

Correlation of Environmental Conditions with Potato Virus X (PVX) and Y (PVY) Disease Severities Recorded on 21 Advance Lines/Varieties of Potato (*Solanum tuberosum* L.)

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ABSTRACT

Potato virus X (PVX) and Y (PVY) disease severities had significant correlation with maximum and minimum temperatures, relative humidity and pan evaporation. PVX had non-significant correlations with wind direction, while PVY with clouds, wind velocity and wind direction. Out of the twenty one lines, none of the variety had significant correlation with clouds, wind velocity and wind direction for the causation of PVX and PVY. Eighteen and six varieties, 18 and four, 18 and one, 18 and three varieties had negative, significant but negative significant and positive significant but negative correlations with maximum temperature (15-31°C), minimum temperature (5-13°C), relative humidity (72-88%) and pan evaporation (0.5-2.8 mm), respectively with PVX and PVY.

Key Words: Potato; Potato virus X; Potato virus Y; Environment

INTRODUCTION

Potato (*Solanum tuberosum* L.) occupies a prominent position among vegetable crops consumed by human beings due to high production, good nutritional value and better quality of the starch. Deposite of growing three crops as spring, summer and autumn crops, in Pakistan, the average yield of potato is 10417 kg ha⁻¹ (Govt. of Pakistan, 2001) which is very low as compared to other countries of world (U.S.A, Ireland and India etc.). Among several factors responsible for the low potato production, potato diseases like early and late blights, potato scab, blackscurf and viral diseases i.e. potato virus X (PVX), potato virus Y (PVY) and potato leaf roll virus (PLRV) are most important. PVX is distributed throughout potato growing areas of Pakistan ranging infection between 1.5-6.2% being more in Punjab, even imported seeds have shown 0.7-30% infections indicating the continuous introduction of PVX in the country (Hussain, 1980). Disease incidence of PVY in potato ranges between 5-25% in Pakistan (Mughal *et al.*, 1988) and it can destroy the whole crop if it occurs along with PVX and PVS. Currently, none of the available high yielding commercial varieties/advance lines has shown durable resistance against these diseases (Qamar *et al.*, 2003). This is mainly due to the presence of disease virulence of these viruses (Ahmad & Ahmad, 1995), continuous introductions of the viruses through imported seeds, recurrent occurrence of the carrier/vector of these diseases i.e. aphid (*Myzus persicae* Schulz), non availability of chemical substances for directly controlling viral diseases of plants in the field. In order to manage the diseases, sowing of moderately resistant variety with enough knowledge of correlation of environmental conditions for

these diseases is the valid option as environmental conditions play a crucial role in the development of these viral diseases in epidemic form. Determination of conducive environmental conditions may help in forecasting of these diseases. The objective of these studies was to investigate the correlation of weekly environmental conditions with PVX and PVY disease severities recorded on 21 advance lines/varieties.

MATERIALS AND METHODS

Establishment of potato germplasm nursery under field conditions. PVX and PVY disease screening nursery comprising of 21 advanced lines/varieties was established in the research area of Department of Plant Pathology, University of Agriculture Faisalabad, during winter season 2001-02. The tubers of these advanced lines/ varieties were obtained from the vegetable section of Ayub Agricultural Research Institute (AARI) Faisalabad. These varieties/lines were sown at 30 cm plant to plant and 60 cm row-to-row distance. The nursery was watered by surface irrigation at regular intervals throughout the season. First irrigation was applied immediately after sowing and then after one-week intervals. Irrigation stopped 15 days before harvesting. Well-rotted FYM at 30 t ha⁻¹ was incorporated into the soil three to four weeks before planting. Fertilizers were applied according to the following ratio (Malik, 1995).

N= 250 kg/ha, P= 125 kg/ha, K= 125 kg/ha

Establishment of potato germplasm nursery in green house. Twenty one varieties, which were planted in the field, were also planted in green house. There were two plants in one pot and each variety was planted in three pots. Plants of two pots were used for inoculation while in the

other pot, these were kept as positive control. Similarly there were three pots of each variety to be treated against PVY. In this case one pot was inoculated with PVY, other was kept as positive control, while the third one was placed in a wooden cage covered with muslin cloth and it was used for the study of aphid transmission of PVY. These varieties/lines were kept in good condition following recommended agronomic practices. Disease severity data was collected on weekly basis following the disease rating scale designed by Mughal and Khan (2001).

