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Status of Potato Viruses and Temporal Dynamics of Potato Viral Diseases in Bhagalpur District of Bihar

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ABSTRACT: The viral diseases are a major threats in potato cultivations and mostly spread by vectors. Vectors population highly influenced by the weather parameters. So, the study of viral diseases along with temporal dynamics of vector population give a clear understanding of epidemiology of viral diseases. Therefore, research was conducted to evaluate the potato virus incidence with relation to vector population and weather parameter in Bhagalpur district. In this survey mosaic, leaf roll and leaf curl diseases were commonly found to be infecting potato crop. The highest incidence of leaf roll (16.9 %), mosaic (12.4 %) and curl (8.9 %) were recorded at Kahalgaon block. Among the observed viral diseases recorded in the district, maximum incidence was found for leaf roll diseases. In order to assess the temporal dynamic of potato viral diseases, periodic observation of disease was recorded along with vector population. An exponential increase of mosaic was recorded between first to last week of January. Maximum increment of leaf roll was observed during last week of December to first week of February. Moreover, a positive correlation was recorded between aphid population with mosaic and leaf roll diseases. The multiple regression analysis showed that the diseases were influenced by all the observed weather variables and vectors e.g., PLRV R^2 0.83, mosaic R^2 = 0.85 and leaf curl R^2 = 0.09. The overall findings of the present study will be helpful to develop disease management module. Government agencies should impose domestic quarantine to potato viruses particularly tuber borne virus in state. The information generated under regression analysis would be helpful to understand the epidemiology of disease.

Keywords: Potato virus, Incidence, PLRV, Vector population, Epidemiology.

INTRODUCTION

In the field, potato (*Solanum tuberosum* L.) is infected frequently with several viruses during a growing season (McDonald, 1984), which leads to reduced yield and quality of tubers. Among the most common viruses affecting potato crops are: Potato leaf roll virus (PLRV, genus Polerovirus), Potato virus X (PVX, genus Potexvirus), Potato virus A and Potato virus Y (PVA, PVY, both genus Potyviruses), Potato virus S (PVS, genus Carlavirus) and leaf curl virus (Kumar *et al.*, 2023). These viruses can occur in single or as mixed infections within the potato crop. Potato is native of Peru, South America and is believed to be introduced in India by Portuguese travelers during 17th century. Its production ranks fourth in the world followed by rice, wheat and maize Devaux *et al.* (2014). In India, Bihar has the major potato growing area after Uttar Pradesh and west Bengal. It has high production potential and superior nutritional quality, therefore it may be a useful tool for fighting hunger and malnutrition in a developing countries like India. Considering the raising demands, it is needed to study the strategic model to understanding the virus epidemiology for the management of virus. As a result enhances higher production, quality, processing and consumption markets. Although several factors like biotic and abiotic stresses are considered for be a constraint to productivity (Burman *et al.*, 2007), out of which late blight followed by viruses is most important. Moreover, pest is indirectly responsible for infestation of various diseases on potato. India's tropical and humid climate also favours the development and infestation of different insect and pest (Landge *et al.*, 2021). Viral diseases greatly hampered the potato cultivation globally. The potato leaf roll virus spread through tubers and aphid species. Moreover, whitefly transmitted geminiviruses e.g., leaf curl viruses also causing severe curling and stunted growth. The spread of these diseases either by insect vector or tuber make it more devastating in nature. They occur abundantly in the warm and humid climatic condition during the cultivation, thus increase the chances of the spread of infection and reducing quality production (Schoen *et al.*, 2004). Scientific research on the biology of virus and the interactions with insect vector provided the

current countermeasures against diseases. The present research was undertaken to develop the information of virus prevalence in the potato growing areas, this leads significant step in adequate time management and safeguarding potato crop. Development and implementation of an effective virus control strategy based on the cropping system is one of the ways in which yield losses associated with viruses can be reduced (Islam *et al.*, 2017). This study was therefore conducted to identify gaps in farmers' perceptions and practices in relation to potato virus control and to suggest aspects of virus control in order of priority for implementation.

