Plant viruses-general characteristics and examples of plant diseases caused by viruses

Virus is a submicroscopic, transmissible, intercellular, obligate parasite and consists of nucleic acid (either RNA or DNA), which is typically surrounded by a protein coat. They are less than 200 millimicron and cannot be grown in artificial media and require living host cell for multiplication. They have both living and nonliving properties. Living characters include their ability to cause disease, reproduce, mutate and have genetic materials. Non-living characters are the lack of cellular structure; enzymatic activities, respiratory activities and they can be crystallized by physical means. Nearly half of the plant virus may be of elongated (rigid rod /flexuous threads) and spherical (isometric / polyhedral) and the remaining are cylindrical bacillus like rods in shape and small enough pass through bacterial filters but too small to be seen under light microscope.

1. Rigid rod: (E.g.) *Tobacco Mosaic Virus* (TMV) and *Tobacco rattle Virus* (TRV)

2. Flexuous rod: (E.g.) *Potato Virus* X (PVX), *Bean Common Mosaic Virus* (BCMV).

3. Filamentous rod: (E.g.) Tenuiviruses likes *Rice Grassy Stunt* (RGSV) and *Rice Stripe Virus* (RSV).

4. Isometric: (E.g.) *Rice Tungro Spherical Virus* (RTSV), *Cucumber Mosaic Virus* (CMV), *Tomato Spotted Wilt Virus* (TSWV).

5. Bacilliform: (E.g.) *Rice Tungro Bacilliform Virus* (RTBV), *Banana streak virus* (BSV) and *Cocoa Swollen Shoot Virus* (CCSV).

Protein forms a protective coat (**capsid**) around the nucleic acid in a virus. Plant viruses have only one kind of protein. Individual protein subunits are called as **capsomers**. Protein subunits are spirally arranged in elongated viruses and packed on the side of polyhedral particles of spherical viruses. Proteins provide the basis for serological differentiation of viruses and other strains. Like all proteins, viral protein is made up of amino acids. Sequence of amino acids within a protein is detected by the sequence of nucleotides in the nucleic acid.

Nucleic acid may be of RNA / DNA and never both. Most of the plant viruses have RNA. But some plant viruses have DNA (e.g. *Cauliflower mosaic virus* (CaMV), *Rice tungro bacilliform virus, Bean golden mosaic virus* and *Banana bunchy top virus*). Nucleic acid **(RNA / DNA)** may be either single stranded (**ss**) or double stranded **(ds**) .Viral nucleic acids are quite small (1 – 3 x 106dalton) when compared to bacteria (1.5 x 109dalton). Nucleic acid may be present as a single

continuous strand **(monopartite)** in one particle or it may be present as two **(Bipartite)** or more pieces (**multipartite**) in the same or different particles made up of same protein subunit. Bi- or multipartite viruses are called as **split genome viruses**. All types of particles with different segments of the genome must be present in the plant for the successful infection. Nucleic acid and protein coat makes up 5 – 40% and 60 – 95% of the virus respectively.

Elongated viruses have less quantities of nucleic acid while the spherical viruses contain more nucleic acid.Some ssDNA viruses appear as twin particles as a result of partial fusion together of two of isometric particles and they are called as **geminiviruses** (E.g. *Maize streak virus, Bean golden mosaic virus* and *Beet curly top virus*)**.** Some group of viruses has outer lipid envelop around the protein coat (E.g. *Tomato Spotted Wilt Virus*)**.**

Multiplication of virus is different from fungi and bacteria. First step in the multiplication is the separation of nucleic acid from the protein coat in the host cell by the enzymes of host cell. Nucleic acid itself involve in the synthesis of new nucleic acid and protein coat by utilizing the amina acids, ribosome and transfer RNA of the host. Once the new nucleic acids and proteins subunits are formed, the nucleic acid arranges the protein subunit around it to form the **complete virus particle** or **virons. Transmission of viruses is** through **vegetative propagation** (E.g. *Banana bunchy top virus* and *Indian cassava mosaic virus)*, **seeds** (E.g. *Bean common mosaic virus)*, **pollen** (E.g. *Prunus necrotic ringspot virus)*, **sap** (E.g. *Cucumber mosaic virus, Potato virus X* and *Tobacco mosaic virus)* and by vecto

Vector

Vector is an organism that carries and transmits a pathogen (inoculum) to a plant. Vectors may be insect, nematodes, fungi, etc.

Symptoms

Symptoms like chlorosis, mosaic, streak, vein clearing, vein banding, leaf crinkle, leaf curl, enation, necrosis, dwarfing, rosette, bunchy top, twisting etc. are produced in crop plants.

