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Topic: TMV (Tobacco Mosaic Virus)
Lecture no. 21

Structure of Tobacco Mosaic Virus (TMV):

TMV is a simple rod-shaped helical virus consisting of centrally located single-stranded RNA (5.6%) enveloped by a protein coat (94.4%). The rod is considered to be 3,000 Å in length and about 180 Å in diameter.

The protein coat is technically called ‘capsid’. R. Franklin estimated 2,130 sub-units, namely, capsomeres in a complete helical rod and 49 capsomeres on every three turns of the helix; thus there would be about 130 turns per rod of TMV.

The diameter of RNA helix is about 80 Å and the RNA molecule lies about 50 Å inward from the outer-most surface of the rod. The central core of the rod is about 40 Å in diameter. Each capsomere is a grape like structure containing about 158 amino acids and having a molecular weight of 17,000 dalton as determined by Knight.

The ssRNA is little more in length (about 3300 Å) slightly protruding from one end of the rod. The RNA molecule consists of about 7300 nucleotides; the molecular weight of the RNA molecule being about 25,000 dalton.

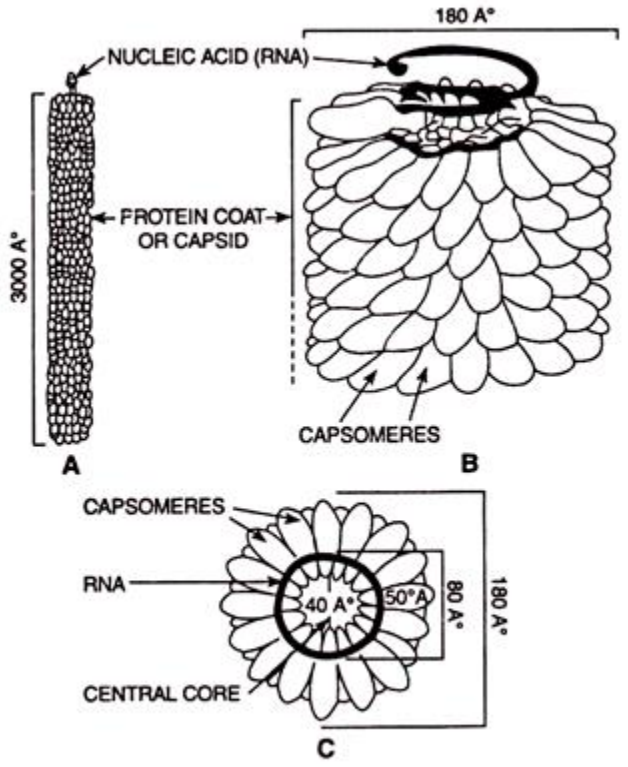

FIG. 13.20. Tobacco mosaic virus (TMV). **A.** surface view; **B.** an enlarged portion showing RNA-capsomere arrangement; **C.** view in section.

Life-Cycle (Replication) of Tobacco Mosaic Virus (TMV):

Plant viruses like TMV penetrate and enter the host cells in toto and their replication completes within such infected host cells (Fig. 13.21). Inside the host cell, the protein coat dissociates and viral nucleic acid becomes free in the cell cytoplasm.

Although the sites for different steps of the viral multiplication and formation of new viruses have not yet been determined with absolute certainty, the studies suggest ha alter becoming free in the cell cytoplasm the viral-RNA moves into the nucleus (possibly into the nucleolus).

The viral-RNA first induces the formation of specific enzymes called ‘RNA polymerases’ the single-stranded viral-RNA synthesizes an additional RNA strand called replicative RNA.

This RNA strand is complementary to the viral genome and serves as ‘template’ for producing new RNA single strands which is the copies of the parental viral-RNA. The new viral-RNAs are released from the nucleus into die cytoplasm and serve as messenger-RNAs (mRNAs). Each mRNA, in cooperation with ribosomes and t-RNA of the host cell directs the synthesis of protein subunits.

