Research & Reviews: Journal of Agriculture and Allied Sciences

e-ISSN:2347-226X
p-ISSN:2319-9857

Characterization of Environmental Conditions Conducive for the Development of *Bemisia tabaci* (Genn.) and Tomato Leaf Curl Virus Disease

Muhammad Jahanzaib*, Muhammad Aslam Khan and Sohail Haider

Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan

Research Article

Received date: 25/05/2017

Accepted date: 14/07/2017

Published date: 21/07/2017

***For Correspondence**

Muhammad Jahanzaib,
Department of Plant Pathology,
University of Agriculture, Faisalabad,
Pakistan.

E-mail: jahanzib211@gmail.com

Keywords: Tomato, Whitefly population, Correlation, Epidemiological factors, Regression

ABSTRACT

Tomato Yellow Leaf Curl Virus (TYLCV), a whitefly-vectored begomovirus, is a major limiting factor for tomato production worldwide. Yields of field-grown tomatoes vary considerably under tropical conditions but the main factors that limit yields remain to be identified. Characterization of environmental conditions conducive whitefly population and tomato leaf curl virus disease showed positively significant correlation of temperature with whitefly population and TLCVD while negatively significant correlation with relative humidity. Rain fall and wind speed showed non-significant correlation with whitefly population and disease incidence.

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is an important short duration vegetable crop worldwide which belongs to family Solanaceae. It was originated from the wild plants which were first present in Andean states of Peru and Chile. First of all tomato was cultivated in Mexico then in the mid-6th century it spread to Spanish and Europe [1]. An area of 4.6 million hectare worldwide and 52.3 thousand hectare in Pakistan was cultivated. In 2011, 159 million tonnes worldwide and Pakistan was 529.6 thousand tonnes in Khalid [2]. The high value of tomato fruit is due to its high consumption. Tomato is consumed as fresh fruit as well as its other products form such as tomato juice, tomato ketchup, tomato paste, tomato salad and tomato sauce etc. Tomato is very healthy and nutritional crop because tomato is rich in vitamin A, B and C, amino acid, iron, minerals and phosphorus. Tomato play very important role in bone growth, cell division, upholding surface linings of eyes, regulation of respiratory system and immune system. It is also useful in maintaining bones, capillaries and teeth. Tomato fruit is use as salads, cooked in sauces, soup and meat or fish dishes etc. [3].

The tomato production is badly affected by both biotic and a biotic factors. Numerous destructive diseases of tomato are caused by bacteria, viruses, nematode and fungi reduce the yield and results in monetary loss [4]. Among the viral diseases tomato leaf curl virus disease is most important. TLCV belongs to family Geminiviridae which is transmitted by whitefly (*Bemisia tabaci*). There are reports of 100% yield losses on tomato crops due to epidemics of TLCV related with increase of whiteflies (*B. tabaci*) has been reported. In India there are 21 different types of TLCV found. It was first reported in Middle East region during 1930s and then spread throughout the world [5]. TLCVD is caused by complex group of viruses including TYLCV (tomato yellow leaf curl virus) with ssDNA genome and TLCV (tomato leaf curl virus). In Pakistan, India and Australia region this virus is recognize as TLCV. In Israel and Europe this virus is recognize as TYLCV [6]. TLCVD symptoms comprises decrease in leaf size area, upward curling, stunted growth, puckering of leaflets, vein clearing, abnormal shoot proliferation, deformation of leaf lets, inward and outward leaf curling, bushy appearance, internode reduction and reduction in yield quantity as well as quality by producing small size fruit or no fruit formation at all [7]. The leaflets cupped inward and downward as hook like shaped showing marginal and interveinal chlorosis and yellowing of leaves are most prominent symptoms of TYLCV D plants [8].

Environmental conditions are very important, TLCVD incidence and whitefly population increase with high temperature and wind speed while decrease with humidity and rain fall. The optimum temperature is 25-30°C for whitefly to buildup and rapid replication [9]. The disease predictive model helps to explain the disease epidemics keeping in view the presence of inoculum in a particular area for specific time period and favorable environmental conditions for disease development to forecast disease in future, to decide the future planning, site selection, and implementation of management practices so that crop can protect [10].

The objective of this study was to find the correlation between environmental conditions and whitefly population as well as disease incidence.