MATERIALS AND METHOD

A roving survey was conducted at farmer's field of major potato growing areas such as Goradih, Jagdishpur, Nathnagar, Sabour, Shahkund, Sultanganj, Kahalgaon, Pirpainty, Sanhaula of Bhagalpur district of Bihar during mid to last December, 2020 at vegetative stage. At each surveyed blocks, five plots were randomly selected with size of 3 × 2.5 m^2. In each plot around 75 plant population was observed. Moreover, experiment was conducted at Vegetable Research Farm of Bihar Agricultural University, Sabour, Bagalpur, in Randomized Block Design with 3 replications. Plot size kept same as survey. Six potato varieties such as Sagar Jamal, KufriJyoti, KufriKhyati, Kufri Ganga and Kufri Pukhraj along with a local market variety were assessed against the viruses. The observation was recorded periodically at 7 days intervals in case of field experiment. Based on the developed symptom of mild mosaic, severe mosaic, leaf roll and leaf curl diseases in survey plot as well as experimental plot, percent disease incidence was calculated using following formula

Percentage of disease incidence (PDI) =

$$\frac{\text{Total number of infected plants}}{\text{Total number of plants assessed}} \times 100$$

Apart from PDI, diseases severity were also calculated for survey plot as well as experimental plot by following formula. Percent diseases severity (PDS) was calculated based on symptomatic rating scale (0-5) described by Mughal and Khan (2001) for mosaic and leaf roll diseases and 1-5 rating scale for leaf curl described by Rao *et al.* (2016)

$$\text{PDS} = \frac{\text{Sum of all numerical ratings} \times 100}{\text{Maximum disease grade} \times \text{Total number of plants observed}}$$

Assessment of aphid and whitefly population: Observation was made on 10 randomly selected plants for whitefly and aphid population. The number of whitefly and aphid were counted on leaves at different positions, i.e., 1 bottom, 1 middle and 1 top of the plant. Counting of vector was done in morning hours. The Assessment of population was considered on all six grown varieties as well as surveyed location.

Collection of meteorological data: Meteorological data was collected from department of Agronomy. Minimum and maximum temperature and relative humidity percentage, rainfall (mm) was recorded as per the standard week.

Data analysis: Multiple regression analysis was done using online available software (*https://stats.blue/multiple_linear_regression_calculator.html*).

RESULTS AND DISCUSSION

A. Assessment of Viral diseases and vector population

The results of the survey revealed that the mosaic incidence ranges from 2.3 to 12.4% and it was found maximum at Khalgaon. The incidence of potato leaf roll disease was recorded between 6.3 to 16.3% in field observation. However, leaf curl incidence was found to have similar as that to mosaic (Fig. 1). Among the disease, overall incidence of leaf roll was found higher across the surveyed location. In observation of leaf roll, diseases severity recorded more than 30%, it was highest at Kahalgaon block, whereas lowest severity at Pirpainty. A similarly fashion was recorded for the diseases severity of mosaic and leaf curl of all the blocks, where, it was higher (>20%) at Kahalgaon followed by Jagdishpur and sabour. Incidence of vector population (aphid and whitefly) was observed that the highest aphid density at kahalgaon block (0.41aphid/plant) followed by goradih (0.38aphid/plant) and sabour (0.35 aphid/plant). The whitefly population was maximum (0.38/plant) at Sabour among surveyed blocks (Fig. 2). Ghorai *et al.* (2018) has been reported up to 98.6% (disease intensity), with an overall incidence of PVX, PLRV, PVA, PVM, PVS, and PVY about 75 %. In order to study the epidemiology of mosaic diseases, percent viral disease incidence was correlated with aphid populations in potato grown districts and recorded highest incidence at Hoshiarpur district (>20 %) in 2015.

