Technical Information Bulletin 13

Bacterial Wilt of Potato

Pseudomonas solanacearum

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Potato plant affected by bacterial wilt

INTERNATIONAL POTATO CENTER (CIP)

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Objectives. Study of this bulletin enables you to:

- explain the importance of bacterial wilt,
- describe symptoms,
- describe the causal organism and its classification,
- explain the epidemiology of *Pseudomonas solanacearum,*
- list integrated control components,
- analyze resistance.

Study materials

- Slides showing symptoms. (Do not transport infected material for demonstration purposes, because you may disseminate the disease.)

Exercises

- Observe symptoms and host range in the field. (Do not carry infected material out of the field. Clean shoes and implements after leaving an infected field.)
- Examine presence of bacteria in cut stem pieces as explained in Section 2.
- Carry out the KOH test as explained in Section 2.

Questionnaire

1 Which hosts are affected by *P. solanacearum* in your country?

2 What damage is caused by bacterial wilt?

3 Describe a characteristic symptom of the disease in above-ground potato organs.

4 How can the presence of the bacterium in stems easily be demonstrated? Describe method.

5 How can latent infections in tubers be detected?

6 How can bacterial wilt and ring rot be differentiated in the field?

7 Which races affect potatoes, and in which type of environment?

8 What is the significance of pathovars?

9 What are the sources of bacterial wilt inoculum?

10 What is the special problem of tubers with latent infections?

11 How does the bacterium survive in the soils of your country?

12 What is the relationship between the presence of nematodes and bacterial wilt incidence?

13 How does temperature influence bacterial wilt development?

14 What is the most appropriate way to control the disease?

15 List control components.

16 Why may crop rotation not be the most practical measure where Race 1 predominates?

17 What is the source of resistance of potato to *P. solanacearum*?

18 How effective is resistance to *P. solanacearum* in potato?

19 Why should a field be 100 % free of *P. solanacearum* in potato seed production?

20 Why is local screening essential in the development of resistant varieties?

21 Which germplasm materials may be provided by CIP?

22 What are the characteristics of advanced clones?

Bacterial Wilt of Potato

Pseudomonas solanacearum

1 Importance of bacterial wilt
2 Symptoms
3 Causal organism
4 Epidemiology
5 Control
6 Resistance
7 Additional study

Bacterial wilt limits production of potatoes, especially seed potatoes, worldwide. Appropriate chemical control measures that are practical and effective do not exist. Other integrated control components, however, may be effective. A requirement for proper disease management is knowledge about the causal organism and its action.

1 IMPORTANCE OF BACTERIAL WILT

Pseudomonas solanacearum affects more than 30 plant families, including crops and wild species. Highly susceptible crops are potato, tobacco, tomato, eggplant, chilli, bell pepper, and peanut. It limits growing of potatoes in Asia, Africa, and Central and South America, where it causes severe crop losses in tropical, subtropical, and warm emperature regions. It may also occur in cooler climates such as at relatively high elevations in the tropics or higher latitudes.

Quarantine measures necessary to avoid spread of the disease to disease free areas often restrict the production of seed potatoes and limit the commercialization of ware potatoes, affecting the economy of the quarantined regions.

Pseudomonas solanacearum **limits production of potatoes in many tropical, subtropical and warm temperate regions. The vascular ring, and later the whole tuber may disintegrate.**

2 SYMPTOMS

Pseudomonas solanacearum causes symptoms in both above and below ground organs of the potato plant.

