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INFLUENCE OF ENVIRONMENTAL CONDITIONS ON TOMATO MOSAIC VIRUS DISEASE DEVELOPMENT UNDER NATURAL CONDITION

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A B S T R A C T

Tomato (*Lycopersicon esculentum* L.) Karst crop in Pakistan is confronted with a number of biotic and environment stresses due to which crop yield remained far lower than the potential. Tomato mosaic virus (ToMV) has attained the status of the second biggest threat to tomato production after tomato yellow leaf curl virus. To handle this problem, a study was conducted in 2008-09 in which three lines/varieties (Money maker, VRI-5 and VRI-29) were sown for screening against ToMV. Money maker, VRI-29 and VRI-5 indicated the HS (Highly Susceptible), S (Susceptible) and MS (Moderately Susceptible) disease response respectively. The disease response of these lines/varieties were correlated with the data of environmental factors (temperature, relative humidity, wind speed and rainfall). Disease severity of ToMV increased on these lines/varieties, with increase in temperature from 20 ºC to 31 ºC, as indicated by r values 0.91, 0.97 and 0.94 of linear regression analysis, respectively. There was negative correlation of relative humidity to ToMV disease development, as the relative humidity increase from 55 to 70 %, as indicated by r values 0.91, 0.89 and 0.75, respectively.

Keywords: Tomato, *Lycopersicon esculentum* L., ToMV, disease development.

INTRODUCTION

Importance of vegetables in human nutrition has long been recognized and they are important commodities in developing countries suffering from malnutrition. Pakistan produces over nine million tons of fruit and vegetables (Anonymous, 2008). Tomato crop in Pakistan is confronted with a number of biotic and environment stresses due to which crop yield remained far lower than its potential. Among these, diseases of viral nature are of great importance because no viricides are available for their management. More than 20 viruses are known to infect tomato around the world and losses up to 20-90% by different viruses have been reported (Hameed, 1995). At least seven viral diseases are known to be present in Pakistan; tomato mosaic virus (ToMV), tomato leaf curl virus (TLCV), potato virus X (PVX), cucumber mosaic virus (CMV), tomato yellow top virus (TYTV), tomato spotted wilt virus (TSWV) and tomato ring spot virus (TRSV) (Mughal, 1985). Among the prevalent viruses, tomato mosaic virus is the most important and commonly associated with tomato crop and is distributed throughout Pakistan (Khan, 1997). Tomato mosaic tobamovirus (ToMV) is a stable and wide-spread RNA virus that infects plant species (Hollings and Huttinga 1976), it generally causes mosaic and leaf curling on leaves, uneven ripening and internal browning or brown wall on fruits of certain varieties. Tomato mosaic virus (ToMV), which is distinguished from TMV by its ability to produce local necrotic lesions in *Nicotiana tabacum* var. White Burley and N. sylvestris (Green and Kim, 1991). ToMV strains include those, which cause corky ring, crusty fruit, yellow streak and aucuba symptoms (Kang *et al*., 1981; Jones *et al*., 1991). ToMV was tentatively identified on the basis of symptoms developed in the infected plants. An average incidence of 29.79 and 25.49% of ToMV was recorded in tomato leaves and seeds, respectively (Khan, 1997). The disease is caused by a tobamovirus; not assigned to a family. Virions consist of a capsid. Virus capsid is not

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enveloped. Capsid/nucleocapsid is elongated with helical symmetry. The capsid is rod-shaped, straight with a clear modal length with a length of 300 nm and a width of 18 nm. Virus is not transmitted by a vector. Virus is transmitted by mechanical inoculation; transmitted by grafting; transmitted by contact between hosts; transmitted by seeds (Buchen-Osmond, 2003).Tomato mosaic virus tobamovirus provokes a serious disease in tomato plants especially in yield of infected susceptible cultivars can be reduced by up to 25%. In spite of existing resistant varieties, susceptible cultivars are commonly cultivated. Apart from resistant varieties, an alternative mean of protection should be sought to resolve the ToMV problem faced by tomato growers (Eraslan *et al*., 2007). Environmental factors play an important role in the development and spread of disease. To forecast the disease, study of epidemiological factors influencing disease development is required. So, keeping in view conducive environmental conditions management practices could be applied to manage the disease. Varieties response differently to disease some are susceptible whereas others show resistance or tolerance. Check of response will be helpful in the selection of germplasm that has resistance against ToMV.