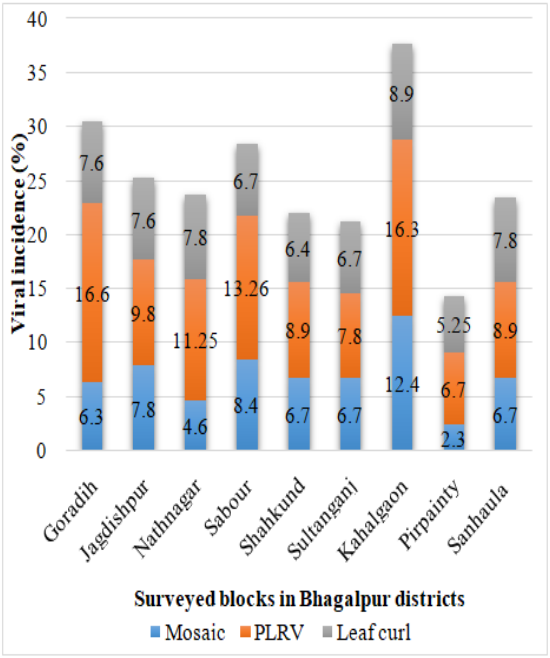

Fig. 1. PDI of PLRV, mosaic and leaf curl at 9 blocks of Bhagalpur.

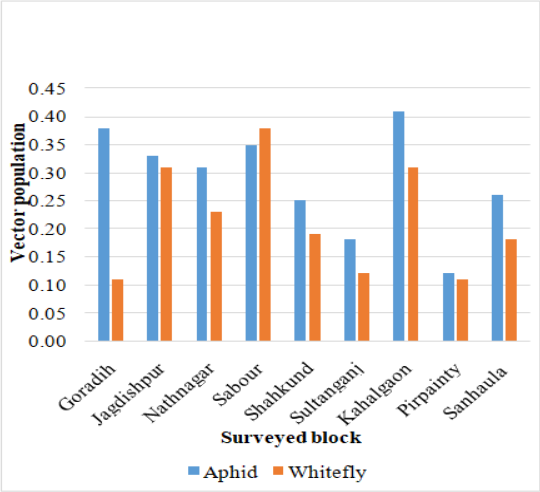

Fig. 2. Vector population of different insect vector in surveyed blocks.

In a survey of potato viral disease in Trai region of Uttarakhand, maximum incidence of PVX (16 %) was reported among three surveyed location (Ansar and Singh 2016). Incidence of different virus diseases *viz.*, PVX, PVY about 30-40 % has been reported earlier by Khurana (1999). Further explained that increasing incidence of diseases of potato due to higher population of aphid which facilitated the in secondary spread of virus. The highest mean percent diseases incidence of PLRV in Kufri Jyoti (53.67 %) followed by KufriKhyati (51 %) were observed in field experiment. However, in case of mosaic and leaf curl, the highest PDI was found in Sagar Jamal 51.3 % and 43 %, respectively. Moreover, the highest aphid population was recorded in kufri Ganga (0.44 aphid population /plant) among six studied varieties. However, in case of whitefly the highest population (0.46 whitefly/plant) was found in variety collected from local market. Similar findings also explained that, the highest population of whitefly recorded in the second fortnight of October on early potato crop in the Western zone of Uttar Pradesh (Kishore *et al.,* 2005). Bhatnagar *et al.* (2017) observed the incidence of whitefly in fields on nine potato cultivars, they found that the highest incidence of whitefly (15.33/5 plant) in KufriPukhraj followed by K. Chipsona-1 (15.0/5 plant). A positive correlation of PLRV and mosaic incidence with aphid population has been earlier reported by Mondal *et al.* (2017).