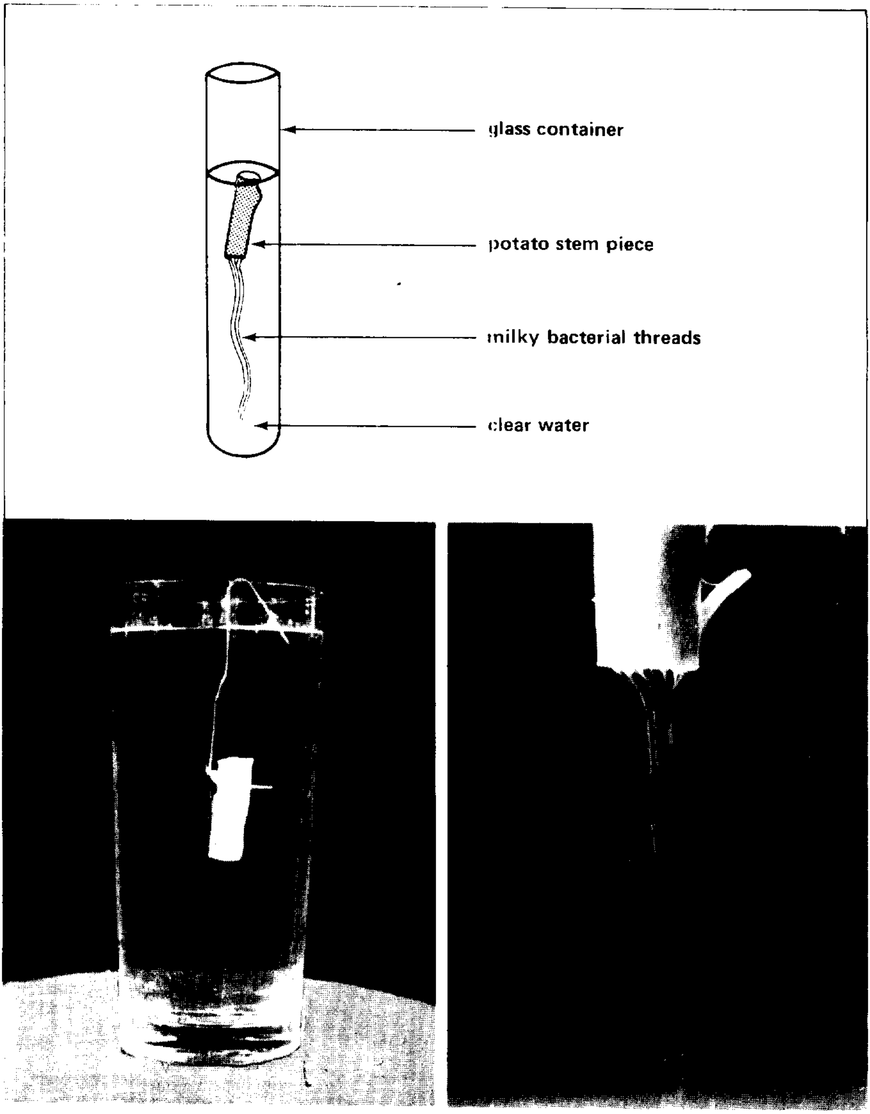
Above ground. Above ground symptoms are wilting, stunting, and yellowing of the foliage. Wilting caused by *P. solanacearum* resembles that which is caused by lack of water, other pathogens such as *Fusarium* or *Verticillium* spp., as well as insect or mechanical damage at the base of a stem.

Characteristic is the initial wilting of only part of the stems of a plant, or even one side only of a leaf or stem. If disease development is rapid, entire plants wilt quickly.

A cross section through a young diseased potato stem reveals brown discoloration of the vascular system. Upon slight pressure a milky slime may exude. In a longitudinal section, the vascular system may show dark, narrow stripes beneath the epidermis.

The milky slime exuding from stems (and tubers – see below) indicates the activity of the bacteria within the vascular system. An easy demonstration shows the presence of *P. solanacearum* in a stem:

Cut a piece, 2 to 3 cm long, from the base of the stem, and place it in clear water in a glass container. It may be positioned horizontally by adhesion to the edge at the water surface, or held with an opened paper clip. Within a few minutes, milky threads stream downward from one or both ends of the cut stem.



Cut a piece, 2 to 3 cm long, from the base of the stem, and place it in clear water in a glass container. Within a few minutes, milky threads stream downward from the cut.

Below ground. External symptoms are not always visible on infected tubers. In case of severe infections, however, bacterial ooze collects at tuber eyes or stolon end, causing soil to adhere.

