Plant virus and virus like diseases

Potato infecting viruses

Potato virus diseases

- Potato is the fourth most important food crop in the world, with a yield of 315 million tons in 2006
- Potato virus diseases had been studied and reported since 1924 (McKay and Dykstra, 1932) where their symptoms, methods of artificial and natural transmission, effects on yield, and control measures were extensively studied.
- Nowadays, more than 35 different viruses are known to affect potatoes.
  - In addition, the potato spindle tuber viroid (PSTVd) and few phytoplasma organisms can affect the crop and cause severe damage.

- Worldwide potato infecting viruses and have the most important effect on yield :
  - potato leafroll (PLRV)
  - potato virus Y (PVY)
  - potato virus A (PVA)
  - potato virus X (PVX)
  - potato virus M (PVM)
  - potato virus S (PVS)
- In the last 10 years a number of re-emerging viruses and newly emerging viruses are threatening the crop.
  - These viruses have the potential of severely limiting potato production in the future if their control is not considered immediately

Table 1. Worldwide potatoes infecting virus genera or families. (Salazar, 1996).

Virus genus or family	Member virus (es)*	Means of natural transmission	Effect on yield
Potyviridae	**PVY**, potato virus Y PVA potato virus A PVV, potato virus V	Aphids	Up to 90%
Luteovirus	**PLRV**, potato leafroll virus SYV, Solanum yellows virus	Aphids	Up to 90%
Potexvirus	**PVX**, potato virus X PAMV, potato aucuba mosaic virus	Mechanical; fungus	Up to 40%
Alfamovirus	AMV, alfalfa mosaic virus PYV, potato yellowing virus	Aphids	Up to 20%
Carlavirus	PVS, potato virus S PVM, potato virus M PVP, potato virus P PRDV, potato rough dwarf virus	Mechanical, aphids	Up to 20%

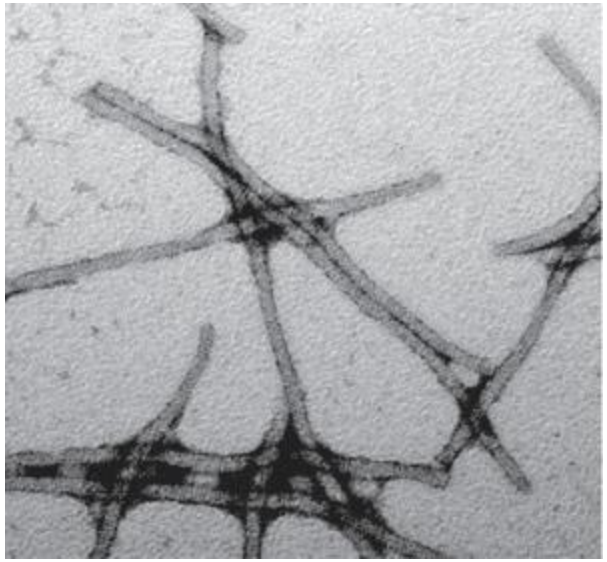
PLRV- Symptoms of PLRV on foliage (rolling of leaves, stunting of plants) and tubers (net necrosis).

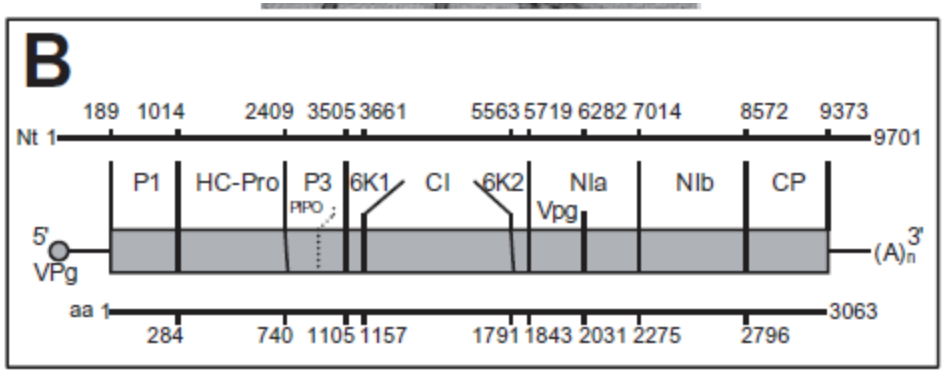
- **PLRV** is transmitted in nature in a persistent manner by several aphid species in particular, *Myzus persicae* Sulz, the most important vector. The virus survives mainly in infected volunteer potatoes and in wild hosts, although it appears that the importance of wild hosts for survival and spread is higher in tropical countries.

