The Importance of Plant Virus Transmission by Insect Vectors

J. Vamshi*

School of Agriculture, SR University, Warangal, 506371

Corresponding Author
J. Vamshi
Email: vamshidctr@gmail.com

OPEN ACCESS

Keywords

Haemocoel, Coat protein, Virus, Transmission, Insects

How to cite this article:

Vamshi, J. 2024. The Importance of Plant Virus Transmission by Insect Vectors. *Vigyan Varta* 5(4): 12-14.

ABSTRACT

Most plant viruses depend on insect vectors for their survival, transmission and spread. They transmit plant viruses by two principal modes, circulative (circulating through the insect's haemocoel, CV) and non-circulative (carried on the cuticle lining of mouthparts or foregut, NC). Transmissibility and specificity between NC viruses and their vectors depend on the coat protein (CP) of the virus in addition to virus-encoded helper proteins. Circulative viruses cross the gut, circulate in the haemocoel and cross the salivary glands to render the insect infective. Circulative luteoviruses depend on small CP and the read-through protein (RTD) for transmission. Electrical penetration graphs have provided evidence on insect feeding behaviour and virus transmission. Recently, studies have shown that viruses can modify vector behaviour in a way that transmission is enhanced. Cultural, physical and novel biotechnological tools can provide virus control by interfering with vector landing and the retention of viruses in their vectors.

INTRODUCTION

Insect vectors of plant viruses are found in 7 of the 32 orders of the class Insecta. Hemipterans are by far the most important virus vectors, comprising more than 70% of all known insect-borne viruses. Among these, aphids and whiteflies are the major vectors of plant viruses transmitting more than 500 virus species. Two major classifications of viruses have been proposed: attending to the time the vector remains viruliferous [persistent, semipersistent (SP) or non-persistent (NP)] or the route of the virus within its vector [noncirculative (NC) or circulative (CV)]. More recently, a third classification was proposed based on the localization of virus–vector retention sites: cuticulaborne or salivary gland-borne. A number of viral and insect proteins have been found to control some virus–vector association, but many remain unknown. Interference with vector landing by manipulation of insect vision together with novel molecules that outcompete viruses from the retention sites in their vectors could help reducing plant virus epidemics.

The Importance of Insect Vectors:

Most plant viruses depend on vectors for their survival for two principal reasons:

1. An impermeable cuticle coats the plant epidermis, preventing entry of virus particles (animal viruses enter readily through natural openings), (Lee, 2022). Most vectors are insects (non-insect vectors include mites, nematodes and fungi). Several plant viruses may spread by contact or vegetative reproduction. Many insects such as hemipterans are well adapted to their role as vectors by their capacity to pierce the epidermis and delicately deposit the virus in the cytoplasm without risking the integrity of the plant cell. Recent findings propose that viruses have adapted to their vectors modifying their behaviour to maximise their own spread.

2. Plants are rooted and lack independent mobility. Therefore, many viruses depend on insects for transport among hosts (unlike animals that, by their own mobility, transport the virus to new niches). Insect-borne plant viruses may cause severe or even crippling losses to many annual and perennial crops. On occasion, insects are responsible for transition from a non-spreading form to the epidemic form of diseases. Outbreaks of disease caused by insect vectors are demonstrated in two examples. In perennials, the almost total destruction of the citrus industry in the 1930s in Argentina and Brazil is attributed to the aphid Toxoptera citricida. In annuals, outbreaks of Tomato spotted wilt virus (TSWV) or begomoviruses in recent decades is attributed to the spread of the thrips Frankliniella occidentalis and the whitefly cryptic species complex, Bemisia tabaci, respectively.

Taxonomy: Insect vectors of plant viruses are found in 7 of the 32 orders of the class Insecta. The majority of vectors are found in the two orders of insects with pierce-sucking mouthparts (number of species in parenthesis): Hemiptera (300) and Thysanoptera (6). Other vector species are found in five orders of chewing insects: Coleoptera (30), Orthoptera (10), Lepidoptera (4), Diptera (2) and Dermaptera (1), (Lee, 2023).

