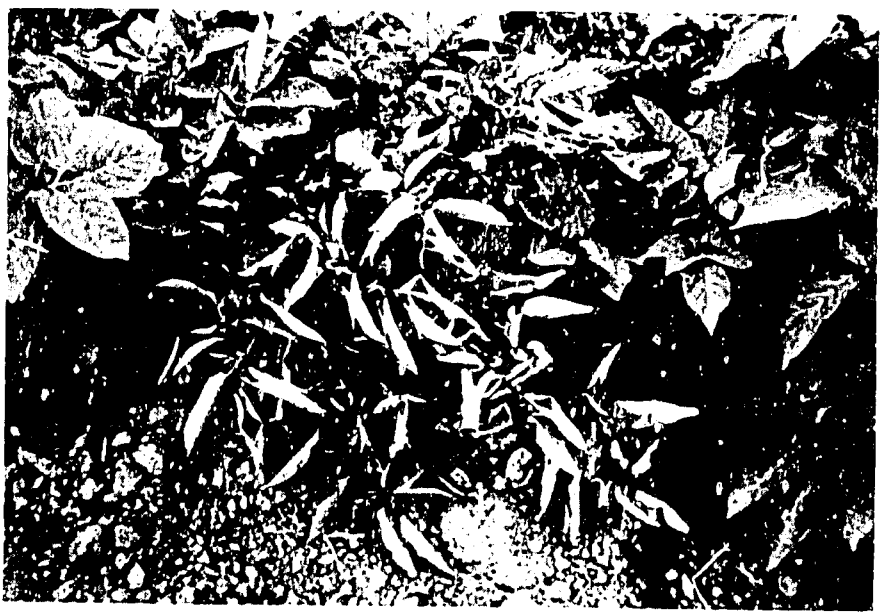
Technical Information Bulletin 22

Potato Leafroll Virus

PLRV

Upali Jayasinghe



PLRV secondary symptom

INTERNATIONAL POTATO CENTER (CIP)

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CIP's Technical Information Bulletins (TIBs)

CIP's Technical Information Bulletins (TIBs) contain information for potato production, training, and research. Although the information is directed at an intermediate professional level, it can be easily adapted for communication with farmers.

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Potato Leafroll Virus

PLRV

Objectives. Study of this bulletin enables you to:

- Explain the importance of potato leafroll virus,
- describe symptoms,
- describe the causal agent,
- explain forms of transmission,
- describe detection methods,
- discuss control measures.

Study materials

- Seed certification regulations.
- Plants and tubers infected with PLRV
- Plants infested with *Myzus persicae*.
- Indicator plants with and without symptoms.
- ELISA test kit.
- Tuber section showing callose staining.

Practicals

- In the field, identify plants with PLRV symptoms, harvest them, and compare their yield with that from healthy plants.
- Compare PLRV incidence in potato fields with your seed certification regulations.
- In the field, identify primary and secondary symptoms, yellow dwarf, and net necrosis.
- Study insect vector populations in the field.
- Inoculate indicator plants and examine symptoms.
- Practice ELISA.
- Practice elimination of infection sources in the field.

Questionnaire

1 In what sense does PLRV cause one of the most important viral diseases of the potato? Name three reasons.

2 What circumstances may cause high losses when plants are only latently infected with PLRV?

3 In what sense does PLRV affect tubers from seed fields that exceed certain infection levels?

4 In the field, how can you distinguish leafrolling caused by PLRV from leafrolling caused by other factors?

5 What is the origin of primary symptoms? Describe them.

6 What is the shape and size (in nm) of PLRV?

7 Where is PLRV localized?

8 Why is serology the only reliable method to distinguish PLRV from BWYV?

9 How is PLRV transmitted in nature?

10 How long does PLRV remain infective in the aphid body?

11 Under what conditions do aphids transmit PLRV during storage?

12 How does efficiency of PLRV dissemination depend on environmental conditions?

13 How reliable are primary symptoms in PLRV detection in the field?

14 Name two indicator plants for PLRV.

15 Why can traditional serological techniques —apart from ELISA— not be used for PLRV detection?

16 What microscopic symptoms accompany ussually PLRV infection?

17 How reliable is the Igel-Lange test?

18 How can you use knowledge on aphid population dynamics to produce a healthy crop of seed tubers?

19 How effective are insecticides to control transmission of PLRV?

20 What are two types of resistance to PLRV?

21 Why do plants with resistance to PLRV multiplication continue to be sources of infection?

Potato Leafroll Virus

PLRV

Potato leafroll virus (PLRV) causes one of the most important viral diseases of the potato. Losses may reach 90%. PLRV affects foliage and sometimes tubers. The virus is localized in the phloem tissues, where it causes necrosis and abnormal formation of a carbohydrate, called callose, which blocks starch transport from the leaves to the tubers. In nature, it is transmitted through infected tubers and insect vectors. PLRV-infected plants cannot be cured with chemical treatments. Preventive measures include use of healthy seed tubers, elimination of infection sources, vector control, and use of PLRV resistance.

