A Bacterial Wilt and Root Rot of Sweet Potato Caused by Erwinia chrysanthemi

N. W. Schaad and D. Brenner

Assistant Professor, Department of Plant Pathology, University of Georgia, Georgia Experiment Station, Experiment, GA 30212; and Chief, Enteric Section, Enterobacteriology Branch, Bacteriology Division, Center for Disease Control, Public Health Service, Department of Health, Education and Welfare, Atlanta, GA 30033.

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ABSTRACT

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Erwinia chrysanthemi has been identified as the cause of a severe wilt and root rot of sweet potato in Georgia. The susceptibility of 14 sweet potato cultivars ranged from the highly resistant Red Jewel to the highly susceptible Georgia Red and Georgia Red 85. Several other plants including chrysanthemum, daisy, tobacco, pepper, tomato, Irish potato, cabbage, eggplant, soybean, petunia, African violet, morning-glory, and *Cuscuta* sp. also were susceptible. *Erwinia chrysanthemi* was isolated from soil and soil debris collected from a harvester, but not from field soil. Of 56 apparently healthy roots collected from a harvester and placed at 32 C in polyethylene bags, 23 were rotted by the bacterium. Seven biochemical tests (malonate, indole, lecithinase, phosphatase, litmus milk, lactose, and maltose) were highly reliable for distinguishing *E. chrysanthemi* from other species of *Erwinia*. Deoxyribonucleic acid from the sweet potato bacterium exhibited an average 80% relatedness to *E. chrysanthemi* as compared to less than 30% relatedness to *E. carotovora*.

Sweet potatoes [*Ipomoea batatas* (L.) Lam], are a very important food crop throughout the tropical-, subtropical-, and a portion of the temperate areas of the world. The main limiting factors in sweet potato production in the southeastern United States have been viral, nematode, and fungal diseases (16); consequently, little attention has been focused on other disease problems. One such problem was the occurrence in 1974 of an unfamiliar disease with symptoms similar to Fusarium wilt. During 1974, the disease reached epidemic proportions in several fields near Omega, Georgia, and in 1975 threatened the existence of the sweet potato industry in Georgia.

Symptoms were yellow leaves and dark green to black water-soaked lesions on stems and petioles. Usually, only one or two branches collapsed and died, but occasionally the entire plant was killed. Internally, black streaks were evident in the vascular system of both stems and roots. By harvest time many roots of diseased plants had rotted in the ground. Losses continued to occur while roots were in shipment to market.

Isolations from diseased stems and roots consistently yielded a bacterium. Since no bacterial disease of sweet potato plants had been reported previously, a study of the disease and identification of the causal bacterium was initiated. Later, in a preliminary description of the disease, Martin and Dukes (15) concluded that the bacterium responsible was similar to *Erwinia carotovora*. In this paper we describe the disease and compare 10 strains of the sweet potato bacterium to several strains of *E. carotovora*, *E. atroseptica*, and *E. chrysanthemi* by biochemical, physiological, and pathological tests. The results show that the new disease of sweet potato is caused by *E. chrysanthemi*.

MATERIALS AND METHODS

Isolations.—Isolations of bacteria from diseased stems and petioles of plants were made in the field. The outer, water-soaked tissue was removed with a sterile scalpel and a small piece of tissue was cut from the edge of the lesion. The tissue was rubbed on yeast extract-$CaCO_3$ (YDC) (20), Miller and Schroth's (MS) (18), and "523" (12) media using sterile forceps. Samples of the same diseased stems and petioles used for isolating bacteria were brought back to the laboratory on ice for fungal isolations using acidified potato-dextrose agar (PDA). Isolations of bacteria from roots were made in the laborabory. After flaming in alcohol, a section of tissue was macerated in a drop of sterile water and a loopful was streaked on YDC, MS, and "523" media. For soil isolation 1-g samples were diluted in water and plated as

described (19) on MS agar. All plates were incubated at 30 C. For dry weight determinations, two 1-g samples were dried at 100 C for 48 hr.

