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# VIRAL PATHOGENS OF PLANTS

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Virology, the science of viruses was born in 1892 with the scientific study of tobacco mosaic virus (TMV), the 'Grand Daddy' of all viruses. However existence of viruses can be traced back for thousands of years ; small pox virus has been described by Chinese in the tenth century before Christ. The earliest record of a plant virus disease dates back to about the middle of the 16th century when a reference was made to 'colour breaking' in tulip flowers.

## 1. Viruses: Living or Non-Living

The first solid awareness of the true nature of viruses came with the isolation of tobacco mosaic virus (TMV). Viruses can be precipitated out of suspensions by substances like ammonium sulphate which are protein precipitants. Many viruses can be crystallised eg. TMV form needle-like crystals, each crystal containing millions of TMV particles. The crystallised viruses will retain their ability to infect. Proteins of viruses can be separated from the nucleic acids by gentle separation methods such as using detergents or acetic acid. The separated nucleic acid retains the ability to infect. The separated nucleic acid and protein can be re-assembled or re-constituted into whole virus particles, which are infective. Crystallisation is a property the viruses share with molecules. Reconstitution of viruses too is a physical and a crystallisation-like phenomenon. In these respects viruses do seem and behave like macromolecules. Crystallisation, separation and reconstitution of viruses while retaining infectivity posed many questions concerning nature of life.

Minimal structural features of a cell include a cell membrane, cytoplasm, nuclear region or nucleus and an energy generation system. Viruses do not have the minimum requirements of a cell and are therefore acellular. Viruses do not have the ability to acquire and utilise nutrients, to grow, or to excrete waste. They do not metabolise, nor do they respond to stimuli. Viruses therefore do not possess the attributes of living organism.

However, when a virus is introduced into a susceptible living cell the virus takes over the normal machinery of the cell and direct the cell to synthesise virus particles at the expense of the host's cell material. On infecting a cell, one single virus particle can produce 100,000 new virus particles. Viruses can mutate. On these counts viruses are like biological organisms.

Are these agents living organisms or non--living molecules? The capacity for reproduction and mutation is a property possessed only by living organisms. Yet they are like perfect inert matter in other aspects. Not only do they posses a dual nature but they also express one aspect of their nature in one situation and the other aspect in another situation. On their own outside a living cell, viruses are simple giant dead molecules. But inside a living cell they are obligate intracellular parasites with a great capacity to reproduce. Viruses therefore lie in no man's land between the chemist's molecule and biologist's organism. We cannot but wonder the aptness of a remark made over 2000 years ago by Aristotle **"Nature makes so gradual a transition from the inanimate to the animate kingdom that the boundary lines which separate them are indistinct and doubtful"**.

## 2. Morphology and Structure

Viruses are too small to be seen with optical microscopes, and hence are referred to as ultra-microscopic. They are studied with the aid of electron microscopes. The size of viruses range from 400 x 250 nm to 17 nm. The largest viruses are the pox viruses which attacks the higher animals including man and measure 400 x 250 nm. Probably one of the smallest viruses is that which attacks the tobacco plant causing tobacco necrosis disease and it measures 17 nm in diameter.

There is a great variation in the shapes of viruses. They can be rod-like, near-spherical to octahedral, filamentous, bacilli form, bullet-shaped, brick-shaped, tadpole-shaped etc. (Figure 1).

Chemical constitution is simple and in the very small viruses consists of a **nucleic acid and protein** (Figure 2). The genetic information is contained in the nucleic acid and is centrally located. The central nucleic acid is surrounded by a protein coat called the **capsid**. The capsid is not a smooth structure. It is composed of many sub units called the **capsomores**. It is the arrangement of the capsomores that gives the external form to the specific virus particle.

Each virus typically consists of a single type of nucleic acid either RNA or DNA. The presence of either RNA or DNA and never both, is an important property which distinguishes viruses from organisms.

Certain larger viruses may contain lipids, glycoproteins, enzymes and polyamines.

### 3. Viruses in Action

Viruses are known to attack every kind of living organisms in both the animal and plant world. So far as is known, all the higher plants are susceptible to virus infection and plant virus diseases are the cause of much loss in food production and cause great damage to horticultural plants. The number of viruses attacking plants is about 600 and new ones are still being discovered. Some diseases previously ascribed to viruses are now thought to be due to Mycoplasma-like organisms, viroids, chlamidiae and rickettsiae. Virus have been also found to attack bacteria, mycoplasma, algae and fungi. A virus does not attack any living cell which it comes across. It is specific to the host which it attacks. Tobacco mosaic virus for example will not infect animals and man but will infect tobacco and some other species of plants only.

