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Population Dynamics of Aphids (Hemiptera: Aphididae) on Wheat Varieties (*Triticum aestivum* L.) as Affected by Abiotic Conditions in Bahawalpur, Pakistan

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ABSTRACT

Population of aphids (Hemiptera: Aphididae) was studied on five wheat varieties in relation to abiotic factors prevailing in Bahawalpur during December, 2012 to May, 2013. Correlation analysis of aphid population with abiotic factors revealed that temperature had positive and significant effect on aphid population ($r = 0.46$, $P < 0.01$). Similarly rainfall had positive and significant effect on aphid population ($r = 0.32$, $P < 0.05$) while relative humidity played a negative and non-significant role on aphid population ($r = -0.18$, $P = 0.17$). Seasonal mean aphid population was found maximum on Faisalabad-08 being statistically higher than on other varieties. Lowest population was recorded on Punjnad-01($P < 0.05$). Population of aphids observed in March, 2013 remained statistically higher than that observed either in February or April, 2013 ($P < 0.05$).

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Authors' Contribution
MWH conceived the idea. TA collected data. MWH analyzed data and wrote paper. MJ and JI were members of the supervisory committee.

Key words
Aphids, Population build up, Weather factors, Sucking pests, Cereals

INTRODUCTION

Aphids (Hemiptera: Aphididae) are important sucking insect pests of wheat and other cereals, vegetables and fruit crops. Aphids suck the cell sap from leaves and shoot that results in curling, chlorosis and distortion of leaves and thus stunted growth (Kindler *et al*., 1995; Akhtar and Khaliq, 2003). These cause considerable losses in yield as well. These have become serious pests of wheat (*Triticum aestivum* L.) in Pakistan (Aheer *et al*., 2008) and yield losses are positively correlated with aphid populations (Riazuddin *et al*., 2004). In addition to this, aphids as pathogens vector play a significant role in transmitting, many fungal and viral diseases in plants (Bukvayova *et al*., 2006). A thorough understanding of the exact relationship between the change in environmental factors and the effect of those factors on the pest population may not only help anticipate the pest losses to the crop, but also help avoid them through some well-timed pest control measures (Aasman, 2001). Successful implementation of integrated management of crop pests chiefly depends on knowledge of abiotic factors of a given area and insect populations build up depending upon biotic and abiotic conditions of that area. Recently we studied population dynamics of aphids on five wheat varieties in Bahawalpur region which showed that varieties with high density of aphids exhibited lower thousand grains weight (Ahmad *et al*., 2015). Present study deals with aphid population density on five wheat varieties grown under Bahawalpur agro-ecological conditions and relationship of weather conditions *e.g.*, temperature, relative humidity and rainfall with aphids population build up on these varieties.

MATERIALS AND METHODS

Experiment was conducted at experimental research area of Islamia University of Bahawalpur, Pakistan in 2012-13. Five wheat varieties namely Faisalabad-08, Inqilab-91, Lasani-08, Punjab-11 and Punjnad-01 were cultivated in the end of December 2012 by standard wheat sowing method (Drill sowing). Unit plot size was maintained (8 x 12 m²) for each variety. There were three replications for all treatments in RCB Design. Fertilizers like NPK in the form of urea (128 kg/ha), DAP (114 kg/ha) and sulphate of potash (62 kg/ha) were applied to all treatments uniformly with recommended dose (Abbas *et al*., 2012). Data was recorded from the 24th of February, 2013 (54 days after sowing) on seven or three-day interval till crop maturity (93 days after sowing). Initially when the crop was small, the data was collected after seven day interval and in the month of March onward the data was collected every three days. Aphid population was recorded from ten randomly selected tillers per plot. The average number of aphids per tiller for each variety was calculated. The data were subjected to Analysis of Variance and means were compared by Duncans's Multiple Range (DMR) test at $P = 0.05$ by

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using SPSS software (version 16.0) for Windows (SPSS, 2008). Aphid population was correlated with abiotic factors namely temperature (°C), relative humidity (%) and rainfall (mm) of Bahawalpur region.