PVY

- **PVY** and **PVA** are transmitted in a non-persistent manner by several aphid species.
  - *M. persicae* is the most efficient and common vector in nature.
- PVY is extremely variable and three groups of strains are recognized (PVY^{O}, PVY^{N} and PVY^{C}).
  - However, several other strains or isolates with particular characteristics have caused outbreaks in potato in the last decades.
  - The most damaging at present is PVY^{NTN} that causes ringspots on the tubers.
  - Some can be considered re-emerging while others are previously unrecorded on potatoes.

PVY

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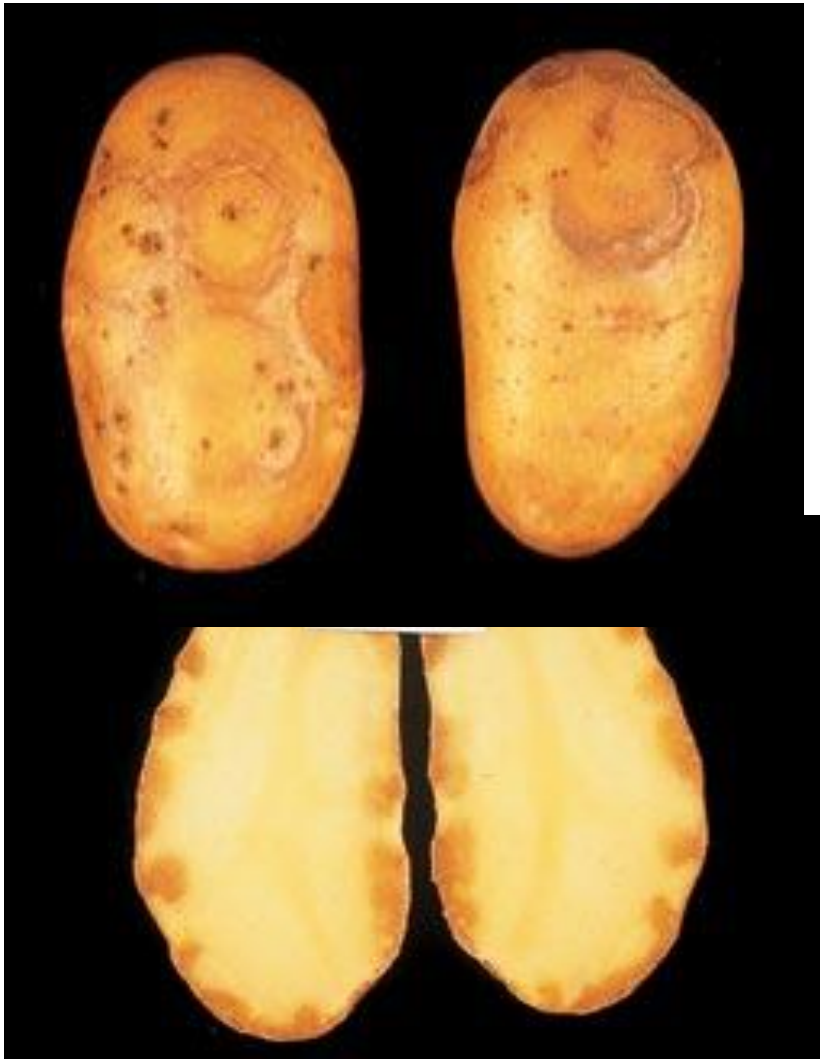
The PVY^{NTN}

