Virus Diseases of Potato

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Severe mosaic symptoms

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Virus Diseases of Potato

Objectives. Study of this bulletin should enable you to:

- describe the importance of potato virus diseases,
- list major virus symptoms,
- explain the nature of potato viruses and viroids,
- discuss means of virus transmission,
- list procedures for virus detection and identification,
- discuss possibilities for virus control.

Study materials.

- Plants infected with different viruses.
- Plants infested with aphids.
- Slides of virus symptoms.

Exercises.

- Practice virus disease recognition in the field by describing symptoms of infected plants.
- Examine plants for presence of virus vectors and discuss principles of virus transmission.

Questionnaire.

1. How important are virus diseases of potato in your country?
2. How do viruses affect potato plants?
3. Why is it not always possible to compare effects of viruses with healthy potato plants in an infected potato field?
4. List effects and symptoms of potato virus diseases.
5. Why are latent infections most troublesome?
6. What is the difference between *primary symptoms* and *secondary symptoms*?
7. How do viruses and viroids differ?
8. What are characteristic shapes of viruses?
9. Describe the size of viruses (example).
10. How do humans transmit potato viruses?
11. What is the difference between viruses transmitted in the *persistent* and the *non-persistent* manner?
12. What are *soil-borne* viruses?
13. Name two ways by which PSTV is transmitted.
14. How is field diagnosis useful as a means of virus detection?
15. What are the advantages of serological methods? What do they require?
16. What is the most efficient way to avoid virus infections?
17. Why should weeds be eliminated in a seed potato field?
18. How would you judge suitability of a seed potato growing area with respect to insect populations?

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Virus Diseases of Potato

1 INTRODUCTION

Viruses and viroids are extremely small infective entities that can cause diseases in plants and animals. Several of them affect potato and may cause extensive yield losses. In practice, virus diseases of potato cannot be controlled directly, although various methods of indirect control exist. Disease management requires knowledge about the nature of viruses, sources of infection, means of transmission and detection, and ways to avoid losses.

2 IMPORTANCE OF POTATO VIRUSES

Approximately 25 different viruses and one viroid are known to infect potato under natural conditions. They cause different symptoms on leaves, stems and tubers. Nearly all virus diseases reduce vigor of the potato plant; several cause severe yield reductions. Frequently two or more viruses may be present within a plant at the same time. Virus diseases seldom cause tuber decay in storage.

Viruses and viroids are often described by their initials. The following are examples:

PLRV – potato leafroll virus
PVY – potato virus Y
PVA – potato virus A
PVX – potato virus X
PVS – potato virus S

PVM – potato virus M
PVT – potato virus T
PMTV – potato mop-top virus
TRV – tobacco rattle virus
AMV – alfalfa mosaic virus

PAMV – potato aucuba mosaic virus
TRSV – tobacco ringspot virus
TBRV – tomato black ring virus
TSWV – tomato spotted wilt virus
APMV – Andean potato mottle virus

APLV – Andean potato latent virus
PYVV – potato yellow vein virus
PSTV – potato spindle tuber viroid

3 MAJOR VIRUS SYMPTOMS

The effect of the virus in a plant is often reflected by the type of symptom produced.

The exact manner in which viruses affect plants varies with the virus and the host. The precise way in which viruses induce disease is not fully understood. Mosaic or yellow symptoms result from impairment of chlorophyll formation or function. PLRV infects phloem cells impairing translocation of carbohydrates.

Symptom severity is influenced by environmental conditions. Satisfactory identification of diseased plants is difficult when plants are grown under unfavorable temperatures, water stress, or certain mineral deficiencies. Generally, conditions for succulent, rapid growth induce the most evident symptoms of virus infection.

Because some potato fields may be completely infected with virus, comparison with healthy plants is not always possible. Thus, symptoms of virus infection may be overlooked and even confused with varietal characteristics.

Viruses may cause –

- loss of yield,
- latent infections,
- changes in leaf color,
- leaf deformations,
- stunting,
- death of foliage tissue,
- tuber necrosis and deformation.

