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Correlation of Conducive Environmental Conditions for the Development of Whitefly, *Bemisia tabaci* Population in Different Tomato Genotypes

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Abstract.- Relationship of whitefly (*Bemisia tabaci*) population and environmental conditions were studied on five tomato cultivars. Environmental conditions had a significant contribution in development of whitely population during two years of study. Temperature and relative humidity contributed towards the whitefly population buildup. The whitefly population increased with increased in temperature while decreased with the decrease in relative humidity. The contribution of maximum temperature was explained by linear regression which showed 83 to 91% variability in whitefly development. The minimum temperature explained 75 to 85% whitefly population variability. Relative humidity exerted 78 to 85 percent contribution in the whitefly population development. The linear regression could not explain the contribution of rainfall and wind speed.

Key words: Correlation, whitefly, environment, tomato, genotypes.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is the second most important vegetable crop by volume of production after potato. Current world production of tomato is about 150 million tons which is cultivated on 4.6 million hectares (FAO, 2011). The area under tomato cultivation in Pakistan is 52.3 thousand hectares and production is 529.6 thousand tones (GOP, 2011). The inferior quality of seed, lack of production technology, poor management practices and the impact of pests and diseases contribute to low tomato yields.

Whitefly, *Bemisia tabaci* (Genn.) causes significant damage to crops through phloem-feeding, induction of phytotoxic disorders, excretion of honeydew and most importantly, transmission of plant viruses (Dalton, 2006; Liu *et al*., 2007; De Barro, 2008). It can transmit more than 15 viruses that cause almost 40 plant diseases (Pan *et al.*, 2012). Among the viral diseases, tomato leaf curl virus (TLCV) has emerged as the most important geminiviral disease (Haider *et al*., 2007). A single whitefly can transmit TLCV after feeding on infected plants in a circulative and persistent manner (Uchibori *et al*., 2013). The transmission rate of the virus may reach upto 100% after increasing the acquisition access period (AAP) and number of whiteflies (Li *et al*., 2010). *B. tabaci* inoculates young leaves more efficiently as compared to older ones (Rashid *et al*., 2008). TLCV can be transmitted between male and female whiteflies during sexual intercourse (Ghanim and Czosnek, 2000). The virus can also be acquired by whiteflies from infected tomato fruits and subsequently transmitted to healthy tomato plants (Delatte *et al*., 2003).

Environmental factors especially temperature is important for growth, development, and reproduction of insects. It also affects the internal and external conditions, including developmental stages, nutritional unbalance, pathogen intrusion, geographic habitats and other environmental stimuli (Denlinger and Yocum, 1998; Feder and Hofmann, 1999; Denlinger and Lee, 2010). Increasing temperature is favorable for activities and developmental processes of whitefly due to which its population increases while the increasing relative humidity inhibits the activities of whitefly (Aktar *et al.,* 2008). At high temperature and low relative humidity maximum whitefly infestation was observed in okra crop (Ali *et al*., 2005).

Due to the heavy losses caused by TLCVD and other physical disorders caused by honey dew secreted by whitefly, it was necessary to record the

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whitefly population with respect to environmental conditions in Pakistan. The main objective of the study was to quantify the environmental factors that play important role in the *B. tabaci* population build-up that would provide a base for the prediction and precise management of whitefly.

MATERIALS AND METHODS

The present study was carried out in the Research Area Department of Plant pathology, University of Agriculture Faisalabad, Pakistan to determine the effect of environmental conditions on whitefly population in different tomato genotypes. Five tomato varieties/lines (Big Beef, Caldera, Sitara-TS-101, 014276 and Salma) were collected from Ayub Agricultural Research Institute, Faisalabad, Pakistan and sown during two years in tomato growing seasons of 2012 and 2013. The experiment was laid out in randomized complete block design with three replications. Each entry was sown in a row of 3m length with 30cm plant to plant and 75cm row to row distance. A line of highly susceptible variety *i.e.* Fanto was sown after every three entries and two rows of the spreader all around the field. Recommended agronomic practices were followed to keep the crop in good condition.

