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Temperature and humidity fluctuation influences population dynamics of aphids (Hemiptera: Aphididae) on wheat (Triticum aestivum L.) under the agroecology of Pusa, Bihar

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Aphids are the oligophagous pest of cereals. They are commonly referred to as plant lice and are significant pests of wheat under the agro-ecology of Pusa, Bihar. The vagaries of agro-climatic conditions in the regime of global warming have an impact on the incidence of this pest on wheat crops. The present investigation was conducted to know the impact of fluctuations in temperature and humidity on the infestation of aphid pests in wheat under the agro-climatic conditions of Pusa. The data were recorded on nine different wheat genotypes planted in the randomized block design under two dates of observations during 2011-12, 2012-13, and 2013-14 under the unprotected condition. The peak population was recorded around 28-30^{0}C when it coincided with the milky stage of the crop. During rabi 2012 first observation was recorded on 15/03/2012 and average number of aphid/plant was found as 20.89 in the experimental plot having vapor pressure deficit 0.17-0.41kPa. 36.67 aphids / plant was recorded during the second observation (20/03/2012) of the year with 0.2-0.55kPa vapour pressure deficit. In comparison to first observation the aphid infestations increased by 1.76 fold till the second date of observation. First observation during subsequent rabi season was recorded on 17/03/2013. The aphid infestation level was found 13.11 aphids / plant under 0.24-0.54kPa vapour pressure deficit. 22.67 aphids / plant was the aphid infestation during the second observation (22/03/2013) of the season with 0.18-0.45kPa as vapo pressure deficit. The infestation level was increased by 1.73 between the two observations. During rabi 2014 the aphid infestation level was noted as 8.78 aphids/plant on first observation (14/03/2014) 0.18-0.45kPa vapour pressure deficit. On second observation (23/03/2014) of the season the infestation level increased to 30.56 aphids / plant with vapour pressure deficit as 0.38-0.97kPa. In most of the genotypes, the late sown crop was found relatively more infested with aphids as the aforesaid temperature coincided with the milky stage of the crop phenology. It can be concluded that temperature fluctuations in the regime of climate change have a significant contribution to the incidence of aphid pests in wheat crops.

Key Words: Temperature, humidity, population dynamism, aphids, wheat

I. INTRODUCTION

In India, wheat is a staple winter cereal crop. The productivity of the crop is heavily affected by several insect pests. More than a dozen insect pests attack wheat crop from sowing to harvesting [1]. The aphids have gained status of regular pests and reported from all major wheat growing regions [2], [3]. Wheat is attacked by more than eleven aphid species, out of them four species namely Sitobion avenae (Fabricius), S. miscanthi and Rhopalosiphum padi and R. maidis are reported to be most predominant [4] and their composite population is designated as wheat aphid complex [5].They suck sap from stem and foliage, and the affected parts become stunted with yellow, reddish, or purple spots on them. Some species can cause chlorosis and tissue death [6]. Under heavy infestation the plants do not produce ears.Long lasting infestation can reduce tillering (Anonymous 1995-2013), number of spikelets and seed [7]. Its damage in the boot stage can result in 19-31% yield loss; later infestation can cause the yield loss up to 20% [8].Aphid's number 50 per ear head can cause 47.7% reduction in grain weight [9].They can cause 35- 40% loss directly by sucking sap and 20-80% indirectly by the transmission of fungal and viral diseases [10].Pest status, species composition and seasonal dynamics of cereal aphid species are influenced by a complex of factors (region, climate, biotype status, seasons, life cycles, agro technical practices, natural enemies) [11], [12], [13], [14].Due to the advent of the rice-wheat cropping system in Indo-Gangetic plains following the "green revolution," earlier minor pests of wheat like aphid have been reported to inflict severe damage to the crop. In recent time climate change is also influencing its population dynamics and intensity of infestation.Keeping in view the factsabove, the present study was conducted to assess the influence of fluctuation in temperature on level of infestation on different genotypes of wheat.