1 IMPORTANCE

Potato leafroll virus (PLRV) causes one of the most important viral diseases of the potato. The disease affects yield and quality of tubers. It also complicates the exchange of plant material due to certification and quarantine regulations.

Yield. Yield losses are difficult to quantify, but may reach 90%. Percent yield loss can be almost as high as the percentage of visibly infected plants.

Potato plants, that are latently infected with PLRV, do not show symptoms and can produce as much as healthy plants. However, losses may be high when plants become infected simultaneously with other viruses.

Quality. Infected plants often produce small tubers, which may not be marketable. The symptom of "net necrosis" appearing in the tubers of certain varieties also reduces market value.

Certification and quarantine regulations. Tubers from seed fields that exceed certain infection levels of seed certification regulations, cannot be used as seed and must be sold for consumption at a lower price. PLRV also complicates the exchange of genetic material for breeding and research purposes.

PLRV affects yield and quality of tubers and complicates the exchange of plant material due to certification and quarantine regulations.

2 SYMPTOMS

PLRV affects foliage and sometimes tubers. Severity of symptoms depends on the variety and the environment. Certain varieties do not produce symptoms and PLRV is impossible to detect visually.

In the field, it is difficult to distinguish leafrolling caused by PLRV from leafrolling caused by other factors. Since leafrolling is a result of disturbances in the phloem translocation system, any other factor that has the same cause also results in leafrolling.

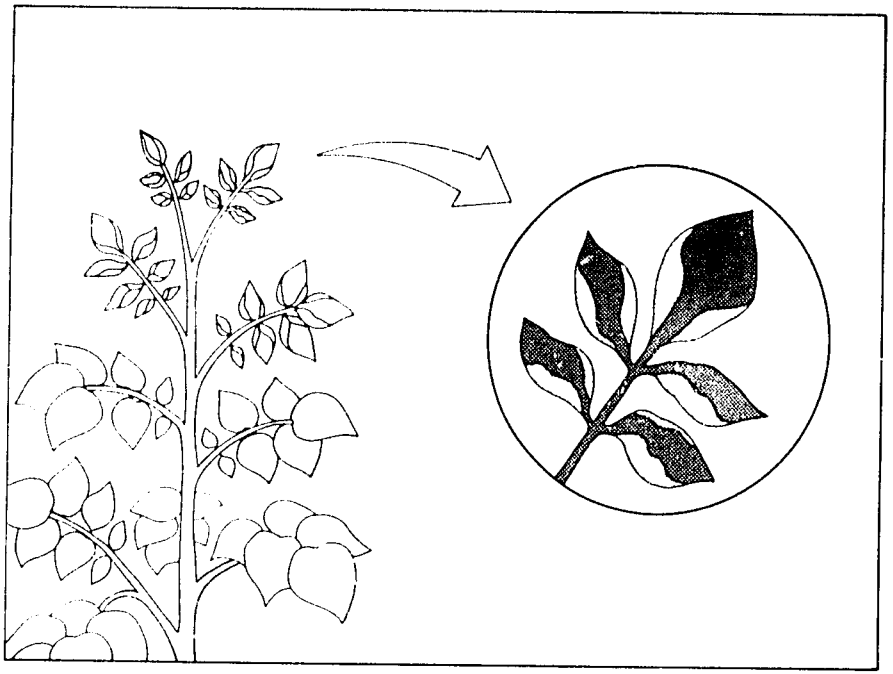
In a seed potato field, because of intensive roguing in previous seasons, only few plants are expected to show leafrolling caused by PLRV. Infected plants appear dispersed. Plants with infections caused by other factors may be restricted to certain areas. Leafrolling is accompanied by additional symptoms that are characteristic for the corresponding disease, such as stem canker caused by *Rhizoctonia*, or aerial tubers caused by purple top mycoplasma.

Some symptoms of PLRV can be seen by eye, while others require a microscope (see Section 5, "Callose Staining").

Certain German varieties, such as Apta, Bismark and Carla, and certain wild *Solanum* species, such as *S. raphanifolium*, *S. tendleri*, *S. berthaultii*, react to PLRV with hypersensitivity. PLRV infection causes severe phloem necrosis accompanied by foliage symptoms. Tubers usually fail to germinate.