Bacterial strains.—Ten strains of the sweet potato bacterium were used. Strains A-15, 16, 17, 18, 19, 22, 23 and 24 were obtained from sweet potato cultivar Georgia Jet. Strains A-20 and 21 were obtained from cultivars Red Jewel and Georgia Red, respectively. All strains were obtained from plants growing in separate fields near Omega, Georgia. All other bacteria used in this study are listed in Table 1. Bacteria for routine work were maintained on YDC agar at 2-3 C. They were stored at 24-27 C on Difco heart infusion agar in 10-mm tubes with wax-impregnated cork stoppers.

Description of the bacterium.—Cells were stained for flagella according to Blenden and Goldberg (2). Cellular appearance was determined from gram-stained smears. Colonies were examined for size, color, consistency, and elevation on YDC, nutrient agar (NA), and MS agars. Starch hydrolysis and reaction in litmus milk were determined by the methods of Király et al (13). Growth in 5% sodium chloride, pigment production, gelatin hydrolysis, rotting of potato, and production of indole were determined by the methods of Dye (8). Hydrogen sulfide production, nitrate reduction, acid production from carbonydrates, and malonate tests were performed by the methods of Edwards and Ewing (10). Lecithinase and phosphatase were determined by the methods of Colwell (7) and Barber and Kuper (1), respectively. Growth at 37 C was determined in medium "523" by the method of Dye (8). All tests were replicated twice. Deoxyribonucleic acid (DNA) reassociation reactions were carried out as described previously (5).

Pathogenicity tests.—Bacteria for pathogenicity tests were grown in medium "523" and diluted to the desired number of viable cells per milliliter, as described (19). Approximately 0.1 ml of a cell suspension was injected into the stems and petioles with a syringe fitted with 0.51-mm diameter (25-gauge) needle. The inoculum concentration was approximately 1×10^7 viable cells/ml, unless stated otherwise. After inoculation, the plants were placed in an ISCO (Instrumentation Specialities Co., Lincoln, Nebraska) dew chamber, inside a Percival (Percival Manufacturing Co., Boone, Iowa) Model PGW-108 environmental chamber, at 30-32 C, 100% relative humidity, and 100 hlux light intensity. *Cuscuta* sp. was inoculated outside during August.

Testing for resistance.—The following sweet potato cultivars were tested: Georgia Red, Red Jewel, Georgia Jet, Coastal Sweet, Centennial, Garnet, White Star, Georgia Red 85, Jasper, number 69, 73-Red Jewel-OP-1, 64-10-OP-4, 73-Muguga-OP-1, and Bunch Porto Rico-M2. Vine cuttings were planted in vermiculite in 10-cm diameter clay pots. The pots were placed in a tray of water in a greenhouse maintained at day/night temperatures of approximately 26/21 C. Three-10 days later, eight plants of each cultivar were inoculated with strain A-15 and placed in the dew chamber as described. The experiment was performed once with 4.0×10^7 and once with 1.5×10^5 viable cells/ml. Disease reactions of the cultivars were rated using a scale for evaluating resitance in sweet potato plants to Fusarium stem rot (11) modified as follows: 3 = stems collapsed after 4 days, 2 = stems collapsed after 7 days, 1 = petiole collapsed after 4 days, 0.5 = petiole

TABLE 1. List of *Erwinia* spp. and strains included in this study that were isolated from hosts other than sweet potato[a]

Erwinia spp. and strains	Host of origin	Received from
Erwinia sp. SB-13	sugarbeet	M. Schroth, California
E. carotovora		
ICPB EC150		R. Goodman, Missouri
ICPB EC105		R. Goodman, Missouri
ATCC 495		ATCC
E. atroseptica		
EA202	Irish potato	M. Schroth, California
ATCC 7407	Irish potato	ATCC
E. chrysanthemi		
B-102	African violet	J. Miller, Florida
5A	African violet	J. Miller, Florida
ICPB EM112	corn	R. Goodman, Missouri
ICPB EC17	chrysanthemum	R. Goodman, Missouri
SR31 (ICPB EC176)	chrysanthemum	A. Kelman, Wisconsin
1552 (EI-1)	chrysanthemum	D. Dye, New Zealand
1559 (EI-8)	carnation	D. Dye, New Zealand
10070 (EI-19)	carnation	D. Dye, New Zealand
1556	carnation	D. Dye, New Zealand
1563	*Dieffenbachia picta*	D. Dye, New Zealand
910 (ICPB EC179)	*Dieffenbachia picta*	NCPPB
1065	corn	NCPPB
1849 (ICPB EC115)	*Parthenium argentatum*	NCPPB

