

# Bacterial Wilt of Potatoes in the Amazon Basin

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## ABSTRACT

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Bioforms I and II of *Pseudomonas solanacearum*, considered synonymous with races 1 and 3, respectively, have been isolated from potatoes (*Solanum tuberosum*) grown in virgin Amazon rain forest following slashing and burning. Race 2, which attacks only musaceous hosts, occurs elsewhere in the Amazon basin. The incidence of bacterial wilt ranged from 5 to 15% in adapted potatoes and from 2 to 13% in unadapted cultivars. Bioform I was isolated in 1975, bioform II in 1977, and both in 1976 and 1978. In one instance, both were found in the same field. Seed tubers were free of *P. solanacearum*, and contamination by flood waters is discounted. Since bioform II has been shown to have a lower temperature requirement when isolated in the highlands or high latitudes, it may have originated in the lowlands and later acquired this characteristic, as well as its narrow host range restricted essentially to potatoes.

observed during the first trial were found to be infected with *P. solanacearum*. A study was initiated to determine if the bacterium was present in tropical virgin soils, using the potato plant to detect it. Other objectives were to characterize the isolates as to bioform (the terms bioform or biovar have replaced biotype in accordance with the Bacteriological Code, 1976) and relate this to the race concept and to observe their survival from one season to another. A preliminary report on this study has been published (14).

## MATERIALS AND METHODS

The research was conducted at the Ministry of Agriculture (Peru) Yurimaguas Experimental Substation in collaboration with the International Tropical Soils Program of North

Bacterial wilt of potatoes, caused by *Pseudomonas solanacearum* E.F.Sm., is a very important limiting factor in potato production, principally in tropical and semitropical areas. High temperature and high soil water content favor disease development, resulting in severe damage to the crop (1-3,8,9,12). Bacterial wilt is potentially the most serious bacterial disease wherever potatoes are introduced into lowland tropical areas (20).

Two of the three races of *P. solanacearum* can cause bacterial wilt in potatoes. Race 1, commonly of lowland tropical origin, infects several solanaceous crops as well as many other cultivated and weed species. Race 3, considered to be of highland tropical origin, is specialized as a potato pathogen, although it sometimes affects other solanaceous hosts under special field and environmental conditions (1,3,9,14). Both races occur in Peru (3), as does race 2, which affects bananas, plantains, and other musaceous hosts that occur farther downstream on the banks of the Amazon River (6,7).

Until about 40 yr ago, agriculture in the lower Amazon basin of Peru was restricted to the alluvial soils along the flood banks of the rivers. Population pressure then led to cultivation of higher lands, many of which are unsuited to continuous cropping because their lateritic soils (pH 3.5-4.5) are rapidly leached and have a high aluminum toxicity. A shifting agriculture, in which the jungle is slashed and burned in preparation for growing a crop of rice or corn and then abandoned to rain forest vegetation for 16-18 yr, is typical of these soils.

In 1975, the International Potato Center (CIP) began to grow potatoes at

Yurimaguas, in the Amazon basin of Peru. Temperatures average 20 C minimum (18 C absolute minimum), 30 C maximum (38 C absolute maximum), with an annual precipitation of 2,134 mm (21-yr average). Wilting potato plants

