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ORIGINAL ARTICLE

Effects of meteorological variables on potato leaf roll virus and potato virus y infections on different potato varieties under natural and mulched conditions

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Abstract
After rice and wheat, potatoes are the third most important staple crop in Pakistan, but due to various virus diseases attacks, yield remains very low. Among viral pathogens, potato leaf roll virus (PLRV) and potato virus Y (PVY) are the most destructive viruses present in all potato-growing areas. A field experiment was conducted at the Research Farm of Plant Virology Section, Ayub Agricultural Research Institute, Faisalabad, to evaluate the effects of meteorological variables on the development of virus infections (PLRV and PVY) on different potato varieties under natural and mulched conditions. Results indicated that the development of infections of PVY and PLRV was delayed in different potato varieties under mulched conditions. The potato variety Simply Red had the highest PLRV and PVY disease incidences under unmulched and mulched circumstances, while Sahiwal Red and Ruby had the lowest infection rates. The least PVY disease incidence was noted under mulched conditions on FD-81-1. Mulched conditions were better in the reduction of diseases than unmulched conditions. The average high temperature (HT) ranged from 21.9 ˚C to 27 ˚C was most favorable for the development of PLRV and PVY on all six tested potato varieties in both conditions. The average low temperature (LT) ranged from 8 ˚C to 15 ˚C was favorable for the progression of PLRV and PVY diseases in both conditions. The relative humidity (RH) range of 50-60% was conducive for the development of PLRV and PVY diseases. It is concluded that mulching application is an essential tool to enhance the yield of potato crops by reducing their specific diseases.

KEYWORDS: Potato varieties, meteorological variables, virus diseases, PLRV, PVY

1. INTRODUCTION

In tropical and subtropical regions of the world, the potato (*Solanum tuberosum* L.), is farmed as a highly nutritious diet containing 79% of it is water, 18% starch, 2% protein, and 1% vitamins, minerals, and trace elements (Dereje and Chibuzo, 2021). In

Pakistan, potato is cultivated in an area of 15403 thousand hectares with a production of 2539.0 thousand tons. It is an important vegetable for low-income countries like Pakistan and three seasons of potato crop growing during spring (Feb-April), summer (May-Aug), and autumn (Oct-Jan) are cultivated as the climatic conditions of Pakistan are ideal for its production**.** The areas of central Punjab province (Okara, Pakpattan, Sahiwal, Gujranwala) and Gilgit Baltistan (GB) are the principal potato-producing regions (Ismail *et al*., 2020). The output of potatoes in Pakistan is, however, somewhat low when compared to other potato growing countries due to biotic and abiotic stress (Iftikhar *et al*., 2020).

More than 50 viruses affect potatoes in the fields (Kreuze *et al*., 2020) , and the potato viruses PVY and PLRV are the most significant viruses based on distribution, pathogenic variability, and quantitative yield loss (Palukaitis, 2012). Different species of aphids acts as vector for the transmission of these viruses. In many potato fields, the presence of multiple virus species in one plant frequently results in significant yield losses (Zhang *et al*., 2001); however, PVY and PLRV effects have been reported to vary depending on the potato variety, with high economic losses in potato varieties lacking resistance (Syller and Grupa, 2014). Potato leaf roll virus is the most significant virus and results in significant losses (90%) in vulnerable types (Mubeen *et al*., 2020). The PLRV belongs to the genus *Polerovirus* and family *Solemoviridae*, with a positive sense single-stranded RNA genome size of 5.2-5.7 kb (Ahouee *et al*., 2010). The symptoms of PLRV include upper leaf rolling during primary infection and lower leaf rolling during secondary infection, as well as young buds that are yellow and purple, erect growth, and plant stunting. Due to the PLRV's high occurrence, it became an emerging disease in Pakistan (Batool *et al*., 2011). The 5th most dangerous plant virus, PVY, belongs to the family *Potyviridae* and contains an economically vital group of plant viruses (Bhoi *et al*., 2022). Worldwide and in Pakistan damages are up to 85% when the crop is developed from infected tubers (Thomas-Sharma *et al*., 2016). Common symptoms produced by PVY are mosaic, leaf drop streak, necrotic lesions rugose mosaic. Environmental factors such as temperature, relative humidity, etc., play dynamic roles in disease incidence as well as in vector populations (Mubeen *et al*., 2017).

Mulching is a fundamental agronomic exercise that alters the physical environment of the soil by reducing weed growth, preserving soil moisture, and enhancing soil fertility (Yang *et al*., 2003). The mulching materials could be organic as well as inorganic. The organic materials include straw, husk, cover crops, etc., while inorganic mulches include black or silver plastic (Iqbal *et al*., 2020). Application of mulch was found to improve emergence, tubers per plant, and yield (Dhakal *et al*., 2011). Therefore, the present experiment was conducted primarily to assess how meteorological variables affect the growth of virus infections (PLRV and PVY) on several potato cultivars in unmulched and mulched environments and secondly to assess the effect mulching application on virus infections (PLRV and PVY) and thirdly to find out the genetic behavior of potato varieties against virus infections.

