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Transmission of Plant Viruses by Aphids

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Plant viruses: More than 2,000 types of viral diseases of plants are known and cause spots on leaves and fruits, stunted growth and damaged flowers or roots. Most plant viruses have an RNA genome. They are sensitive to environmental factors like UV light, desiccation, non-motile and are obligate parasites so they tend to be transmitted either by vectors or within reproductive host structures. Virus uses different methods of transmission like Mechanical or Sap Transmission, Graft Transmission, Transmission using Dodder, Seed Transmission and through various vectors.

Transmission: A process by which plant virus spread between hosts or individuals of same host.

Two types of transmission are there:

1. Horizontal transmission: The plant virus is transmitted as a result of an external source i.e. mechanical means, plant cuttings.
2. Vertical Transmission: The virus is inherited from a parent plant, i.e. vegetative reproduction, and seed embryo infection by virus infected plant

Insect Transmission

Vectors: The regular and specific agents which carries and transmits the virus are called as Vectors. About 94% of the animals known to transmit plant viruses are arthropods and 6% are nematodes. 99% of the arthropod vectors are insects and 55% of these are aphids.

Transmission of viruses results from successful conclusion of 4 events:

- Acquisition of virus particles by a vector
- Survival of infectivity during the association of virus and vector
- Inoculation into the host plant at the correct place (for example epidermal or phloem tissue)
- Initiation of infection i.e., progeny virus particles

(Control measures may be initiated at any of these points)

Useful Terms

Acquisition access period: Period of time given for the vector to acquire the virus.

Acquisition feeding period: It is the time for which an initially virus-free vector actually feeds on a virus source.

Inoculation access period: It is the time for which a virus-carrying vector is allowed to access a virus-free plant.

Inoculation feeding period: It is the time for which a virus-carrying vector appears to be feeding on a virus-free plant.

Latent period: It is the time between the beginning of an acquisition feeding period and the vector having the capability to infect healthy plants.

Transmission threshold period: It is the minimum total time that a vector needs to acquire a virus and inoculate it to a virus-free plant.
Persistence/Retention: It is the time for which a vector remains infective after leaving a virus source.

Virus vector relationships
Watson and Roberts (1939) gave the basic concept for virus vector relationship.
Based on virus retention time by the vector:

- Non-persistent
- Persistent

Sylvester (1958) introduced term Semi-persistent
Virus vector relationship is also based on site of retention of the virus in vector:

- Stylet borne
- Circulative
- Propagative
- Transovarial transmission

Aphid as vector (Historical aspects):
Japanese workers were the first to experimentally prove the involvement of insects in the spread of plant viruses about the beginning of the 20th century i.e. between 1895 and 1901. They demonstrated the transmission of *Rice dwarf virus* by the leafhopper. In 1916, in US transmission of *Cucumber mosaic virus* was found to be done by *Aphis gossypii*. In 1920, *Potato leaf roll virus* was found to be transmitted by *Myzus persicae* in the Netherlands.
Classification

- Kingdom: Animalia
- Phylum: Arthropoda
- Class: Insecta
- Order: Hemiptera
- Family: Aphididae

Aphids are ideal vectors of plant viruses and are the largest group of insect vectors. They are small (2-3mm) and have good reproductive ability. They have piercing and sucking type of mouth parts, it is because of this mode of feeding aphids transmit viruses. About 290 viruses are known to be transmitted by aphid in non-persistent manner. *Myzus persicae*: is the most efficient among all, transmits >100 viruses in apterous as well as in winged forms.

How salivary duct is formed?
Mandibles and maxillae form 2 pairs of long bristle-like stylets. The maxillary stylets come together, their inner faces forming a food canal and smaller one as salivary duct. Penetration is assisted by secretions from the salivary glands containing cellulase and pectinase enzymes and then sap is sucked along with which viruses are transmitted.