What happens to a plant when it is attacked by a virus? The steps in the process include:

(a) *Entry* of the virus into the cell and to the replication sites within the cell. Viruses are obligate parasites-which means they must get into cells in order to multiply. In this they differ from pathogenic fungi and bacteria. The problem then is how viruses get into appropriate cells. In most cases they are introduced into plant cells by **vectors** or organisms such as insects, mites, nematodes, fungi; etc. which either feed on or parasitise the plants. The viruses are also introduced via acciidental or deliberate wounding. Figure 3 illustrates some vectors.

(b) *Decoating* - The protein coat of the virus is stripped off and the nucleic acid is exposed.

(c) *Replication* - Viral nucleic acid is replicated and viral coat protein is synthesised. Once inside the cell the viral nucleic acid becomes the presiding deity, inhibits synthesis of host cell protein and host RNA by some mechanism and directs the synthesis of its own RNA and protein at the expense of the host cell materials. Viruses are thus parasites at the genetic level.

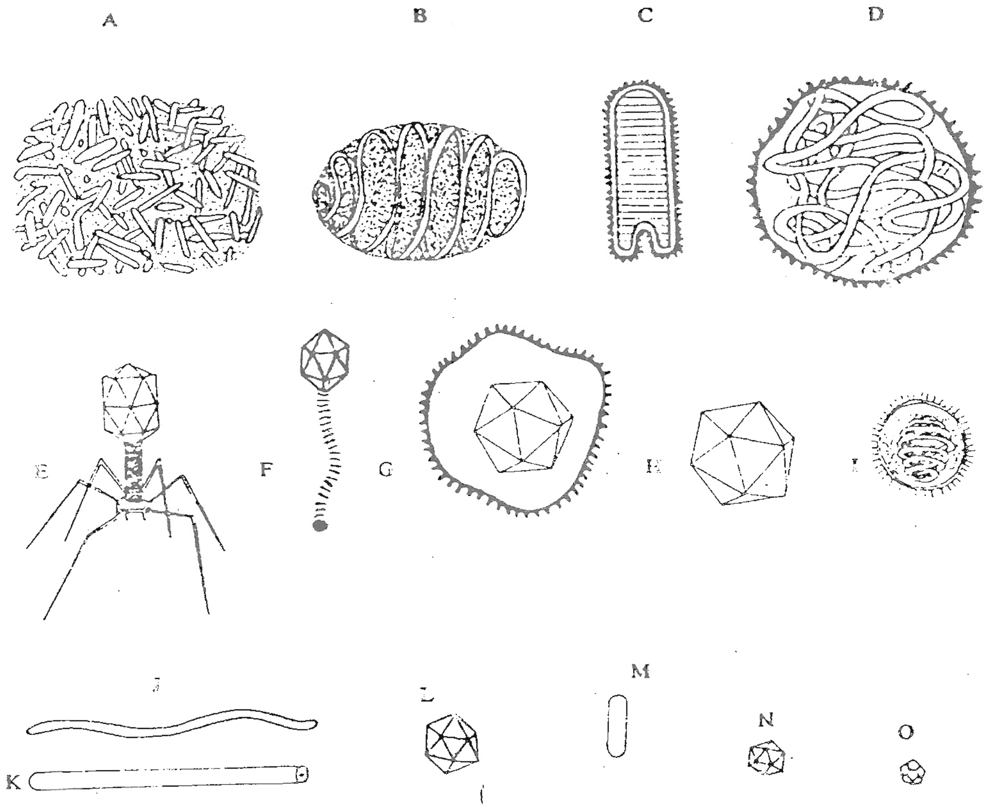
(d) *Assembly* of the newly formed coat protein and nucleic acid to form intact virus partilces.

(e) *Release* - New virus particles move out of the cell through plasmodesmata and in turn infect other cells. Virus particles are carried to other parts of the plant through phloem in most cases and xylem in a few cases.

When replicated virus particles reach the different parts of the infected plant, abnormalities develop in all parts of infected plants, both externally and internally. It is in the leaves of the plants that the most noticeable symptoms develop. Changes also occur noticeably on the stem, flowers and sometimes fruits.

Among the symptoms are mosaics and mottles of different types which accompany varying amounts of blistering and distortion of infected leaves as seen on tobacco leaves infected with tobacco mosaic virus and papaw leaves infected with papaya ringspot virus. In extreme cases leaves may be almost completely chorotic as in diseases called yellows diseases. There may be extensive thickening of the infected leaf, dwarfing, eppinasty, curling and rolling or a combination of these. Examples of diseases showing these are potato leaf roll disease, tobacco leaf curl disease and rice dwarf disease.