Table I.- Seasonal aphid population on five wheat varieties in Bahawalpur during 2012-2013.

Varieties	Mean ± S.E	Homogeneous groups
Faisalabad-08	34.55 ± 7.20	A
Inqilab-91	25.24 ± 5.29	B
Lasani-08	24.18 ±4.89	B
Punjab-11	23.41 ± 4.94	B
Punjnad-01	15.28 ± 3.02	C
P	0.0000	

(P < 0.05)

RESULTS

Aphid population on different wheat varieties

According to post hoc multiple comparisons test cumulative maximum population was observed on Faisalabad-08 being statistically higher than that on Inqilab-91, Lasani-08, Punjab-11 and Punjnad-01. Punjnad-01 had statistically least aphid population compared with all other varieties (Table I, P <0.05). Date wise DMR test showed that statistically highest population was recorded on 22-03-2013 and 28-03-2013 with no significant difference between these two dates. It was followed by aphid population on 19-03-2013, 25-03-2013 and 31-03-2013 and aphid population remained statistically similar between these later three dates. Aphid population observed on 16-03-2013 was significantly lower than that on above mentioned dates but higher than those on10-03-2013, 13-03-2013, 03-03-2013, 24-02-2013 and 03-04-2013. Aphid population observed on last three dates was significantly lowest than on all other dates during this experiment (P < 0.05, Table II). Results from ANOVA table indicate that population of aphids remained significantly different on five varieties of wheat observed on different dates from February, 2013 to April, 2013 (P < 0.05)

Correlation (Pearson) of aphid population with abiotic factors

Aphid population observed on different dates on different varieties was correlated with the abiotic factors *e.g.*, temperature (°C), relative humidity (%) and rainfall (mm) of Bahawalpur area (Table III). Weather data was obtained from Pakistan Meteorological Department (PMD, 2014) starting from December, 2012 to December, 2013. Overall correlation (Table III) of aphid population with abiotic factors showed temperature *e.g.*, maximum, minimum and mean temperatures had significant and positive effect on aphid population buildup (r = 0.47, P < 0.05; r = 0.36, P < 0.05, r = 0.46, P < 0.05 respectively). Similarly rainfall had significant and positive effect on aphid population buildup (r = 0.32, P < 0.05) and relative humidity had non-significant and negative effect on aphid population (r = - 0.18, P = 0.17).

Table II.- Aphid population on different dates in Bahawalpur during 2012-2013.

Dates	Mean ± S.E	Homogeneous groups
28/03/2013	41.91 ± 4.72	A
22/03/2013	40.27± 6.07	A
19/03/2013	36.95 ± 2.50	B
25/03/2013	36.85 ± 3.99	B
31/03/2013	34.73 ± 2.21	B
16/03/2013	29.43 ± 2.47	C
10/3/2013	25.21± 2.01	D
13/03/2013	13.17 ± 1.60	E
3/3/2013	5.72 ± 0.32	F
24/02/2013	3.43 ± 0.35	FG
3/4/2013	2.17 ± 0.26	G
P	0.0000	

(P < 0.05)

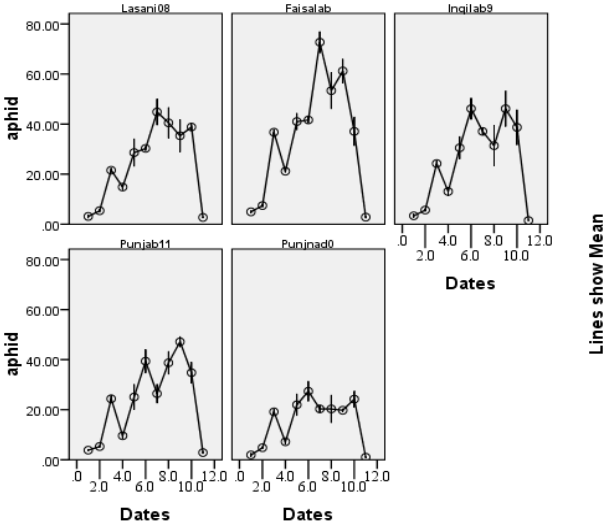

Fig. 1. Aphids population on different dates on five individual wheat varieties.