Loss of yield. Loss of yield is the most important result of virus infection. Yields may be severely reduced, although infected plants may show only slight symptoms. Virus-infected plants (with rare exceptions) produce fewer or smaller tubers than healthy plants. These tubers, when used for seed the following growing season, usually produce infected plants, resulting in general crop degeneration.

Latent infections. Virus infections without symptoms or with mild symptoms are the most troublesome aspect of virus diseases. Plants may be diseased and show virtually no evidence of infection. They may appear nearly normal in plant type and vigor and produce normal appearing tubers (e.g. PVS, PVX). Newly infected plants may not show symptoms for some time or for the remainder of the growing season. However, the virus infection is usually in the tubers and, if tubers are used as seed, they will produce diseased plants.

Changes in leaf color. Symptoms appear as mosaic, mottling, or yellowing.

Mosaic or mottling is characterized by lack of uniformity in foliage color. Areas of the leaf vary from dark green to light green. Sometimes leaf veins may be lighter than normal in color. Some viruses producing these symptoms include PVX, PVY. Visible symptoms are not constant, and frequently plants with mosaics appear symptomless for parts of the day or during parts of the growing season.

Other viruses may cause leaves to yellow in irregular patches. Yellowing may be associated with leaf veins or margins. Plants may be generally off-color, pale, slightly or markedly yellow.

Leaf deformations. Distorted or off-shape leaves can be smaller than normal, puckered, rolled or more erect, or have irregular margins. Rugosity or crinkle appears as puckering of leaves with irregular, uneven surfaces. PVY may cause such symptoms.

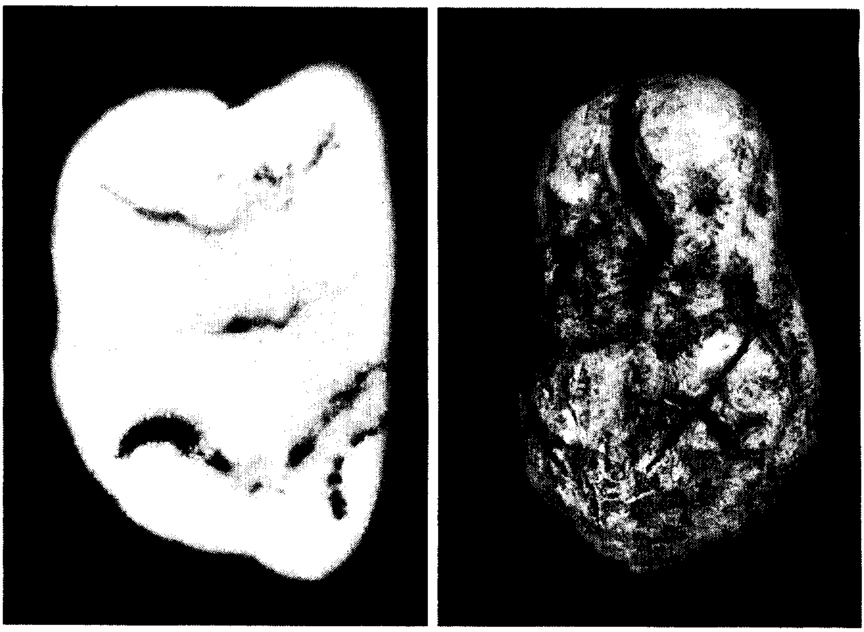
Leafroll is characterized by upward rolling of leaf margins (cupping) so that the undersurface is partially exposed. When the leafroll virus (PLRV) is carried by the seed tuber, leaf rolling is first evident on lower leaves (secondary symptoms). On recently infected plants, rolling usually begins on the upper leaves (primary symptoms). Leaf rolling also results from causes other than viruses.

Stunting. Internodes are shortened and stems are either thicker than normal or, sometimes thin and spindly. Stunting is usually most severe when virus infection has been established through a number of tuber multiplications.

Death of foliage tissue. Viruses seldom kill potato plants directly. They often cause plants to mature early. Symptoms may appear as scattered spots on leaves, or the entire leaf may die and drop.