MATERIALS AND METHODS

Plant material: Seeds of three tomato lines/varieties (Money maker, VRI-29 and VRI-5.) were obtained from the vegetable section Ayub Agricultural Research Institute, Faisalabad.

Nursery sowing and its transplantation: The seeds of these lines/varieties were sown in one small plot (1 m^2) to raise tomato nursery. After 40 days the tomato seedling were uprooted and transferred in field in the research area of Department of Plant Pathology, University of Agriculture, Faisalabad. The experiment was run in Randomized Complete Block Design (RCBD) with three replications. Each variety was planted in a sub-plot with row length 3 m, row to row 60 cm and plant to plant spacing 30 cm respectively. The conventional agronomic practices were performed to maintain plants.

Transmission Studies

Mechanical transmission: Transmission of virus through mechanically inoculation was carried out following the procedure described by using S.M Mughal method. (Mughal and Khan 2006). ToMV was mechanically inoculated to the tomato plants 21 days after seedling transplantation. Virus inoculum was prepared from middle trifoliate leaves taken from naturally-infected tomato plants at the six trifoliate stages showing the symptoms of ToMV. The leaves were ground in 0.02 M sodium phosphate buffer (pH 7.0) in pestle and mortar. The homogenate was filtered through two layers of muslin cloth. Carborundum powder was dusted on the leaves of healthy test plants and then inoculum was applied on the leaves with a cotton swab. The inoculated plants were observed for the appearance of characteristics mosaic symptoms.

Confirmation of ToMV through indicator plants: Indicator plant Pigweed (*Chenopodium amaranticolor*) was used for the confirmation of ToMV. Leaves from disease tomato plants supposedly showing the symptoms of ToMV were ground in 0.02M sodium phosphate buffer (pH 7.0) in pestle and mortar. The homogenate was filtered through two layers of muslin cloth. Carborundum powder was dusted on the leaves of healthy test plants and then inoculum was applied on the leaves with a cotton swab. ToMV was confirmed by the appearance of characteristics symptoms on these plants (Eraslan *et al*., 2007).

Varietal screening: The data on ToMV disease severity were taken according to the following disease severity scale published by (Bashir *et al*., 2005). The disease incidence was determined by using the following formula.

$$Disease\ incidence = \frac{No.\ of\ infected\ plants}{Total\ no.of\ plants} \times 100$$

Table 1. Disease rating scale for ToMV (Bashir and Zubair, 2005).

Disease severity Index	Percentage(%) infection	Host reaction
0	All plant free of virus symptoms.	HR (Highly Resistant)
1	1-10% infection	R (Resistant)
2	11-20% infection	MR (Moderately Resistant)
3	21-30% infection	MS(Moderately Susceptible)
4	30-50% infection	S (Susceptible)
5	More than 50% infection	HS (Highly Susceptible)

Environmental Data: The data of different environmental factors (maximum temperature, minimum temperature, relative humidity, rainfall and wind speed) during the experimental period was obtained from the Department of Crop Physiology, University of Agriculture, and Faisalabad and the weekly averages of these parameters were calculated and correlated with disease severity following the procedure described by (Steel *et al*., 1997).

RESULTS

Money maker, VRI-29 and VRI-5 indicated the HS (Highly Susceptible), S (Susceptible) and MS (Moderately Susceptible) disease response respectively. The disease response of these lines/varieties was correlated with the data of environmental factors (temperature, relative humidity, wind speed and rainfall). Disease severity of ToMV increased on these lines/varieties, with increase in temperature from 20 ºC to 31 ºC, as indicated by r values 0.91, 0.97 and 0.94 of linear regression analysis, respectively. There was negative correlation of relative humidity to ToMV disease development, as the relative humidity increase from 55 to 70 %, as indicated by r values 0.91, 0.89 and 0.75, respectively.

Table: 2 Reaction of tomato lines/varieties to ToMV

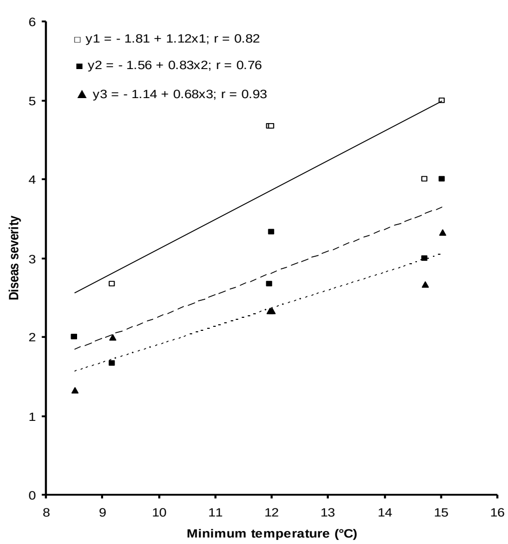
Lines/ varieties	Disease severity grade	Percent plant infection				Resistance/susceptibility level
		R1	R2	R3	Mean	
VRI-5	3	30	29.5	28	29.16	MS
VRI-29	4	46.5	49	52	49.16	S
Money Maker	5	82	78.5	80.5	80.33	HS