Correlation of aphid population with abiotic factors regarding different varieties

Aphid population on variety punjnad-01 Punjab-11, Inqilab-91, Faisalabad-08 and Lasani-08 (Table III) showed highly significant and positive correlation with maximum temperature and mean temperature, while they

Table III. - Effect of weather factors (Pearson correlation = r) on population dynamics (Means ± S.E) of aphids (Hemiptera: Aphididae) on different wheat varieties observed on different dates

Date	Weather factors					Aphids (Means ± S.E) on wheat varieties and correlation with weather factors				
	Rainfall	R.H.	Min. T	Max. T	Mean T	Lasani-08	Faislabad-08	Inqilab-91	Punjab-11	Punjnad-01
24.2.2013	0	75	10.5	21.5	16	3.1±0.75	4.93±0.35	3.37±0.87	3.83±0.34	1.93±0.37
03.03.2013	0	53	11.5	29.5	20.5	5.4±0.68	7.43± 0.64	5.63±0.97	5.3±0.20	4.83±0.62
10.03.2013	0	57	16.5	29	22.8	21.55±0.83	36.73±8.50	24.23±3.67	24.37±0.81	19.17±2.82
13.03.2013	0.1	68	16.9	25.5	21.2	14.83± 2.12	21.17±0.23	13.07±2.03	9.6±1.07	7.2±0.60
16.03.2013	0	57	12.8	29.4	21.1	28.6±3.27	41±7.75	30.5±2.67	25.07±3.01	21.97±2.57
19.03.2013	0	61	16.1	33.5	24.8	30.27±0.48	41.63±3.97	46.13±9.02	39.37±2.81	27.37±2.39
22.03.2013	0.1	57	16.5	30.1	23.3	44.83±3.14	72.7±12.66	37.07±0.78	26.43±2.23	20.3±0.85
25.03.2013	0	60	14	27.5	20.8	40.50±3.69	53.37±4.36	31.37±5.79	38.73±2.70	20.3±3.30
28.03.2013	3	62	18.5	29.5	24	35.33±3.90	61.2±9.27	46.13±4.27	47.13±8.79	19.77±0.32
31.03.2013	0	38	18.8	34.1	26.5	38.83±1.69	37.07±5.42	38.7±4.22	34.8±2.52	24.23±1.94
03.04.2013	0	51	17.2	31.5	24.1	2.70±0.49	2.8±0.38	1.47±0.07	2.87±1.13	1±0.15
Temperature (Mean)						$r = 0.48^{0.004}$	$r = 0.39^{0.02}$	$r = 0.61^{0.002}$	$r = 0.54^{0.001}$	$r = 0.55^{0.0008}$
Temperature (Maximum)						$r = 0.42^{0.01}$	$r = 0.30^{0.09}$	$r = 0.52^{0.002}$	$r = 0.45^{0.008}$	$r = 0.55^{0.001}$
Temperature (Minimum)						$r = 0.47^{0.005}$	$r = 0.44^{0.01}$	$r = 0.52^{0.002}$	$r = 0.50^{0.003}$	$r = 0.42^{0.01}$
Relative humidity						$r = -0.28^{0.11}$	$r = -0.09^{0.60}$	$r = -0.22^{0.22}$	$r = -0.19^{0.28}$	$r = -0.31^{0.08}$
Rainfall						$r = 0.24^{0.18}$	$r = 0.39^{0.02}$	$r = 0.40^{0.02}$	$r = 0.48^{0.004}$	$r = 0.15^{0.41}$
Overall Correlation on different wheat varieties	$r = 0.32^{0.01}$	$r = -0.18^{0.17}$	$r = 0.36^{0.0072}$	$r = 0.47^{0.0003}$	$r = 0.46^{.0004}$					

Superscripts denote P values (significant at $p < 0.05$; highly significant at $p < 0.01$)

showed significant correlation with minimum temperature. They showed non-significant and negative correlation with relative humidity, while it showed non-significant correlation with rainfall (Table III).