Leaves may die because of necrosis of veins or because necrotic areas of leaves enlarge and eventually spread downwards through the petiole. Rugose mosaic usually causes leaves to die beginning at the base of the plant and progressing upwards towards the tip. Viruses can also cause general yellowing of the leaf and its eventual death.

Tuber necrosis and deformation. Tubers usually show no symptoms except for size reduction. However, some viruses cause visually evident external or internal necrotic areas of several types including small spots, rings or arcs, flecks or circular spots (e.g. TRV, AMV, PMTV). Tubers may be elongated as with PSTV, otherwise deformed, or with growth cracks.



Tuber internal necrosis (TRV) and deformation (PMTV).

Leaf rolling of PLRV.

Healthy appearing leaf (left) contrasts with severe mosaic symptoms (right).

4 NATURE OF VIRUSES AND VIROIDS.

Viruses are of several different types and all are distinct from viroids.

Viruses. Virus particles consist of nucleic acid protected by a protein coat. Potato viruses now characterized are all of the ribonucleic acid type (RNA). Characteristic shapes, as seen with the electron microscope (viruses are too small to be seen with the normal light microscope), include rods, filaments, isometric, and bacilliform types.

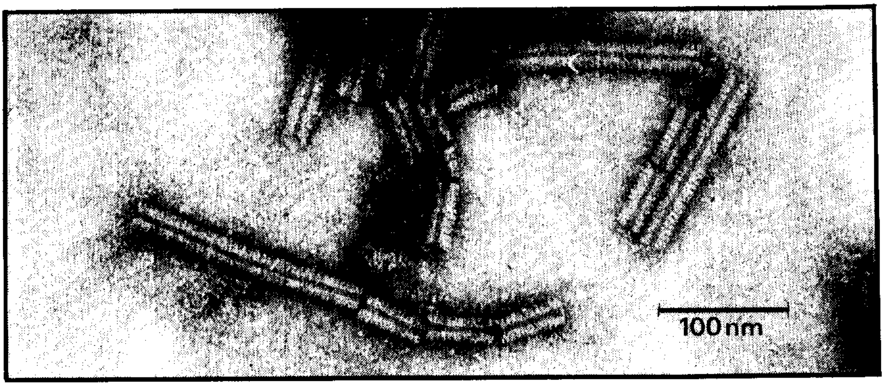
Rods are relatively thick and straight. Particles of TRV are typical rods.

Filaments are thin and flexuous. Some medium size virus particles are approximately 500 nanometers (nm) long (1 000 000 nm = 1 mm). This means that 2 000 of them arranged end to end would measure one millimeter in length. Potato viruses Y, X, S, M are about this size and shape although they differ slightly in average size.

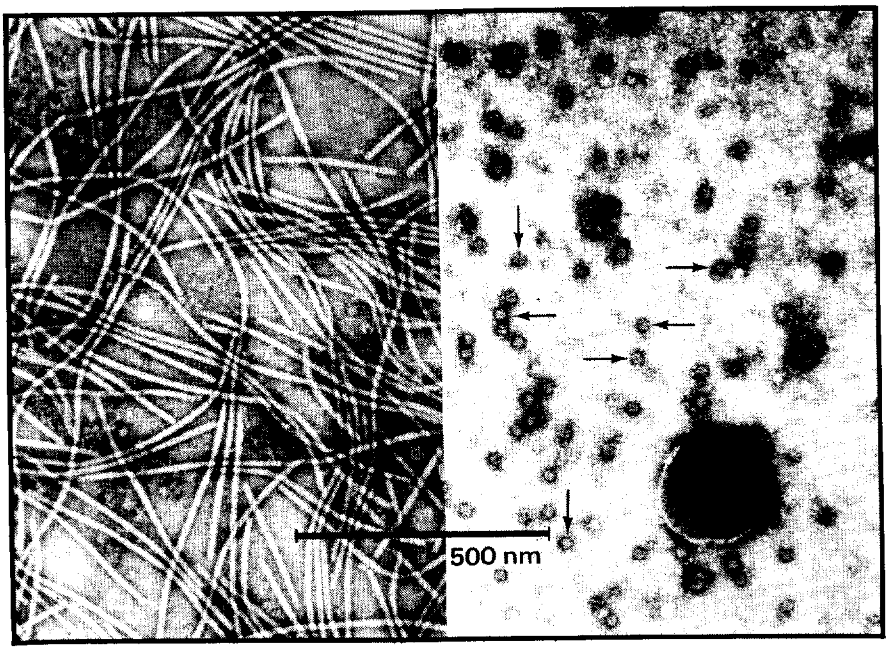
Isometric virus particles are more or less spherical with hexagonal outlines and measure 25 to 30 nm in diameter. Isometric viruses include PLRV, APLV and APMV.