2. METHODOLOGY

Experimental site

The experiment was laid at the Research Farm of the Plant Virology Section in Agricultural Research Institute Faisalabad (31.4022386, 73.0479517) during the winter of years 2022-23. The texture of the experimental soil was sandy loam with an average pH of 6.5-6.7.

Plant materials

The six potato varieties (FD-35-36, Ruby, FD-81-1, Simply Red, Sahiwal Red, and Sahiwal White) were selected having various genetic make ups for resistance against the PLRV and PVY diseases. The potato germplasm was collected from the Potato Research Institute, Sahiwal (District) Pakistan. Healthy potato tubers of all five varieties were selected for cultivation.

Experimental design and treatment details

Sowing of potato tubers was done in 1st week of November during the year 2022 and the experiment was laid out in Randomized Complete Block Design (RCBD) with 4 replications. The 6 potato varieties were cultivated on beds having a distance Bed × Bed 75 cm and Plant × Plant 20 cm. Each bed for each replication of each potato variety was 4 m long. The mulched and unmulched conditions were provided to all six potato varieties in each replication. The rice straws were used as mulching material. The mulching layer was 4 inches thick. All recommended agronomic practices were adopted to maintain the growth and health of potato plants. No insecticide was sprayed to enhance the aphid's activity for the spread of both viruses.

Disease data observation

The data regarding *PLRV* and *PVY* disease incidences were recorded at two-week intervals according to the slightly self-modified formula (Ismail *et al*., 2020).

$$\text{Percent Disease Incidence} = \frac{\text{No. of Infected Plants}}{\text{Total No. of Plants}} \times 100$$

Meteorological data observation

The meteorological data including high and low temperatures, relative humidity (%), and rainfall (mm) was obtained from the Regional Agromet Center, AARI, Faisalabad. The trends of percent incidences of PLRV and PVY diseases were noted along with the trends of meteorological variables.

Statistical analysis

The disease data of PLRV and PVY was analyzed through the statistical software Gentstat (10th Edition) for analysis of variance (Montgomery, D.C. 2005 and George and Mallery, 2019) and graphs were built using the Microsoft Excel Program.

3. RESULTS AND DISCUSSION

Correlation of mulching with diseases incidences

The mulched conditions were less conducive for the development of PLRV and PVY diseases as shown in Figures 2 and 4 respectively. Under un-mulched and mulched conditions, maximum PLRV and PVY disease incidences were recorded on potato variety Simply Red. The minimum PLRV incidence was recorded on potato variety Sahiwal Red in un-mulched and on potato variety Ruby in mulched environments. Without mulching application, the symptoms of PVY appeared on potato varieties FD-35-36, Ruby, FD-81-1, and Simply Red, during the 1st week of January and on potato varieties Sahiwal Red and Sahiwal White during the 2nd week of January 2023 as depicted in Figure 3. Under mulched conditions, the PVY disease symptoms appeared early on FD-35-36 and Simply Red (during the 3rd week of January) and late on other potato varieties (FD-81-1, Ruby, Sahiwal Red, and Sahiwal White) during the 3rd week of February as depicted in Figure 4. Minimum PVY disease incidence was recorded under mulched conditions on FD-81-1.

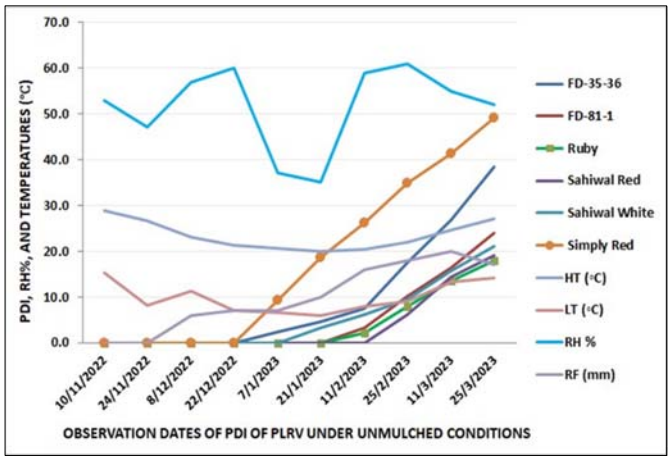

Figure 1. *Trends of PDI of PLRV on six potato varieties having no mulching (NM) along with meteorological variables.*

These results are closely equivalent to the Doring *et al*., (2005) which demonstrated that seed potatoes grown organically with straw mulch have a reduction in viral occurrence. Another study reported that small to moderate levels of straw mulch (around 3.5-5 t ha^{1}) reliably lower aphid infestation and the incidence of PVY in potatoes (Saucke and Döring, 2004). Many scientists reported that mulching also reduces the infection level of PLRV (Fereres 2000; Boiteau *et al*., 2009; Dupuis *et al*., 2010; Kirchner *et al*., 2014).

