Plant virus Disease Epidemiology

P.N. Sharma
Department of Plant Pathology,
CSK HPKV, Palampur (H.P.)
Epidemiology of Plant Virus Diseases

Introduction

Generally the word epidemic is used to indicate rapid and widespread disease development and more accurately the word refers to the increase of disease with time which can occur slowly or rapidly.

The importance of the term epidemiology in modern plant pathology can be judged from various examples.
Important Epidemics

- Citrus tristeza
- Cotton Leaf curls
- Papaya ring spot virus
- Coconut cadang- cadang
Disease development in populations of plants

- **How fast?** speed
- **How many?** efficiency
- **How far?** movement
some crop of economic importance appears to be infected by a disease then various questions will rise in one’s mind that:

- What will happen over the next few weeks?
- Will all the plants die, leaving nothing to harvest? Or
- Will only currently infected plants will yield less?
- Are all the plants infected and only few showing symptoms?
- Is the pathogen air/water/wind/vector dispersed?
- Can this crop be planted next season etc.?
Epidemiology helps in answering these entire questions by describing disease development pattern during the single season and from year to year.

Thus epidemiology can be defined as the study of population of pathogen in the population of host and disease resulting there from under the influence of environmental and human factors.
Components of Virus Epidemiology

- The Virus
- The Host
- The Vector
- Environment

Classic Virus Disease Triangle
Only the vector element compounds the epidemic complexity and necessitate an understanding of the interactions between
  – the pathogen and its vector and
  – between the vectors and the host of the virus

To understand such a complex pathosystem interactions,
  – requires a multidisciplinary efforts to investigate
    plant/virus,
    virus/vector and
    plant/vector interactions under variable environments.
The Virus

A virus mainly consist of nucleic acids (DNA or RNA; Single or double standard) and proteins.

However majority of plant viruses are composed of SSRNA.

Highly complex pathogen

Possess strains
In the study of vector-borne virus epidemiology there are five parameters (Racch and Irwin, 1988).

- Identity of the virus causing infection i.e. virus detection
- Source plant from which virus is acquired
- Role of vector in transmission
- Movement of vector
- Environmental conditions influencing above parameters.
Methods Of Plant Viruses Detection

BIOLOGICAL

PHYSICAL

BIOCHEMICAL

SEROLOGICAL

MOLECULAR
Visual inspection of infected plants

This method has been/is most common and simplest way to monitor virus infection in plants in the field.

- A trained person can field-screen no. of plants by walking along the plant rows.
- Since this method is rapid and simples but it fails to detect all the plants because of following reasons:
  - Certain viruses do not cause symptoms in their host plant in the field
  - Some symptoms are expressed during the later stages of virus infection, long after the host plant serve as a source of virus acquisition by vectors
  - Masking of symptoms and
  - Symptoms only appear on other parts of plants (fruit, flower etc.)
Prior to the discovery of modern detection techniques the diseased plants were tested for virus presence by:

- Mechanical inoculation on series of host
- Grafting
- Use of indicator host plants but these methods were laborious and time consuming.
Sources of virus/es

Most important elements of pathogen factor in the epidemiology of all the plant diseases.

Being strictly obligate so require a biotic source for their survival during off season.

The number of virus sources and their distance from the cultivated plants determines the intensity and distribution of virus infection in the field.

There are different sources of survival of plant viruses

Different parts of the host e.g. seed or vegetatively propagative organs

Weeds and wild plants
To know the role of different sources in epidemiology, it is necessary:

– To identify the virus on various sources
– To prove that identified virus can infect the crop plant
– To identify the vector associated with the source and its transmission ability of that virus from the source to crop
Host factor

- Type of host
- Host range of the virus and vector
- Cv. Grown
- Genetic makeup of the host
- Genetic uniformity of the host
- Distance of the host from virus source
Host Plant

The role of the host plant in the epidemiology of the virus is three fold. It may be involved in the biology of the vector or it may be the host in which the damage by the virus occurs or it may act as a source or reservoir for disease spread.