Bacilliform virus particles resemble elongated bacteria with rounded ends except that they are much smaller than bacteria. These vary from essentially round to elongate with rounded ends. AMV is an example.

Viroids. Viroids are infectious ribonucleic acids of extremely small size that lack the protein coat typical of viruses. PSTV is the only known viroid naturally infecting potato.



Section of a rod-like virus particle. Viruses consist of nucleic acid protected by a protein coat. Viroids are infectious nucleic acids that lack the protein coat.



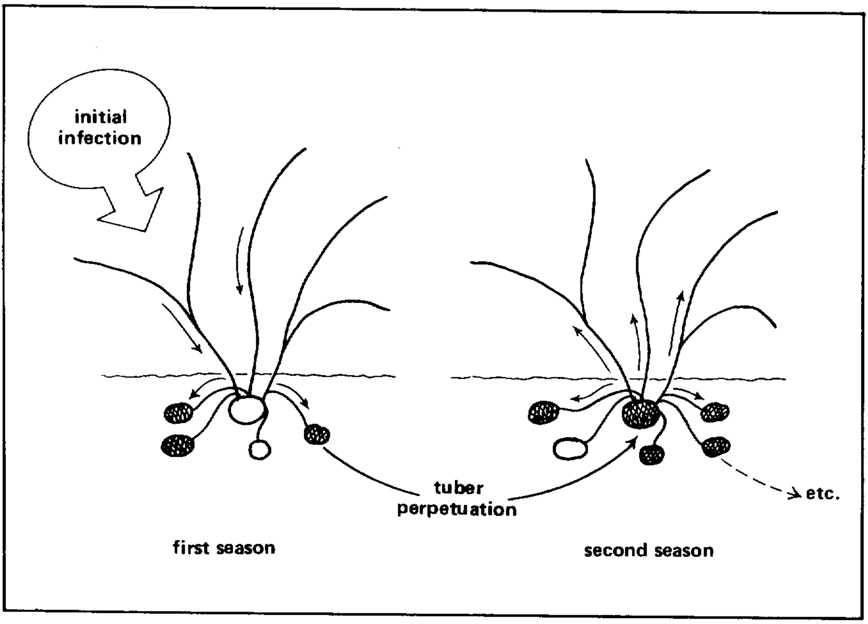
Characteristic virus particles as seen with the electron microscope include filaments (PVY), and isometric (PLRV) particles (1 nm = 0.000 001 mm).

5 MEANS OF VIRUS TRANSMISSION.

Viruses are transmitted by:

tubers	(5.1),
animal vectors	(5.2),
fungi	(5.3),
true seed and pollen	(5.4).

5.1 Tuber perpetuation results from planting virus-infected tubers. Certain viruses may infect a plant but not necessarily all progeny tubers. However, infected plants usually produce infected tubers.



Infections occurring during the current growing season are so-called *primary infections,* while viruses borne in seed tubers perpetuate the disease. Certain viruses may infect a plant, but not necessarily all of the progeny tubers may become infected (left). However, infected plants usually produce infected tubers (right).

5.2 Transmission by animal vectors. Several animal vectors transmit viruses.

Humans transmit viruses by causing leaf or sprout contact from infected to healthy plants (mechanical transmission) and by planting and harvesting procedures. Some viruses survive for a time on clothing, hands, hoes, or cultivators, and may be transmitted in field operations. Man is the major vector of PVX and, as far as presently known, of the viroid (PSTV).

Aphids are the major natural vectors of most plant viruses. Several aphid species during normal feeding transmit the most important potato viruses. Viruses can be transmitted by aphids in a non-persistent or persistent manner.