II. MATERIALS & METHODS

The present investigation was conducted at the Experimental area of the PUSA, Bihar. The experiments were conducted in the field where no insecticide had been applied in the preceding crop to control the aphid pest and no insecticide was applied for the control of any pest during the experiment. For the study, nine genotypes of wheat were planted under Randomized Complete Block Design (RCBD) with three replications. Each genotype was grown in a 5 rows of 3 m length. The rows were planted with a spacing of 23 cm. The plot-to-plot spacing was kept at 1.0 m to reduce insect movement between the plots.The crop was sown during last week of November in 2011-12, 2012-13 and 2013-14. All the recommended cultural and agronomical practices were followed uniformly to raise a good crop. The observations were carried out when crops were mostly between 58 to 69 Zadoks growth stages during the peak period of the insect's activity. Excursions were made to the experimental field at sensitive growth stage of the crop for three successive seasons, i.e. during 2012, 2013 and 2014 and observations were recorded on two dates. For recording the aphid's population density five wheat plants were randomly selected from each cultivar replicate (15 plants/ cultivar). Population density of aphid was determined by counting all individuals per plant on leaves, stem and spike using 10x lenses in the field. The aphid species collected during the experimental period was brought to the laboratory for identification. Available taxonomic keys were used to identify different collected aphid species according to Blackman (2000) and Helmi (2010).The mean number of aphids per stem, standard deviation and the percentage of each type (of the total number of respective insect) were calculated. Analysis of variance (ANOVA) was used to analyze the data of aphids population after square root transformation.

III. RESULT & DISCUSSION

Table1. Analysis of variance showing sum of squares, mean squares, F-ratio and significance test for aphid incidence among 09 wheat genotypes across six environments
(2 dates of observation and 3 years 2012, 2013 and 2014).

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Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	67.790			
Factor A (Year)	2	3,705.938	1,852.969	452.350	0.00000
Factor B (Date of observation)	1	10,097.784	10,097.784	2,465.087	0.00000
Int A X B	2	966.012	483.006	117.912	0.00000
Factor C (Genotypes)	8	7,837.272	979.659	239.156	0.00000
Int A X C	16	2,445.951	152.872	37.319	0.00000
Int B X C	8	951.272	118.909	29.028	0.00000
Int A X B X C	16	648.765	40.548	9.899	0.00000
Error	106	434.210	4.096		
Total	161	27,154.994			

The analysis of variance for aphid infestation on nine different genotypes of wheat across six environments is presented in Table 1. The genotypes were grown during rabi season of 2012, 2013 and 2014 and observations on number of aphid per plant were recorded on two different dates during each growing season representative of two different micro-thermal regime of sensitive phonological phase of the crop cycle. The results indicated highly significant effect (p-value < 0.01) for the six environments (three growing seasons and two dates of observation which compose six environments) on aphid infestation. More importantly, the analysis of variance revealed highly significant variance among the studied genotypes. The results suggested that the magnitude of differences among genotypes was sufficient to provide a scope to characterize the influence of temperature fluctuation on aphid infestations. It had significant two-way and three-way interactions (environments X genotypes, environments x dates of observation, dates of observation x genotypes and environments x dates of observation x genotypes) effects.

During the study period, four different aphid species e.g. R. maidis, R. padi, S. miscanthi and S. avenae found infesting the genotypes under study. Out of the four S. miscanthi and S. avenae were found dominating the experimental plots whereas the presence of R. maidis, R. padi were found very meager. Total count of the aphids as well as composition of the aphid complex varied from year to year (Fig 1.). The dominance of S. avenae in natural aphid populations under present study is in agreement with previous reports [15], [16]. Similarly previous studied have also recorded S. avenae as most common and R. padi as least common aphid on wheat crop [17] [18]. S. miscanthi was also reported as major aphid pest of wheat [19]. The composition of the species, however, differed between years, with S. miscanthi being the most common aphid in 2013 (48.84%) and declining in 2014(43.82%), while S. avenae was most common species in 2014 (49.49%) (Fig.1). Species composition of aphids also differed between years under investigation [20]. A total of 2528 aphids were recorded during the year 2012. During heading to late dough stage of the crop (58 to 69 Zadoks growth stages), the year experienced 28.67^{0}C average maximum temperature, 11.64^{0}C average minimum temperature, 82.59% relative humidity and 0.24 – 0.68kPa vapor pressure deficit. In the year 2013, during the same sensitive growth phase of the crop, we observed an average maximum temperature of 29.68^{0}C, minimum temperature 15.37^{0}C, relative humidity 90.31% and Vapor Pressure Deficit 0.17-0.40 kPa with 1259 aphids in experimental plot under investigation. 1869 was the total aphids count in the year 2014, which experienced an average maximum temperature of 28.29^{0}C, minimum temperature 14.32^{0}C, relative humidity 86.59% and Vapor Pressure Deficit 0.22-0.52 kPa during the same sensitive growth phase of the crop. The trend indicates that aphids count increased with increase in vapor pressure deficit and moist heat could not favor the aphid multiplication. Previous researcher also found significant difference for aphid density between years [17].