DISCUSSION

Aphids' population varied significantly on five wheat varieties (Table I, $P < 0.05$). Faisalabad-08 was the most attacked variety by aphids and Punjnad-01 was least preferred by aphids. Varieties Inqilab-91, Lasani-08 and Punjab-11 had higher aphid populations than that on Punjnad-01 and lower than that on Faisalabad-08 (Table I). Our results are in agreement with Ciepiela (1993), Parvez, and Ali (1999), Rana and Ombir (1999), Ahmad and Nasir (2001), Singh *et al.* (2001) and Ali *et al*. (2015) who reported significant, variation among different, varieties of wheat in response to the population of aphids. However, they used different genotypes or varieties of wheat in their studies in contrast with our studies.

Significant variation in aphid population buildup seen during different dates ranging from 24-02-2013 to 03-04-2013 could be due to crop growth stage and environmental factors *e.g.*, temperature, relative humidity and rainfall. Significantly higher populations were observed on different dates in March, 2013 than those in February as well as April 2013. It could be due to the nourishing crop growth stage and favorable or optimum temperature and humidity range as well as some mild showers during March while in April aphids reduced suddenly which could be due to maturity of crop and adverse environmental factors which can go beyond favorable range for wheat aphids.

The meteorological data of the various environmental factors for the year 2013 was taken and is shown for explanation (Only data of corresponding dates is shown with mean aphid populations, Table III). However analysis is based on correlation of all replications data of aphid populations with corresponding weather data on given dates. This meteorological data was taken for an estimation of the correlated response of temperature, relative humidity and rainfall with aphid density. Temperature displayed a significant ($P<0.05$) and positive correlation ($r = 0.46$) with population of aphids whereas relative humidity exerted a non-significant and negative role ($r = -0.18$). These results are in line with those of Nasir and Ahmad (2001). The meteorological data of temperature showed in the month of March average maximum temperature as 30.1°C, average minimum temperature of 14.9°C and average monthly relative humidity of 54 % which were the most favorable environmental conditions for building up the aphid population beyond the economic threshold level on these varieties of wheat (Table III). According to Nasir and Ahmad (2001) the most conducive conditions for aphid growth were 30.3°C maximum temperature, 13.7 minimum temperatures and 45.3% relative humidity nevertheless their values represent weekly means of temperature and relative humidity. Our study demonstrated that the effect of rainfall was found to be significant ($P<0.05$) and showed positive correlation ($r=0.32$) with aphid population (Table III). These findings can compared with those of Singh *et al.* (2001) who described the importance of weather factors for aphid population but on the other hand they reported that winter showers resulted in a decline of the aphid population.

Aphid population on five wheat varieties started to appear in the end of February and increased with passage of time. Aphid population began to rise increasingly since the 5th date of observation (16th March) thereby it reached its peak in mid-March and a final highest mean population was recorded on 31st of March (Table II, Fig. 1). In first week of April (3rd April) a least mean aphid population was recorded on all five varieties (Fig. 1, Table II). Climatic factors considerably influence the aphid pest populations (Ramalho *et al.*, 2012). Temperature is considered the most important abiotic factor affecting physiology (Chakravarty and Gautam, 2004), aphid reproduction rates (Chakravarty and Gautam, 2004) and, consequently aphid population dynamics (Cividanes and Santos-Cividanes, 2012). Insects are able to function faster and more efficiently at higher temperatures. They can feed, develop, reproduce, and disperse when the climate is warm, though they may live for a shorter time (Drake, 1994).