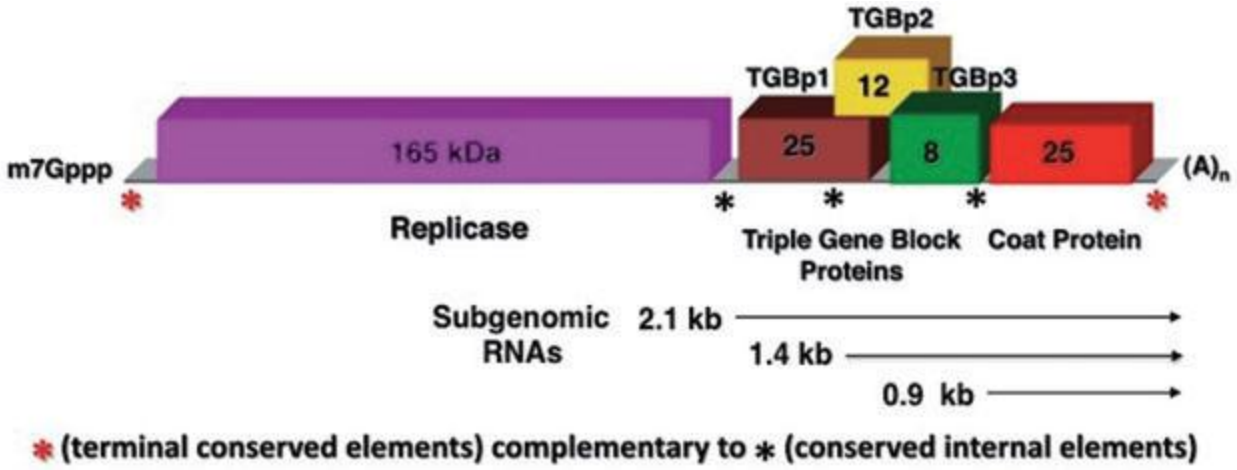
- Among the re-emerged viruses we can include **PVY^{NTN}**.
- The PVY^{NTN} was first recorded in Europe by 1980 (Beczner et al., 1984) and since then outbreaks have been reported in many regions in the world.
- The virus, which is not an apparently uniform entity, causes necrotic ringspots on tubers of several cultivars, usually causing severe economic losses due to reduce market value and harvest yield

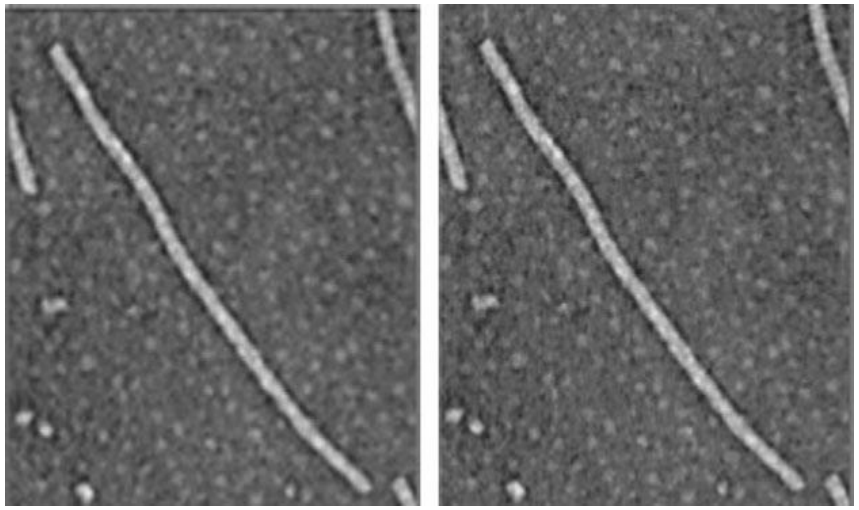


PVX

- **PVX** is the type member of the *Potexvirus* family of plant viruses.
- Plants often do not exhibit symptoms, but the virus can cause symptoms of chlorosis, mosaic, decreased leaf size, and necrotic lesions in tubers.
- PVX can interact with PVY and PVA to cause more severe symptoms and yield loss than either virus alone.
- The source of this virus is infected tubers.
  - It is transmitted mechanically, not by an insect vector.
- Tobacco, pepper, and tomato can also serve as hosts of PVX.