Procedure for sap inoculation. The young infected tissue showing primary symptoms of PVX were used for inoculation. The procedure was as follows:

- 1- The leaves with severe disease symptom of PVX and PVY collected from the field were crushed in sterilized pestle and mortar, preferably in chilled 0.05 M phosphate buffer (normally used at 1 g mL^{-1} , till a fine homogenate was obtained. This sap was filtered through cheese cloth.
- 2- Leaves of the test plants were dusted with Carborundum powder (600 mesh) using aspirator.
- 3- Leaves of tested plants were held in the left palm and plant sap inoculum applied gently with forefinger of right hand covered with gloves.
- 4- Each plant was labeled with date, time and name of the virus inoculated.
- 5- The inoculated plants were rinsed off with water immediately after inoculation.
- 6- These plants were kept under observation for a month to see the disease symptoms.

Confirmation of PVX and PVY on indicator plants. These varieties/ lines showing symptoms of PVX and PVY was tagged and from these varieties/ lines mechanical inoculation was done on indicator plants such as *Nicotiana tabacum* and *Datura stramonium* for PVX and *Physalis floridana* and *Nicotiana glutinosa* for PVY.

For the confirmation of PVX, indicator plants were divided into two sets; one set was sap inoculated, the other was kept as positive control.

For the confirmation of PVY indicator plants were divided into three sets; one set was inoculated from the sap of leaves of varieties/lines having the symptoms of PVY; other set/ second was kept as positive control, while the third set was placed in an isolated wooden chamber and aphids collected from PVY disease affected plants were

released on such indicator plants.

Data recording and analysis. Scales designed by Mughal and Khan (2001)

a) For Disease severity of PVX

0 = No visible symptom, 1 = Mild mottling on the upper leaves, 2 = Interveinal mosaic symptoms on more than one leaves, 3 = Mosaic symptoms on all leaves, 4 = Distinct mosaic symptoms on all leaves with slight stunting and necrosis, 5 = All above symptoms and small number of sized tubers

For PVY

0= No symptoms

1(a) Blackening and banding of veins on few leaves,

(b) Mosaic starting on all leaves.

2(a) Blackening and banding of veins on all leaves, (b) Narrowing of leaves, (c) Venial necrosis severe mosaic, (d) Leaf crinkling.

3 = Rugosity and leaf drop streak, dwarfing

4 = Lower leaves dead, drooping, collapse of plants with very small tubers

Level of resistance/susceptibility

0= Immune, 1= Resistant, 2= Moderately Resistant, 3= Moderately Susceptible, 4= Susceptible

RESULTS AND DISCUSSION

Overall correlation of environmental conditions, with varieties, potato virus X and potato virus Y. Potato virus X disease severity had significant correlation with maximum and minimum air temperature, relative humidity, clouds, wind velocity and pan evaporation and had non-significant correlation with wind direction. Potato virus Y disease severity had significant correlation with maximum and minimum air temperature, relative humidity and pan evaporation and had non-significant correlation with clouds, wind velocity and wind direction (Table I).

Correlation of environmental conditions with potato virus X disease severity. The correlation of bi-weekly maximum and minimum air temperature, relative humidity, clouds, wind velocity, pan evaporation and wind direction with potato virus X disease severity was determined at variety level (Table I). None of the variety had significant correlation with clouds, wind velocity and wind direction. Eighteen varieties i.e. 394038-37, 9620, Sante, Desiree,

Table I. Overall correlation of varieties/lines, PVX, PVY disease severities with environmental factors

Dependant variables	Air Temperature Max.°C Min. °C		Relative humidity (%age)	Clouds (Octa)	Wind velocity (Km/hr)	Pan evaporation (mm)	Wind direction A (Direction from north)	Wind direction B (Direction from north)
Variety	-0.00008	-0.00009	0.00009	0.00002	0.00003	-0.00008	-0.00004 *	-0.00003
	0.9941	0.9825	0.9936	0.9831	0.9919	0.9727	0.9924	0.9826
PVX	-0.53015	* -0.55596 *	0.50017 *	0.18301 *	0.22555 *	-0.55390 *	-0.20476	-0.06159
	0.0021	0.0139	0.0028	0.0018	0.0016	0.0023	0.0038	0.0842
PVY	-0.12904	* -0.13247 *	0.09354 *	0.03625	0.02010	-0.13348 *	-0.05669	-0.01733
	0.0028	0.0036	0.0019	0.3127	0.5721	0.0127	0.1134	0.6343