Symptoms of viral diseases

Chlorosis

Yellowing of normally green tissues due to chlorophyll destruction or failure of chlorophyll formation is known as chlorosis.

i. Infections chlorosis of banana - Cucumber Mosaic Virus (CMV)

Symptoms

Severe mosaic symptoms in young growth showing broadly streaked chlorotic or yellowish green bands (from margin to midrib) and patches or chlorotic mottling distributed in patches over the leaf lamina; leaves are narrow and smaller than normal and the infected plants are dwarf; rolling of leaf margins twisting and bunching of leaves at the crown and a rigid erectness in newly emerged leaves.

Vector

Aphids - *Aphis gossypii* and *A. maidis*

Mosaic

Intermingling patches of green and light green or pale green or yellowish colour on the leaves is known as mosaic.

Mottling and streaking of banana leaves and flowers due to cucumber mosaic virus

Tobacco mosaic-*Tobacco mosaic Virus (TMV) / Nicotiana Virus 1*

Symptoms

Leaves develop characteristic light and dark green pattern on the lamina. Dark green areas are usually associated with the veins, which later develop into irregular crumpled swellings / blisters due to more rapid growth. Dark brown necrotic spots develop under hot weather (mosaic burn).

Virus

Rod shaped ss RNA.

Transmission

Sap, farm equipments and by contact.

Cowpea aphid-borne mosaic virus (CAMV) on cowpea

Symptoms

Chlorosis, dark green and light green patches alternated on leaves; distortion of leaves.

Vector

Aphids - *Aphis gossypii, A.craccivora, Myzus persicae.*

Cassava mosaic virus on cassava (Tapioca)

Symptoms

Mosaic mottling on leaves; chlorosis of leaves; distortion of leaves; twisting of leaves; stunting of plants and tuber splitting.

Vector

White fly - *Bemisia tabaci*

Yellow mosaic of greengram and blackgram caused Mungbean Yellow Mosaic Virus (MYMV)

Symptoms

Small yellow patches or spots intermingled with green patches on the leaves initially, later entire leaf changes yellow in colour, in severe infections discolouration of pods and seeds to yellow.

Vector

Whitefly - *Bemisia tabaci*

Sterility mosaic of pigeonpea - Pigeonpea sterility mosaic virus

Symptoms

Intermingling of light green and dark green patches in the leaves, reduction in leaf size; small leaves clustering near the tip of the plants, shortening of internodes, stimulation of auxillary buds giving a bushy appearance. No flower and pod formation leading to sterility of affected plant. Plants remain green till harvest.

Sterility mosaic disease symptoms, mild (left) to severe (right), on pigeonpea leaves caused by *Pigeonpea sterility mosaic virus*

Vector

Eriophyid mite - *Aceria cajani*

Stripe

Stripe is characterized by elongataed or areas of pale green to yellow or white, of indefinite length, on leaves with parallel venation or on stems.

i. Barley stripe mosaic - Barley stripe mosaic virus

Symptoms

Light green stripes on the leaves and stunting of plants.

Streak

Development of chlorotic streaks on leaves.

Maize streak - Maize Streak Virus

Symptoms

Elongated chlorotic stripes appear on one side of mid rib near its base, which later become necrotic. Plants are stunted and produce small ear heads.

Virus

Isometric with ss DNA geminate particles and monopartite genome.

Vector

Leaf hopper -*Peregrinus maidis*

Vein clearing

Yellowing of veins or clearing of the tissues in or immediately adjacent to the veins is called vein clearing.

i. Vein clearing or yellow vein mosaic of bhendi - Bhendi yellow vein mosaic virus (BYVMV)

Symptoms

Initially light yellow streaks along with the smaller veins, later all the veins become yellow giving **yellow network of veins**. Chlorosis of interveinal areas, reduction in size of leaves and small and fibrous fruits.

Virus

Isometric with ssDNA geminate particles and bipartite genome.

Vector

Whitefly *Bemisia tabaci*

Vein banding

The tissues along the veins are dark green than the tissues between the veins is called vein banding.

i. Potato vein banding - Potato vein banding virus.

Symptoms

Veins only remain green and interveinal areas become bleached to yellow. Newly emerged leaves are smaller and show crinkling, rolling upward to form cap like structures and distortion. Affected plants are stunted and leaves are brittle.

Virus

Filamentous particle with 1 or 2 ss RNA

Vector

Myzus persicae (Aphid).