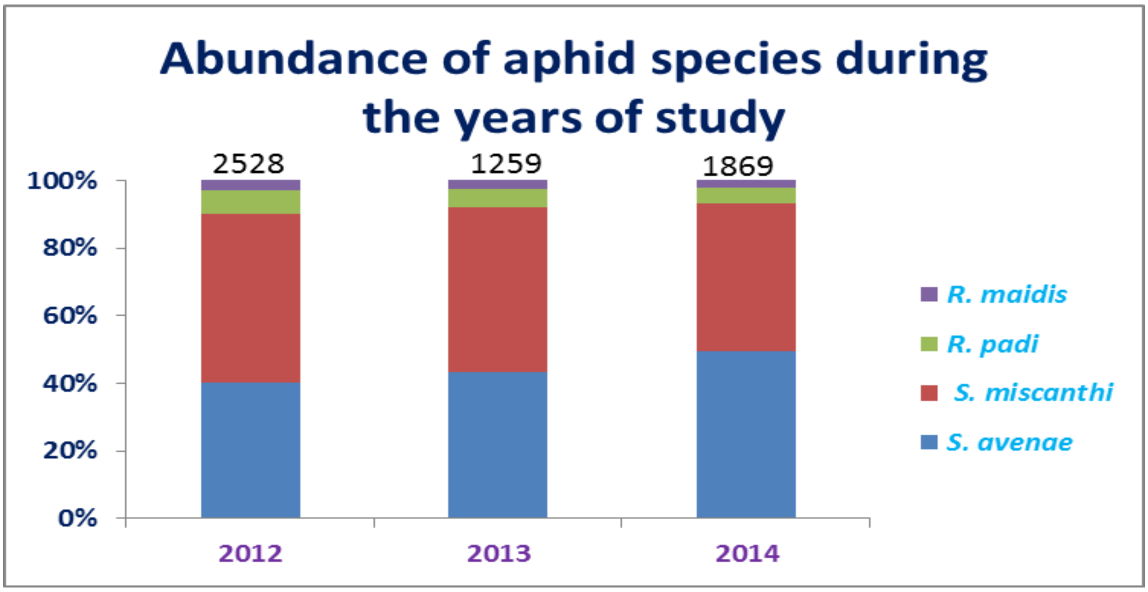

Fig. 1. Composition of aphid complex of wheat during years of study.