Data collection

B. tabaci population data were collected from the disease screening field sown in 2012 and 2013. Three plants from each variety were selected for *B. tabaci* population data. Whiteflies numbers from upper, middle and lower leaf of selected plants were counted and calculated on weekly basis. Differences were estimated on the basis of mean *B. tabaci* population. The data of different environmental factors such as maximum and minimum temperature, relative humidity during (RH) the growth period of the crop was acquired from the website www.uaf.edu.pk.

Data analysis

The data were analyzed using two statistical software package *i.e.* Statistics 8.1 and IBM SPSS statistics 22. The environmental and *B. tabaci* population data were statistically analyzed using Pearson's correlation coefficient. Analysis of variance (ANOVA), and comparison between *B. tabaci* population and environmental conditions were made through least significant difference test (LSD at $P<0.05$). Effects of environmental variables (maximum and minimum temperatures, relative humidity, rainfall and wind speed) on *B. tabaci* population were determined by correlation analysis (Steel and Torri, 1997). Environmental variables exhibited significant relationship with *B. tabaci* population was graphically plotted and critical ranges of environmental variables conducive for *B. tabaci* population development were determined.

RESULTS

Effect of environmental conditions on whitefly population

The whitefly population was recorded at one week interval from upper, middle and lower leaves of three selected plants from each variety/line. The data were recorded upto six weeks in both the years (2012 and 2013) during which temperature (maximum and minimum) was increased and RH decreased. Whitefly population increased with increase in temperature (maximum and minimum) and decrease in RH during 2012 and 2013 (Table I).

Correlation of environmental conditions with B. tabaci *population*

A highly significant role was played by temperature (maximum and minimum) in the development of *B. tabaci* population in all five varieties/lines *i.e.*, big beef, caldera, sitara-TS-101, 014276 and salma during two years as depicted by their respective values of correlation coefficients (r) and levels of probability at 5% level of signicance (Table II). The overall correlation of RH was highly significant and negative with *B. tabaci* population on all five varieties during both years. Rainfall and wind speed showed non-significant relationship with *B. tabaci* population on all the five varieties. Minimum average whitefly population was found in variety big beef (3.53) and maximum was in salma (4.88).

Environmental conditions conducive for the development of B. tabaci

The environmental conditions conducive for the development of *B. tabaci* population were

Table. I.- Effect of environmental conditions on whitefly population during 2012 and 2013.

Years	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Rainfall (mm)	Wind speed (Km/h)	Whitefly population Mean ± SEM
2012	39.6	25.3	51.9	0	3.03	1.58±0.09
May-June	40.71	26.53	49.3	0	7.8	2.94±0.08
	42	28.9	47.75	0.5	5.2	3.44±0.25
	42.5	28.9	43	0	6.3	5.65±0.39
	43.3	36.14	42.1	0	7.3	6.5±0.48
	44.14	37	39	6.7	5.85	8.2±0.56
2013	35.81	25.67	51.86	0	4.84	1.6±0.11
May-June	39.86	26.07	45.14	0	8.74	3.0±0.27
	40.11	26.08	43.43	0	6.43	4.18±0.63
	40.29	27.23	29.1	1.51	7.43	5.76±0.61
	42.54	29.02	25.71	2.33	6.3	6.6±0.59
	44.82	30.63	17.14	0	6.61	7.56±0.61

Whiteflies were collected from upper, middle and lower leaves of the plants through aspirator.
Mean whitefly showing 3 samples/plant.
Average Whiteflies population was taken from 3 plants/row.

Table II.- Correlation of environmental conditions with *B. tabaci* population during two years (2012 and 2013).