[a]Abbreviations: ATCC, American Type Culture Collection, Rockwell, MD; ICPB, International Collection of Plant Pathogenic Bacteria, University of California, Davis, CA; NCPPB, National Collection of Plant Pathogenic Bacteria, Harpenden, England.

collapsed after 7 days, 0.4 = vascular discoloration extending greater than 25% of the stem length after 7 days, and 0 = no vascular discoloration after 7 days. A plant with a score of 1.0 or less was considered resistant and that with a score of 2.0 or more was considered susceptible.

Host-range test inoculations.—The following plants were tested: chrysanthemum [*Chrysanthemum morifolium* (Ramat) Hemsl.], *Dieffenbachia picta* Schott, Shasta daisy (*Chrysanthemum maximum* Ramond), petunia (*Petunia hybrida* Vilm, African violet (*Saintpaulia ionantha* Wendl.), tobacco (*Nicotiana tabacum* L. 'Samsun'), tomato (*Lycopersicon esculentum* Mill. 'Rutgers'), eggplant (*Solanum melongena* L. 'Money Maker'), pepper (*Capsicum frutescens* L. 'Yolo Wonder'), Irish potato (*Solanum tuberosum* L. 'Norgold' and 'Russet'), cabbage (*Brassica oleracea* var. *capitata* L. 'Enterprise'), peanut (*Arachis hypogaea* L. 'Florunner'), corn (*Zea mays* L. 'Pioneer 3030'), *Cuscuta* sp., morning-glory [*Ipomoea purpurea* (L.) Roth], and soybean [*Glycine max* (L.) Merr. 'Hampton 266 A']. Chrysanthemum, Shasta daisy, and African violet were 2- to 3-week-old rooted cuttings. Petunia, tobacco, tomato, eggplant, soybean, peanut, and corn were at the three-to five-leaf stage. Irish potatoes were at the six- to eight-leaf stage and were grown from tubers received from M. Harrison (Ft. Collins, Colorado). Morning-glory plants were transplants taken from a field. *Dieffenbachia* plants were at the four- to five-leaf stage and were purchased locally. All plants were grown in the greenhouse except *Cuscuta* sp., which was growing naturally in a field near Griffin, Georgia. Symptoms were recorded after 3 and 7 days, unless stated otherwise.

Two plants of each species tested were inoculated as described with each strain of the sweet potato bacterium; *Cuscuta* and morning-glory were inoculated with strain A-17 only. Two plants each of chrysanthemum, corn, pepper, tomato, tobacco, and petunia were inoculated with each strain from plants other than sweet potato. Each experiment was repeated twice. Results were the same for all strains, unless stated otherwise.

Effect of temperature and moisture on symptom development.—Georgia Red sweet potato plants growing in 10-cm diameter pots were preincubated for 24 hr in growth chambers at 22, 27, and 32 C. The light intensity was approximately 100 hlux and the relative humidity 60-70%. Two stems and two petioles of each of four plants were inoculated with strain A-17 as described. As a control, two stems and two petioles of a fifth plant were inoculated similarly but with sterile distilled water. Half the plants inoculated with A-17 and the single plant injected with water were covered with a polyethylene bag to maintain a high relative humidity. The two remaining plants were left uncovered. Symptoms were observed and data recorded after 5 and 10 days.

RESULTS

Isolations.—The bacterium was isolated from plant tissues and differentiated from other bacteria most easily on MS agar [plating efficiency (19) = 50-60% of NA]. The colonies were slightly raised, smooth, slightly undulated, and clear with an orange center. They were 1 and 3 mm in diameter after 2 and 4 days, respectively. No fungi were isolated on MS or PDA agars.