To understand the influence of micro thermal regime on aphid population dynamics during heading to late dough phase of the crop, the observations were recorded on two dates during the sensitive phase in each year understudy (Fig. 2a &2b; 3a & 3b; 4a & 4b). During rabi 2012 first observation was recorded on 15/03/2012 and average number of aphid/plant was found as 20.89 in the experimental plot. Average micro thermal regime of five days preceding the date of observation was maximum temperature 27.14^{0}C, minimum temperature 9.94^{0}C, relative humidity 86.4% and vapor pressure deficit 0.17-0.41kPa. 36.67 aphids / plant was recorded during the second observation (20/03/2012) of the year with 29.56^{0}C maximum temperature, 13.12^{0}C minimum temperature, 86.8% relative humidity and 0.2-0.55kPa vapour pressure deficit as average micro thermal regime. In comparison to first observation the aphid infestations increased by 1.76 fold till the second date of observation. First observation during subsequent rabi season was recorded on 17/03/2013. The aphid infestation level was found 13.11 aphids / plant and the average micro-thermal regime five days preceding the date of observation was 31.04^{0}C maximum temperature, 17.28^{0}C minimum temperature, 88% relative humidity and 0.24-0.54kPa 980avour pressure deficit. 22.67 aphids / plant was the aphid infestation during the second observation (22/03/2013) of the season with 31.34^{0}C maximum temperature, 16.28^{0}C minimum temperature, 90.2% relative humidity and 0.18-0.45kPa as 980avour pressure deficit as the micro-thermal regime. The infestation level was increased by 1.73 between the two observations. During rabi 2014 the aphid infestation level was noted as 8.78 aphids/plant on first observation (14/03/2014) with the micro-thermal regime of 29.28^{0}C maximum temperature, 14.42^{0}C minimum temperature, 89% relative humidity and 0.18-0.45kPa 980avour pressure deficit. On second observation (23/03/2014) of the season the infestation level increased to 30.56 aphids / plant with increase in maximum temperature (31.46^{0}C), minimum temperature (16^{0}C), 980avour pressure deficit (0.38-0.97kPa) and decrease in relative humidity (79%). Overall trend during the three years of experimentation indicates towards increase in aphid infestation level with increase in temperature and 980avour pressure deficit with an exception to the year 2013. During the rabi 2013 the fold increase in aphid infestation was the least in comparison to the other two rabi season. It may be due to relatively less contrast in micro-thermal regime of the two observation and other factors like crop growth stage 980avouring towards aphid multiplication. Other investigators have also reported that pest status, species composition and seasonal dynamics of cereal aphid species are influenced by a complex of factors (region, climate, biotype status, seasons, life cycles, agro technical practices, natural enemies) [11], [12], [13], [14]. Recently scientists have reported that temperature has a positive while relative humidity plays a negative role on population dynamics of aphids infecting wheat genotypes [21] [22]. Aphids are gaining importance as a major pest of wheat crop due to climate change as many aphids are able to feed through the winter on the crops without recourse to sexual reproduction. Further fluctuation in temperature is playing a major role in building up their population particularly during reproductive and grain filing phase of the crop cycle which may have severe impact on the crop yield.

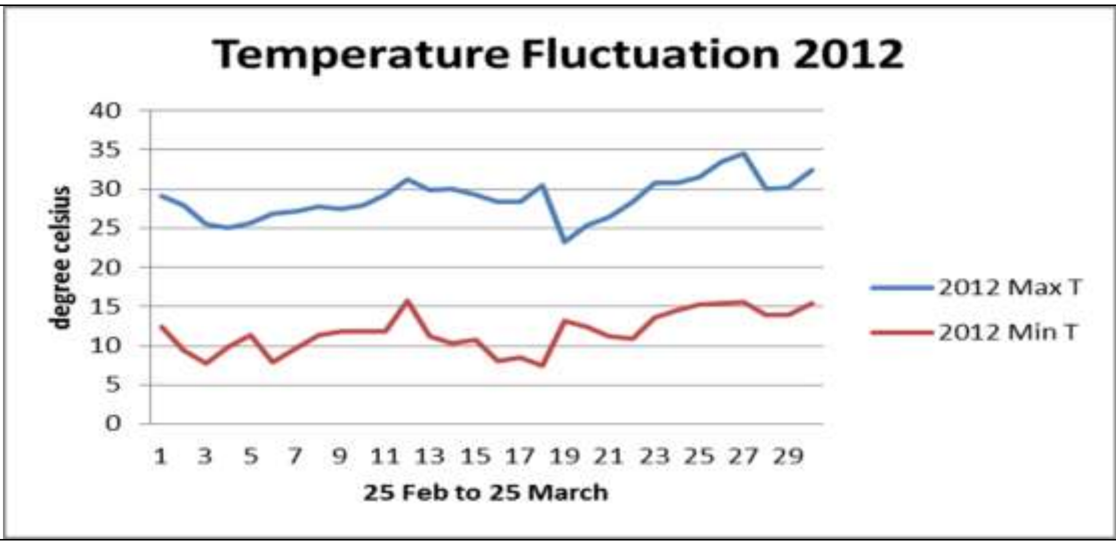

Fig. 2a. Temperature fluctuation during sensitive phenological phases of wheat crop during 2012