Varieties/lines	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Rainfall (mm)	Wind speed (Km/h)	Average whitefly population
Big beef	0.857**	0.780**	-0.788**	0.535 NS	0.284 NS	3.53±0.02
	0.000	0.003	0.002	0.073	0.371	
Caldera	0.864**	0.783**	-0.781**	0.538 NS	0.289 NS	3.83±0.22
	0.000	0.003	0.003	0.071	0.362	
Sitara-TS-101	0.873**	0.770**	-0.775**	0.532 NS	0.307 NS	4.64±0.38
	0.000	0.003	0.003	0.075	0.332	
014276	0.887**	0.774**	-0.770**	0.537 NS	0.311 NS	4.72±0.06
	0.000	0.003	0.003	0.072	0.325	
Salma	0.873**	0.771**	-0.767**	0.533 NS	0.291 NS	4.88±0.24
	0.000	0.003	0.004	0.074	0.359	

**, Significant at P = 0.05; NS, Non significant.
Upper values in the table indicate the extent of correlation between environmental variables and whitefly population, whereas lower values indicate the level of probability at $p < 0.05$.

characterized on five tomato varieties *i.e.*, big beef, caldera, sitara-TS-101, 014276 and Salma. All the environmental variables contributed towards the *B. tabaci* population development. There was significantly positive relationship between temperature and *B. tabaci* population. The relationship between RH and *B. tabaci* population was significantly negative. The relationship of *B. tabaci* population was very poor with rainfall and wind speed. The five varieties performed significantly during two years. The maximum temperature ranged from 36 to 45°C during two years. The *B. tabaci* population increased with increase in maximum temperature and linear regression model explained 83 to 91% variability in the *B. tabaci* population development. Highly significant correlation of maximum temperature with *B. tabaci* population was found in case of variety 014276, where it contributed 91% towards *B. tabaci* population development. The minimum temperature which ranged from 25 to 37°C significantly correlated with *B. tabaci* population during two years. The correlation of minimum temperature was best explained by linear regression model as indicated by significant r values. The minimum temperature explained 75 to 85% of the variability in *B. tabaci* population development. The minimum temperature contributed 85% towards *B. tabaci* population development in the case of caldera.

RH had significant influence on *B. tabaci* population and linear regression model explained 78 to 85% variability in *B. tabaci* population development. There was negative correlation *i.e.* as the RH increased the *B. tabaci* population decreased. The maximum influence of RH was observed in the case of big beef where it contributed 85% towards *B. tabaci* population development. Rainfall had no significant influence on *B. tabaci* population and polynomial regression explained 35 to 42% of the variability in *B. tabaci* population development. A linear relationship was not found in case of rainfall with *B. tabaci* population development as indicated by very low r values. The rainfall explained 42% variability in *B. tabaci* population development in case of 014276. The wind speed had non-significant effect in the *B. tabaci* population development and its contribution was very poor. The linear model indicated very low r values. The wind speed exerted maximum influence of about 36% in disease development in the case of 014276.

DISCUSSION

Whitefly (*B. tabaci*) population increased with the increase in temperature and decrease in relative humidity (Table I). Maximum temperature was also significantly correlated with whitefly density in the semi-arid region of Rajisthan, India (Kumhawat *et al*., 2000). This is due to the enhanced developmental activities of the *B. tabaci* with the increase in temperature. The mean development time in days from egg to adult was 37 at 20°C and 20 at 25-30°C. Temperatures of 25°C and 30°C were found to be the most favourable for the development of egg and nymph stages of *B. tabaci* (Darwish *et al*., 2000). The optimum temperature and relative humidity ranged for the buildup of whitefly population was 20-24°C and 46-60%, respectively (Bishnoi *et al*., 1996). Sowing time also affected the whitefly infestation in tomato as *B. tabaci* attacks were more severe during months of high temperature and low RH and rainfall (Rashid *et al*., 2008). Abiotic conditions had significant negative influence on *B. tabaci* population. In case of relative humidity gradient a positive influence was observed (Kaushik, 2012).

