	-0.12	-0.19	-0.69**	-0.19	NIA Amber	-0.14	-0.29	-0.58*	-0.06
Faisalabad 08	0.09	0.02	-0.68**	-0.37	NIA Sunder	-0.52	-0.61**	-0.71*	0.14
Faisalabad 83	-0.15	-0.29	-0.58*	-0.05	NIFA Barsat	-0.18	-0.36	-0.66*	-0.04
Fakhar e Sarhad	0.06	0.03	-0.88**	-0.49	Nasir 2000	-0.18	-0.36	-0.71**	-0.4
Galaxi 13	-0.29	-0.43	-0.66*	0.01	Nowshera 96	-0.23	-0.35	-0.81**	-0.13
Hamal Faqir	-0.31	-0.46	-0.70**	0.01	Pakitan 2013	-0.1	-0.15	-0.69**	-0.23
Inqlab 91	-0.22	0.32	-0.70**	-0.09	Parwaz 94	0.07	0.2	-0.73**	-0.55
Iqbal 2000	0.02	0.06	-0.83**	-0.48	Pirsabak 08	-0.27	-0.4	-0.62*	0.01
Janbaz	-0.24	-0.41	-0.67*	-0.01	WL 711	0	0.05	-0.63*	-0.37
Jauhar 78	-0.36	-0.48	-0.64*	0.06	Wafaq 01	-0.4	-0.52	-0.69**	0.07
KT 2000	-0.27	-0.39	-0.57*	0.92	Zam 04	-0.28	-0.42	-0.64*	0.01
Karwan	-0.11	-0.2	-0.59*	-0.14	Zardana	-0.08	-0.03	-0.63*	-0.3
Khyber 87	-0.31	-0.43	-0.6*	0.04	Zarlashta	-0.38	-0.46	-0.56*	0.09
Kirin 95	0.19	0.32	-0.62*	-0.59*					

**Significant at 1%; *Significant at 5%.

S. graminum population on Pakistani wheat varieties began to rise increasingly since 2nd date of observation i.e. 02-03-2020 (Table 2). These findings are in contradiction with Ahmad *et al.* (2015) who documented highest mean population of *S. graminum* on 31st of March. Climatic factors substantially influence the aphid population dynamics (Ramalho *et al.*, 2012). Results of the present study showed that correlation of *S. graminum* population dynamics was negative and significant with relative humidity as compared to temperature. These findings are not agreed with Chakravarty and Gautam (2004) that temperature is the most important meteorological factor affecting aphid density.

Mycoses and host plant senescence influencing the aphid population and cause abrupt decline in pest density (Honek and Martinkova, 2004). More than 30°C temperature have fatal behavioural consequences, decrease survival and fecundity rate, and increase the physiological developmental time of aphid even when acting for shorter time (Asín and Pons, 2001; Ma and Ma, 2012; Jeffs and Leather, 2014).

Conclusions and Recommendations

This study mainly focused on response of Pakistani wheat varieties with respect to population density of wheat aphid specie i.e. *S. graminum* during favourable meteorological factors conducive for high aphid population density. It is concluded that aphid population varied significantly with respect to different wheat varieties. Highest mean population was recorded significantly on NIA Sarang than any other variety of wheat. Statistically significant less mean population was recorded on Bathoor-08. Seasonal aphid population dynamics remained high from last week of February to first week of March and then reduced gradually. Meteorological factors i.e. temperature and relative humidity played most important role in aphid population dynamics. Moreover, 20 wheat varieties were recorded moderately resistant, 41 lowly resistant while 34 lowly susceptible, 16 moderately susceptible and 14 highly susceptible to aphid population. It is recommended that the Pakistani wheat varieties with lowest population of aphid i.e. serial no. 1–61 (Table 3) would be helpful to manage the aphid threat in Peshawar, Pakistan and further selections of these varieties for future breeding programs.

Novelty Statement

Wheat aphid (*Schizaphis graminum*) population remained maximum in February-March each year. So, we evaluated different Pakistani wheat varieties against this pest during favourable weather period (feb-march) and found 20 moderately resistant wheat varieties, 41 lowly resistant, 34 lowly susceptible, 16 moderately susceptible and 14 highly susceptible.

Author's Contribution

UK conducted the experiment, data collection, data analysis and wrote the manuscript. MZ and SJAS improved the basic idea, experimental design and methodology. NF helped in writeup. SJAS, MZ and NF critically reviewed the manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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