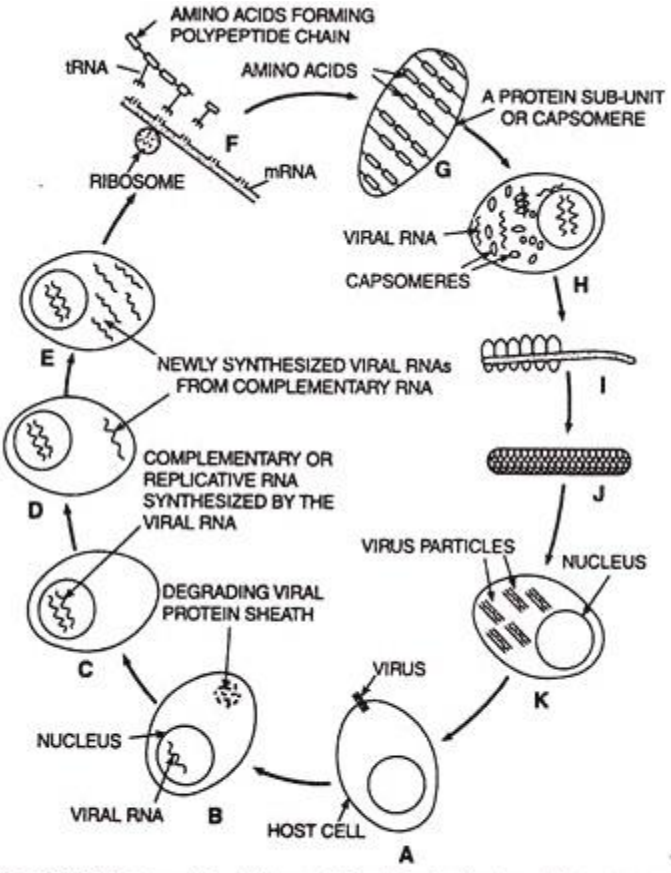

FIG. 13.21. Replication of TMV (diagrammatic). **A.** Virus particle entering inside the cell of the host plant; **B. & C.** Viral RNA enters inside the nucleus and synthesizes its complementary copy; **D. & E.** Complementary RNA synthesizes new viral RNA that comes in the cytoplasm; **F.** Polypeptide chain synthesis; **G., H. & I.** Arrangement of capsomeres around viral-RNA; **J.** Complete virus particle; **K.** Host cell containing many virus particles.

After the desired protein sub-units (capsomeres) have been produced, the new viral nucleic acid is considered to organize the protein subunit around it resulting in the formation of complete virus particle, the virion.

No ‘lysis’ of the host cell, as seen in case of virulent bacteriophages, takes place. The host ells remain alive and viruses move from one cell to the other causing systemic infection. When transmitted by some means the viruses infect other healthy plants.

This is the best known of all virus diseases. The tobacco mosaic virus affects all dicotyledonous plants of which most important are tobacco and tomato. But it does not affect any monocotyledonous plants.

Although Adolph Mayer in 1886 first pointed out the mosaic pattern on leaves of affected tobacco plants, it was not until 1898 the first scientific proof of the existence of a virus was given by Beijerinck. Earlier than this, in 1892 Iwanowski demonstrated that tobacco mosaic virus would pass through a bacteria-proof filter.

He was able to demonstrate that a diseased tobacco plant juice was able to induce mosaic disease in healthy tobacco plants.

But Iwanowski could not find out the true significance of this. Holmes in 1929 described the primary infection lesions of tobacco mosaic virus and in 1935 Stanley first isolated crystals of tobacco mosaic virus and indicated their paracrystalline nature. Again Takahashi and Rawlins in 1933 demonstrated the physical phenomenon of tobacco mosaic virus.

Whereas, C. A. Knight showed that the tobacco mosaic virus is made up of sixteen amino acids.

The tobacco mosaic virus affects photosynthetic tissue of the host leading to distortion, blistering and necrosis. It also causes dwarfing of affected plants. It is

one of the most damaging viruses of plants, causes enormous loss of tobacco crop by reducing yield and quality.

2. Symptoms of Tobacco Mosaic Virus:

The symptom is systemic mosaic type. The primary symptom on young leaves is faint circular chlorotic lesions appear with gradual vein clearing.