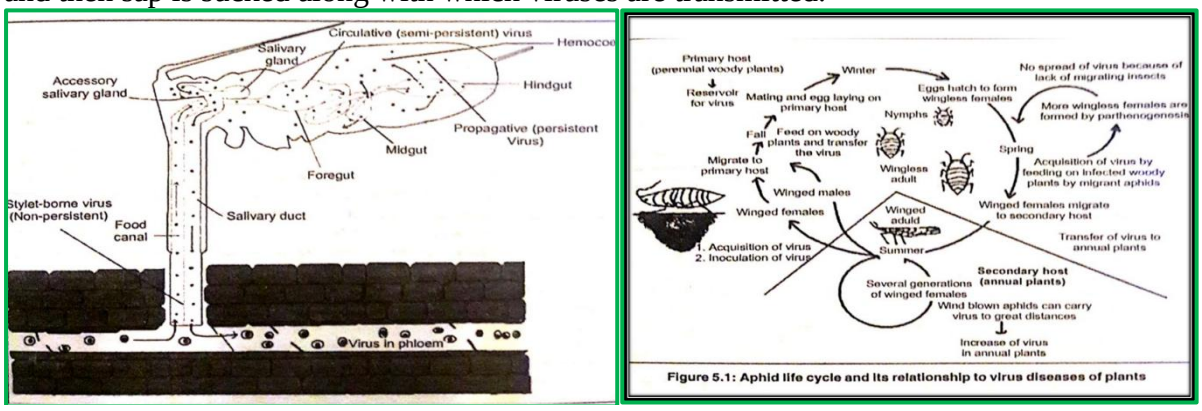

Figure 5.1: Aphid life cycle and its relationship to virus diseases of plants

Features of aphid-transmitted viruses:

S.No.	Feature	Type of persistence		
		Non-persistent	Semi-persistent	Persistent
1.	Mechanical	+	-	-
2.	Common Symptoms	Mosaic	Yellowing	Leaf roll, yellowing
3.	Tissue of virus acquisition	Epidermis	Mesophyll	Mesophyll
4.	Fasting effect	+	-	-
5.	Acquisition time	Seconds to min.	Min. to hours	Hrs. to days or more
6.	Latent period	No latent period	No latent period	Presence of latent period
7.	Retention of virus through moulting	-	-	+
8.	Vector specificity	Low	Medium	Medium to high
9.	Examples	CMV, PVY	CTV, CaMV, Beet yellows	PLRV etc.

Helper virus: These are the viruses transmitted by aphid vectors under certain conditions. An aphid can transmit the virus only if the source plant is infected by 2nd virus. So, it is a dependent virus and 2nd virus is referred as the helper virus.

S. No.	Virus	Helper virus	Vector	Type of transmission
1.	Potato aucuba mosaic virus	PVA or Y	*Myzus persicae*	Non-persistent
2.	PVC	PVY	*Myzus persicae*	Non-persistent
3.	Carrot mottle virus	Carrot red leaf	*Cavariella aegopodii*	Semi-persistent
4.	Tobacco mottle virus	Tobacco vein distortion	*Myzus persicae*	Persistent

Examples of plant viruses transmitted by aphids:

Virus	Vector	Type of transmission
Alfalfa mosaic virus	*Myzus spp.*	Non-persistent
Bean common mosaic virus	*Acyrthosiphon pisum*	Non-persistent
Bean yellow mosaic virus	*A. pisum*	Non-persistent
Beet mosaic virus	*Myzus persicae*	Non-persistent
Cucumber mosaic virus	*Myzus spp.*	Non-persistent
Lettuce mosaic virus	*M. persicae*	Non-persistent
Potato virus X	*M. persicae*	Non-persistent
Soybean mosaic virus	*A. pisum*	Non-persistent
Turnip mosaic virus	*M. persicae*	Non-persistent
Barley yellow dwarf virus	*A. dirhodum*	Persistent
Beet yellow western virus	*M. persicae*	Persistent
Lettuce necrotic yellow virus	*Hyperomyzus lectucae*	Persistent
Pea enation mosaic virus	*A. pisum*	Persistent
Citrus tristeza virus	*Toxoptera citricidus*	Semi-persistent