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Effect of climate change on tomato leaf curl virus (ToLCV) disease in tomato

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The interrelationship between the environments and plant diseases has been there from last over two thousand years but the close relationship between the environment and disease suggested that climate change will cause modifications in the current phytosanitary scenario in each region (Chakraborty and Pangga 2004). Tomato is one of the most popular and widely grown vegetable in the world (Ara *et al.* 2009, Zdravkovic *et al.* 2011) and suffering from both biotic and abiotic stresses. Among the biotic stresses, *tomato leaf curl virus* disease (ToLCV) is transmitted by a vector whitefly (*Bemisia tabaci*), which has been first ranked among tomato diseases (Singh *et al.* 2010, Singh *et al.* 2013). Symptom of ToLCV has been encountered in many tomato fields in India and caused most devastating problem for its cultivation all over the world, e.g. 23% in Nigeria, 50% in Sudan, 55-90% in Spain, 63% in Lebanon, 90% in India, 100% in Mediterranean (Maruthi *et al.* 2003). Epidemiological studies indicated that maximum incidence of ToLCV in the semi-tropical climatic zone of Egypt recorded during beginning of spring and early summer (February-April), when tomato plants have just established (Maruthi *et al.* 2003). However, in Tanzania, both ToLCV symptoms and whitefly vector were reported during November to February (Nono-Womdim *et al.* 1996).

The incidence of *tomato leaf curl virus* disease was recorded high in rainy season rather than winter season crop in all tomato growing states of India (Banerjee and Kalloo 1989). Due to climate change, it was observed that the incidence pattern has been changed. The present investigation was carried out with a objective, to see the impact of climate change on *tomato leaf curl virus* disease and stability of resistance in tomato genotypes.

The present study was conducted on 83 morphologically diverse tomato genotypes (Table 1) were grown at Indian Institute of Vegetable Research, Varanasi for three years (2007-08, 2008-09 and 2009-10) in both rainy (June-October) and winter (November-March) seasons. Twenty one days old seedlings of all genotypes were transplanted in complete randomized block design with three replications consisting 20 plants in each replication at spacing of 60 cm (row to row) and 45 cm (plant to plant) and repeated planting of susceptible tomato variety Punjab Chhuhara after every 10 rows. Raising good crops, all standard agronomical practices were followed without application of any fungicides and insecticides. For seeing effect of climate on ToLCV disease, periodically temperature, humidity and rainfall were also recorded during years of experimentation and correlated with disease incidence. The disease was scored on a 0–5 scale with some modifications (Banerjee and Kalloo 1987). Stability analysis was done for ToLCV disease as suggested by Eberhart and Russell (1966) with various stability parameters to get the individual genotype response entry on the environmental index.

Fig. 1, showed effect of environment on *tomato leaf curl virus* (ToLCV) disease incidence indicated positive

Table 1 Eighty three genotypes of tomato (*Solanum lycopersicum*) used in the study

Genotypes (83)	Species
ALT 97-94, ALT 97-94-1, BT 11-3-2, BT 20-2-1, BT 20-2-2, DVRT 2-1, EC 32481, EC 519730, EC 519731-1, EC 519769, F 3303-1, F 4002-1, F 4002-2, F 4012-1, F 4036-1, F 4036-2, F 4047-1, F 4047-2, F 4049-1, F 5013-1, F 5013-2, F 5013-3, F 5013-4, F 5020-1, F 5025-1, F 5051-1, F 5053-1, F 5070-1, F 5070-2, F 5070-3, F 6004-1, F 6010-1, F 6010-2, F 6012-1, F 6012-2, F 6016-1, F 6021, F 6022-1, F 6024-1, F 6030-1, F 6050-1, F 6059-1, F 6059-2, F 6061-1, F 6102-1, F 6109-1, F 7001-1, F 7011-1, F 7012-1, F 7012-2, F 7025-1, F 7028-1, F 7028-2, F 7045-1, FEB 4-2, H 86-3, HAT 118-1, HAT 122-1, LA 3772-1, LA 3772-2, LA 3940-1, LA 3941-1, LA 3969, LA 3997-1, LA 4012, LA 4036-1, LA 4040-1, LA 4040-2, LA 4055-1, LA 4055-2, LA 4055-1, LA 4055-2, NDTVR 60, TLH 17-1, TLH 27-1, TLH 30-1, VRT 5-1, VRT 35-1, VRT 35-2, VRT 40-1, VRT 40-2, VRT 41-1 and VRT 43-1	*Solanum lycopersicum*