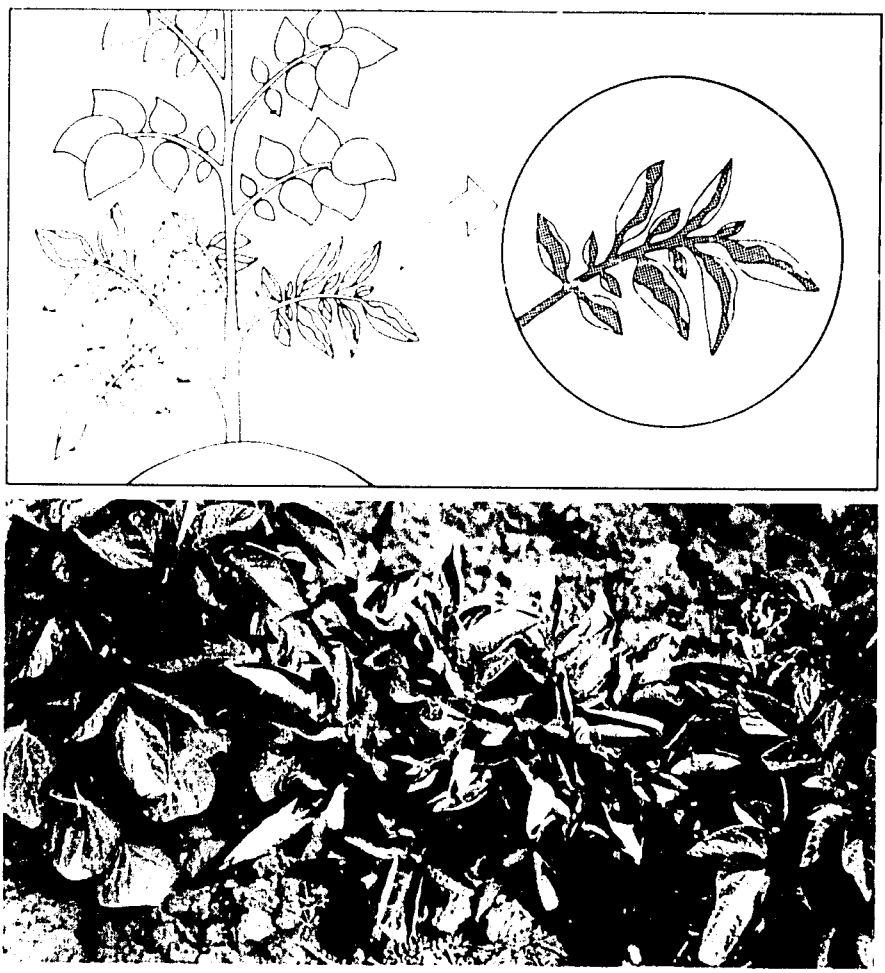
Symptoms described in the following are typical for *Solanum tuberosum* ssp. *tuberosum*, the most widely grown potato subspecies.

Foliage symptoms Plants that become infected in the current growing season show what are called *primary symptoms*. These begin on the apical leaves with rolling, erect growth, and paleness. In certain varieties, rolling may remain restricted to the leaflet base. As the disease progress, rolling may extend to older leaves. Appearance and severity of primary symptoms are related to the moment of infection. Late infection may remain latent and make disease recognition difficult.



Plants that become infected in the current growing season show what are called *primary symptoms.*

Symptoms that appear on plants growing from infected tubers are called *secondary symptoms*. Plants present a reduced and erect growth. Lower leaves are severely rolled, rigid, take a leathery texture, and produce a sound like paper when crushed. Younger leaves are pale, and rolling is less severe than in the case of primary symptoms.



Symptoms that appear on plants growing from infected seed tubers are called *secondary symptoms*.

In *S. tuberosum* ssp. *andigena*, cultivated in the South American Andes, foliage symptoms are different. Plants of ssp.*andigena* present a markedly reduced and erect growth. Leaflets become smaller and present marginal and interveinal chlorosis. Leafrolling is usually mild or absent. In South America the syndrom is called "enanismo amarillo" (yellow dwarf). Hybrids between ssp. *tuberosum* and ssp. *andigena* often present leafrolling combined with marginal and interveinal chlorosis, as well as stunting.

Tuber symptoms The majority of potato varieties do not show tuber symptoms. Only certain North American varieties such as Russet Burbank and Green Mountain develop brown necrotic discoloration, *net necrosis*, on the phloem cells of tubers. Net necrosis appears after both primary or secondary infections and is more evident in larger tubers. Seed tubers affected by net necrosis always produce plants with leafroll symptoms.