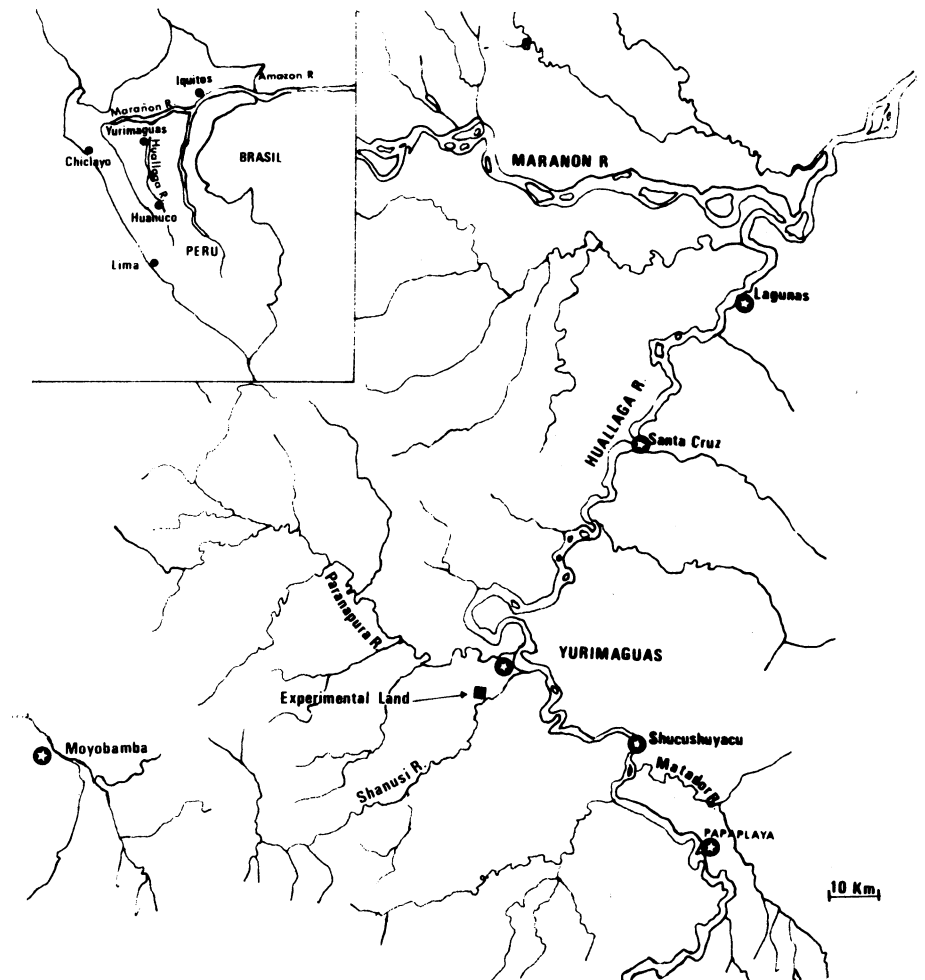


Fig. 1. Location of experimental land where bacterial wilt of potato occurs, near Yurimaguas, Peru, in the Amazon River basin.

Carolina State University. The experimental fields were located on the left bank of the Shanusi River, a tributary of the Amazon (5° 41' south latitude, 76° 05' west longitude, elevation 190 m) (Fig. 1). The land is not subject to flooding, and the Shanusi River basin has little agricultural land not cropped to potatoes.

One potato crop in 1975 and two in 1976 were planted in fields previously cropped to rice and followed by 16–18 yr of jungle regrowth. In 1977 and 1978, “virgin” fields were planted after slashing and burning of the native jungle. Plantings in all 4 yr were made by the Breeding and Genetics Department of CIP with adapted clones previously screened at San Ramon, a high (850 m) jungle site, in a field free of bacterial wilt (15,16). In addition, in 1977 three highland Peruvian cultivars susceptible to bacterial wilt—Mariva, Renacimiento, and Ticahuasi—were planted in a virgin area to study the incidence and distribution of bacterial wilt. Both the material from the breeding program and the three cultivars came from “disease-tested” stocks from CIP’s seed program.

One hundred tubers per cultivar were planted in a complete randomized design (10 replications of 10 tubers each). Replicates of the genetic material planted at Yurimaguas were also planted at two slightly cooler lowland locations to observe their adaptability at different sites in Peru.

**Isolations.** Stems of wilting plants were collected periodically 30–60 days after planting and flown to CIP’s laboratories in Lima, when weather permitted the use of the dirt airplane landing strip at Yurimaguas. Stem sections were washed thoroughly in tap water, and small pieces about 20 mm long were placed in sterile water in test tubes. After 10–15 min to allow bacteria to ooze from the vascular bundles, sections were removed and the suspension was streaked on tetrazolium chloride (TZC) medium (13). Plates were observed after 48 hr at 30 C, and five to seven colonies of *P. solanacearum* were resuspended in sterile water and streaked again to insure purity.

Assay for bioform determination was done as described by Hayward (9,10). Isolates were maintained in sterile tap water in screw-cap test tubes and periodically purified by selecting wild type colonies when aberrant colonies were found on TZC medium.

When isolates were shown to be of the same bioform for a given plot, only one isolate was maintained. Three additional older isolates were used: 072 or Wisconsin No. 130 isolated by French and Sequeira (7) in 1966 from tomato on the banks of the Amazon near Iquitos (elevation 100 m); 015 isolated from a potato crop in 1973 by I. A. Herrera at Tea Gardens (1,600 m) near Huanuco, Peru; and NCPPB 2505 from potato in Sweden.

**Table 1.** Bioform determinations of isolates of *Pseudomonas solanacearum* from the Amazon basin of Peru

Isolate number	Month and year of collection	Location (altitude)	Host	Bioform
072	August 1966	Iquitos (100 m)	Tomato	III
015	May 1973	Huanuco (1,600 m)	Potato	I
018	March 1975	Yurimaguas (190 m)	Potato	I
061	January 1976	Yurimaguas (190 m)	Potato	II
063	February 1976	Yurimaguas (190 m)	Potato	II
077	October 1976	Yurimaguas (190 m)	Potato	I
108	March 1977	Yurimaguas (190 m)	Potato	II
141	January 1978	Yurimaguas (190 m)	Potato	I
142	January 1978	Yurimaguas (190 m)	Potato	II
147	February 1978	Yurimaguas (190 m)	Potato	I