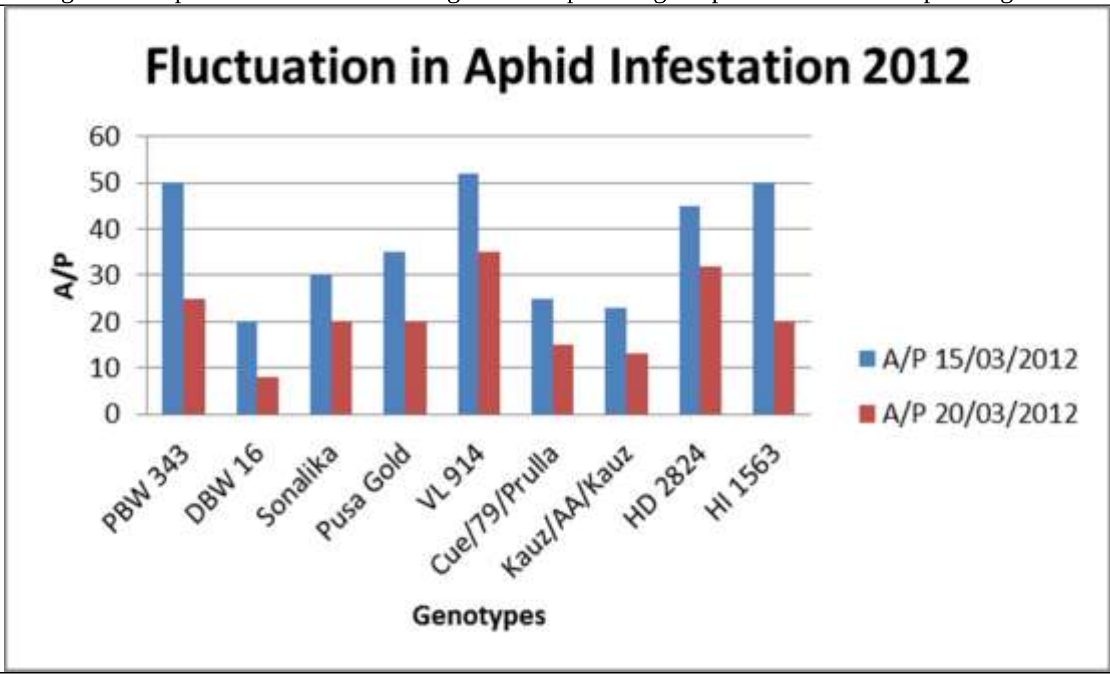

Fig. 2b. Fluctuation in aphid population on two dates of observation during 2012

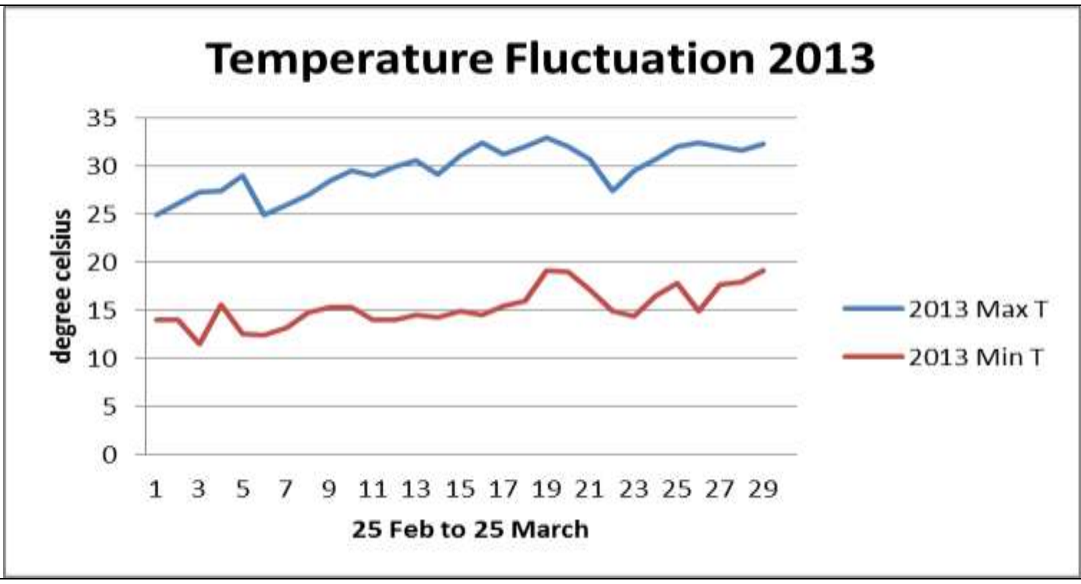

Fig. 3a. Temperature fluctuation during sensitive phenological phases of wheat crop during 2013