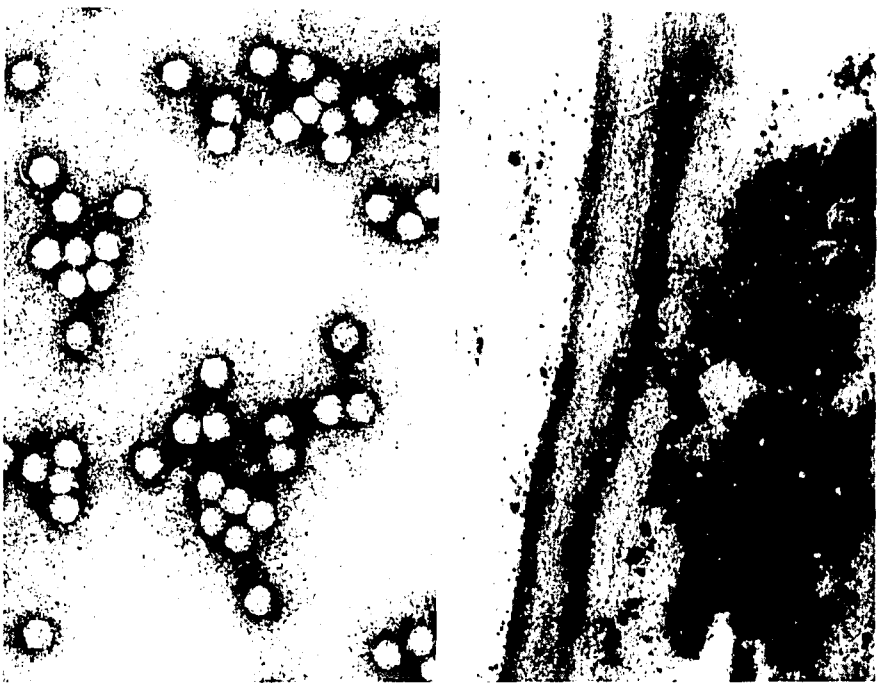
In the South American Andes, plants of ssp. *andigena* infected with PLRV often present the syndrome of "enanismo amarillo" (yellow dwarf; left). Certain varieties develop brown necrotic discoloration, *net necrosis*, on the phloem cells of tubers (right).

3 CAUSAL AGENT

PLRV consists of spherical particles with a diameter of 24 nm (0.000 024 mm). Virologists have identified isolates that induce symptoms of varying severity on potato varieties and on the indicator plant *Physalis floridana*, but the isolates cannot be easily differentiated by serology or vector specificity.

The virus is localized in the phloem tissues, where it causes necrosis and abnormal formation of a carbohydrate, called callose, which blocks starch transport from the leaves to the tubers.

In the United States beet western yellow virus (BWYV), a virus similar to PLRV, presents typical leafroll symptoms on potato. However, this virus does not infect potato in Canada, Australia, and New Zealand. Also BWYV symptoms on *P. floridana* and transmission by the vector *Myzus persicae* are similar. Serology is the only reliable method to distinguish PLRV from BWYV.



PLRV consists of spherical particles with a diameter of 24 nm (left). The virus is localized in the phloem tissues (right).

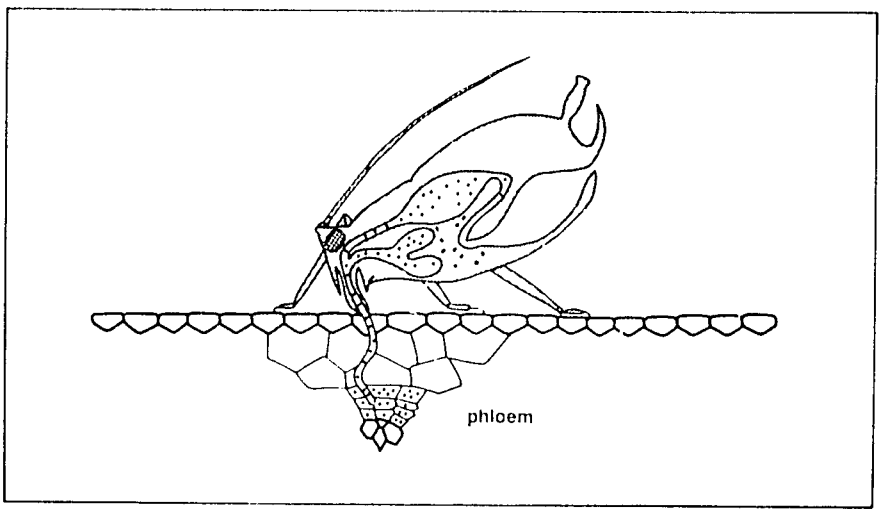
4 TRANSMISSION

In nature, PLRV is transmitted through infected tubers and insect vectors. Experimentally, PLRV can also be transmitted by grafting.

PLRV is not transmitted through botanical seed (true potato seed); nor is it transmitted mechanically, and therefore no danger exists of contamination by tools or contact between plants.

Infected tubers Diseased plants generally produce diseased tubers. If these tubers are planted or left in the field at harvest time, they produce diseased plants again. Thus, both intentionally planted potatoes and volunteer potatoes may serve as source of infection.