B. Periodic assessment of diseases severity and vector dynamics in field study

Periodic observation of PLRV, mosaic and leaf curl diseases severity was done from 20th December 2020 to 14th February 2021 (Fig. 3) to assess the peak period of these diseases. In case of PLRV, severity was exponentially increased from 4th week of December to 1st week of February (up to 55 %). There was no further increment noticed after first week of February. A similar trend of severity was observed in case of mosaic where it was maximum (30%) in 1st week of February. However, the severity of leaf curl was exponentially increase from first week to last week of January with 35%. Moreover, Population dynamics of insect vector e.g., aphid and whitefly were assessed in potato crop during winter season 2020-21(Fig. 4). An abrupt increment in both whitefly and aphid vector was found between last week of December to first week of January 2021 with population of 0.46 and 0.47/plant, respectively. Whitefly population continuously declined onward to middle January and a least population (0.11/plant) noticed in middle February. However, aphid population slightly increases onward to 10th January and it was found constant in subsequent observations. Similar findings reported by Saljoqi (2006) elaborated that aphid population was highest during the last week of February, with density of 0.61 aphids/leaf. There was an increase of aphid population with significant differences in the second week of March (2006), where 3.42 aphids/plant was recorded. The highest incidence of PLRV (25%) noticed during mid-February and March when appearance of aphid was found more (Kumar *et al*., 2020).

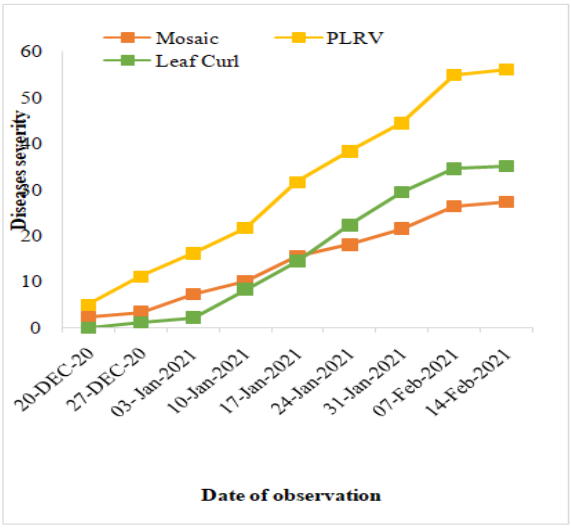

Fig. 3. Diseases severity of PLRV, mosaic and leaf curl at periodic interval.

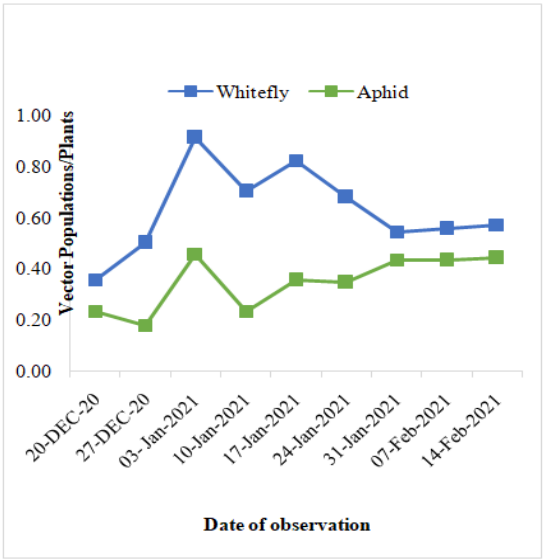

Fig. 4. Vector population dynamics on potato crop during rabi season 2020-21.

C. Relationship of viral diseases incidence with vector population

In order to understand the relationship between different insect vectors and associated viral disease, periodic observation was made in the crop. To establish the relationship between aphid population (independent variable) with leaf roll and mosaic disease (dependent variable) a linear regression analysis was done, (Fig. 5 A and B). The analysis exhibited a positive correlation of both leaf roll and mosaic with aphid population (R2= 0.1035 and 0.065 respectively). However, a negative correlation was observed between whitefly and leaf curl disease (-0.0074x+0.3777, R^2 = 0.353) depicted in (Fig. 5 C). The earlier findings also reported a positive correlation of aphid with mosaic and leaf roll, (Mondal *et al.*, 2017) in field study.