Figure 1: Virus Particle Morphology




A. POX VIRUS (VACCINIA)
B. POX VIRUS (ORF)
C. RHABDOVIRUS
D. PARAMYXOVIRUS
E. T-EVEN PHAGE
F. FLEXUOUS TAILED PHAGE
G. HERPES VIRUS
H. ADENOVIRUS
I. INFLUENZA VIRUS
J. POTATO VIRUS (FLEXUOUS FILAMENTOUS VIRUS)
K. TOBACCO MOSAIC VIRUS (ROD LIKE VIRUS)
L. POLYOMA VIRUS
M. ALFALFA MOSAIC VIRUS
N. POLCO VIRUS
O. X 174 PHAGE

Figure 2 : Structure of Tobacco Mosaic Virus Particle

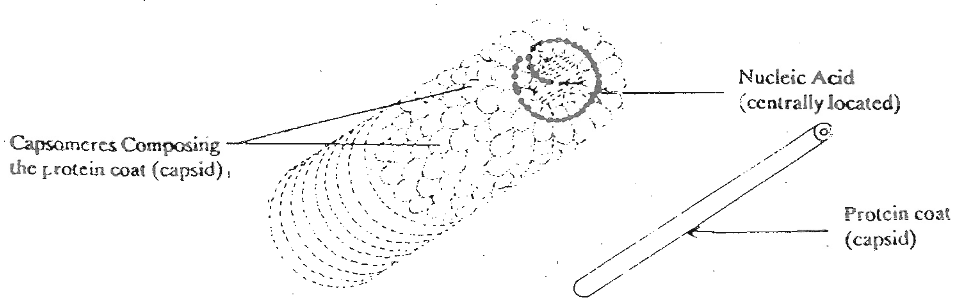
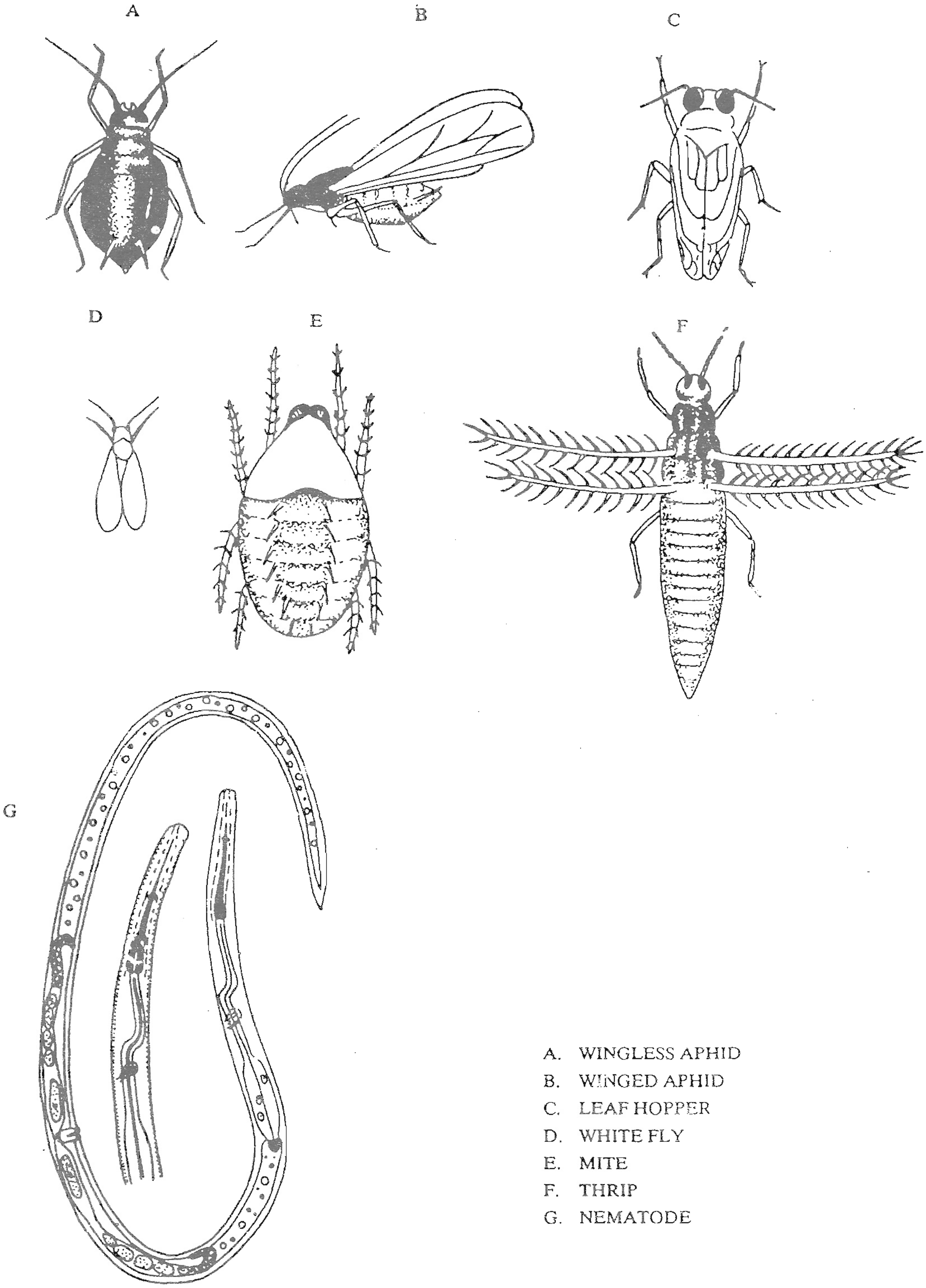