Our results showed that in all five wheat varieties, out of the three factors *e.g.*, temperature, humidity and rainfall, correlation of aphids population dynamics was positive and significant (minimum, maximum and mean temperatures) with temperature for all varieties of wheat compared with other two factors *i.e.*, humidity and rainfall. These results are in agreement to above statement (Chakravarty and Gautam, 2004) that temperature is the most important abiotic factor affecting aphid population dynamics. This is emphasized as we got same results of correlation study for population dynamics of aphids with temperature for all five wheat varieties. Relative humidity (%) exerted negative and non-significant effect on population of aphids however rainfall (mm) which remained mild in the agro climatic conditions of this region and it exerted a positive and significant effect on aphid population (Table III). These findings are somewhat similar to those of Wains *et al.* (2010) for effect of rainfall on aphid population dynamics

that shows that rainfall exerted a positive but non-significant effect on aphid population.

Aphids are small soft bodied insects on wheat based ecosystem that depend heavily on environmental factors as well as their host plant. The seasonal fluctuation in their dynamic is determined by population growth rate and length of the period for which the population can grow. Aphid abundances grow quickly and may attain more than 100 individuals per tiller in late June or early July (Honek and Martinkova, 1999). The peak is followed by an abrupt decline caused by host plant senescence and spreading of mycoses (Honek and Martinkova, 2004). High temperatures of ≥30°C have fatal behavioral consequences (Ma and Ma, 2012) increase physiological developmental time and decrease fecundity and survival (Asín and Pons, 2001), even when acting for short periods (Jeffs and Leather, 2014).

Our results showed that in first week of April (3rd April data) temperature ranged to 31.5 °C and relative humidity reached a level of 51 %. Least population of aphids was recorded in first week of April and afterwards there were no aphids on all wheat varieties. These results are in line with above statements which report that a temperature of ≥30°C has adverse effects on pest biology due to which their survival is affected. It results in poor growth rate of insect pests like aphids and an ultimate decline is seen in the pest population. In an environment, temperature and relative humidity change with respect to each other. If temperature changes it also affects relative humidity of that area. It can be observed that there is almost an inverse relationship between mean monthly temperatures and relative humidity which means as temperature continued to increase relative humidity went on decreasing (Table III). Negative correlation can also be seen between aphid population build up and relative humidity (Table III). Increased temperature beyond the optimum range may also affect different crop growth stages negatively. Heat stress at reproductive stages affects negatively wheat yield in different wheat varieties particularly in month of April (Nawaz *et al.* 2013). In April wheat plants approach maturity and these are near to harvesting stage. In other words environmental factors like temperature in the month of April are sufficiently high for crop maturity and grain hardiness. During this time aphids population move towards decline because firstly due to a very high temperature and secondly due to their host (wheat crop) that has also approached maturity and aphids being sucking insect pests are unable to find nutrition in their host at this stage of host plants.

In April there was a total decline in aphid population in second week. Our findings are in agreement with former findings of other scientists which emphasized the importance of nutrition in ears of tillers during March that supported the aphid population and unavailability of food for aphids in mature and near to harvest plants as aphids are chiefly sucking pests and their population builds up depends upon availability of plant sap. It has also been described that higher temperature in April goes beyond the favorable temperature range for aphid pests (Kiechkhefer *et al.*, 1994; Parvez and Ali, 1999; Ahmad and Nasir, 2001; Aslam *et al.*, 2004; Ashfaq *et al.*, 2007; Iqbal *et al.*, 2008).

CONCLUSIONS

From this study it is concluded that aphids' population dynamics varied significantly with respect to five wheat genotypes. Significantly higher population was observed on Faisalabad-08 it being statistically higher than the aphid population on other varieties of wheat. Significantly less population was observed on Punjnad-01. Seasonal population dynamics remained highest from mid to end of March. Population of aphids was significantly lower in the data either recorded in February or in April. Environmental factors like temperature, rainfall and relative humidity played significant role in population dynamics of aphids. Population of aphids declined in April due to a higher temperature and a bit lower humidity percentage in air as compared to range of these factors in the month of March. Comparatively high temperature and low relative humidity in April are responsible for wheat crop maturity. During this month high temperature and low relative humidity range as well as the ready to harvest wheat crop contains little food (sap) for aphids due to which aphid population declines on wheat crop.

Statement of conflict of interest

Authors have declared no conflict of interest.

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