Non-persistently transmitted or stylet-borne viruses (some of the mosaic-producing viruses) are transmitted on or in the aphid's mouthparts for a short time only (less than an hour), as the aphid moves from plant to plant. To be successful, transmission must occur within a short time after the aphid has fed on a diseased plant. PVY (rugose mosaic) is a good example of this type of transmission.

Persistently transmitted viruses survive for a long time once they are within the body of the aphid. They are generally transmitted for the duration of the life of the aphid. PLRV is an example.

Leafhoppers transmit viruses after feeding on an infected plant. However, an incubation period is required during which the virus multiplies or circulates within the insect's body. After incubation the virus is transmitted during the remaining life of the insect. Potato yellow dwarf and sugar beet curly top are examples of potato viruses transmitted by leafhoppers.

Nematodes transmit several viruses that are sometimes inaccurately called soil-borne viruses. These include TRV, and TBRV.

Chewing insects transmit viruses in some cases, although they are not considered efficient vectors.

5.3 Fungi transmit few viruses. PMTV is transmitted by *Spongospora subterranea* and is limited to areas where powdery scab of potato exists.

5.4 True seed and pollen transmission. The viroid, PSTV, and few viruses such as PVT and APLV are carried by true seed. Thus, the seedling is infected at its earliest stage. Pollen from infected plants may carry a viroid or a virus to the developing embryo and thus infect the seedling. Pollen and true seed transmission of PSTV increase the difficulty in controlling this disease.

6 VIRUS DETECTION AND IDENTIFICATION

Detection and/or identification of viruses is difficult and sometimes involves elaborate procedures. Identification may include field diagnosis, plant or tuber indexing, indicator hosts, serological methods, electron microscope examination, or other means.

Field diagnosis of diseased plants is mainly useful in roguing seed potato crops to eliminate plants with symptoms. Accurate identification of a specific virus on the basis of field symptoms is virtually impossible. Thus, some other means of identification must also be employed.

Plant or tuber indexing determines only presence or absence of disease. It neither identifies the specific virus present nor does it detect infected plants which do not show symptoms. Viruses in seed tubers may be detected by planting a single tuber from a hill or an eye from a parent tuber in a place suitable for careful observation. The rest of the hill or the parent tuber is saved if the plant is healthy or is discarded if diseased.

Indicator hosts are usually plants other than potato. They may be inoculated mechanically, by grafting, or by suitable animal vectors. Selection of the proper indicator host or combination of hosts and a careful examination of the type of symptoms developed may give positive identification or at least suggest possible viruses which may be present.

Serological methods are highly specific and require only a short time for incubation and observation. Preparation of serum and procedures for conducting the test are precise operations involving skill of a trained virologist or technician. Various types of serological tests are used. All depend upon production of antibodies within the body of an animal (usually a rabbit) after purified virus has been injected over a period of time. Antiserum, containing antibodies for the specific virus injected, is separated from the blood. This combines specifically with the virus in a serological test.

Electron microscopy is extremely useful. It requires an expensive instrument which may not be available to most potato investigators, and a trained observer is required. If a virus is present in sufficient quantity, the electron microscope aids in detection and shows the particle type. It cannot identify a specific virus although it provides valuable information as to the shape and size of the particle.

7 VIRUS CONTROL

Direct control of viruses is impracticable. Indirect control concentrates on

- use of healthy seed tubers,
- elimination of sources of infection,
- control of insect vector transmission,
- avoidance of mechanical transmission.

Use of healthy seed tubers. Use of healthy seed is the most efficient way of avoiding virus infections. Virus-free seed tubers produce healthy plants. Following infection during the current growing season, yield reductions are usually small. However, infected plants generally produce infected tubers which, if used as seed, produce infected plants. In subsequent seasons, yield reductions become progressively greater. Healthy plants cannot be grown from infected seed tubers except in rare instances.