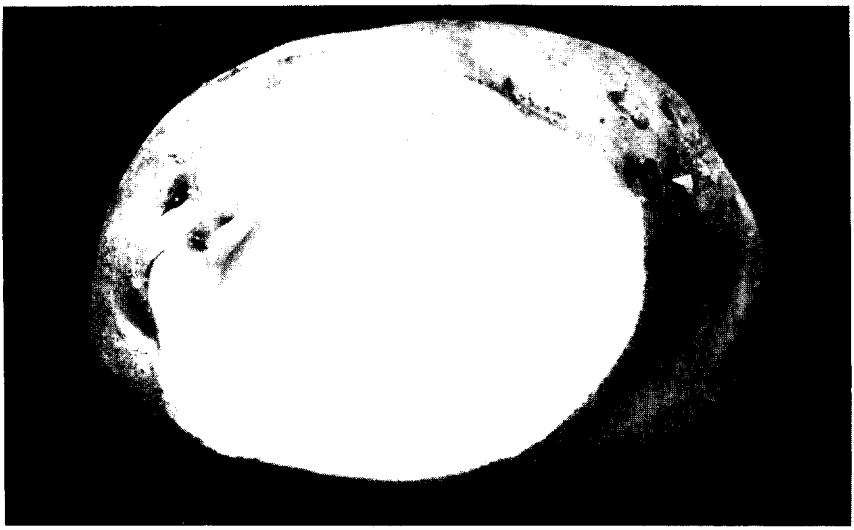
A cut tuber often shows brownish discoloration of the vascular ring. Slight squeezing forces the typical pus-like slime out of the ring, or it oozes out naturally. The vascular ring, or the whole tuber, may disintegrate completely at more advanced stages of disease development.

Not all tubers of a wilted plant may be affected, and not all affected tubers may show symptoms. Latent infections can be detected by incubating tubers at 30 °C and high humidity. After two to three weeks the typical tuber symptoms can be observed.

Symptoms caused by *P. solanacearum* may be confused with those caused by *Corynebacterium sepedonicum* (ring rot). A major difference is that *P. solanacearum* causes direct collapse of green plants, whereas ring rot wilting is usually associated with chlorosis, yellowing, and necrosis of foliage.

In the laboratory, these two species of bacteria can be differentiated by a staining procedure, known as the Gram reaction. *P. solanacearum* is Gram negative, *C. sepedonicum* is Gram positive.

Another differential test may be performed quickly with the ooze or the cultured bacteria: Place two drops of 3 % KOH (potassium hydroxide) on a glass slide. Transfer the bacteria with a wooden toothpick and mix with rapid circular movements for 5 to 15 seconds. The formation of a milky thread upon lifting the toothpick indicates the presence of *P. solanacearum*. *C. sepedonicum* does not produce the thread.



Pseudomonas solanacearum causes symptoms in both above and below ground organs of the potato plant. Above ground the initial wilting of only parts of the plant is characteristic (above). Below ground, soil adheres to the bacterial ooze in tuber eyes or stolon end. A cut tuber often shows a brownish discoloration of the vascular ring. Slight squeezing forces the typical pus-like slime out of the ring, or it oozes out naturally. The vascular ring, or the whole tuber, may disintegrate (below).

3 CAUSAL ORGANISM

Pseudomonas solanacearum is an aerobic, rod-shaped, and Gram negative bacterium, which is usually immobile.

Great variation has led to two classification systems: the race system and the biotype system.

Race system. Based on the host range under field conditions, four races can be distinguished:

Race 1 affects a wide range of plant species including **potato**, tomato, eggplant, tobacco, chilli, peanut, and several weeds. It is frequent in warmer areas, and at lower elevations in the tropics.

Race 2 affects plants of the musaceae family such as banana, plantains, abaca, and *Heliconia* spp.

Race 3 affects mainly **potato**. In contrast to Race 1, it is more common at greater elevations or latitudes.

Race 4 affects mulberry (in China).

Biotype system. In specialized biochemical tests, five biotypes (I to V) can be differentiated. Biotype II coincides with Race 3, biotype V with Race 4, and biotypes I, III, and IV are in Race 1.

Independent of race or biotype differentiation are pathovars or strains. A pathovar at one location may affect a host or potato variety, but another pathovar may not.

4 EPIDEMIOLOGY

Wilting, the most obvious symptom in the field, is possibly a result of restricted water movement due to the formation of slime that surrounds the bacterial masses in the stem xylem vessels. Bacterial wilt may originate from two sources of inoculum:

- infected seed tubers,
- infested soil.

Infected seed tubers. Infected seed tubers are the most common source of inoculum; especially latent infections cause problems. Seed tubers produced in cool climates, such as tropical elevations above 2500 m may not show any symptoms. When planted at warmer locations, however, disease development may be severe. *P. solanacearum* may be carried over long distances through infected seed tubers.

Infested soil. *P. solanacearum* is native in many tropical soils. Survival of the bacterium is influenced by temperature, humidity, and other physical and chemical soil factors. In certain soils, *P. solanacearum* may survive for many years, in others the bacterium may disappear from one growing season to the next.