Vectors. Several aphid species may transmit PLRV, but the aphid *Myzus persicae* is the most important vector. *M. persicae* transmits PLRV in persistent form. To acquire the virus, the aphid must feed on the phloem for at least 20 to 30 minutes. The virus enters the aphid body, but the aphid remains non-viruliferous during an incubation period of several hours. Then the virus becomes infective and persists throughout the aphid's life. The wind can transport winged aphids over distances of several hundred kilometers, while wingless aphids disseminate the disease from plant to plant.

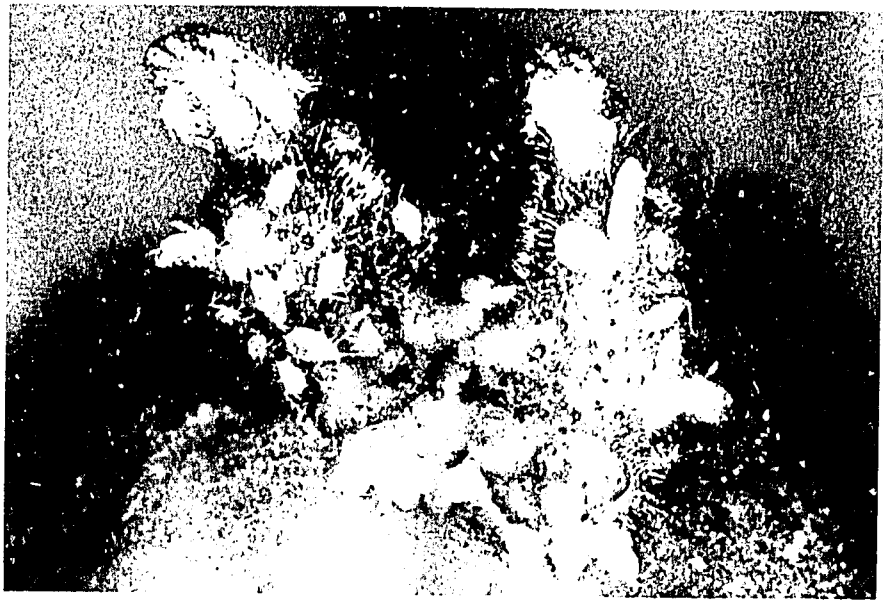


To acquire PLRV, the aphid must feed on the phloem for at least 20 to 30 minutes.

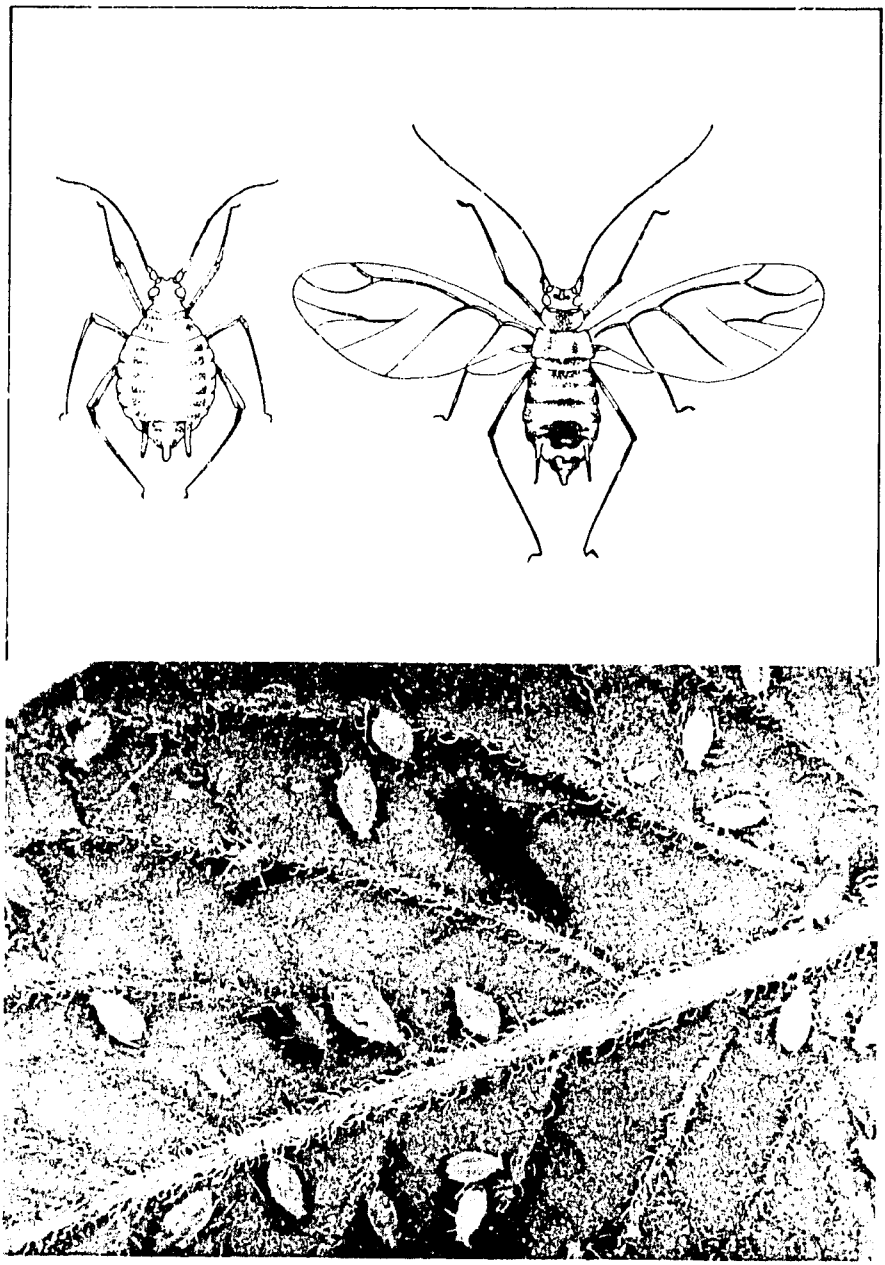
Aphids also transmit PLRV during storage, especially when the tubers sprout. Research at CIP has shown that stored tubers can become completely infected.