A field of sweet potatoes (cultivar Red Jewel) being harvested near Omega, Georgia, was sampled on 14 August 1975 to determine the presence of the bacterium in the soil and plants. There were no symptoms of the disease in plant parts above ground, but between 5 and 10% of the harvested roots were rotted. The bacterium was not isolated from soil samples collected from around diseased roots of six plants just after they were uprooted by the harvester but was isolated from four samples of soil collected from the harvester. Two samples of soil from the conveyor belt and two samples of soil with plant debris collected below the conveyor belt contained at least 1×10^4 and 5×10^5 cells/g dry weight, respectively. Of 56 apparently healthy roots collected at random from the conveyor belt, 23 rotted when placed in polyethylene bags at 32 C for 7 days. The pathogen was isolated from all 23 rotted roots. The identity of three strains from each source of isolation was confirmed by pathogenicity tests.

To determine the presence of the bacterium in seed roots, 15 partially rotted roots (cultivar Georgia Red) were collected from each of two plant beds (different growers) near Omega, Georgia, just before the roots were covered with soil on 18 February 1976. The bacterium

TABLE 2. Characteristics useful for differentiating species of *Erwinia* from sweet potato erwiniae[a]

Species	No. of strains	Malonate	Indole	Lecithinase	Phosphatase	Litmus milk	Acid from: Lactose	Acid from: Maltose	Growth on[b]: XLD	BG	m Endo	MS
E. carotovora	3	A	−	−	−	A,C	+	−	YM	YM	RM	U
E. atroseptica	2	A	−	−	−	N	+	V(1)	YM	YM	RM	U
E. sp.	1	A	−	−	−	C	+		YM	YM	RM	U
E. chrysanthemi	12	Alk	+	+	+	C[c]	+,D	V(2)	YM[d]	V;RM, GM	Poor growth	M
Sweet potato strains	10	Alk	+	+	+	A,C	+,D	−	RM	RM	RC	U

[a]Symbols: +, positive; −, negative; A, acid; Alk, alkaline; C, coagulated; D, delayed; N, neutral; V, strains varied (number positive given in parentheses); RM, red medium; YM, yellow medium; M, mucoid; U, undulate; PC, pink colonies; and RC, red colonies.

[b]Abbreviations: XLD, Bioquest XLD agar; BG, Brillant Green agar; m Endo, Bacto m Endo agar LES; and MS, Miller-Schroth agar.

[c]Isolates EM112 and 1065 A, C.

[d]Isolate 1849, red medium.

was isolated from two roots from one of the beds. Both strains were pathogenic.

Identification of the causal bacterium.—Cells of the bacterium were Gram-negative peritrichous rods. Cells from 24-hr cultures grown at 30 C were 0.50-0.80 × 1.0-3.0 μm. The mean width was 0.75, and the mean length, 2.0 μm.

Growth on YDC agar and NA agar was rapid, with visible colonies present after 24 hr at 30 C. After 72 hr, colonies on YDC were slightly convex, finely granular, undulate, white to light tan in color, and averaged 5 mm in diameter. On NA, colonies were effuse to low-convex, transparent, entire, colorless, and averaged 4 mm in diameter. Growth on MS agar was slower than on YDC,