Leaf crinkle

In leaf crinkle the surface of leaves is not uniform and is with undulations.The leaves are thick and brittle and remain green till harvest.

i. Leaf crinkle of blackgram - urdbean leaf crinkle virus (ULCV)

Symptoms

Crinkling and curling of leaves, stunted and bushy plants and malformed inflorescence with sterile flowers.

Virus

Isometric with ssDNA, geminate particles and bipartite genome.

Vector

Whitefly - *Bemisia tabaci*

Leaf curl

In leaf curl the leaves curl from the margins backward bringing the centre of the lamina upward.

i. Tomato and tobacco leaf curl - Tobacco leaf curl virus. (TLCV)

Symptoms

Leaves curled, twisted and puckered, leafy outgrowth called enations can be seen on the under surface of leaves, thickening and greening of veins in the leaf and calyx, mottling and vein clearing, stunted plant growth, inflorescence greatly condensed and complete or partial sterility.

Vector

Whitefly - *Bemisia tabaci*

ii. Black gram leaf curl- *Tomato Spotted Wilt Virus (TSWV)*

Symptoms

Lateral veins show chlorosis near the leaf margin and the lamina curl downwards slowly. Infected leaves are brittle and sometimes vein necrosis present on the under surface of the leaves, which extends up to the petiole. Plants may produce few small and malformed pods

Virus

Spherical with negative ss RNA and are enveloped with a lipid membrane.

Vector

Thrips-*Thrips tobaci, Frankliniella schultzii*

Enation

Enations are leaf-like outgrowth from the veins on the under surface of the leaves diseased by different viruses.

Tomato and tobacco leaf curl-*Tomato Leaf Curl Virus (TLCV)*

Symptoms

Leaves become warty, rough, puckered with downward curling. Leafy outgrowth like structure is noticed on the veins in the lower surface of the leaves.

Virus

Isometric with ss DNA geminate particles and monopartite genome.

Vector

Bemisia tabaci (white fly)

Tobacco and tomato leaf curl - Tobacco leaf curl virus (TLCV)

Necrosis

Necrosis (death of cells) of tissues in the growing shoots due to virus infection.

i. Bud necrosis of groundnut - Tomato spotted wilt virus (TSWV).

Symptoms

Young leaves show chlorotic spots or mottling and necrosis of terminal buds which spreads downwards and covers the entire plant or part of the plant; reduction in leaflet size; distortion of lamina and **shoe-string** formation stunting and bushy appearance of plants.

Virus

Spherical with negative ss RNA and are enveloped with a lipid

Vector

Thrips - *Frankliniella schultzei, Thrips tabaci* etc.

Dwarfing

A decrease in overall size without alteration of the proportions between parts of the plant is known as dwarfing.

i, **Rice dwarf - Rice dwarf virus.**

Symptoms

Yellowish white to white specks are seen along the veins of young leaves; on succeeding leaves specks develop in more numbers and are connected to form continuous streaks along the veins; plants are extremely stunted with: shol1ned internode and innumerous unproductive tillers giving a rosette appearance.

Vector

Green leafhoppers - *Nephotettix cincticeps.*

Rosette

In rosette shortening of internodes with reduction in leaf size is seen. The plants show stunting with bushy appearance.

i. Groundnut rosette - Groundnut rosette virus (GRV)

Symptoms

Stunting of plants with chlorotic, twisted and distorted leaflets.

Vector

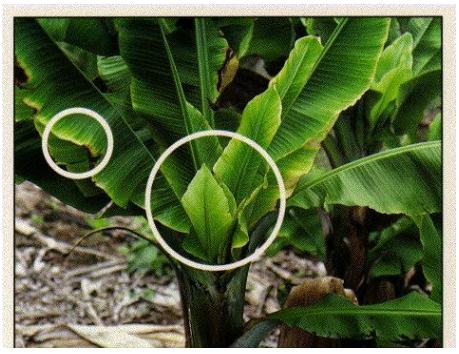
Aphids- *Aphis craccivora*

Bunchy top

In bunchy top extreme stunting of the plant with bunching of small, erect and brittle leaves at the crown of plants is seen.

i. Bunchy top of banana - Banana bunchy top virus (BBTV)

Symptoms



Leaves with broken green, bands parallel to, veins; small and brittle leaves with short petiole crowding of small leaves at the crown coupled with stunting of plants giving a bunchy appearance; the infected plants are normally 30-60 cm in height; plants do not produce bunches.

Virus

Isometric with ss DNA geminate particles and monopartite genome.

Vector: Banana aphid- *Pentalonia nigronervosa* var. *typica.*