**Pathogenicity.** Six isolates were tested for pathogenicity on 10 plants each of the tomato cultivar Huando and potato cultivar Ticahuasi. Tomatoes were inoculated 15 days after transplanting and potatoes 20 days after emergence by pouring 40 ml of a bacterial suspension of  $2 \times 10^6$  cells per milliliter onto the soil of each 12-cm clay pot (one plant per pot). Plants inoculated with NCPPB 2505 (bioform II), previously shown to be highly pathogenic, and an uninoculated set served as controls. Plants were maintained for 40 days in a glasshouse with night/day temperatures of 25/31  $\pm$  1 C. Wilt symptoms were recorded weekly.

## RESULTS

**Incidence and isolation.** In the climatic conditions of Yurimaguas, clones bred for adaptation usually emerged in 15 days or less; wilt symptoms appeared within 30 days of planting. Because most plants matured rapidly, they were all harvested after 60–70 days. Plant survival ranged from 60 to 80%—some seed tubers rotted because of fungal or bacterial soft rots, while other plants were killed by *Choanephora* blight (21).

Wilting occurred in all plots each year, distributed randomly with incidences of 5–15%. Although symptoms were mostly typical of bacterial wilt, *P. solanacearum* was successfully isolated from about half the specimens from each plot. Other bacteria and fungi were isolated from some of the remaining plants. Replicate plantings in the two other hot tropical locations did not wilt, indicating that the seed tubers were free of *P. solanacearum*. The unadapted cultivars grown in 1977 grew poorly, and few small tubers formed. Wilt incidence was low (2% in Ticahuasi, 0.7% in Mariva, and 13% in Renacimiento).

**Bioform determination.** Bioform determinations were made for 21 of 37 isolates. The representative isolates selected for further study and two earlier isolates from other locations in the Amazon basin are shown in Table 1. Bioforms I and II both occurred in the Yurimaguas fields; they occurred together in the same field in 1978 (isolates 141 and

142). Bioform I was isolated in 1975, 1976, and 1978; bioform II in 1976–1978. The tomato isolate from Iquitos (about 400 km downstream on the Amazon) was bioform III. The isolate from a higher elevation (Huanuco) was bioform I (Table 1, Fig. 1).

**Pathogenicity tests.** The bioforms isolated at Yurimaguas—isolates 077, 108, 141, and 142—and bioforms I and II isolated from other sites seemed more aggressive on tomato than potato in this controlled, high-temperature regime, while the control isolate NCPPB 2505 from Sweden was highly aggressive on both crops. Although the pathogenicity of the isolates was clearly established, additional research is under way to clarify the apparent differences in aggressiveness.

## DISCUSSION

Bioforms I and II of *P. solanacearum* were found to attack potatoes that were grown in virgin soils never before planted to potatoes or other wilt-susceptible crops and that could not have been contaminated by water flow or infected seed, suggesting that these strains pathogenic to potato are indigenous in Yurimaguas. Seneviratne (17) in Sri Lanka demonstrated that bioform II occurred in virgin lands above 6,200 ft (1,891 m) in the hill country wet zone, and he considered it improbable that the bacterium could have been introduced in the seed of European origin. Seneviratne (18) also cites other reports of the endemic presence of *P. solanacearum* in virgin soils. Additional work is under way to determine the probable geographic origin of the potato strains and their hosts in the jungle.

So far, bioform II has been shown consistently to be synonymous with race 3 (11), the most widespread race in the world (2,5). Race 3 is considered to have a markedly lower optimal temperature than other races, in keeping with its distribution at greater elevations in the tropics and the greater latitudes elsewhere (10,12,17,19). One would not a priori expect bioform II isolates from Yurimaguas to be similarly adapted, which would be the first recorded exception to the synonymy of

bioform II with race 3.

The host range of these Yurimaguas isolates is being investigated. Should bioform II isolates be restricted primarily to potato and those of bioform I have a wider host range, then a form of bioform II with affinity for the potato must account for its wide distribution on this crop. Such an affinity might be the restriction of bioform II to the vascular system of tubers, resulting in reduced tuber decomposition. Potatoes and *P. solanacearum* may have come together initially at the 800–1,000 m elevation as potato cultivation was extended from the highlands into the upper reaches of the tropical rain forest. The proven adaptability of some Andean potato cultivars and the presence of both bioforms I and II (E. R. French and C. Martin, unpublished) makes this possible. After many years or even decades of latent infection in the vegetatively reproduced potato, the adaptive pressure might have led to a strain specialized in its temperature requirements but having lost its wider host range.

The variability of *P. solanacearum* in Yurimaguas stresses the need to breed for broad resistance in tropical potatoes. This has already been recommended for traditional potato-growing areas because of the variation among natural regions in the world (4).

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