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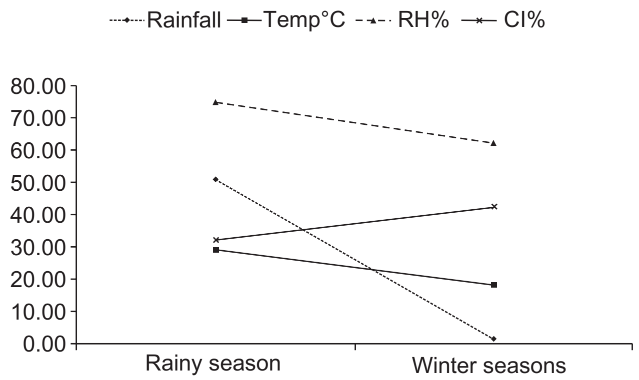

Fig 1 Response of rainfall, average of maximum and minimum temperature, relative humidity on coefficient of infection (CI%) for ToLCV disease under field condition during rainy and winter season of 2007-2010.

relationship with CI% and climatic factors (temperature, rainfall and humidity). In rainy season for three years (2007-2010), average rainfall was 75.50 mm, minimum and maximum temperature ranged from 24.86°C to 40.00°C, respectively with relative humidity of 74.82% and CI (%) of ToLCV disease was reached on 32.5%. Whereas, in winter season, rainfall was minimum and static on 1.78mm, minimum and maximum temperature ranged from 7.14°C to 28.70°C, respectively coupled with 62.39% relative humidity and CI (%) of ToLCV disease increased and reached up to 42.62%. In present investigation, ToLCV disease incidence increased in winter season (October-February) than rainy season (July-September) grown crop. This may be population of vector whiteflies did not survived and multiplied in rainy season due to high temperature whereas, winter season was more favourable for faster multiplication of whitefly population. Konet *et al.* (2008) found that the whitefly population was more in December to February when the temperature was low. In agreement of this study the both whitefly and disease pressure was more in *rabi* season (Singh *et al.* 2013). Whereas, the role of *B. tabaci* population size in relation to ToLCV incidence has also been recorded by Cohen and Antignus (1994) in the Jordan Valley. In semi-tropical climatic zone of Egypt, it was recorded that in beginning of spring and early summer (February-April), when tomato plants have just established. However, in Tanzania, ToLCV disease incidence was very low but its peak of symptoms and whitefly population occurred between the first week of September to Mid-October and November to February when minimum and maximum temperature ranged from 15^0C to 32.5^0C, respectively (Nono-Womdim *et al.* 1996). Therefore, it was also recorded disease incidence was more in winter season transplanted crop than rainy season at eastern part of Uttar Pradesh in Varanasi, India which support our findings (Singh *et al.* 2010, 2013).

Table 2 and 3 reveal response of tomato genotypes to ToLCV incidence during rainy season 2007-08 as 0 highly resistant, 3 resistant and 14 genotypes moderately resistant while 49, 12 and 5 were moderately susceptible, susceptible and highly susceptible, respectively. But in winter season none of genotypes was found highly resistant and resistant, only 6 were moderately resistant, while moderately susceptible, susceptible and highly susceptible were 39, 25 and 13, respectively. Whereas, in the year, 2008-2009, no genotype was highly resistant in both rainy and winter seasons. While, tomato genotypes in both rainy and winter seasons were 3 and 0 resistant, 16 and 7 moderately resistant, 42 and 38 moderately susceptible, 17 and 31 susceptible and 5 and 7 highly susceptible, respectively. Similar results were found in year, 2009-2010, none genotype showed highly resistant reaction during both rainy and winter seasons. The disease reaction of tomato genotypes in rainy season was 4 resistant and 8 moderately resistant while 45, 20 and 5 genotypes were moderately susceptible, susceptible and highly susceptible, respectively. But in winter season, none of genotypes was found resistant, only 3 were moderately resistant, whereas moderately susceptible, susceptible and highly susceptible were 27, 34 and 19, respectively. However, in response of these three years 2007-08, 2008-09 and 2009-10, resistant genotypes were more in rainy season (3, 3 and 4) than winter season (0) indicating more disease pressure in winter season than rainy season (Table 2). On the basis of overall mean of