Efficiency of PLRV dissemination depends on environmental conditions. Dissemination of PLRV is directly related to aphid behaviour. Any conditions that affects the aphid population, such as rainy and cool climate, affects PLRV dissemination. In the tropics, aphid populations are usually high and active throughout the year. Nevertheless, temperatures above 26 C reduce the efficiency of dissemination.

Grafting. Virologists use grafting to transmit PLRV for experimental purposes. Any part of the potato plant can be used as graft, such as leaves, stem sections with a bud, or tuber pieces.



Aphids also transmit PLRV during storage, especially when the tubers sprout. Stored tubers can become completely infected.



The aphid *Myzus persicae* is the most important vector of PLRV. In the tropics, populations are usually high and active throughout the year.

5 DETECTION

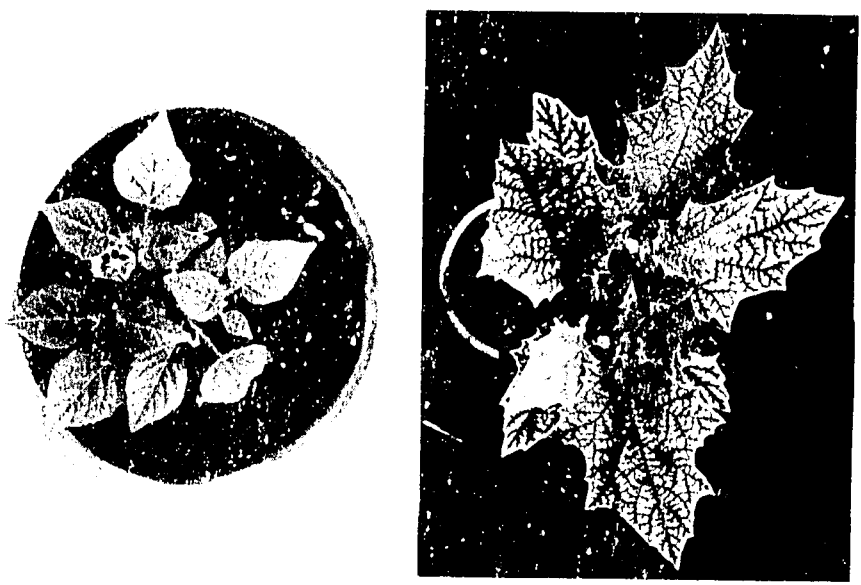
PLRV can be detected by field observation of symptoms, use of indicator plants, serology, and callose staining.

Field observation of symptoms. Because primary symptoms depend on time of infection, variety, and environmental conditions, their detection is difficult and not very reliable. Latent infections or mild symptoms in tolerant varieties cannot be detected at all. Secondary symptoms are usually obvious and easy to detect visually.

Indicator plants. PLRV also infects other hosts. Some of them, especially *Physalis floridana* and *Datura stramonium*, react with characteristic symptoms. The two hosts can also be used to maintain the virus for experimental purposes.

P. floridana presents interveinal chlorosis, slight rolling of the leaf basis, reduction of leaf size and plant growth. With age, plants become pale.