Upper values indicate Pearsons Correlation Coefficients; Lower values in a column indicate level of probability; *=Significant at $P = 0.05$

394029-129, 391202-13, Diamont, 394017-45, 394033-82, FSD-Red, 394001-167, 394038-57, TPS-9801, Kiran, 394016-112, SH-5, 9804 and 392486-69 had negative correlation with maximum temperature. During disease rating period maximum temperature varied between 15 to 31°C. Eighteen varieties i.e. 394038-37, 9620, Sante, Desiree, 394029-129, 391202-13, Diamont, 394017-45, 394033-82, FSD-Red, 394001-167, 394038-57, TPS-9801, Kiran, 394016-112, SH-5, 9804 and 392486-69 had significant but negative correlation with minimum temperature. During disease rating period minimum temperature varied between 5 to 13°C. Eighteen varieties i.e. 9620, 394038-37, Sante, Desiree, 394029-129, 391202-13, Diamont, 394017-45, 394033-82, FSD-Red, 394001-167, 394038-57, TPS-9801, Kiran, 394016-112, SH-5, 9804 and 392486-69 had significant and positive correlation with

relative humidity. During disease rating period relative humidity varied between 72 to 88%. Eighteen varieties i.e. 394038-37, 9620, Sante, Desiree, 394029-129, 391202-13, Diamont, 394017-45, 394033-82, FSD-Red, 394001-167, 394038-57, TPS-9801, Kiran, 394016-112, SH-5, 9804 and 392486-69 had significant but negative correlation with pan evaporation. During disease rating period pan evaporation varied between 0.5 to 2.8 mm.

Among the environmental factors, temperature played a critical role in the development of the disease on these varieties/advance lines. At maximum temperature ranging from 15-20°C, the disease severity of PVX increased and when temperature increased above 28°C, the disease severity decreased. Maximum disease severity was found between 25-28°C temperature. Zaklukiewicz (1983) treated potato plants infected with potato virus X, M, and S at 37°C

Table II. Correlation of environmental conditions with potato virus X disease severity recorded on twenty one varieties/lines of potato