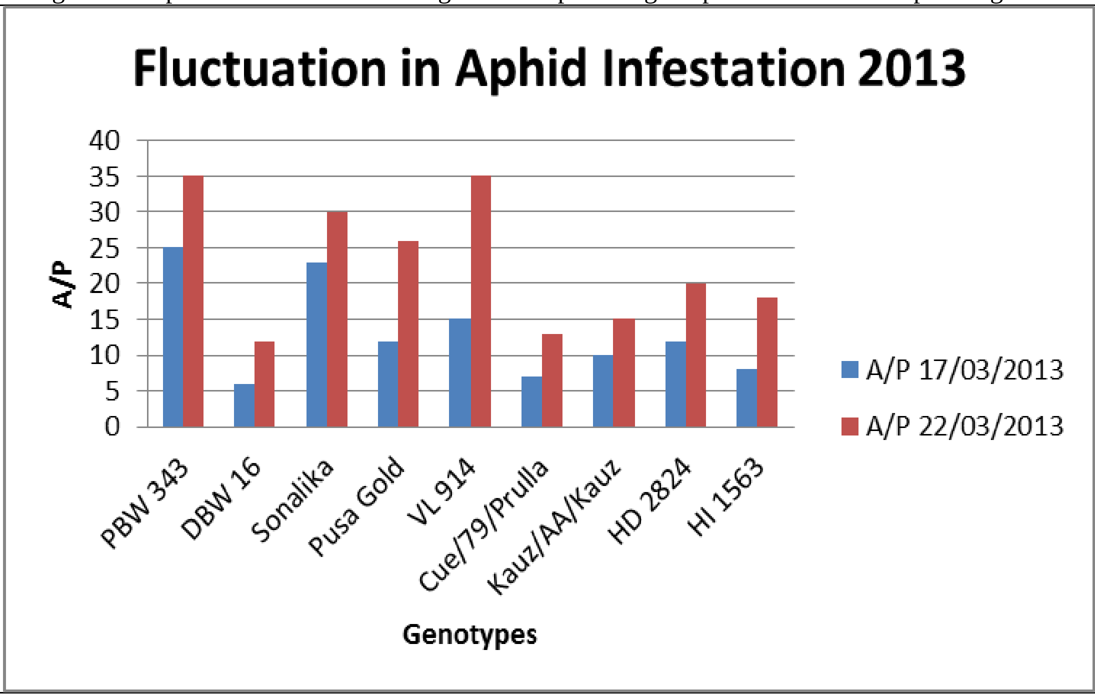

Fig. 3b. Fluctuation in aphid population on two dates of observation during 2013

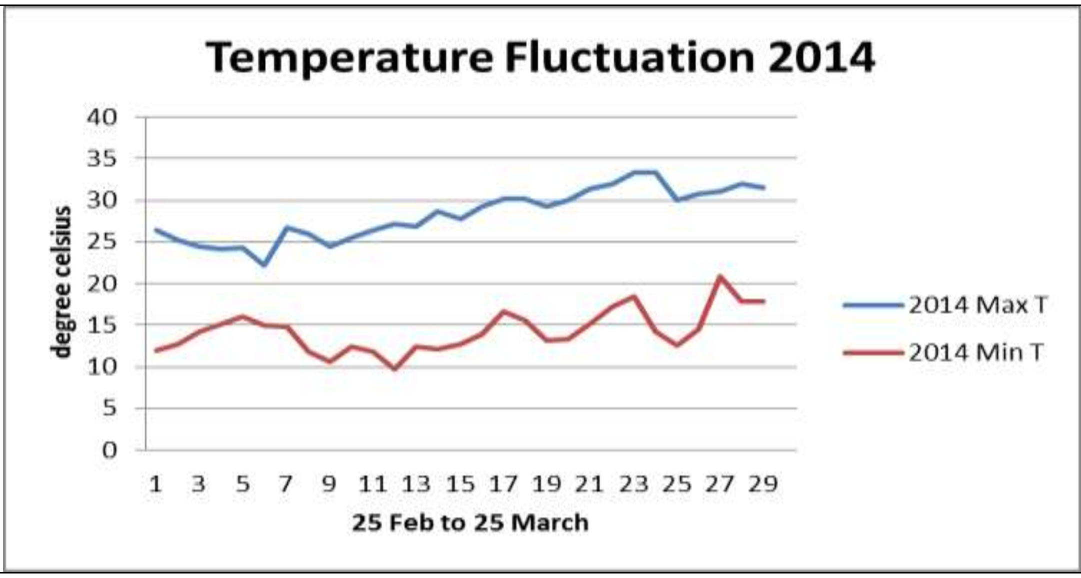

Fig. 4a. Temperature fluctuation during sensitive phenological phases of wheat crop during 2014