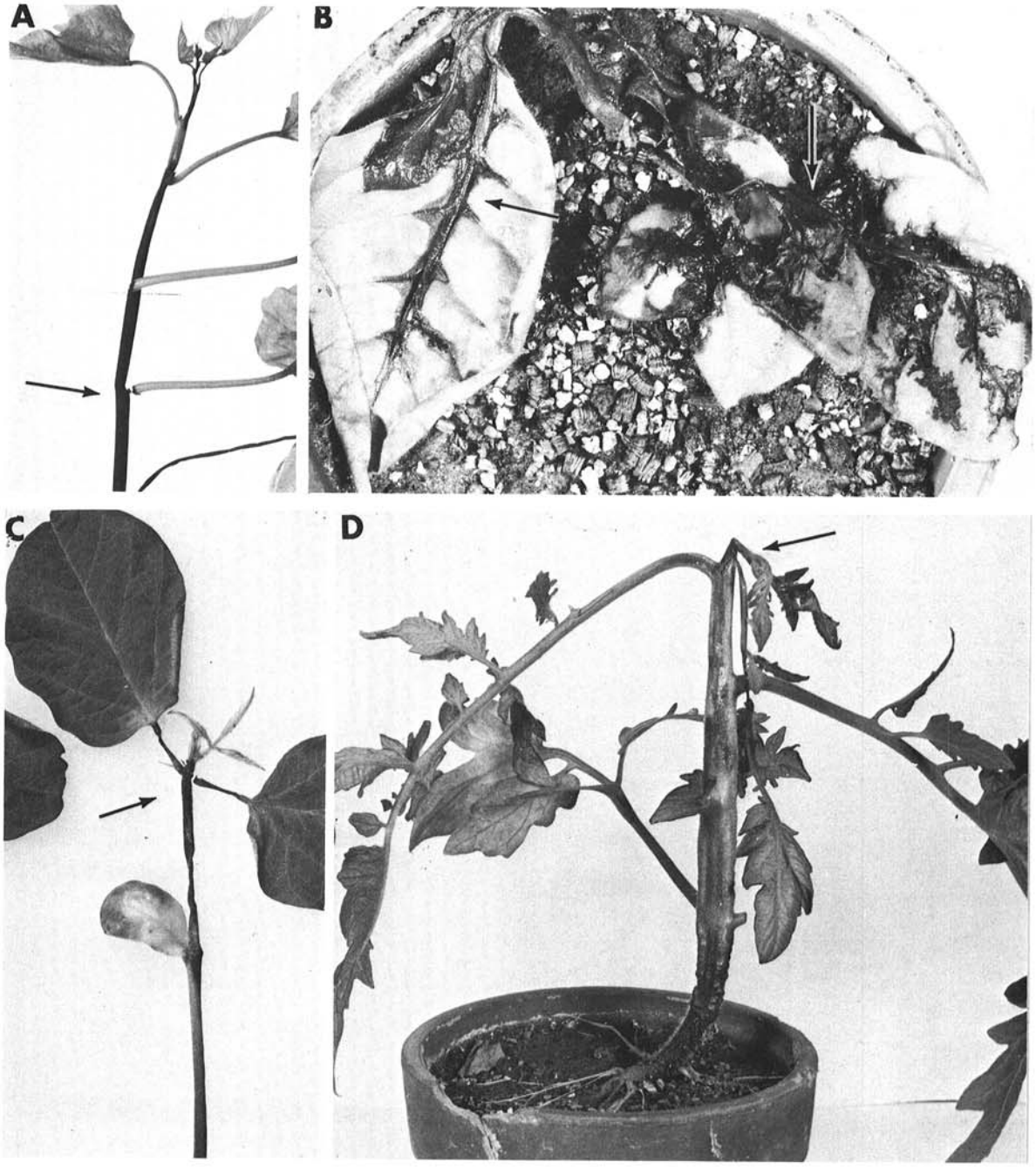

Fig. 1-(A to D). Reactions of **A)** sweet potato cultivar Georgia Jet, **B)** tobacco cultivar Samsun, **C)** soybean cultivar Hampton 266A, and **D)** tomato cultivar Rutgers 7 days after being inoculated with a suspension containing approximately 1×10^7 viable cells/ml of sweet potato bacterium strain A-17 of *Erwinia chrysanthemi*; Arrows indicate the black, collapsed tissue.

with visible colonies present after 48-72 hr. Colonies averaged 2-3 mm after 72 hr at 30 C, and were convex, transparent, slightly undulate, and orange with colorless margins. Colonies growing in mass were blue. The bacterium was distinguished from other erwiniae by its characteristic growth and reaction on MS agar, XLD agar (Baltimore Biological Laboratory, Baltimore, Maryland), Bacto Brillant Green agar, and Bacto m Endo agar LES (Table 2).

All 10 strains of the sweet potato bacterium reduced nitrate, liquefied gelatin, rotted Irish potato, and produced indole. Acid was produced from mannose, rhamnose, d-ribose, salicin, mannitol, dextrose, raffinose, and inositol after 7 days and from lactose after 14 days. No acid was produced from glycerol, trehalose, or maltose, and starch was not hydrolyzed. The ability to grow in 5% NaCl varied with the strain.

Of the 20 biochemical tests normally used for differentiating species of *Erwinia* (8), results of only seven tests (malonate, indole, lecithinase, phosphatase, litmus milk, lactose, and maltose) were the same with all strains of the sweet potato bacterium. With the seven tests, the bacterium was easily differentiated from *E. carotovora* and *E. atroseptica*, but not from other strains of *E. chrysanthemi* (Table 2).