Potato virus X (PVX) genome.





Transmissibility and Approaches to Control

- Many developing countries follow regulations established in developed countries in their seed production, virus detection programs without having made appropriate and extensive surveys to determine the important viruses in the crop.
  - This situation may lead to future outbreaks of new viruses or new strains of known viruses, as was probably the case for PVYNTN now found in several countries in the world.

Transmissibility and Approaches to Control

- Aphid transmitted viruses such as PLRV or the potyviruses are thought to continue to affect potatoes in the 21st century and it is likely that new viruses or strains of these viruses will continue to appear in the crop.
- As new vectors become established in the crop (e.g. white flies or psyllids) viruses from other crops or weeds vectored by these insects might become adapted to potato.
- Evidence for this already exists in the case of Solanum apical leaf curling virus, a geminivirus with three-partite particles, and found affecting potatoes in the low jungle valleys in Peru (Hooker and Salazar, 1983).

Transmissibility and Approaches to Control

- Due to the large number of viruses that affect the crop and the prohibitive cost of testing for all of them, reagents directed to the detection of virus groups or genera (e.g. Carla-, potex- and potyviruses) rather than individual viruses should be encouraged.

Potato spindle tuber viroid

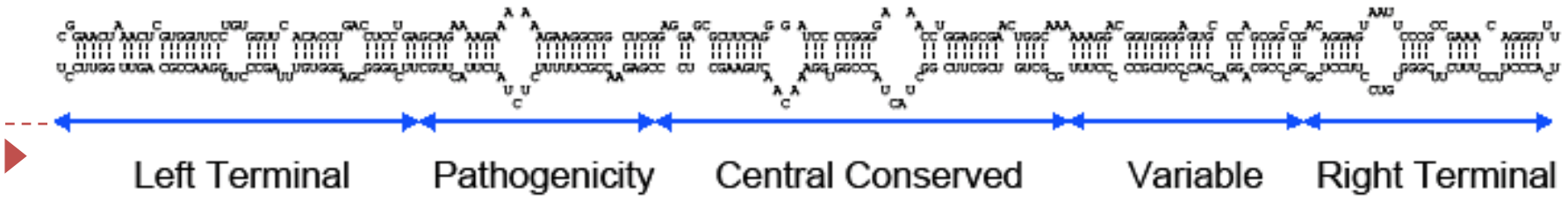
Viroids

- Viroids are very small rod-like RNA molecules (200-400nt), with a high degree of secondary structure.
- They have no capsid or envelope & consist only of a single nucleic acid molecule.
- Viroids are associated with plant diseases & are distinct from satellites in a number of ways.

Potato Spindle Tuber Viroid

Genomic Sequence and Proposed Secondary Structure

(Intermediate strain)



The Satellites

- Satellites are small RNA molecules which are absolutely dependent on the presence of another virus for multiplication.
- Most satellites are associated with plant viruses, but a few are associated with bacteriophages or animal viruses,
  - e.g. the Dependovirus genus, which are satellites of adenoviruses.
- Two classes of satellites can be distinguished,
  - Satellite viruses, which encode their own coat proteins,
  - Satellite RNAs (or 'virusoids'), which use the coat protein of the helper virus.

Viroids

- The first viroid to be discovered & the best studied is *Potato spindle tuber viroid* (PSTVd).