Host factor which favor the disease include:

- Susceptibility of the plant to infection
- Age of the host plant
- Susceptibility of the plant to aphid/vector

Two types of interactions occurs in the host plant

- Interaction between host and vector
- Interaction between virus and host
VIRUS SPREAD

The spread of virus in the field depends on the source of initial foci of infections, means of spread, environmental condition and time factor.

Source of initial foci of infection
- Main Crop
- Weeds
- Alternate & Collateral Hosts
- Volunteer plants
Means of spread and Mode of spread

- Direct contact
- Pollens and/or seed
- Soil inhabiting vectors
- Arthropod vectors
- Vegetative propagation

Spread of virus diseases can be categorized into:
- Local spread (local distribution of inoculum)
- Distant spread (long distance distribution)

The rate at which a virus spread between plants varies according to the type of virus, crop, environment and mode of transmission. Disease spread between plants within a field and between different fields or regions w.e.t. space and time (Vanderplank, 1965).
The Vector

- **Vector is the most important and integral component of virus disease epidemiology.**
- **Different vectors have been reported to transmit many kinds of virus.** Single virus can be transmitted by more vector and one vector can transmit more than one virus.
- The vectors include mainly Aphid, leafhopper, whiteflies, fungi, nematodes.
- **Wind and water disperse virus containing material, Air currents carry vector organism.**
- Vectors need specific alternate host (wild) for survival during winter e.g. aphid survive in the egg stage during winter like *Myzus psersicae* overwinter on *Prunus* sp. and *Lycium* sp. of plant. However, in the tropics, development of aphids is continuously viviparous (anholocyclic).
- **Vector development also depends on crop density and age.**
Mode of transmission

- Non-persistent viruses
- Semi persistent
- Persistent viruses
  -- Circululative
  -- Propagative
Vector potential

The capability of vector to transmit the virus is an important step to know its potential, as different vectors transmit the virus/es in variable proportion.

Irwin and Ruesink (1986) devised the term “Vector propensity” to describe the actual probability that a given vector will transmit the virus under field conditions. There are various methods by which the vector potential is studied e.g. Infectivity test
Vector population and activity

While studying the epidemiology of the vector transmitted virus, vector abundance i.e. no. of vector (e.g. aphids) per unit area i.e. the population density is population density varies with time, environment and host type.

The vector density must be affecting the virus spread by influencing vector movement and associated activity. The understanding of vector abundance and vector movement is very important before monitoring of population density.

Vector density depends on environment factors, host type and growth stage e.g. effect of temperature.
Vector population and activity

Earlier the relationship between vector no. and virus spread was studied by making counts of aphids (vectors) actually on plants at different times/intervals but relationship between such counts and virus spread were hot so apparent.

Doncaster and Gregory (1948) made a significant observation and pointed out the importance of migrant winged aphids (particular these that move through the crop in early season).

The large size of vector population depends upon local weather and other conditions of the crop.
Vector movement and host seeking activity

Vectors can move long distance in their air (Taylor, 1986) and also shorter distance between and within field. The vector can move between plants by flying or by waling. Alate aphids can easily walk among plants when the canopy closes.

Irwin has observed considerable early season spread of SMV across as well as along the rows, especially in the early season, attributed to movement by vector flight.

- Monitoring aphid landing coupled with vector propensity provide a good estimate of vector intensity. Vector monitoring is done by various types of traps and generally used are yellow metallic traps, sticky traps, suction traps and horizontal mosaic green pan trap.

Without host seeking activity by the vector, the virus can not be carried to potential non-infected host plant.

Host seeking activity involves

- Finding a suitable host plant for the vector
- Landing
- Probing and often feeding even on vector non-compatible plants
Environmental factors influence each element of epidemic i.e. host, virus, vector etc. e.g.

**Movement** of vector (migratory type) is dependent on air currents and temp.

**Vector Biology** (growth, multiplication et al.) is generally influenced by temp., moisture and day light etc.
Temperature

This is very important element of environmental component as it affect both virus, host and the vector.