The whitefly increased with the rise in minimum temperature and decreased with the increase in the relative humidity, while rainfall and wind speed had no significant relationship with whitefly population in okra (Ali *et al*., 2005). Stepwise regression analysis showed that the influence of air temperature, rainfall and relative humidity was significant on whitefly population in mungbean (Khan *et al*., 2006). Whitefly completed different stages of its development in 20 days at 30°C and in 56 days at 17°C. The functional relationship between the effect of temperature on the population dynamics provides a basis for the development of population models (Bonato *et al*., 2007).

The year wise effect of temperature (maximum and minimum) on whitefly population, was significantly positive and of relative humidity was significantly negative. The relationship between rainfall and whitefly population buildup was significant during both years (2012, 2013) (Table II). These results are in contrast with those of Singh (1990) who found that hot weather with little or no rainfall was conducive for the multiplication of *B. tabaci*. Similarly adult whitefly population declined after rain flashes (Henneberry *et al*., 1995). During rain whitefly eggs and nymphs were reduced (Castle, 2001). High concentration of whitefly was observed with the increase in wind speed because of ease in migration towards the field of host plant. Higher wind speed could be deleterious to the whitefly flight (Pasek, 1988).

REFERENCES

AKTAR, M. M., AKHTER, M. S. AND AKANDA, A. M., 2008. Impact of insecticides and organic oil spray on the growth and yield of tomato under TYLCV infected condition. *Bangladesh Res. Publ. J.,* **1**: 199-205.

ALI, S., KHAN, M. A., HABIB, A., RASHEED, S. AND IFTIKHAR, Y., 2005. Correlation of environmental conditions with okra yellow vein mosaic virus and *Bemisia tabaci* population density. *Int. J. Agric. Biol.,* **7**: 142-144.

BISHNOI, O.P., SINGH, M., RAO, V. U. M., SHARMA, P. D., SINGH, M. AND NIWAZ, R., 1996. Population dynamics of cotton pests in relation to weather parameters. *Indian J. Ent.,* **58**: 103-107.

BONATO, O., LURETTE, A., VIDAL, C. AND FARGUES, J., 2007. Modelling temperature-dependent bionomics of *Bemisia tabaci* (Q-biotype). *Physiol. Ent*., **32**: 50-55.

CASTLE, S. J., 2001. Differences between cotton and melon in host acceptance by *Bemisia tabaci*, Proceedings of the belt wide cotton conference. National Cotton Council, Memphis, TN, pp. 1056-1059.

DALTON, R., 2006. Whitefly infestation: the Christmas invasion. *Nature*, **433**: 898-900.

DARWISH, Y. A., MANNAA, S. H. AND REHMAN, M. A. A., 2000. Effect of constant temperature on the development of egg and nymphal stages of the cotton whitefly, *B. tabaci* (Genn.) (Homoptera; Aleyrodidae) and use of thermal requirements in determining its annual generation number. *Assiut. J. agric. Sci.,* **31**: 207-216.

DE BARRO, P. J., 2008. *Bemisia tabaci*: A top 100 invader. *J. Insect Sci.,* **8**: 16.

DENLINGER, D. L. AND YOCUM, G. D., 1998. Physiology of heat sensitivity. In: *Thermal sensitivity in insects and application in integrated pest management* (eds. G. J. Hallman and D. L. Denlinger), Westview Press, Boulder, Colorado, USA, pp. 11-18.

DENLINGER, D. L. AND LEE, R. E., 2010. *Low temperature biology of insects*. Cambridge University Press, Cambridge, UK.

DELATTE, H., DALMON, A., RIST, D., SOUSTRADE, I., WUSTER, G., LETT, J. M., GOLDBACH, R. W., PETERSCHMITT, M. AND REYNAUD, B., 2003. Tomato yellow leaf curl virus can be acquired and transmitted by *Bemisia tabaci* (Gennadius) from tomato fruit. *Pl. Dis*., **87**: 1297-1300.

FAO, 2011. Statistical Division Database.

FEDER, M. E. AND HOFMANN, G. E., 1999. Heat-shock proteins, molecular chaperones, and the stress response: evolutionary and ecological physiology. *Annu. Rev. Physiol.,* **61**: 243-282.