**Figure 3 :** **Vectors of Plant Viruses**



Orugrowths develop on some infections and there may be vein thickenings, vein banding and vein clearing as seen in bandakka yellow vein mosaic. Leaves are sometimes reduced, lamina is greatly suppresed to appear fern-like or shoestring-like as seen to tomato mosaic. Changes in the colour of the flowers are common. Fruits may be affected in various ways such as they may be small, misshapen and bumpy. Some fruits show mottling. It will be apparent from this account that viruses exert a generalised disturbing effect on the metabolism of the infected plant. This in turn will affect the quality, and quantity of the produce of crops.

## 4. How do Plant Viruses Spread from Plant to Plant?

Plant viruses are more dependent on an agent to transfer them from a diseased plant to a susceptible healthy one than any other plant pathogen.

1. Any factor inflicting wounds on healthy tissue will facilitate mechanical transmission of plant viruses. For example rubbing of leaves against each other by wind in the field is sufficient to transmit potato viruses and tobacco mosaic virus. Viruses like tobacco mosaic virus can be carried on the hands and implements of workers tending the plants in the field. Cutting, pruning or tapping knives also spread infection as in the case of papaya viruses.

2. Some viruses are transmitted by their infected seeds. eg.. cowpea mosaic virus.

3. A very important method of spread is by vegetative propagation. If a plant is systemically infected with a virus, all the vegetative parts used to propagate it will contain the virus so that new plants produced by this method will also be virus infected. This method of spread is important in vegetatively propagated plants like fruit trees, potato, roses and sugarcane.

4. All viruses systemically distributed in plants can be transmitted to susceptible plants by grafting. Grafting plays an important role in the spread of fruit and ornamental trees as also in the transmission of citrus diseases.

5. Most important method of spread is by other organisms or **vectors**. Almost all types of organisms feeding upon or parasitising plants are capable of acting as vectors. A large number of viruses depend exclusively or largely on insect vectors for their transmission. These include aphids, leafhoppers, beetles, whiteflies, mealy bugs and mites. Nematodes and fungi also carry viruses from plant to plant.

   Egs. Potato leaf roll virus - aphid
   Tobacco leaf curl virus - whitefly
   Rice dwarf virus - leafhopper
   Tobacco ring spot virus - nematode
   Tobacco necrosis virus - fungi

## 5. Methods of Control

There are various methods of approach to the problem of control of plant virus diseases. All the methods cannot be applied in the same way to all viruses. They would require a combination of two or more methods.

*(a) Using virus free planting material*

It is of paramount importance that the planting material must be virus free, since many viruses are transmitted by infected seeds and by infected vegetative propagules. If uninfected planting material is not available, it can be obtained either by tissue culture methods or by treating the infected parts with heat in the form of hot water or hot air.

*(b) Removal of sources of infection*

All sources of viruses such as diseased plants in the field, infected weeds, remnants of previous diseased crops should be removed and burnt. Some viruses, notably tobacco mosaic virus, are contagious to varying extents. Precautions must be taken through washing of hands of workers with soap and sterilising implements by heat or chemicals.

*(c) Control by using resistant varieties*

This is one of the most convenient methods of control. Virus-immune or resistant varieties are continuously being bred by plant breeders. Some successes have already been achieved in a few viruses like sugar cane mosaic.

*(d) Control of vectors*

Some virus diseases can be successfully controlled by means of insecticides against insect vectors. Transmission by vectors can also be controlled by avoiding vectors. Growing of seed potatoes in Pidurutalagala is a practical illustration of a large scale control of potato virus diseases by avoiding the aphid vector. The climate is too cool and moist for the vector. Avoiding the vector can also be done by warding them off the crop by means of screens or cages.

*(e) Cure of virus infected plants*

In some virus diseases, viruses can be eliminated from infected plants by exposing the infected plants to hot water or hot air for apppropriate periods of time. At the moment there is no well established example of practical control of a plant virus disease by means of chemicals acting on the virus in the host.

## 6. Conclusion

Control of plant viral diseases and the nature of the pathogen are growing fields of study. The more we understand about the pathogen, the agents which spread them, including man and the plant-virus relationships, the better equipped we will be in protecting our crops.