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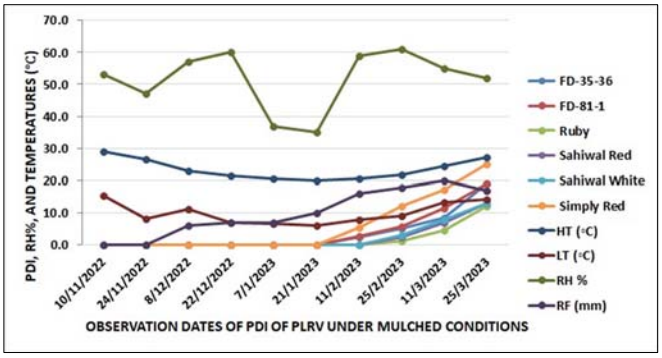

Figure 2. *Trends of PDI of PLRV on six potato varieties having mulching applications (MA) along with meteorological variables.*

To provide early warning of the disease emergence, it is crucial to measure the association between the incidence of disease and epidemiological variables because environmental factors significantly influence the growth of infections on any crop. The present study indicated that high temperature (HT) ranging from 21.9 °C to 27 °C was most favorable for the development of PLRV and PVY on all six tested potato varieties in both conditions. The average Low Temperature (LT) ranged from 8 °C to 15 °C was favorable for the progression of PLRV and PVY diseases in both conditions. The relative humidity (RH) range of 50 to 60% was conducive for the development of PLRV and PVY diseases.

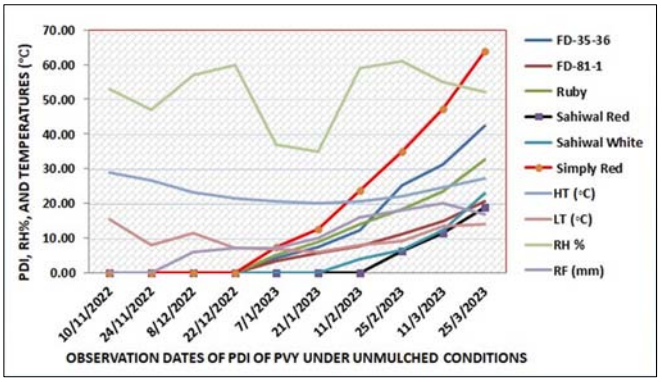

Figure 3. *Trends of PDI of PVY on six potato varieties having no mulching application (NM) along with meteorological variables.*

The noteworthy correlation of temperature with virus disease incidence can be enlightened by the fact that it has a major role in different phases of disease development. It has been noted that viral disease symptoms were postponed at low temperatures in numerous plants (Patel and Parmar 2023). The relationships between plants and pathogens are influenced by temperature and high temperatures can either boost or reduce disease resistance (Szittya *et al.*, 2003). At a greater temperature, virus resistance was reduced in plants.

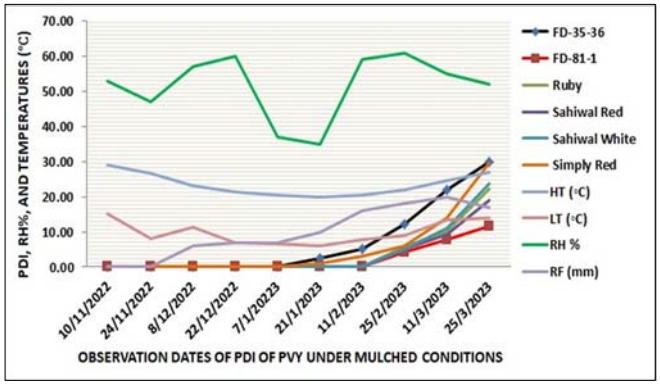

Figure 4. *Trends of PDI of PVY on six potato varieties having no mulching application (MA) along with meteorological variables.*

The minimum temperature of 5-18.5 °C, maximum temperature of 19.1-34.4 °C, rainfall (3-5 mm), and relative humidity (35-85%) contributed significantly to PLRV disease development (Ali *et al.*, 2022). Two genotypes of potatoes were selected to investigate the association between climatic factors (temperatures, relative humidity, and rainfall) and viral diseases of potatoes (Kumar *et al.*, 2011). It was observed in year 2008-09, minimum temperatures (7.3-10.3 ^{0}C) and high temperatures (27.1-23.3 °C) with minimum relative humidity levels (51-53%) and maximum relative humidity levels (93.6 and 92.7%) encourage disease, while in the year (2009-10) minimum temperature (4.8-7.6 °C), maximum temperature (23.42-17.0 °C) with minimum relative humidity (45.85-71.57%) and maximum relative humidity from (87.71-90.71%) resulted in high disease incidence.

Author Contributions

M Iqbal conceptualized, designed, executed, and analyzed the study. B Ishfaq proofread and improved the manuscript. R Kalsoom wrote the manuscript. A Mustafa participated in the execution of experiments. MI Ul-Hassan analyzed the data. All

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authors have read and agreed to the published version of the manuscript.

Data Availability Statement

All data is available and present in the publication.

Conflict of Interest

The authors declare no conflict of interest.

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