D. stramonium develops a strong interveinal chlorosis.



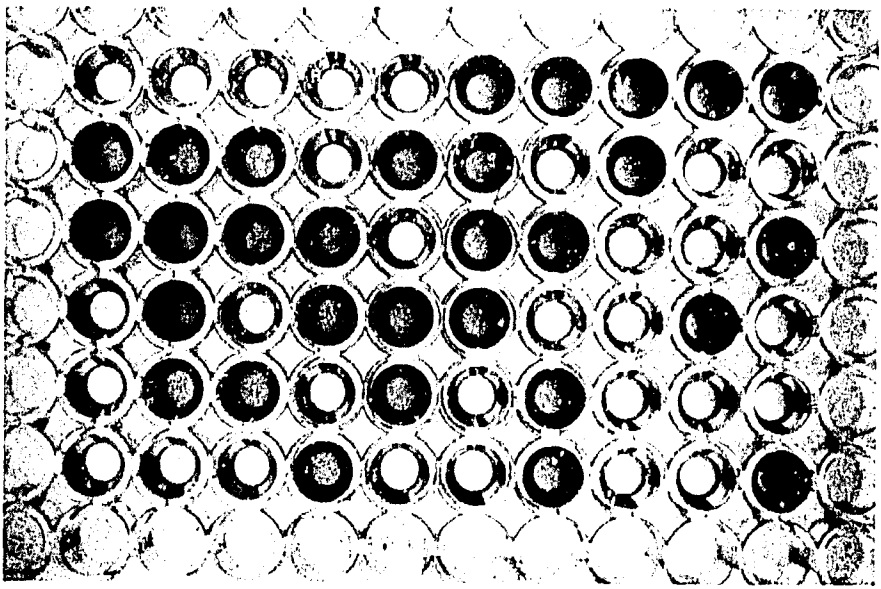
Physalis floridana **(left) and** ***Datura stramonium*** **(right) react with characteristic symptoms.**

Serology. Probably because of low PLRV concentration in infected plants, traditional serological techniques, such as microprecipitation, latex test, and gel diffusion, cannot be used for PLRV detection. Enzyme-linked immunosorbant assay (ELISA) is the only serological detection method available. Plant sap for the ELISA test can be taken from leaves, petioles, and tubers.

For tuber testing, the sap is taken preferably from growing sprouts. Dormant tubers can also be tested by extracting the sap from the basal end of the tuber.

An ELISA test kit accompanied by simple instructions is available from CIP.

Although ELISA is a sensitive method, some infected plants and tubers may escape detection. If accurate PLRV detection is necessary, negative ELISA samples should be tested by grafting onto indicator plants.



ELISA is the only serological detection method available.

Callose staining. PLRV infection is usually accompanied by necrosis of phloem cells and accumulation of callose especially near the sieve plate. These symptoms can only be seen through a microscope after staining of the samples. Callose staining is the principle of the "Igel-Lange test" which has formerly been used to detect infected plants and tubers.

The method uses thin longitudinal sections from tubers or stems that are stained for 10 minutes in 1% aqueous solution of resourcin blue. Under 25x magnification, deep-blue staining of callose can be examined. Older phloem cells always contain callose, even when healthy. Therefore, young phloem close to the cambium should be used.

The amount of callose in healthy as well as diseased tubers varies among varieties. Infected tubers harvested early may not have well-formed phloem cells yet, giving erroneous test results. Thus, callose staining is unreliable compared to ELISA.

An ELISA kit accompanied by simple instructions is available from CIP.

6 CONTROL

PLRV-infected plants cannot be cured with chemical treatments. Preventive measures include

- use of healthy seed tubers,
- elimination of infection sources,
- vector control,
- use of PLRV resistance.

Use of healthy seed tubers. The use of disease-free seed is a basic condition for high yield. Seed tubers should only be multiplied in areas with low aphid populations. Knowledge on aphid population dynamics is important for deciding where, when, and how to grow and protect a crop of seed tubers.

Because the virus from infected foliage needs some time to reach the tuber, seed tubers should be harvested no later than eight to ten days after aphid populations have reached a critical limit.

To avoid tuber infestation from infected foliage, the foliage may be destructed mechanically or chemically before harvest.

For experimental purposes, infected tubers may be freed from PLRV by thermotherapy at 37.5 C for 25 days. In tissue culture techniques, thermoteraphy helps to eliminate PLRV from meristematic parts of a plant.

Elimination of infection scurces. Potato plants and weeds are sources of infection, which can also harbor viruliferous aphids. Therefore, infected potato plants (including volunteer plants) and host weeds should be eliminate within and around the field. Elimination of infection sources is only effective when carried out in the entire neighborhood. This is especially important when the crop is grown to produce seed tubers.

Vector control. Study of insect vector populations helps to decide if an area or season is appropriate to grow seed potatoes and allows to determine the moment of insecticide application and foliage destruction.

Seed potato fields should be isolated from commercial potato fields. They are best situated up-wind in the prevailing wind direction from commercial potato fields to avoid immigration of wind-borne insect vectors into seed fields.

