

TMV: Life cycle, symptoms and control measures

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TMV

- TMV was the first virus to be discovered over a century ago and was the first virus ever purified.
- In 1889, Martinus Beijerinck, found that ‘tobacco mosaic disease’ was caused by a pathogen able to reproduce and multiply in the host cells of the plant.
- He called it ‘virus’ (from the Latin virus, meaning poison) to differentiate this form of disease from those caused by bacteria.
- **Tobacco yield losses** due to TMV are currently estimated at only 1%, because resistant tobacco varieties are routinely grown.
- However, TMV affects other crops, and losses of up to 20% have been reported in tomatoes.

TMV

- TMV is made up of a piece of nucleic acid (ribonucleic acid; RNA) and a surrounding protein coat.
- The complete virus is a submicroscopic, rigid, rod-shaped particle.
- Once inside the plant cell, the protein coat falls away and nucleic acid portion directs the plant cell to produce more virus nucleic acid and virus protein, disrupting the normal activity of the cell.
- TMV can multiply only inside a living cell but it can survive in a dormant state in dead tissue, retaining its ability to infect growing plants for years after the infected plant part died.
- Most other viruses die when the plant tissue dies.

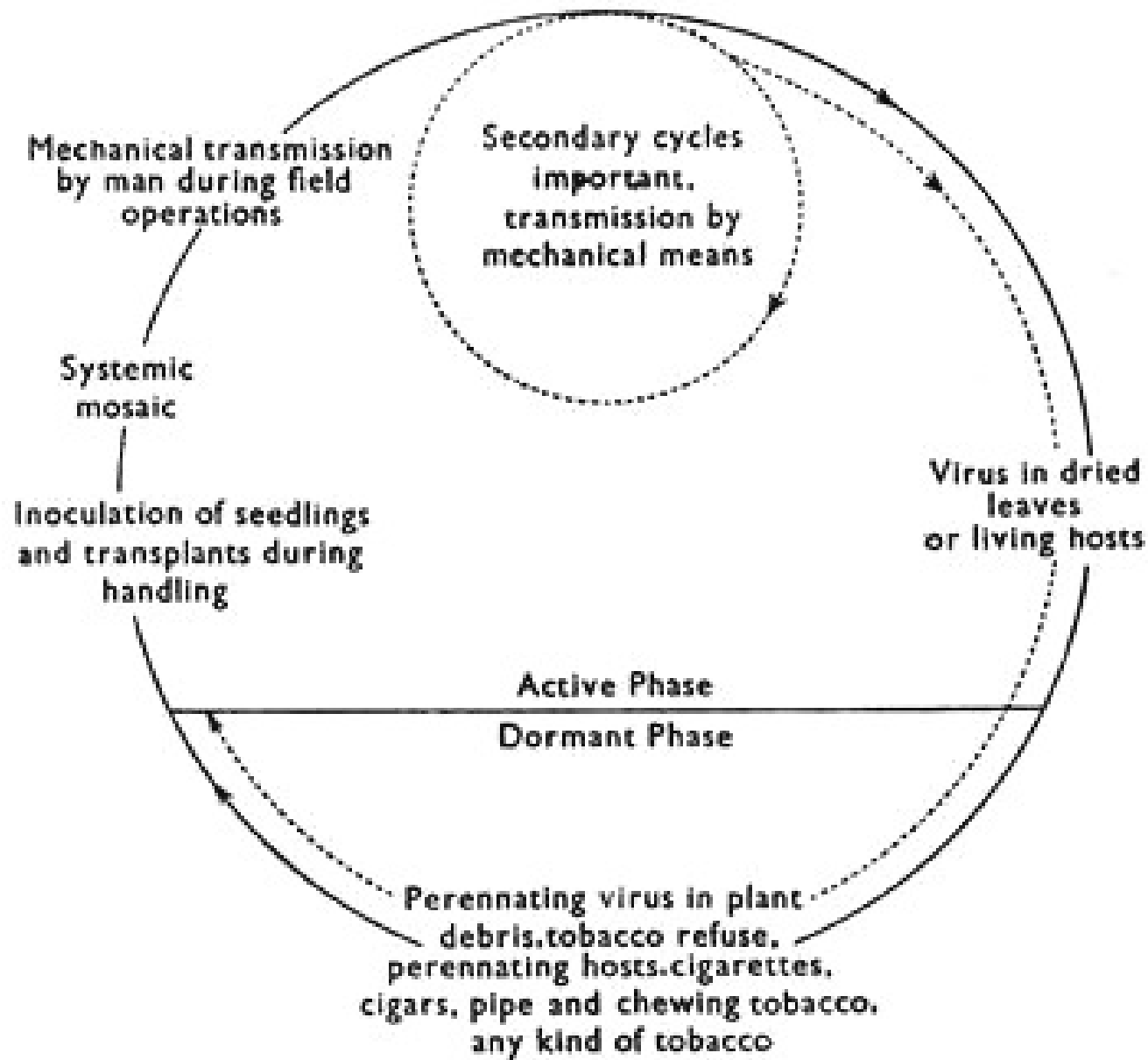
Transmission

- TMV is usually spread from plant to plant via 'mechanical' wounds caused by contaminated hands, clothing or tools such as pruning shears and hoes.
- This is because TMV occurs in very high concentrations in most plant cells.
- When plants are handled, the tiny leaf hairs and some outer cells are inevitably damaged and leak sap onto hands, tools and clothing.
- Seeds from infected plants can also carry the virus on their seed coats.
- The earlier the age at which the mother plant is infected, the more likely it is that the virus will contaminate the seed coat during seed harvesting.
- When the seed germinates, the virus may enter the seedling through small cuts caused by transplanting and handling, or during the germination/emergence process.
- Once inside the plant, the virus releases its genetic code (RNA). The plant mistakes this for its own RNA, and starts to produce viral proteins.
- The virus then spreads to neighbouring cells through microscopic channels in the cell walls (plasmodesmata), and eventually enters the translocation system of the plant (xylem and phloem).
- From here, it spreads to the entire plant.

Molecular mechanism

- *Tobacco mosaic virus* (TMV) encodes four known functional proteins: the 126 and 183 kDa replication-associated proteins, the movement protein (MP), and the structural capsid or coat protein (CP).
- In order to have a successful infection, these four multifunctional proteins cooperate with many host components.
- The host membrane and cytoskeleton are sub-cellular structures important for TMV infection. TMV-induced granules or inclusion bodies that contain membranes also contain host proteins.
- *Tobacco mosaic virus* enters plant cells only through mechanical wounds which either transiently open the plasma membrane or allow pinocytosis.