Viroids

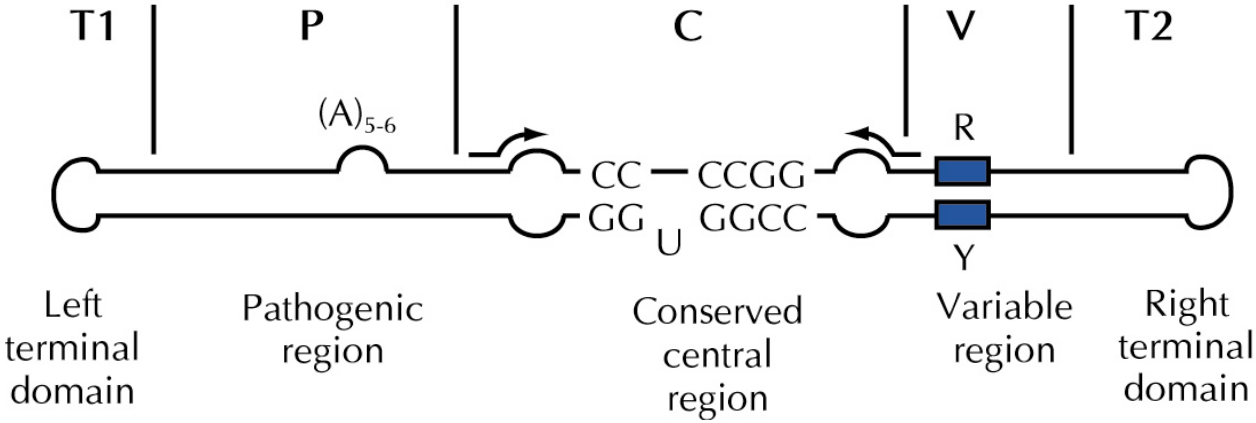
- Viroids **do not encode any proteins** & are replicated by host cell RNA polymerase II, or possibly by the product of an RNA dependent RNA polymerase gene in some eukaryotic cells.

- The details of replication are not understood, but it is likely to occur by a rolling circle mechanism followed by autocatalytic cleavage & self-ligation to produce the mature viroid.

Viroids

- All viroids share a common feature, a **conserved central region** believed to be involved in their replication.

- One group of viroids is capable of forming a hammerhead structure, giving them the enzymatic properties of a ribozyme (an autocatalytic, self-cleaving RNA molecule).



Viroid Pathogenesis

- It is not clear how viroids cause pathogenic symptoms, but obviously these must result from some perturbation of the normal host cell metabolism.
  - It has been suggested that viroids may interfere with post-transcriptional RNA processing in infected cells.
- In vitro experiments with purified protein kinase PKR have shown that the kinase is **strongly activated** (phosphorylated) by viroid strains that cause severe symptoms, but far less by mild strains.
  - Activation of a plant homologue of PKR could be the triggering event in viroid pathogenesis