Name of potato variety/line	Temperature Max. °C Min. °C		Relative humidity(%)	Clouds (Octa)	Wind velocity (Km/hr)	Pan evaporation (mm)	Wind direction A (Direction from north)	Wind direction B (Direction from south)
394038-37	-- 0.68420*	-- 0.69447*	0.69798*	0.25314	0.53765	-- 0.73138*	-- 0.38211	-- 0.14929
	0.0413	0.0321	0.0325	0.5118	0.1312	0.0221	0.3122	0.7026
9620	-- 0.68420*	-- 0.69447*	0.69798*	0.25314	0.53765	-- 0.73138*	-- 0.38211	-- 0.14929
	0.0431	0.0323	0.0311	0.5117	0.1328	0.0222	0.3125	0.7024
Sante	-- 0.72010*	-- 0.77725*	0.72560*	0.30730	0.38415	-- 0.73752*	-- 0.30797	-- 0.16609
	0.0241	0.0147	0.0242	0.4244	0.3041	0.0246	0.4221	0.6621
394038-10	-- 0.00285	-- 0.15601	-- 0.48392	-- 0.93379*	-- 0.21134	0.09212	-- 0.30248	0.11106
	0.09 14	0.6816	0.1811	0.0017	0.5819	0.8125	0.4224	0.7729
Desiree	-- 0.80504*	-- 0.80559*	0.78503*	0.42359	0.22877	-- 0.85961*	-- 0.11396	0.04677
	0.0328	0.0214	0.0641	0.3721	0.2736	0.0325	0.5036	0.8131
394029-129	-- 0.83831*	-- 0.84387*	0.83315*	0.38668	0.41298	-- 0.89554*	-- 0.26391	-- 0.04755
	0.0036	0.0025	0.0028	0.3019	0.2625	0.0017	0.4925	0.9028
391202-13	-- 0.84953*	-- 0.90117*	0.66619	0.13524	0.17070	-- 0.87540*	-- 0.22095	0.08632
	0.0028	0.0032	0.0536	0.7227	0.6611	0.0025	0.5614	0.8236
394021-64	-- 0.53134	-- 0.59775	0.63581	0.16744	0.22028	-- 0.55326	-- 0.29001	-- 0.22839
	0.1412	0.0815	0.0627	0.6626	0.5622	0.1223	0.4421	0.5548
Diamont	-- 0.84953*	-- 0.90117*	0.72560*	0.13524	0.17070	-- 0.87540*	-- 0.22095	0.08632
	0.0014	0.0023	0.0528	0.7231	0.6618	0.0013	0.5632	0.8242
394017-45	-- 0.67715*	-- 0.71486*	0.73499*	0.23679	0.43912	-- 0.71691*	-- 0.37500	-- 0.20076
	0.0425	0.0326	0.0235	0.5341	0.2318	0.0238	0.3215	0.6039
394033-82	-- 0.79265*	-- 0.81289*	0.75008*	0.40202	0.33568	-- 0.82775*	-- 0.19255	-- 0.02046
	0.0128	0.0026	0.01	0.28	0.37	0.00	0.6113	0.9524
FSD-Red	-- 0.69206*	-- 0.73081*	0.72560*	0.33488	0.41130	-- 0.70275*	-- 0.25413	-- 0.08907
	0.0319	0.0243	0.0628	0.3733	0.2738	0.0328	0.5027	0.8143
394001-167	-- 0.67715*	-- 0.71486*	0.73499*	0.23679	0.43912	-- 0.71691*	-- 0.37500	-- 0.20076
	0.0428	0.0338	0.0229	0.5339	0.2347	0.0228	0.3246	0.60
394038-57	-- 0.82783*	-- 0.85870*	0.86125*	0.38413	0.26704	-- 0.87748*	-- 0.21574	-- 0.07086
	0.0025	0.0031	0.0025	0.3038	0.4839	0.0029	0.6125	0.9516
TPS-9801	-- 0.72010*	-- 0.77725*	0.72560*	0.30371	0.38415	-- 0.73752*	-- 0.30797	0.16609
	0.0234	0.0238	0.0124	0.0239	0.4224	0.3011	0.0213	0.66
Kiran	-- 0.82239*	-- 0.87776*	0.78627*	-- 0.20588	-- 0.00496	-- 0.90671*	-- 0.36759	-- 0.03298
	0.0036	0.0028	0.0539	0.5935	0.9824	0.0028	0.3328	0.9328
394016-112	-- 0.84953*	-- 0.90117*	0.66619*	0.13524	0.17070	-- 0.87540*	-- 0.22095	0.08632
	0.0021	0.0024	0.0528	0.7234	0.6626	0.0036	0.5729	0.8517
SH-5	-- 0.68420*	-- 0.69477*	0.69798*	0.25314	0.53765	-- 0.73138*	-- 0.38211	-- 0.14929
	0.0423	0.0316	0.0325	0.5135	0.1326	0.0214	0.3135	0.7038
9804	-- 0.80692*	-- 0.81873*	0.55055*	0.24439	0.20623	-- 0.81170*	-- 0.35510	-- 0.15569
	0.0025	0.0025	0.1255	0.5253	0.5944	0.00	0.3428	0.6828
9803	-- 0.52371	-- 0.49744	0.47925	0.19258	0.53575	-- 0.58492	-- 0.26511	0.00243
	0.1828	0.2036	0.2235	0.6486	0.1738	0.1225	0.5227	0.9939
392486-69	-- 0.68420*	-- 0.69447*	0.69798*	0.25314	0.53765	-- 0.73138*	-- 0.38211	-- 0.14929
	0.0427	0.0328	0.0323	0.5165	0.1335	0.0224	0.3118	0.7028

Upper values indicate Pearsons Correlation Coefficient; Lower values in a column indicate level of probability; * = Significant at P = 0.05