- TMV begins to disassemble within 3 min after entry and disassembly of CP from the capsid is associated with translation of viral RNA.
- TMV RNA is released from the capsid at the site of viral RNA (vRNA) granule formation.
- The granules are associated with the endoplasmic reticulum (ER), which may serve as the replication site on transport of the vRNA to cortical vertices or perinuclear regions of the ER.
- Transport to these locations requires microfilaments (MF).

- Other membranes such as the vacuolar (V) membrane may serve as a scaffold for virus replication, but this requires further analysis.
- A virus replication complex (VRC) is formed in the cortical vertices or perinuclear region of the ER.
- VRCs contain vRNA, movement protein (MP), replication proteins and host proteins.
- For TMV intercellular movement, VRCs move from sites of replication to plasmodesmata (PD).
- vRNA transports through PD within a VRC or simply with vRNA and MP, the latter being phosphorylated (MP^P) in the PD to release the vRNA for translation in the next cell.
- After vRNA transfer to the neighboring cell, VRC remnants associate with endosomes for transport to vacuoles.
- Transport is proposed to involve the actomyosin network.
- Likely prior to this transport, CELL-DIVISION CYCLE protein48 (CDC48) extracts the MP from the ER-associated VRC for attachment to the MT and later degradation (m).



Disease cycle of Tobacco Mosaic Virus.

Signs and symptoms

- Symptoms first appear about 10 days after infection.
- The plants do not usually die, but growth can be seriously stunted.
- In the case of tomatoes, certain TMV strains can cause deformed fruit, non-uniform fruit colour and delay ripening.
- Specific symptoms depend on the host plant, age of the infected plant, environmental conditions, the virus strain and the genetic background of the host plant.
- However, common signs include:
 - mosaic-like patches (mottling) on the leaves,
 - curling of leaves and
 - the yellowing of plant tissues.

Managing the virus

- No chemicals can cure a plant infected with a virus, and TMV is no exception.
- As mentioned before, however, resistant plant varieties are available.
- Ultimately, effective TMV management involves using virus-free seedlings or plants and implementing strict hygiene procedures:
- Use new potting mix and new or thoroughly cleaned seedling trays when growing seedlings;
- Remove and destroy the plants and restrict access to the area, or always work in the affected area last and decontaminate yourself and your equipment afterwards;
- Remove all crop debris from the land, seedling production beds and benches in greenhouses;
- Place tools in a disinfectant solution for at least 10 minutes and rinse thoroughly with tap water;
- Disinfect door handles and other greenhouse structures;
- Thoroughly wash your hands with recommended disinfectants, such as carbolic soap, or a mixture of non-fat milk powder at 20% weight/vol, 10% bleach, and 70% ethanol, after handling tobacco products or TMV-infected plants.
- Make sure that the solutions are fresh, and replace regularly.