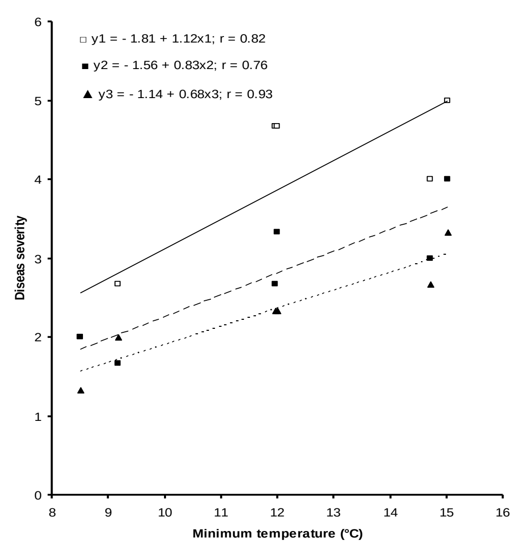
(P>0.05).

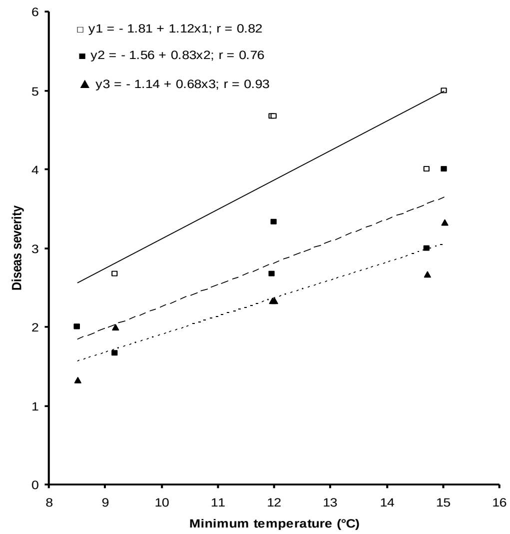
Table: 3 Correlation matrix among different environmental variables.

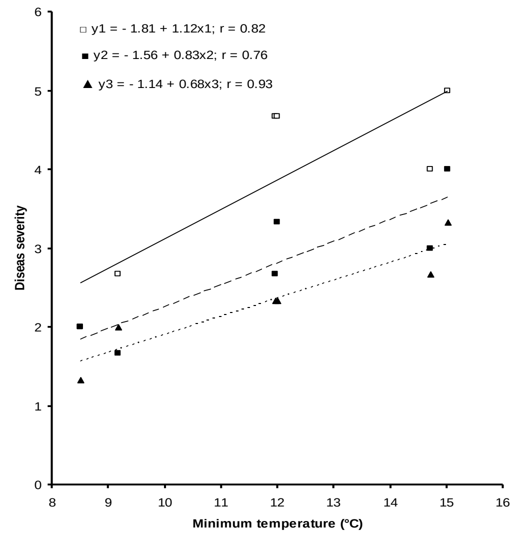
Sr. No.	Lines/ Varieties	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	Wind speed (km/h)
		Maximum	Minimum			
1	Money maker	0.910*	0.824*	-0.910*	-0.453	-0.912*
		0.012	0.044	0.012	0.367	0.011
2	VRI-5	0.971**	0.872*	-0.888*	-0.593	-0.839*
		0.001	0.023	0.018	0.214	0.037
3	VRI-29	0.937**	0.927**	-0.865*	-0.157	-0.618
		0.006	0.008	0.026	0.766	0.191

