

GENERAL CHARACTERISTICS AND CLASSIFICATION OF VIRAL PLANT PATHOGENS

Aim: To acquaint the students with general characteristics and classification of viral plant pathogens

Introduction

- Viruses are sub-microscopic, intracellular, infectious entities and are composed of nucleic acid and proteins.
- Some viruses attack humans, animals or both and cause diseases like mumps, measles, chicken-pox, polio, rabies etc; some others attack plants.
- In plants, tulip breaking was reported in 17th century.
- Adolf Mayer in 1886 first proved that the sap from tobacco leaves infected with mosaic could transmit the disease to healthy leaves.

General characteristics

Characteristics of viruses which separate them from other causes of plant pathogens are:

- They are acellular.
- They are sub-microscopic and intracellular.
- They lack lipid membrane system and energy production.
- They use host machinery for their replication.

Structure of virus

- **Virion** is a technical term used for the virus particle. A virion consists of nucleic acid surrounded by a protein coat.
- The nucleic acid is called 'nucleoid' which may be either deoxyribonucleic acid (DNA) or ribonucleic acid RNA (mostly RNA in plant viruses), but never both; and forms the genome.
- The protein coat is called 'capsid'. It consists of many subunits which are similar and occasionally dissimilar, and these subunits are called **capsomeres**.
- The combined genome and the capsid are called 'nucleocapsid'.
- Some viruses possess an envelop around the protein coat which is made of virus proteins and host cell lipids. These viruses are called '**enveloped viruses**'.
- In many groups of viruses, there is an additional protein layer between the capsid and the nucleoid. This is called '**virus core**'.
- In addition to the typical nucleoprotein composition, some viruses have carbohydrates/ lipids / enzymes.

Nucleoid

- The nucleoid (nucleic acid component) is located internally within a protein coat.
- Only one type of nucleic acid, i.e. either RNA or DNA is found in a virus.
- The amount of nucleic acid in a virion varies from 1 to 50 per cent.
- Higher percentage of nucleic acid is associated with larger DNA viruses like bacteriophages; while low content is found in animal viruses.

- The nucleic acid is infectious part and contains the genetic information for the synthesis of proteins and its own replication; and their assembly into the virion.
- Most of the plant viruses contain RNA, with exceptions like *Cauliflower mosaic virus*.

Capsid

The capsid is a protein coat surrounding the nucleoid and has the following functions:

- It protects nucleic acid from unfavourable extracellular environment.
- It facilitates nucleic acid entry into the host cells.
- It is antigenic.
- As compared to nucleoid, the protein coat shows a complex structure and provides shape to the virus particles.
- It interacts with the vector for specific transmission.

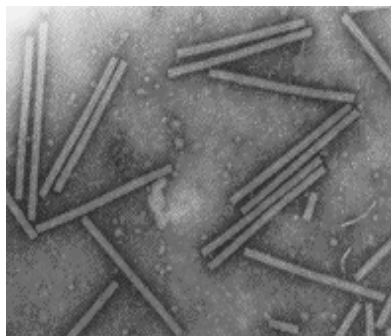
Morphology of Viruses

Viruses are of different shapes and sizes. They may be:

- i. Elongated (rigid rods or flexuous threads)
- ii. Spherical (isometric or polyhedral)
- iii. Cylindrical (bacillus-like rods)



Flexuous rod-shaped virus particles



Rigid rod-shaped virus

Polyhedral virus

- Some elongated viruses are rigid rods about 15 x 300 nm in size, but most appear as long, thin, flexible threads that are usually 1-10 nm wide and 480-2000 nm in length.
- Rhabdoviruses are short bacillus-like cylindrical rods approximately three to five times as long as they are wide (52-75 x 300-380 nm in size).
- Most spherical viruses are actually polyhedral, ranging in diameter from about 17 nm (*Tobacco necrosis satellite virus*) to 60 nm (*Wound tumor virus*).
- *Tomato spotted wilt virus* is surrounded by a membrane and has a flexible, spherical shape about 100 nm in diameter.
- Many plant viruses have spilt genome consisting of two or more distinct nucleic acid strands encapsidated in different-sized particles made of the

same protein subunits. For example: **Bipartite**, *Tobacco rattle virus* consisting of two rods, a long one (195 x 25 nm) and a shorter one (43 x 25 nm) and **Multi-partite** *Alfalfa mosaic virus*, consisting of four components of different sizes.

Composition and structure of viral proteins

- Viral proteins, like all proteins, consist of amino acids.
- The sequence of amino acid within a protein, which is encoded by the sequence of nucleotides in the genetic material, determines the nature and properties of the protein.
- For example, the protein subunit of *tobacco mosaic virus* consists of 158 amino acids in a constant sequence and has a mass of 17,600 daltons.

Composition and structure of viral nucleic acids

- Nucleic acid of most plant viruses consists of RNA, but now, a larger number of viruses have also been shown to contain DNA as its genome.
- Both RNA and DNA are long chain-like molecules consisting of hundreds or most of them thousands of units called nucleotides.
- Each nucleotide consists of a ring compound called the base attached to a five-carbon sugar (ribose in RNA, de-oxyribose in DNA), which in turn is attached to phosphoric acid.
- The sugar of one nucleotide reacts with the phosphate of another nucleotide, which is repeated many times, thus forming the RNA or DNA strand.
- In viral RNA, only one of four bases, adenine, guanine, cytosine and uracil can be attached to each ribose molecule. The first two, adenine and guanine, are purines and interact with the pyrimidines, uracil and cytosine.

Virus Infection and synthesis

- Plant viruses enter cells only through the wounds made mechanically or made by vectors, or are deposited into an ovule by an infected pollen grains.
- In a RNA replication of an RNA virus, the nucleic acid (RNA) is first freed from the protein coat.
- It induces the host cell to form the viral RNA polymerase.
- The RNA polymerase utilizes the viral RNA as a template and forms complementary RNA.
- The first new RNAs produced are not the viral RNAs but are the mirror images (complementary copies) of that RNA.
- As the complementary RNA is formed, it is temporarily connected to the viral strand. Thus, the two form a double-stranded RNA that soon separates to produce the original virus RNA and the mirror image (-) strand, with the latter then serving as a template for more virus (+) strand RNA synthesis.

- In dsDNA viruses, the viral ds DNA enters the cell nucleus and appears to become twisted and supercoiled and forms a minichromosome.
- The latter is transcribed into two single-stranded RNAs.
- The smaller RNA is transported to the cytoplasm, where it is translated into virus-coded proteins
- The larger RNA is also transported to the same location in the cytoplasm, but it becomes encapsidated by coat protein subunits and is used as a template for the reverse transcription into a complete virion dsDNA.

Spread of viruses

- For successful infection, viruses move into the adjacent cell through plasmodesmata intracellularly with cytoplasmic streaming.
- Some viruses move through host parenchyma cells, causing mostly local lesions.
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- Many viruses move over fairly long distances through phloem specifically through sieve tubes and spread systemically and often quite rapidly in their host plant through vascular streams.
- Such movement is mostly through phloem but rarely xylem transport also occurs, e.g.,
Lettuce necrosis yellows virus and *Southern bean mosaic virus*.
- Once the virus enters the phloem, it moves rapidly into the sieve tubes towards the growing regions and other food utilizing parts of the plant.
- Virus movement is mostly upwards. Once the virus reaches the phloem, it spreads systemically throughout the plant and then moves to adjacent parenchyma cells through the plasmodesmata. This systemic distribution of viruses affects all parts of host plant except the apical meristem in some cases.