MATERIALS AND METHODS

Six tomato varieties (Roma, Naqeeb, Morgal, Nemador, Baby Red and Nagina) were cultivated in the research area of Department of Plant Pathology, University of Agriculture Faisalabad under natural field conditions which were collected from the Vegetable Research Institute, Ayub Agriculture Research Institute (AARI), and Faisalabad. The experiment was sown in 5th march, 2016. Tomato nursery was transferred on raised bed with plant to plant distance 60 cm and row to row distance 75 cm. All agronomic practices were adopted to maximize the results and output. Disease occurred naturally so artificial inoculation was not required. Confirmation of disease was done by graft transmission and vector transmission methods. The graft and vector inoculated plants showed the disease symptoms **(Table 1)**. Observations were noted on weekly basis, and data of disease incidence was recorded with the help of following formula:

$$\text{Disease Incidence} = \frac{\text{Number of Infected leaves on a plant}}{\text{Total number of leaves on a plant}} \times 100$$

The following disease rating scale was used which was developed by Khalid [2].

Table 1. Disease rating scale.

Index	Disease Incidence Scale	Variety Response
1	0%	Immune (I)
2	1-9%	Highly Resistant (HR)
3	10-20 %	Resistant (R)
4	21-35 %	Moderate Resistant (MR)
5	36-50 %	Moderate Susceptible (MS)
6	51-65%	Susceptible (S)
7	66-100%	Highly Susceptible (HS)

EPIDEMIOLOGICAL STUDY

Data regarding disease development and whitefly population were recorded on weekly basis and these were correlated with environmental parameters (maximum temperature, minimum temperature, rainfall, humidity and wind speed). The data of different environment conditions (maximum temperature, minimum temperature, rainfall, relative humidity and wind speed) during the experimental period was collected from the Department of Crop Physiology, University of Agriculture, and Faisalabad. The weekly average of these parameters were calculated and correlated with disease incidence and whitefly population.

STATISTICAL ANALYSIS

The data on the whitefly population and percent plant infection were subjected to statistical analysis using RCBD factorial design. To determine the relation of environment with white fly population and percent plant infection data were subjected to the correlation and regression analysis.

RESULTS

Over All Correlation of Environmental Conditions with Whitefly Population and Disease Incidence during 2016

In overall correlation analysis the effect of environmental variables (Maximum temperature, minimum temperature, relative humidity, rain fall and wind speed) on whitefly population and TLCV disease incidence (%) was determined on five varieties (Roma, Naqeeb, Nagina, Morgal, Baby Red and Nemador). The environmental variables (maximum temperature, minimum temperature and relative humidity) showed significant correlation while rain fall and wind speed showed non-significant correlation with whitefly population and TLCV disease incidence. Maximum and minimum temperature showed positive correlation while relative humidity showed negative correlation with whitefly population and TLCV disease incidence. This overall relationship is explained in **Table 2**.

e-ISSN:2347-226X
p-ISSN:2319-9857

Table 2. Over all correlation of environmental conditions with whitefly population and disease incidence (%) of TLCVD.

	Maximum Temperature	Minimum Temperature	Relative Humidity	Rain Fall	Wind Speed
Whitefly population	0.2821**	0.5597**	-0.4898*	0.1775	0.2789
P value	0.0056	0.0004	0.0424	0.0404	0.0795
Whitefly population	0.2474**	0.4622**	-0.4819*	0.1260	0.3293
P value	0.0057	0.0045	0.0429	0.1339	0.0499

*Significant when P-value <0.05; **Highly significant when P-value <0.01
NS: Non-Significant; when P-value >0.05

Correlation of Environmental Conditions (Maximum Temperature, Minimum Temperature, Relative Humidity, Rain Fall and Wind Speed) with Whitefly Population on Tomato Crop during 2016

Correlation of environmental variables (maximum temperature, minimum temperature, relative humidity, rain fall and wind speed) with whitefly population was determined for six varieties (Roma, Naqeeb, Morgal, Nemador, Baby Red and Nagina). The environmental variables (maximum, minimum temperature and relative humidity) showed the significant correlation with whitefly population while the other variables (rain fall and wind speed) showed non-significant correlation with whitefly population. Maximum and minimum temperature showed positive correlation while relative humidity showed negative correlation with whitefly population. Rain fall and wind speed showed non-significant correlation with whitefly as shown in **Table 3**.