This is followed by the development of characteristic systemic mosaic. With the maturity of the leaves, abnormally dark-green spots appear which develop into ir-regular crumpled blister-like areas while the rest of the tissue becoming more or less chlorotic (Fig. 392). Various degrees of leaf malformation like enations follow and some leaves exhibit only a mild diffuse mottle.

The development of symptoms is governed by many variable factors of which the most important is the difference in virulence of the virus strains.

For example, one strain of tobacco mosaic virus may cause yellow mottling on the leaves, a second may cause necrosis only, whilst a third induces a gross malformation. Another variable factor is the variety of plant affected. In flowers, petals show mosaic symptoms. Severe strains cause streaking of stem. The disease is seldom fatal to the host.

Fig. 392. Tobacco Mosaic Virus. Disease symptoms on tobacco leaves induced by ordinary or field strain.

3. Causal Organism of Tobacco Mosaic Virus:

The typical tobacco mosaic virus is Tobacco mosaic virus 1, Marmor tabaci Holmes.

The virus remains active in extracted host plant juice even up to 25 years. It is a very resistant virus, can stand desiccation for 25 years or more. It occurs in very high concentration in plant and its dilution end point is 10^{-6}. The thermal inactivation point of virus is 90^{0}.

The virus particles are rod-shaped measuring 280 μ in length by 15 μ, in width.

The X-ray studies reveal that the virus particle consists of a number of protein subunits set in helical array with 49 subunits to one turn of helix and 2130 subunits in one rod. The ribonucleic acid thread intertwines more or less centrally between the protein subunits.

The cells of tobacco plants infected with tobacco mosaic virus are characterized by the presence of certain cell inclusions. They are: (i) two types of intracellular inclusions, and (ii) intra-nuclear inclusion. The intracellular inclusions are: (a) X-bodies and (b) striate material of crystalline plates (Fig.).

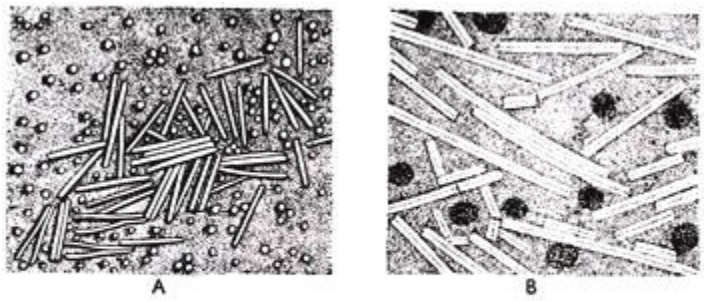

Fig. 393. Tobacco Mosaic Virus. A—B. Virus particles. A. Shadowed with palladium-gold. B. Stained with phosphotungstic acid.

The X-bodies are amorphous, protoplasmic more or less vacuolated inclusions. Whereas striate material of crystalline plates gives protein reaction. These crystals resemble the purified virus-protein crystals. The intra-nuclear fibrous and crystalline inclusions are produced by a yellow-mottling strain of tobacco mosaic virus.

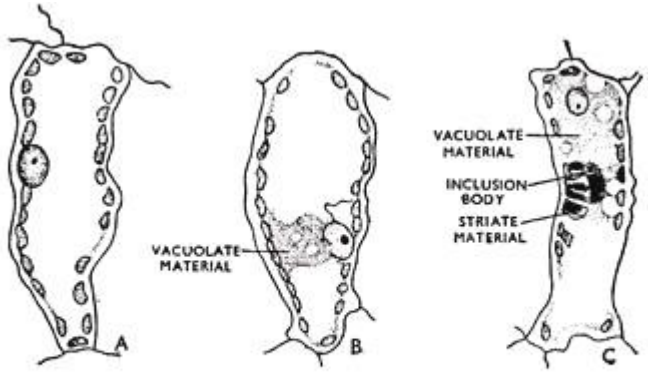

Fig. 340. Intracellular inclusions. A. Virus-free palisade cell of potato. B. Mild mosaic virus-infected palisade cell of potato showing vacuolate material close to the nucleus. C. Common tobacco mosaic virus-infected palisade cell of potato showing inclusion body (X-body).