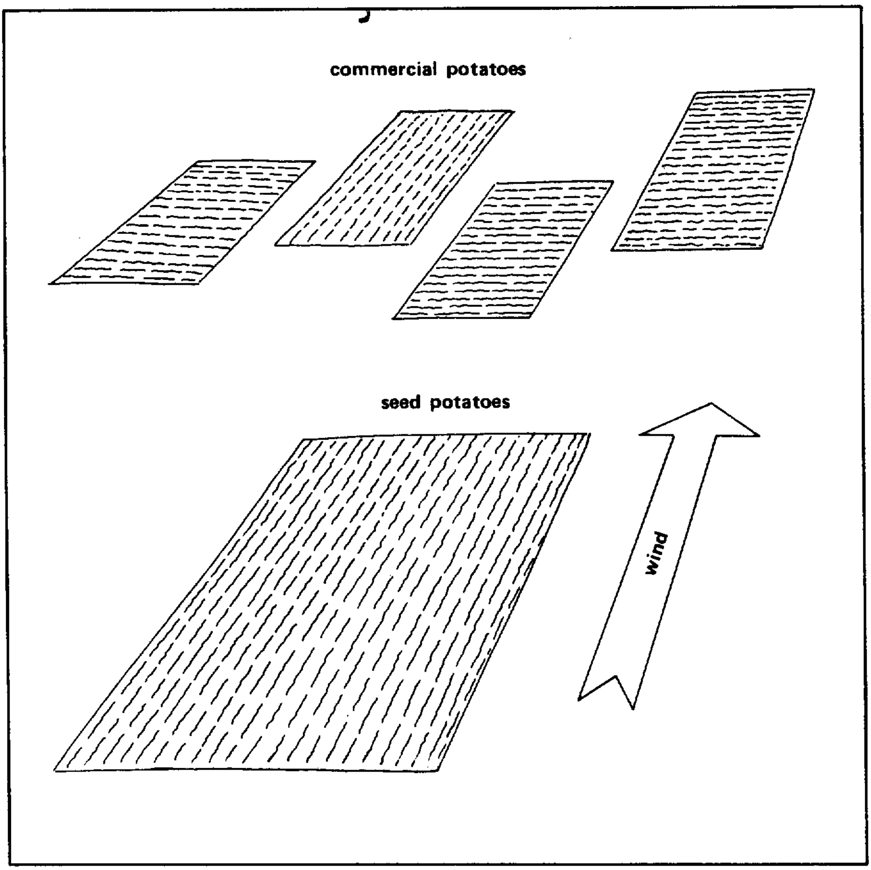
Elimination of sources of infection. Diseased cultivated potato plants and volunteer potato plants inside or around the field are sources of infection and virus spread. Certain weeds may also serve as sources of virus inoculum. Diseased potato plants in seed fields should be removed as soon as infection becomes visible. Weeds, whether potential virus sources or not, should be eliminated by proper weed control so as to avoid harboring insects.

Control of vector transmission. Many possibilities exist to control vector transmission of viruses. Monitoring insect vector populations aids in deciding if an area or season is suitable for growing seed potatoes and will guide in timing vine destruction in seed fields. Seed potato fields should be isolated. They are best situated up-wind in the prevailing wind direction from commercial potato fields or other alternative host crops to avoid immigration of wind-borne insect vectors. Aphid multiplication on potato plants, or on sprouted tubers in storage, should be controlled by proper use of insecticides. Insecticides when properly applied can control aphid populations and virus dissemination within the sprayed fields. However, insecticides do not prevent infection when viruliferous insects migrate into the field from other areas.

Soil treatment or suitable crop rotations for controlling nematodes may be necessary when nematode transmitted viruses are present.

Avoidance of mechanical transmission. During sorting, handling and planting operations, virus from sprouted tubers may be transmitted to healthy sprouts. Carefully handle sprouted tubers to avoid virus transmission.

Contact-transmitted viruses are spread by brushing leaves of healthy plants with virus from infected leaves, infected sprouts, or other sources. Machinery or humans passing through a field with dense foliage can transmit virus from plant to plant. Rows should be widely spaced to reduce mechanical virus transmission. Do not walk through the field, or enter with machinery, when vines are large.



Seed potato fields should be situated up-wind to the prevailing wind direction from commercial potato fields to avoid immigration of wind-borne insect vectors.

8 ADDITIONAL READING

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