Mechanisms of transmission: Progress in the molecular biology of viruses and their vectors has assisted greatly in the localization of virus retention sites in their vectors and in identifying motifs in the viral genome and in viral and vector proteins, thus adding to the understanding of the process of virus transmission by insects.

The Major Transmission Modes: Persistent Versus Non-persistent; Circulative Versus Noncirculative Plant viruses demonstrate a high level of specificity for the group of insects that may transmit them (a virus that is transmitted by one type of vector will not be transmitted by another). CV viruses that propagate in their insect vectors are not considered in this article. Modes of transmission: In the 1930s, Watson and Roberts proposed modes of virus transmission by insects. The basis for their assigning viruses to these modes was the duration of virus retention in the vector. Originally, they proposed two modes: NP for short retention or 'less than the time the virus survives in leaf extracts'; and persistent for extended retention, often for life. However, several viruses showed an intermediate retention in their vector. This led Sylvester to designate the term SP viruses (Raccah, 1986). In time, a different terminology was proposed for modes of transmission, based on the site at which the virus is retained in the insect. Thus, NP viruses were termed stylet-borne, whereas persistent viruses were termed CV. NP viruses are acquired and inoculated during brief probing times, do not require a latent period in the vector and are transmitted by many aphid species, mostly by those not colonising the crop. SP viruses need longer periods (hours) for acquisition and transmission than do NP viruses, (Pidikiti, 2023). They have a narrower range of vector species. However, they do not require latent period and are lost when the vector moults. In persistent viruses, several hours or even days are needed for efficient acquisition and inoculation. They have a narrow range of vectors, mostly those that colonise the crop, pass through moult and need a latent period. Many thorough biological, microscopical, immunological, molecular techniques and electronic monitoring feeding devices have subsequently been used to elucidate the mechanisms of transmission.

Two Principal Modes of Transmission Emerged

1. CV or internal, where the virus crosses gut barriers and enters the circulatory system of the insect and accumulates inside the salivary glands.

2. NC or external, where the virus remains attached to the cuticle of the insect mouthparts or foregut and does not cross gut barriers.

CONCLUSION:

Plant viruses rely on insect vectors for their survival, transmission, and dissemination. The transmission of plant viruses by insects occurs through two main modes: circulative and non-circulative. Circulative transmission involves the virus circulating through the insect's haemocoel, while non-circulative transmission occurs when the virus is carried on the cuticle lining of the insect's mouthparts or foregut. The ability of non-circulative viruses to be transmitted and their specificity with their vectors is influenced by the coat protein (CP) of the virus, as well as virus-encoded helper proteins. Circulative viruses, on the other hand, have the ability to cross the insect's gut, circulate in the haemocoel, and ultimately cross the salivary glands to make the insect infective. Circulative luteoviruses rely on a small coat protein (CP) and the read-through protein (RTD) for their transmission.

REFERENCES

Lee, H., Stephanus, A.P., Fowles, T.M., Wintermantel, W.M., Trumble, J.T., Gilbertson, R.L. and Nansen, C., 2022. Insect vector manipulation by a plant virus and simulation modeling of its potential impact on crop infection. *Scientific Reports*, *12*(1), p.8429.

Lee, K.Y. ed., 2023. Relationship between insect vectors and plant pathogens. *Scientific Reports*, *1*(1), p.89.

Pidikiti, P., Sudhakar, C.S., Singh, H., Kumar, A. and Meshram, S., 2023. A review on molecular aspects of virus-vector relationship to the aphids: NA. *Journal of Applied and Natural Science*, *15*(2), pp.616-623.

Raccah B (1986) Nonpersistent viruses: epidemiology and control. Advances in Virus Research 31: 387–429.