Table 3. Correlation of environmental conditions with whitefly population of TLCVD.

Varieties	Max Temp	Min Temp	RH	Rainfall	Wind Speed
Roma	0.0872** 0.0089	0.3428* 0.0459	-0.6838* 0.0341	0.1561 0.0667	0.2790 0.0493
Naqeeb	0.4742* 0.0342	0.8229* 0.0443	-0.7940* 0.0493	0.2481 0.1355	0.2033 0.0069
Morgal	0.2006* 0.0371	0.6191* 0.0019	-0.7191* 0.0172	0.1046 0.0437	0.4924 0.1321
Nemador	0.5848* 0.0228	0.9228** 0.0087	-0.6817* 0.0358	0.4865 0.1237	0.6537 0.0652
Baby Red	0.4118* 0.0172	0.7561* 0.0280	-0.6512* 0.0413	0.2963 0.0986	0.5290 0.0285
Nagina	0.4982* 0.0314	0.8170* 0.0472	-0.6227* 0.0168	0.4021 0.0529	0.5848 0.1228

Upper values indicated Pearson's correlation coefficient; Lower values indicated level of significance at 5% probability
*Significant when P-value <0.05; **Highly significant when P-value <0.01
NS: Non-Significant; when P-value >0.05

Correlation of Environmental Conditions (Maximum Temperature, Minimum Temperature, Relative Humidity, Rain Fall and Wind Speed) with Disease Incidence on Tomato Crop during 2016

Correlation of environmental variables (maximum temperature, minimum temperature, relative humidity, rain fall and wind speed) with disease incidence was determined for six varieties (Roma, Naqeeb, Morgal, Nemador, Baby Red and Nagina). The environmental variables (maximum, minimum temperature and relative humidity) showed the significant correlation with disease incidence while the other variables (rain fall and wind speed) showed non-significant correlation with whitefly population. Maximum and minimum temperature showed positive correlation while relative humidity showed negative correlation with disease incidence as shown in **Table 4**.

Table 4. Correlation of environmental conditions with disease incidence (%) of TLCV.

Varieties	Max Temp	Min Temp	RH	Rainfall	Wind Speed
Roma	0.6474* 0.0146	0.9481* 0.0040	-0.7113* 0.0113	-0.3343 0.0173	0.3985 0.1339
Naqeeb	0.6476* 0.0144	0.9218** 0.0089	-0.6925* 0.0273	-0.2917 0.0748	0.2731 0.0663
Morgal	0.4900* 0.0238	0.8523* 0.0311	-0.7659* 0.0458	-0.2119 0.0478	0.3708 0.0462
Nemador	0.3249* 0.0298	0.7219* 0.0153	-0.7309** 0.0089	-0.2206 0.0467	0.4797 0.0656
Baby Red	0.4508* 0.0396	0.8207 0.0454*	-0.7623* 0.0481	-0.2007 0.1307	0.3729 0.0466
Nagina	0.5058* 0.0360	0.8465* 0.0335	-0.6955* 0.0122	-0.3486 0.0493	0.4869 0.1274

Upper values indicated Pearson's correlation coefficient; Lower values indicated level of significance at 5% probability
*Significant when P-value <0.05; **Highly significant when P-value <0.01
NS: Non-Significant; when P-value >0.05

Environmental conditions play an important role in the spread and development of TLCVD incidence and whitefly population. Data of whitefly population and disease incidence was recorded on weekly basis and the means were correlated with environmental conditions (maximum temperature, minimum temperature, relative humidity, rain fall and wind speed). Significant effect of environmental conditions on whitefly population and disease incidence was revealed. There was positively significant effect of maximum and minimum temperature on whitefly population and disease incidence. But relative humidity showed negatively significant effect on disease incidence and whitefly population. The maximum temperature was positively correlated with whitefly population and disease incidence showing that disease incidence increased as maximum temperature increased. The correlation of minimum temperature with disease incidence was also positive i.e., disease incidence increased with the increase in minimum temperature. The correlation of relative humidity with disease incidence was negative indicating that disease incidence decreased as the mean relative humidity increased. The correlation of rainfall and wind speed with whitefly population and disease incidence of TLCV was non-significant. Whitefly population decreased with the increase in relative humidity and rainfall. But wind speed had no effect on the population of whitefly; it only helps in spread of viruliferous whiteflies.