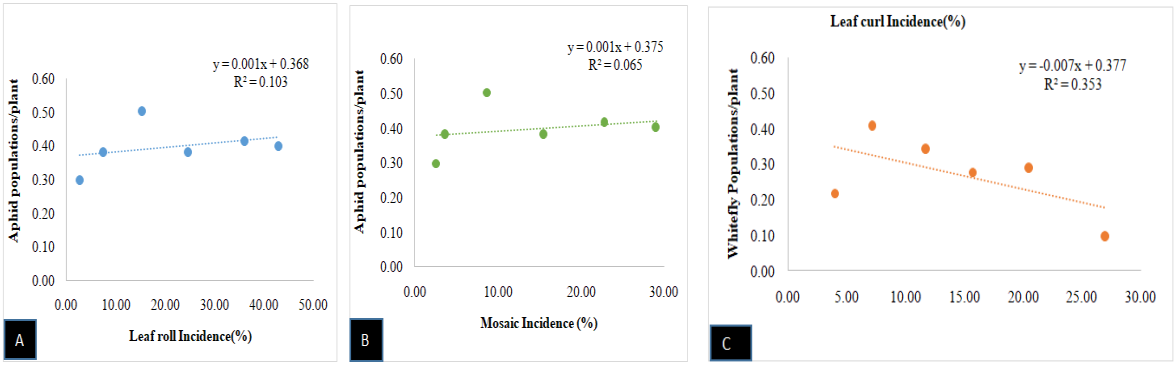

Fig. 5. Linear regression using scattered plot between vector population and percent diseases incidence of three diseases A: Leaf roll, B: Mosaic, C: Leaf curl.

D. Multiple regression analysis between diseases and other independent variables

In multiple regression analysis was done between diseases (dependent variable) and other weather factors and insect vectors (independent variables). Disease severity was assessed at periodic intervals along with weather variables like temperature, relative humidity, rainfall and vector was recorded. A multiple regression equation was described for leaf roll disease and other independent variables (PLRV=85.7017−8.0162, Temperature (Max) +10.0552, Temperature (Min) +2.4145, Relative Humidity (M) −2.7715, Relative Humidity (E) +0.7231 aphid). The derived R^2 value 0.8308 Indicated that, >83% influence in leaf roll disease due to all these five independent variables. Similarly, R^2 = 85.5% in case of mosaic showed influence of all five independent variables to disease development. Additionally, a multiple regression analysis between leaf curl disease with weather variables and whitefly population (leaf curl = −63.4291−5.5407; temperature-max + 8.5023; temperature-min + 2.875; RH-M −1.8937; RH-E −37.5996). Whitefly had R2 = 0.9121, which exhibits >91% influence in leaf curl disease due to studied variables. This results mimicked in population dynamics study, the peak aphid population observed during second fortnight of February. Aphid population was positively correlated with temperature, rainfall while negatively correlated with relative humidity. A significant cumulative effect of all these abiotic parameters was noted on aphid population in potato crop (Amitava and Santanu 2006). Kumar and Gupta (2016) found that Potato apical leaf curl virus diseases (PALCVD) transmitted by whitefly and which greatly influenced by weather variables.

CONCLUSIONS AND FUTURE SCOPE

In this study survey as well as epidemiology was done. In this survey mosaic, leaf roll and leaf curl were commonly found to be infecting potato crop. The highest incidence of leaf roll was observed in survey area. Field experiment showed susceptibility of KufriJyoti to PLRV and Sagar Jamal to mosaic and leaf curl diseases. The study of temporal dynamic exhibits an exponential increase of mosaic disease between first to last week of January. Maximum increment of leaf roll was observed during last week of December to first week of February. Moreover, a positive correlation was recorded between aphid and mosaic; leaf roll diseases. The multiple regression analysis showed the influenced of all weather variables and vectors in disease development. The overall findings of the present study would be helpful to understand the disease epidemiology and development of suitable management strategies.

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Conflict of Interest. None.

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