Aphid multiplication on potato plants or on sprouted tubers should be controlled with insecticides.

In persistent transmission of viruses, the incubation period of the virus in the aphid body is long enough to allow insecticides to act before vectors transmit the virus. Insecticides can considerably reduce PLRV dissemination within a field, but they cannot control infection by aphids migrating from other fields.

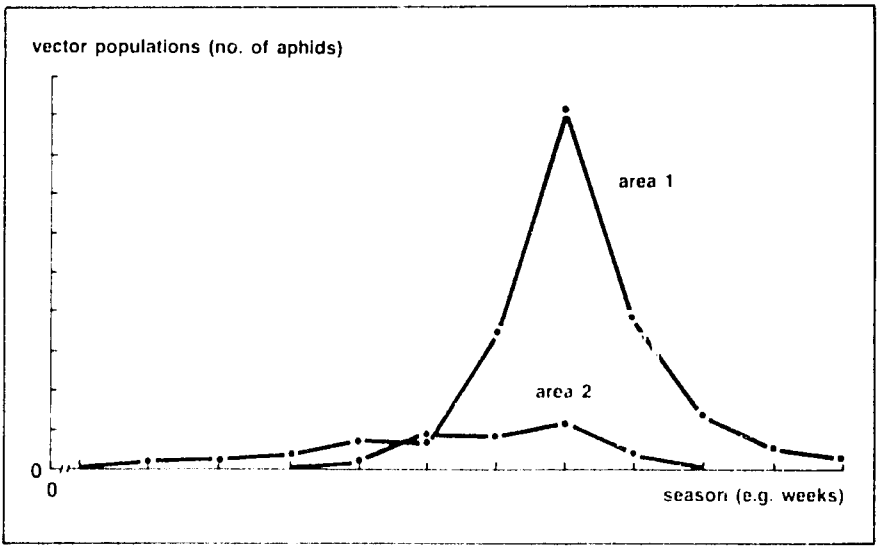
Use of PLRV resistance. Resistance to PLRV is due to additive effects of many genes, whose incorporation into cultivated potatoes is gradual and constitutes a long-term breeding process. To date, the use of PLRV resistance is limited.

Two types of PLRV resistance exist:

- resistance to infection through aphids,
- resistance to PLRV multiplication within the plant.

Plants with **resistance to infection** do not become easily infected. High populations of viruliferous aphids are required to infect a plant. Resistance to infection depends on environmental conditions, especially the temperature and health of plants. Plants already infected with PVX or PVY loose their resistance to PLRV infection.

In plants with **resistance to multiplication**, the virus concentration is lower than in susceptible plants. Usually, plants show only mild or no symptoms at all. Yield losses may be less severe than in susceptible plants. Nevertheless, the plants continue to be sources of infection that are difficult to detect and eliminate.



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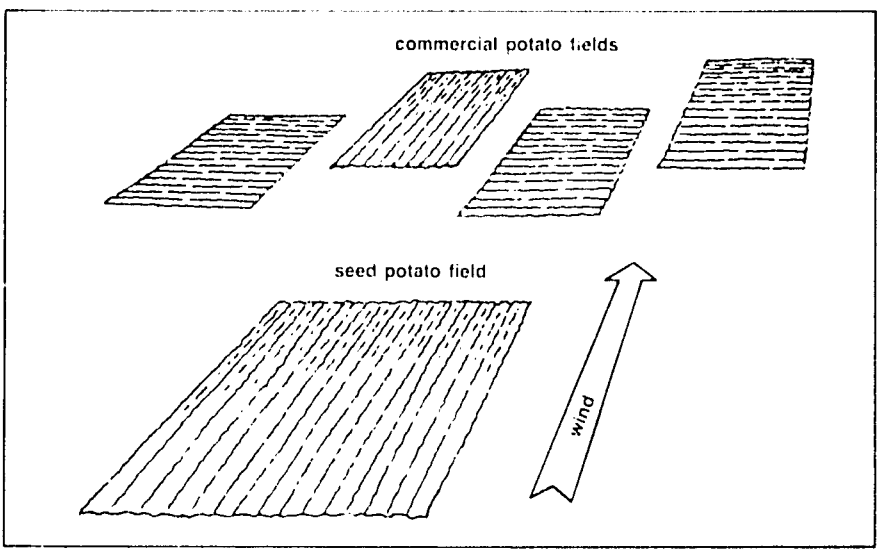

Seed potato fields are best situated up-wind in the prevailing wind direction from commercial potato fields.

Both types of resistance are present in wild *Solanum* species such as *S. acaule*, *S. etuberosum*, *S. chacoense*, *S. stoloniferum*, and *S. demissum*. However, to date their use in breeding has had only limited success.

7 ADDITIONAL STUDY

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