- Air temperature mainly affect rate of multiplication and movement of airborne virus vector e.g. winged aphids tends to fly only when the conditions are warm.
- Multiplication rate is higher at comparatively high temperature.
Rainfall

• Rainfall way influential both air borne and soil borne virus vectors. The air borne vectors are adversely affected (Wallin and Loonan, 1971).

• Cooper and Harrison, 1973b found increased incidence of *Potato mop-top virus* in high rainfall areas in Scotland. They correlated this enhanced incidence due to increase in fungal vector (*Spongospora subterranea*) of the virus in wetter soils.
Wind

This is an important factor affecting spread of viruses by air borne vectors.

Wind breaks may affect the local incidence of vectors and viruses in complex way (Lewis and Difley 1970).

- Winged aphids tend not to fly when wind spread is high. The direction of flight is also influenced by the prevailing wind. Hampton (1967) studied the influence of prevailing wind on the distribution of bean yellow mosaic virus by *M. persicae* into bean field from nearby red clover infected with the virus.

Aphid may sometimes be transported over long distances by strong wind.
Patterns of epidemics

Interactions among the elements of epidemics, as influenced over time by factors of the environment and by human interference, are expressed in patterns and rates.

*disease–progress curve*

*Disease gradient curve*
Indexing for disease progress

Indexing for disease progress in the field at specific incidence intervals provide a cumulative record of the number of plants over a period of time.

**Indexing of plants can be done by**

- By labeling the infected plants.
- By testing the percentage of infected plants i.e. (dieses incidence) periodically.
- Serological methods allow fast and reliable indexing of plant material for analytical purpose (Raccah, 1986).

When indexing is done just to study the disease progress, the disease incidence is determined through time and space. However, when the objective of the study is to study the components of disease progress (i.e. to differentiate among the components that produce the disease progress), it is important to relate the actual number of new potential infections over time to vector activity. To access; these information following methods are used:

- Use of bait trip plant
- Repetitive planting of field plots
- Infectivity tests with field captured vectors
Indexing incoming infection in the fields

Use of trap plants

- Trap plants are virus free potted plants that are placed in the field for predetermined length of time. Use of trap plants help to study the infection pressure in the field during the period of exposure. e.g.

- The peaks of CMV infections in trap plants have been correlated well with vector species that were active during trap plant exposure (Raccah et al. 1985).
Repetitive planting of Field Plots

- Repetitive plantings in isolated plots are used to correlate infection pressure with vector activity. In this method normal field growth of plants and similarly aged plants are exposed to potential vectors throughout the season.

- This technique works well with non-persistent viruses where the primary inoculum is from seedlings that contained virus as seed borne.

Schultz et al (1985) exposed field sown test plants for 2 weeks, after which all infector plants were removed and adjacent rows were examined after one week. This ensured minimum secondary spread except from infector plant. All the four repetitive plantings during the season were treated in the same manner. Two variables that were not controlled were vector activity and weather condition.

- Time of sowing, inoculation and symptom indexing are critical for the success of this technique. Schultz et al (1985) found that aphid species were important vector at different times during the growing season.
Disease progress curve

The progress of an epidemic measured in terms of the numbers of lesions/ the amount of diseased tissue, or the numbers of diseased plants plotted over time is called the disease-progress curve.

(A) Saturation type of curve
- Three monocyclic diseases of different epidemic rates.

(B) Sigmoidal curve
- Polycyclic disease, such as late blight of potato.

(C) Bimodal curve
- Polycyclic disease, such as apple scab, in which the blossoms and the fruit are infected at different, separate times.
Disease gradient curve

The progress of an epidemic measured in terms of changes in the number of lesions/ the amount of diseased tissue, and the number of diseased plants as it spreads over distance, is called disease gradient curve (spatial pattern).

- **disease-gradient curve:** The percentage of disease and the scale for distance vary with the type of pathogen or its method of dispersal:
  - being small for soil borne pathogens or vectors and
  - larger for airborne pathogens.
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PN Sharma