GHANIM, M. AND CZOSNEK, H., 2000. Tomato yellow leaf curl geminivirus (TYLCV-Is) is transmitted among whiteflies (*Bemisia tabaci*) in a sex-related manner. *J. Virol.,* **74**: 4738-4745.

GOP, 2011. *Economic survey of Pakistan,* Finance and Economic Affairs Division. 2011. Islamabad, pp. 22.

HAIDER, M. S., TAHIR, M., EVANS, A. A. F. AND MARKHAM, P.G., 2007. Coat protein gene sequence analysis of three begomovirus isolates from Pakistan and their affinities with other begomoviruses. *Pakistan J. Zool*., **39**: 165-170.

HENNEBERRY, T. J., HENDRIX, D. H., PERKINS, H. H., NARANJO, S. E., FLINT, H. M., AKEY, D., JECH, L. F. AND BURKE, R. A., 1995. *Bemisia argentifolii* (Homoptera: Aleyrodidae) populations and relationships to sticky cotton and cotton yields. *Southwest. Entomol.,* **20**: 255-271.

KAUSHIK, C., 2012. Incidence and abundance of whitefly, *Bemisia tabaci*, Genn. and the occurrence of tomato yellow leaf curl virus disease (TYLCV) in relation to the climatic conditions of Alipurduar, Jalpaiguri, west Bengal, India. *J. entomol. Res.,* **36**: 35-40.

KHAN, M. A., RASHID, S. AND ALI, S., 2006. Evaluation of multiple regression models based on epidemiological factors to forecast *Bemisia tabaci* and mungbean yellow mosaic virus. *Pak. J. Phytopathol.,* **18**: 107-110.

KUMHAWAT, R. L., PAREEK, B. L. AND MEENA, B.L., 2000. Seasonal incidence of jassid and whitefly on okra and their correlation with abiotic factors. *Annl. Biol.,* **16**: 167-169.

LI, M., JIAN, H., FENG-CHENG, X. AND SHU-SHENG, L.I., 2010. Transmission of tomato yellow leaf curl virus by two invasive biotypes and a Chinese indigenous biotype of the whitefly *Bemisia tabaci*. *Int. J. Pest Manage*., **56**: 275-280.

LIU, S.S., DE BARRO, P.J., XU, J., LUAN, J. B., ZANG, L. S., RUAN, Y. M. AND WAN, F. H., 2007. Asymmetric mating interactions drive widespread invasion and displacement in a whitefly. *Science,* **318**: 1769-1772.

PAN, H., CHU, D., YAN, W., SU, Q. AND LIU, B., 2012. Rapid spread of tomato yellow leaf curl virus in China is aided differentially by two invasive whiteflies. *PLoS One*, **7**: 34817.

PASEK, J. E., 1988. Influence of wind and windbreaks on local dispersal of insects. *Agric. Ecosyst. Environ.,* **23**: 539-554.

RASHID, M. H., HOSSAIN, I., HANNAN, A., UDDIN, S. A. AND HOSSAIN, M. A., 2008. Effect of different dates of planting time on prevalence of tomato yellow leaf curl virus and whitefly of tomato. *J. Soil Nature,* **2**: 01-06.

SINGH, J. S., 1990. Etiology and epidemiology of whitefly transmitted virus disease of okra. *Indian Pl. Dis. Res.,* **5**: 64-70.

STEEL, R.G.D. AND TORRI, J.H., 1997. *Principles and procedures of statistics: A biometrics approach*, 2nd ed. McGraw-Hill, New York.

UCHIBORI, M., HIRATA, A., SUZUKI, M. AND UGAKI, M., 2013. Tomato yellow leaf curl virus accumulates in vesicle-like structures in descending and ascending midgut epithelial cells of the vector whitefly, *Bemisia tabaci*, but not in those of non-vector whitefly *Trialeurodes vaporariorum*. *J. Gen. Pl. Pathol*., **79**: 115-122.

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