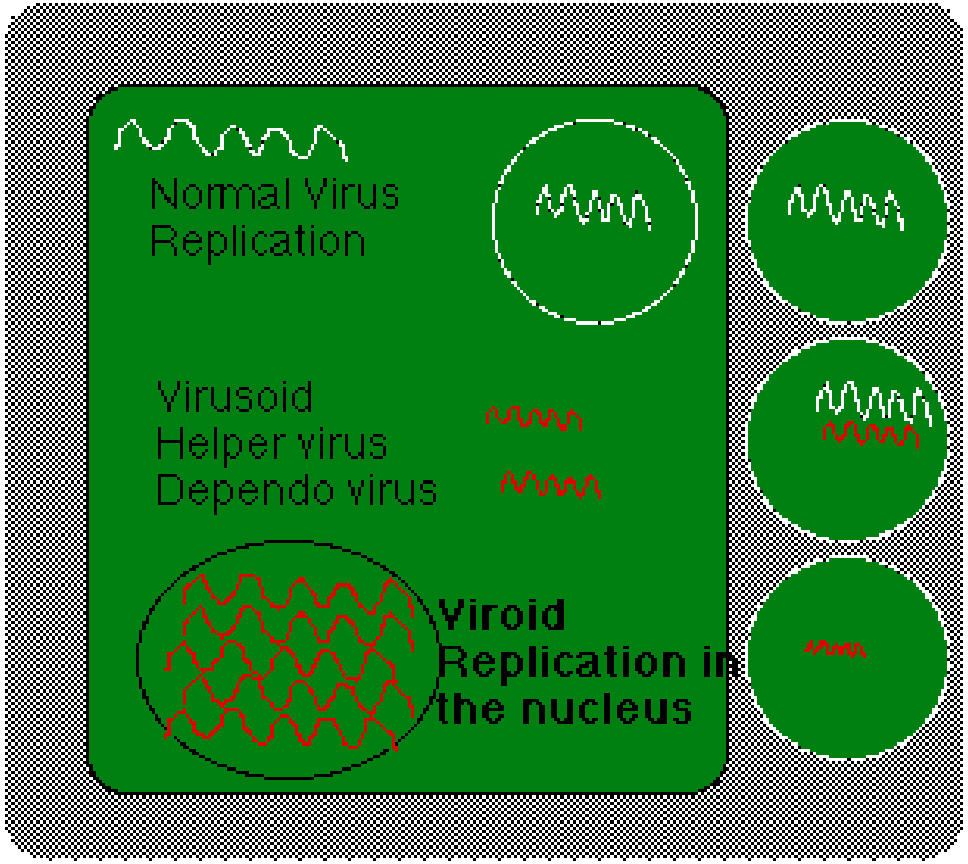
Propagation of Viroids

- Most viroids are transmitted by vegetative propagation,
  - although a few can be transmitted by insect vectors (non-propagative) or mechanically.

- Because viroids do not have the benefit of a protective capsid, viroid RNAs would be expected to be at extreme risk of degradation in the environment.
  - However, their small size & high degree of secondary structure protects them to a large extent & they are able to persist in the environment for a sufficiently long period to be transferred to another host.

Replication of viroids

- Vd has circular folded RNA
  - Central 20± bp highly conserved
- No AUG or CAU for translation initiation!
- No viroidally directed polypeptides ever detected!
- Situated in the **nucleolus**
  - Genomic code similar to rRNA introns
- Genomic replication
  - Probably uses host's DNA-directed RNA polymerase II
  - Rolling circle



Examples of viroids

Diseases (mostly plant)	**number of nucleotides**
• **Potato spindle tuber**	**359**
• Chrysanthemum stunt	354 and 356
• **Citrus exocortis**	**371**
• Cucumber pale fruit	303
• Hopstunt	297
• Avocado sunbloch	247
• Cadang-cadang (coconut palm)	246, 287, 482, and 492
• Several tomato isolates	360

Cachexia

- The cachexia disease is found in most citrus growing areas of the world where exocortis is found.

- **Symptoms**:
  - **Gum** in scion just above the bud-union and also at the cut-back joint of the new growth area.

FIGURE 45
The trunk portion of a field tree of Parson's Special mandarin as a rootstock under a grapefruit scion with the bark cut away to show the brown gum-stain. This tree was inoculated with a severe isolate of citrus cachexia viroid (Central California)

Exocortis

- The exocortis disease of citrus, caused by the *Citrus exocortis viroid* (CEVd), was first reported and described by Fawcett and Klotz (1948) as a bark-shelling disorder of trifoliate orange rootstock .

- The disease is present in almost all citrus growing regions of the world.
  - Although many of the commercial citrus cultivars are symptomless carriers, trees may be **stunted** to some degree on rootstocks normally considered tolerant.

FIGURE 43
The effect of CEV on tree size (California)

a) Five-year-old trees of Valencia orange on Troyer citrage. CEV-infected tree is on the left

b) Older trees of Valencia orange on trifolate rootstock. CEV-infected trees are on the right (All CEV-infected trees show severe bark cracking on the trifoliate rootstock)

FIGURE 41a
Classic severe symptoms of CEV in citron showing severe epinasty of leaves.
A few normal control leaves are shown on the left

Diagnosis

- Field diagnosis
  - First symptoms: CEV (4 to 10 weeks)
  - Symptoms: CEV - Severe leaf epinasty and bark cracking
- Graft transmission to indicator plants
- Nucleic acid hybridization probe
- RT-PCR

Graft transmission to indicator plants