Table 2 Number of tomato genotypes showed ToLCV disease reaction on (0-5%) in both rainy and winter seasons for three years (2007-2010)

Reaction of ToLCV disease (CI %)	Number of tomato genotypes used for screening under open field (Natural) condition — Year, period and seasons						Number of genotypes according to overall mean of CI %
	2007-2008		2008-2009		2009-2010		
	June- Oct Rainy Season	Nov-March Winter Season	June- Oct Rainy Season	Nov-March Winter Season	June- Oct Rainy Season	Nov-March Winter Season	
Highly resistant (0-5%)	0	0	0	0	0	0	0
Resistant (5.1-12%)	3	0	3	0	4	0	0
Moderately resistant (12.1-25%)	14	6	16	7	8	3	6
Moderately susceptible (25.1-50%)	49	39	42	38	45	27	49
Susceptible (50.1-75%)	12	25	17	31	20	34	24
Highly susceptible (75.1-100%)	5	13	5	7	5	19	4

Table 3 Stability analysis of six tomato genotypes against ToLCV disease and environmental interaction

Variety	Mean (X)	ßi	S²Di
EC 519730	5.4000	1.170	–0.0377
F 6021	4.3611	2.353	0.7202**
F 6050-1	5.2611	2.377	0.5879**
LA 3969	4.1111	–1.505	–0.0027
LA 4012	4.6000	0.305	3.3123**
LA 4040-1	4.7778	1.300	–0.0400
Total		6.000	

Population mean: 4.7519, Std. err. mean: 0.6314, Bi mean: 1.0000, Std.err. bi: 1.1343.

three years data, out of 83 genotypes no genotype recorded as highly resistant or resistant to ToLCV disease (Table 2). However, six genotypes, viz. EC 519730, F 6021, F 6050-1, LA 3969, LA 4012 and LA 4040-1 expressed moderately resistant disease reaction with CI % ranged from 12.3% to 16.2%. Most of the genotypes were found in category of moderately susceptible, susceptible, and highly susceptible disease reaction, it may be due to changing of viral strain and not stable to any genotypes for ToLCV resistance (Singh *et al.* 2010, 2013). A classical example is that H 24 line of tomato is being used as donor parent for resistance to ToLCV in many parts of the world but today this line has become moderately resistant and susceptible may be due to climate change (Singh *et al.* 2010, 2013).

Stability analysis for ToLCV resistant genotypes in resilient climates in each favourable and unfavourable environment as presented in Table 3. This results revealed that the stability estimates of mean (x), deviation from regression (sd^2) and regression coefficient (b) indicated that EC 519730, F 6021, F 6050-1, LA 3969, LA 4012 and LA 4040-1 showed average response were less than 1 (b<1) or more (b>1). Hence, these genotypes exhibited lowest disease incidence indicating stable and adaptive genotypes. Out of six moderately resistant genotypes, three EC 519730, LA 3969 and LA 4040-1 exhibited low for b<1 as well as non-significant of both sd^2 and b values and stable in each environment which can be successfully grown in each leaf curl virus infested area. Similar study states that the low disease incidence with less than one regression value showed good stability in each environment for tomato genotypes (Singh *et al.* 2013).

SUMMARY

Eighty three genetically diverse genotypes of tomato screened in field condition to know the effect of climate change on *tomato leaf curl virus* (ToLCV) disease. Among genotypes, EC 519730, F 6021, F 6050-1, LA 3969, LA 4012 and LA 4040-1 were scaled as moderately resistant reaction. It was also concluded that ToLCV incidence was more in winter season (November to March) than rainy season (June-October) grown crop and only thee genotypes, EC 519730, LA 3969 and LA 4040-1 were stable as moderately resistant in both rainy and winter seasons and could be utilized freely in breeding purposes and can be grown in any ToLCV infested area.

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