Table III. Correlation of environmental conditions with potato virus Y disease severity recorded on six varieties/lines of potato

Number of jassids on potato variety/line	Temperature		Relative humidity (%age)	Clouds (Octa)	Wind velocity (Km/hr)	Pan evaporation (mm)	Wind direction A (Direction from north)	Wind direction B (Direction from north)
	Max. °C	Min. °C						
TPS-9801	-0.69206*	-0.73081*	0.63039	0.33488	0.41130	-0.70275 *	-0.25413	-0.08907
	0.0321	0.0223	0.0643	0.3776	0.2723	0.0312	0.5051	0.8138
	-0.66353*	-0.62279	0.26123	0.05355	-0.10077	-0.64214	-0.34138	-0.17501
9804	0.0535	0.0725	0.4956	0.8945	0.7913	0.0613	0.3623	0.6556
	-0.80504*	-0.80559*	0.78503 *	0.42359	0.22877	-0.85961*	-0.11396	0.04677
391202-103	0.0021	0.0023	0.0134	0.2556	0.5519	0.0046	0.7735	0.9054
	-0.69204*	-0.73076*	0.63039	0.33488	0.41130	-0.70275 *	-0.25413	-0.08907
394017-45	0.0318	0.0229	0.0675	0.3758	0.2735	0.0345	0.5042	0.8123
	0.66353*	0.62279	0.26123	0.05355	-0.10077	-0.64214	-0.34138	-0.17501
9620	0.0527	0.0739	0.4956	0.8996	0.7839	0.0634	0.3615	0.6523
	-0.67770*	-0.77989*	0.40904	-0.06440	-0.25036	-0.77667 *	-0.56210	-0.11051
394029-129	0.0427	0.0139	0.2736	0.8635	0.5163	0.0115	0.1136	0.7723

Upper values indicate Pearsons Correlation Coefficient; Lower values in a column indicate level of probability; * = Significant at P = 0.05

and observed that nearly all meristems samples from heat-treated plants were virus free. It indicates the direct role of temperature for the causation of this disease. Temperature also influences the population of Aphid (*Myzus persicae*) which is the sole carrier of this disease. Mirza *et al.* (1982). Similarly when minimum temperature raised from 5°C to 13°C disease severity of PVX was also increased. All the varieties showed increasing trend of disease severity of PVX as the minimum temperature raised from 5-13°C. Relative humidity significantly correlated with the diseases. It is due to the critical role of humidity as Wislocka (1982) reported that incidence of PVY was maximum under dry conditions after inoculation with PVY than that growing under optimum conditions. Similarly pan evaporation also correlated significantly while wind velocity, wind direction and clouds correlated these diseases non significant.

Correlation of environmental conditions with potato virus Y disease severity. The correlation of bi-weekly maximum and minimum air temperature, relative humidity, clouds, wind velocity, pan evaporation and wind direction with potato virus X disease severity was determined at variety level. None of the variety had significant correlation with clouds, wind velocity and wind direction (Table.3). Six varieties i.e. TPS-9801, 391202-103, 394017-45, 9804, 9620 and 394029-129 had significant but negative correlation with maximum temperature (15-31°C). Four varieties i.e TPS-9801, 391202-103, 394017-45 and 9620 had significant but negative correlation with minimum temperature (5-13°C). Only one variety i.e. TPS-9801 had significant and positive correlation with relative humidity (72-88%). Three varieties i.e. TPS-9801, 394029-129, 394017-45, had significant but negative correlation with pan evaporation (0.5-2.8 mm). TPS-9801 had non-significant correlation with relative humidity, clouds, wind velocity and wind direction. TPS-9804 had non-significant correlation with minimum air temperature, relative humidity, clouds, wind velocity, pan evaporation and wind direction. The line 391202-103 had non-significant correlation with clouds, wind velocity and wind direction. The line 394017-45 had

non-significant correlation with relative humidity, clouds, wind velocity and wind direction. TPS-9620 had non-significant correlation with minimum air temperature, relative humidity, clouds, wind velocity, pan evaporation and wind direction. 394029-129 had non-significant correlation with minimum air temperature, relative humidity, clouds, wind velocity, pan evaporation and wind direction.

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(Received 13 February 2003; Accepted 26 March 2003)