The results revealed in correlation of environmental conditions with disease incidence and whitefly population matched with [11] who also found the similar relationship of environmental conditions with disease incidence and whitefly population. Environmental conditions conducive for TLCVD development and whitefly population density were determined. The overall correlation of maximum and minimum temperature with TLCVD and whitefly population was positive while the relationship of relative humidity was negative with TLCVD and whitefly population. Similar results of correlation of environmental condition s with TLCVD and whitefly population was found by Hussain [12].

TLCVD incidence and whitefly population was high during the month of high temperature and low relative humidity and rain fall. These results matched with Kumawat et al. [13] who found a good correlation between TYLCVD incidence and whitefly population at higher temperature. The temperatures of 25-30°C were found most favorable for the development of egg and nymph stage of whitefly. Similarly the optimum temperature for juvenile development was 32.5˚C [14].

The results in respect of whitefly population were also in accordance with the results which reported that rain having the negative effects on whitefly population adult whitefly populations decline after a rain incident. The results of experiment were matched with the results of Gerling et al. [15] who stated that relative humidity affects whitefly development because highest relative humidity is unfavorable for development of whitefly. Likewise the results with respect to the whitefly distribution or dispersion were in accordance with the findings of Isaacs et al. [16] who stated that wind direction and wind speed influence long distance and trivial migrations of whitefly, because whitefly are capable of sustaining flights more than 2 hours and into head winds up to 30 cm/s.

CONCLUSION

It is concluded that positive significant correlation of maximum and minimum temperature with disease incidence and whitefly population showed that increase in temperature increased the disease incidence and whitefly population. Negative significant correlation of relative humidity showed that increase in relative humidity and rain fall decreased the disease incidence and whitefly population.

REFERENCES

1. Glick E, et al. The viral etiology of tomato yellow leaf curl disease. Plant Prot Sci. 2009;45:81-97.
2. Khalid M. Present status and prospects of tomatoes in Pakistan. J Agric Sci. 2013;32:51-58.
3. PAR. Present status and prospects of tomatoes in Pakistan: a report in Agric Corner. 2016.
4. Rivard CL and Louws FJ. Grafting to manage soil-borne diseases in heirloom tomato production. Hort Sci. 2014;43:2104-2111.
5. Lefeuvre P, et al. The spread of tomato yellow leaf curl virus from the Middle East to the world. PLoS Path. 2015;6:1-11.
6. Fauquet C and Stanley J. Revising the way we conceive and name viruses below the species level: A review of geminivirus taxonomy calls for new standardized isolate descriptors. Arch Virol. 2015;150:2151-2179.
7. Díaz-Pendón JA, et al. Tomato yellow leaf curl viruses: Ménage à trois between the virus complex, the plant and the whitefly vector. Mol Plant Pathol. 2016;11:441-450.
8. Zhang YP, et al. Molecular identification and complete nucleotide sequence of TLCV isolate from Shanghai of China. Virus Genes. 2014;36:547-551.
9. Tiwari SP, et al. Whitefly-a strong transmitter of plant viruses. Int J Phytopath. 2013;2:102-120.
10. Naerstad R, et al. Exploiting host resistance to reduce the use of fungicides to control potato late blight. Plant Pathol. 2015;56:156-166.
11. Zeshan MA. A disease predictive model for the management of *Bemisia tabaci* (Genn.) population and tomato leaf curl virus disease incidence. PhD Dissertation University of Agriculture, Faisalabad, Pakistan. 2015;96.

e-ISSN:2347-226X
p-ISSN:2319-9857

12. Hussain MD. Impact of acetamaprid, imidacloprid and diafenthiuron on *Bemisia tabaci* and tomato leaf curl virus disease incidence. M. Phil. Thesis, University of Agriculture Faisalabad Pakistan. 2015;35.

13. Kumawat R, et al. Seasonal incidence of jassid and whitefly on okra and their correlation with abiotic factors. Annals Bio. (Ind). 2000.

14. Bonato O, et al. Modelling temperature-dependent bionomics of *Bemisia tabaci* (q-biotype). Physiol Ent. 2013;32:50-55.

15. Gerling D, et al. Autecology of *Bemisia tabaci*. Agric Eco Envioron. 1986; 17:5-19.

16. Isaacs, et al. The Spread of tomato yellow leaf curl virus from the Middle East to the world. Plos Pathog. 2013;6:1-12.