4. Disease Cycle of Tobacco Mosaic Virus:

The virus perennates in infected tobacco plant derbies, tobacco refuse from warehouses, cigarettes, cigars, pipe and chewing tobacco and in perennating hosts which from the source of primary inoculums. This is one of the most infectious of

plant viruses. The virus is disseminated from plant to plant by mechanical transmission, by handling tobacco plants during transplanting; through other field operations; and contact by man and cultivation implements. The virus enters in the host tissues; it multiplies very rapidly producing disease symptoms.

Disease cycle of TMV is presented in the Fig. below:

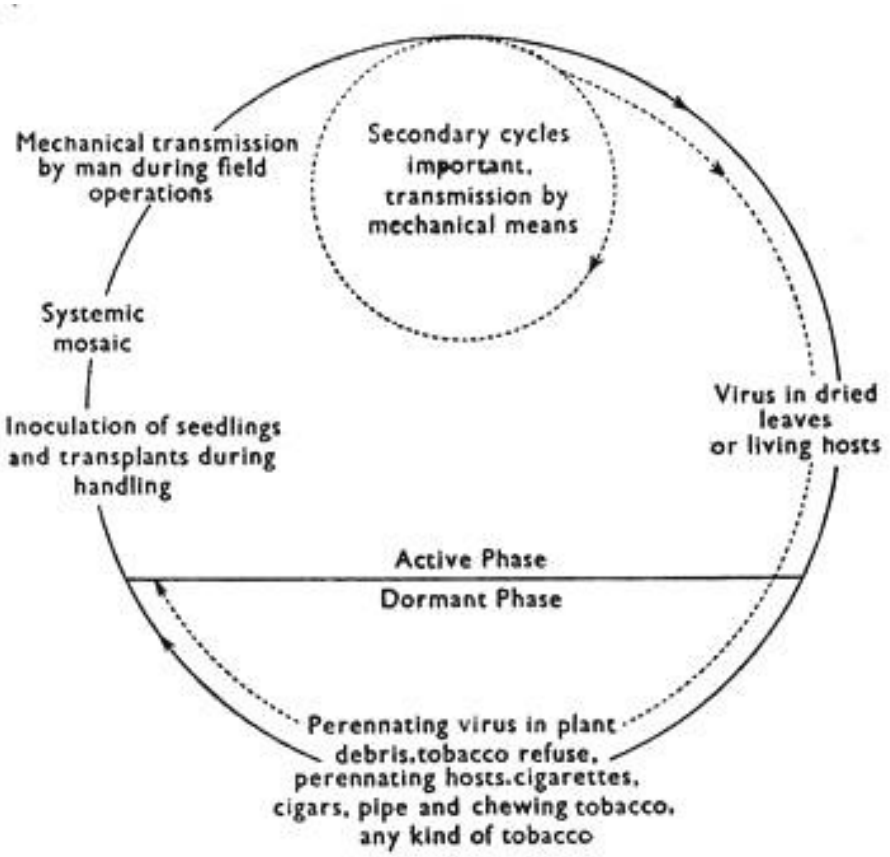

Fig. 394. Disease cycle of Tobacco Mosaic Virus.

5. Control of Tobacco Mosaic Virus:

Following are some of the suggested control measures:

- Seed beds should be located at a great distance from the tobacco warehouse.
- Seed beds should be free from any tobacco refuse.
- Seed bed soil should be sterilized by steam.

- Care should be taken to avoid contamination through lands and cultivation impliments.
- Since pipe tobacco, cigarettes and chewing tobacco are all source of primary inoculation, smoking or chewing of any kind of tobacco should be avoided.
- Susceptible hosts, weed or otherwise in which virus may harbor, should be destroyed.
- Previous year’s plants debris should be destroyed by burning.
- Diseased plants should be removed and burnt to stop further spread of the disease.
- Growing resistant varieties produces good results.