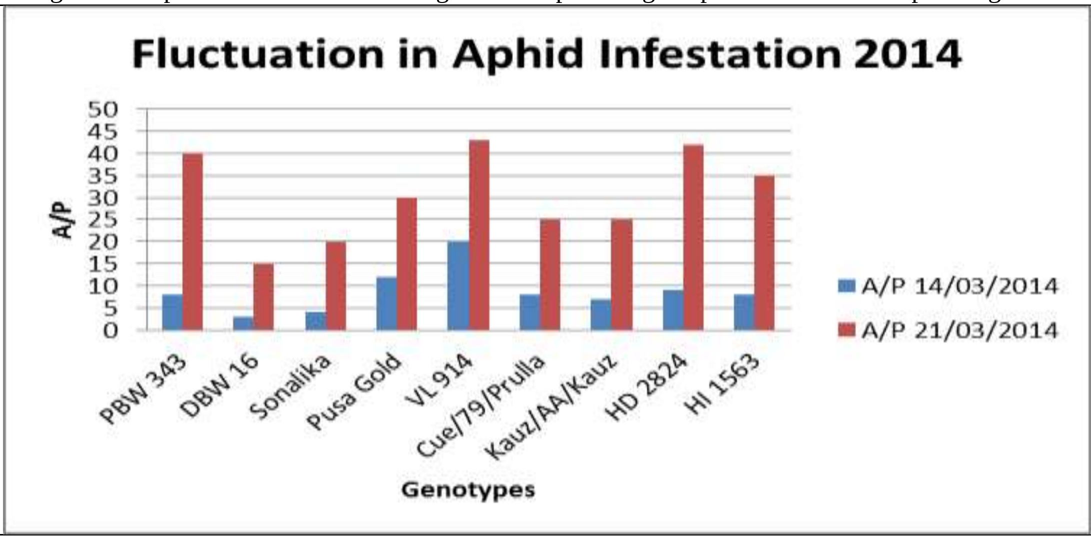

Fig. 4b. Fluctuation in aphid population on two dates of observation during 2014

Conclusion: Based on the aforesaid observations it can be concluded that temperature and relative humadity fluctuations in the regime of climate change has significant contribution on the incidence of aphid-pest in wheat crop.

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Competing Interests: The authors declare that they have no competing interests.

Author Contributions: Authors have substantially contributed to the study conception and design as well as the acquisition and interpretation of the data and drafting the manuscript.

REFERENCES

[1]. Bindra, O. S.1968. Wheat production under rainfed conditions: present status of research and future programme of work. Proc. 7th All India Wheat Research Workshop, Pantnagar, India.

[2]. Singh, V. S. 1986.Management of insect and mite pests of wheat. In: JP Tondon& AP Sethi (eds.). Twenty five years of co-ordinated wheat research 1961-86. Wheat Project Directorate, IARI, New Delhi, India.

[3]. Singh,V. S. 1988.Pest management in wheat.Indian Farming.**48**: 47-50.

[4]. Jarosik, V.Honek, A. and Tichopad, A. 2003.Comparison of field population growths of three cereal aphid species on winter wheat.Plant Protect. Sci. **39;** 61-64.

[5]. Aslam, M., Razaq, M., Ahmad, F., Faheem, M. and Akhter, W. 2004.Population of aphid (Schizaphis graminum R.) on different varieties/lines of wheat (Triticum aestivum L.).Intl. J. Agric. Biol**. 6;** 974-977.

[6]. Tyler,J.M., Webster,J.A. and Merkle O.G.1987. Designations for genes in wheat germplasm conferring greenbug resistance.Crop Sci.,**27**: 526-527

[7]. Pike, K.S. Schaffner, R.L. 1985. Development of autumn populations of cereal aphids, Rhopalosiphum padi (L.) and Schizaphis graminum (Rondami) (Homoptera: Aphididae) and their effects on winter wheat in Washington state. J. Econ. Entomol.**78**:676–80.