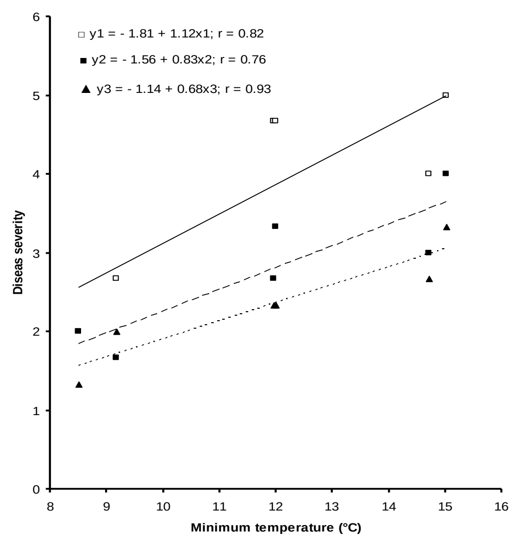
Upper values indicated Pearson's correlation coefficient, Lower values indicated level of significance at 5% probability, * = Significant (P<0.05); ** = Highly significant (P<0.01).











Relationship between maximum (Fig 1), minimum temperature (Fig 2), relative humidity (Fig 3), rainfall (Fig 4) and wind speed (Fig 5) with tomato mosaic virus (disease severity) recorded on (◇) Money maker (y1), (■) VRI-5 (y2) and (▲) VRI-29 (y3), respectively.

DISCUSSION

The result of screening of these three lines/ varieties of tomato (Money maker, VRI-29 and VRI-5.) indicated the HS (Highly Susceptible), S (Susceptible) and MS (Moderately Susceptible) disease response against Tomato mosaic virus respectively (Table 2). The disease data collected from the above experiments were correlated with the data of different environmental conditions (maximum, minimum temperature; relative humidity and rainfall) obtained during the growth period of the crop and analyzed using appropriate statistical procedure (Table 3) (Steel *et al.*, 1997). The correlation of temperature with disease severity for all the varieties was highly significant. Increase in temperature from 20 ºC to 31 ºC was found positively correlated with the severity of disease and it was explained by linear regression as indicated by r values 0.91, 0.97 and 0.94 for the three lines/varieties (Fig. 1). Similarly (Fig. 2) it is clear that with the increase in minimum temperature from 10 ºC to 16 ºC the disease severity also increased as explained by r values 0.82, 0.76 and 0.93 through linear regression. Change in relative humidity also influenced the disease severity on three lines/varieties as the relative humidity increase from 55 to 70 percent disease severity decrease (Fig. 3). The correlation was negatively significant as indicated by r values 0.91, 0.89 and 0.75. The relationship of disease severity with rain fall is described in Figure 4. From the figure it is clear that with increase in rain fall disease severity on all varieties decreased. The correlation of rainfall with ToMV disease severity was negatively non significant as indicated by r value -0.45, -0.59 and -0.16. The relationship of disease severity with wind speed is described (Fig. 5). The correlation of wind speed with ToMV disease severity was negative, i.e. disease severity decreased with increase in wind speed. It was suggested that temperature and relative humidity are the most critical factors in ToMV disease development. These results were in accordance with the finding of (Hassan *et al*., 1993) who studied the epidemiology of tomato viruses. Similarly (Tomlinson 2008) studied epidemiological factors which determine virus infection of vegetable crops. (Howles 1948) also studied the relation between susceptibility to virus infection of mild tobacco mosaic virus and atmospheric humidity. The rate of transpiration did not appear to influence the severity of virus symptoms but the effect of rate of multiplication of the virus, the rate of symptom development is greater in the turgid plant. (Schuerger 1995) studied effect of temperature on disease development of tomato mosaic virus in sweet or hot pepper (*Capsicum annuum* L.) and noted that severity of foliar systemic symptoms and rate of disease development were greatest in foliar inoculated pepper plant at 24^{0}C. A simple positive significant correlation between MYMV disease incidence, temperature, relative humidity, rainfall and number of rainy days was reported (Nath, 1994). (Murugesan *et al.,* 1977) conducted simple correlation and regression analysis of yellow mosaic disease with weather factors. They revealed a positive correlation of disease incidence at 45 days old crop with maximum temperatures. Similarly (Broadbent *et al*., 2008) studied the epidemiology of tomato mosaic. Tomato plants were easily infected with tomato mosaic virus by contact. ToMV persisted for over three years in a dark enclosed space, but was inactivated within a few weeks in daylight.

CONCLUSION

From the present study it was concluded that temperature and relative humidity have positive whereas wind speed and rainfall had statistically non-significant correlation with ToMV. Rise in minimum temperature was conducive for disease development. These finding can be used to develop a disease forecasting model to manage disease economically.

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