Survival depends also on the race involved. Because of its numerous hosts, Race 1 usually persists for many years, whereas Race 3 tends to decline in a few years, as long as no potato volunteers help to maintain the inoculum.

Locally, the disease can be disseminated by irrigation water and soil adhering to shoes and tools.

Infection is usually through the root system. The pathogen enters through wounds occurring during cultivation or natural growth of secondary roots. Also root-knot (*Meloidogyne* spp.) and other nematodes promote penetration of the bacterium by injuring the roots.

P. solanacearum may spread from root to root during formation of secondary roots. Once the bacterium penetrates the roots, it multiplies and moves through the plant via the xylem vessels of stems and petioles.

Disease development is mainly influenced by temperature. High temperature promotes bacterial wilt development, and the bacterial population is reduced in cold soils. The optimum temperature for bacterial culture *in vitro* is around 30 °C. In the field, disease symptoms usually appear when days are above 20 °C and average soil temperatures above 14 °C.

High soil moisture promotes survival, infectivity, disease development, and spread of the bacterium. Periodic drying, or flooding as in rice fields, reduces the viability of the bacterium and disease incidence.

5 CONTROL

Control of *P. solanacearum* is difficult because of its wide host range, its survival in soil, and its biological variation. Most appropriate is an integrated combination of control measures. Consider especially the following control components:

Resistance. For the farmer, the use of resistant varieties is the most practical control component (see Section 6).

Health of seed tubers. Use only disease-free seed tubers. To assure freedom from latent infection, seed tubers should originate from areas where the disease does not occur.

Crop rotation. Crop rotation with non-host plants reduces the inoculum potential in the soil. Consider that volunteer plants of potatoes, as well as weeds, especially those from the Solanaceae family, are hosts of *P. solanacearum*. Because of the wide host range, crop rotation may not be the most practical measure where Race 1 predominates.

Crop management. Avoid injury to roots and stolons during cultivation. It has been observed that disease incidence is reduced under minimum tillage **during** the growing season. In shallow soils, on the other hand, frequent tilling **between** growing seasons seems to reduce the inoculum.

Nematode control. To reduce nematode-disease interaction, control nematodes, especially *Meloidogyne* spp.

Chemical control. Chemical control is not possible at the moment.

Quarantine. Once the disease is discovered in an area, transport of seed potatoes from this area should be stopped.

6 RESISTANCE

The resistance to *P. solanacearum* available now in potatoes originates mainly from *Solanum phureja* and is controlled by few genes. It is seldom expressed as immunity since it is overcome by increasing the level of factors favorable for this disease: temperature, soil moisture, damage to the root system, etc. Thus, resistance may mean that fewer plants become infected.

Resistance is not general, but pathovar specific. A pathovar at one location may overcome the resistance effective at another. More than one pathovar may occur in a given field.

Since the expression of resistance is pathovar and environment specific, an essential step in the development of resistant varieties is local screening.

The acceptable level of resistance depends on the use of the potatoes produced. When used for consumption, a certain percentage of infection may be tolerated. In seed production, it is preferable not to tolerate any bacterial wilt, because few infected seed tubers can spread the disease over a wide area.

The development of resistant clones is a priority objective of CIP. CIP's breeding effort is also directed towards stability of bacterial wilt resistance under warm conditions and nematode infestation.

Different types of germplasm materials may be provided by CIP: tuber families, selected clones, and advanced clones.

Tuber families. Although a tuber family originates from the same cross, each resulting tuber is a genetically different clone. The individual clones might first be multiplied and then screened in the field by interplanting with a susceptible crop in an infested field.

Selected clones. Selected clones originate from tuber families that have already been submitted to resistance testing. They may be available in sets of five tubers per clone. These can be further tested in a one-plot or randomized experimental design.

Advanced clones. Advanced clones have gone through several cycles of testing and their agronomic characteristics have been evaluated. They may be further tested in a randomized block design.

To evaluate resistance it is usually possible to establish differences on the basis of number of plants that wilt during the entire growing season (see French, 1982). For finer differences, the degree of wilting at a given time may be evaluated using the following scale applied to each plant:

State of plant	Score
Plant healthy	1
One leaf wilting	2
One-third of plant wilting	3
Two-thirds of plant wilting	4
Whole plant wilting or dead	5

7 ADDITIONAL STUDY

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