[8]. Voss, T. S., Kieckhefer, R. W., Fuller, B. W., McLeod, M. J. and Beck, D A. 1997. Yield losses in maturing spring wheat caused by cereal aphids (Homoptera: Aphididae) under laboratory conditions. J. Eco. Entomol.,**90** (5): 1346-1350.

[9]. Deol, G.S. Gill, K.S. and Brar, J.S. 1987. Aphid out break on wheat and barley in Punjab.Newsletter Aphid Soc. India.**6**; 7-9.

[10]. Thackray, D.J., Diggle, A.J. and Jones, R.A.C. 2009. BYDV predictor: a simulation model to predict aphid arrival, epidemics of Barley yellow dwarf virus and yield losses in wheat crops in a Mediterranean – type environment. Plant Pathol., 58: 186-202.

[11]. Vickerman.G.P. and Wratten,S.D. 1979. The biology and peststatus of cereal aphids (Hemiptera: Aphididae) in Europe: areview. Bull. Entomol. Res. **69**: 1–32.

[12]. Dean G.J. Jones, M.G. and Powell W. 1981: The relative abundance of hymenopterous parasites attacking Metopolophium dirhodum (Walker) and Sitobion avenae F. (Hemiptera:Aphididae) on cereals during 1973–79 in southern England. Bull. Entomol. Res. **71**: 307–315.

[13]. Plantegenest, M., Pierre J.S., Caillaud, C.M., Simon, J.C.,Dedryver, C.A. and Cluzeau, S. 1996. A model to describe the reproductive rate in the aphid Sitobionavenae (Hemiptera: Aphididae): a case study. Eur. J. Entomol., 93: 545–553.

[14]. Brewer M.J. and Elliott N.C. 2004: Biological control of cerealaphids in North America and mediating effects of host plantand habitat manipulations. Annu. Rev. Entomol. **49**: 219–242.

[15]. Zhou,H., Chen,J., Cheng,D., Francis, F., Liu,Y., Sun,J., Huang,H., Wang,X., Liu,X.,Xiaoming, L. and Zen,J. 2011.Evaluation on the resistance to aphids of wheat germplasm resources in China.Afr. J.Biotechnol., 10 (63): 13930-13935.

[16]. Li,F. Kong,L. Liu,Y. Wang,H. Chen,L. and Peng,J. 2013. Aphid (Hemiptera: Aphididae) response of wheat germplasm to infestation of English grain. Journal of Economic. Entomol. **106** (3); 1473-1478.

[17]. Thies, C. Roschewitz, I. and Tscharntke, T. 2005. The landscape context of cereal aphid–parasitoid interactions. Proc. R. Soc. B.**272;** 203–210.

[18]. Schmidt, M. H. Lauer, A. Purtauf, T. Thies, C. 2003. Schaefer, M. and Tscharntke, T. 2003: Relative importance of predators and parasitoids for cereal aphids control. Proc. R. Soc. (B) **270**:1905–1909.

[19]. Khan, M.S. and Maqbool, R, 2002.Varietal performance of wheat (Triticum aestivum) against wheat Aphid (Macrosiphum miscanthi) and its chemical control with different doses of insecticides. Asian Journal of Plant Science.1;**2**. 205-207.

[20]. Tomanović, Z. Kavallieratos, G. N. Starý, P. Obradović, O. P. Athanassiou, C.G. and Stanisavljević, L. Z. 2008. Cereal aphids (Hemiptera: Aphidoidea) in Serbia:Seasonal dynamics and natural enemies Eur. J. Entomol. 105: 495–501.

[21]. Ahmad, T., Hassan M. W., Jamil, M. and Iqbal, J. 2016. Population Dynamics of Aphids (Hemiptera: Aphididae) on Wheat Varieties (Triticum aestivum L.) as Affected by Abiotic Conditions in Bahawalpur, Pakistan. Pakistan J. Zool., 48(4), 1039-1044.

[22]. Abbasi , Z., Sultana, R. and Wagan, M. S. 2019. Impact of abiotic factors on population fluctuation of aphid (Hemiptera: Aphididae) on the different wheat varieties from Larkana district. J. Entomol. Zool. Stud., 7(1): 608-611