Relatedness between DNA from several strains of the sweet potato bacterium ranged from 85% to 100%. Deoxyribonucleic acid from the sweet potato bacterium exhibited an average 80% relatedness to *E. chrysanthemi* strains SR-31 and 5A, 60% to strain EM112 (corn stalk-rot strain) and less than 30% relatedness to *E. carotovora*. DNA relatedness values of 70% or higher are considered an indication that the strains tested belong to the same species (5).

Inoculation studies with sweet potatoes.—Two or 3 days after sweet potato plants were inoculated with the 10 strains of the bacterium, water-soaked lesions were present several cm beyond the point of inoculation. By 5-7 days the entire stem or petiole was black and had collapsed (Fig. 1-A). The symptoms were similar to those produced by natural infections. Several *E. chrysanthemi* strains from other hosts were also tested. The results varied with the strain. Strains 10070, 1559, 1556, 1563, 910, EM112, and 1065 did not produce symptoms in the sweet potato, whereas strains B-102, 5A, 1849, EC17, and 1552 produced symptoms indistinguishable from those produced by the sweet potato strains.

Testing for resistance.—At 4×10^7 viable cells/ml only one cultivar, Red Jewel, was rated as resistant (Table 3). At 1.5×10^5 viable cells/ml Red Jewel, 73 Red Jewel-OP-1, Jasper, and Bunch Porto Rico-M2 were significantly more resistant than the others. None of the cultivars was

TABLE 3. Disease indexes of 14 sweet potato cultivars inoculated with *Erwinia chrysanthemi* at two inoculum concentration levels

Cultivar	Disease index[y]	
	Viable cells per milliliter	
	4×10^7	1.5×10^5
Red Jewel	1.00[z]e	0.37 cef
Bunch Porto Rico-M2	2.30 bcd	0.37 ef
Jasper	1.70 cd	1.00 cde
73-Red Jewel-OP-1	3.00 a	1.00 cd
Centennial	2.00 cd	–
64-10-OP-4	2.70 ab	2.00 b
Code 69	2.30 bcd	2.25 ab
Coastal Sweet	3.00 a	2.25 ab
Garnet	3.00 a	2.50 ab
White Star	2.50 abc	2.50 ab
Georgia Jet	2.70 ab	2.50 ab
73 Muguga-OP-1	3.00 a	2.50 ab
Georgia Red	3.00 a	2.75 a
Georgia Red 85	3.00 a	2.75 a

[y]Mean of eight replicates. Disease index ranges from the most susceptible reading of 3.0 (all plants collapsed after 4 days) to the most resistant reading of 0 (no plants collapsed after 7 days, and no vascular discoloration in surviving plants).

[z]Values within a column followed by the same letter are not significantly different ($P = .05$) (Duncan's multiple range test).

TABLE 4. Reaction of several plants to strains of *Erwinia chrysanthemi* from hosts other than sweet potato[a]

Bacterium strain	Host of origin	Reaction[a] of inoculated:					
		Chrysanthemum	Corn	Pepper	Tomato	Tobacco	Petunia
B-102	African violet	+	–	–	++	++	–
5 A	African violet	+	–	++	++	–	–
EM112	Corn	++	+	–	+	++	++
1065	Corn	+	–	++	–	–	–
EC17	Chrysanthemum	++	–	++	++	++	–
1552	Chrysanthemum	++	–	++	–	–	++
1559	Carnation	++	–	++	–	++	–
10070	Carnation	+	–	–	–	–	–
1556	Carnation	+	–	++	–	–	–
1563	*Dieffenbachia picta*	+	–	++	–	–	–
910	*Dieffenbachia picta*	+	–	–	+	–	++
1849	*Parthenium argentatum*	+	–	++	++	++	++

[a]Symbols: ++, wilting and collapse (soft rot); +, vascular system black; and –, no symptoms 10 days after having been inoculated with a suspension containing approximately 1×10^7 viable cells/ml. Each test was repeated twice using two plants.

immune. At the higher inoculum concentration all plants of Georgia Red, Coastal Sweet, Georgia Red 85, 73-Red Jewel-OP-1, 77 Muguga-OP-1, and Garnet collapsed after 4 days.

Host-range test inoculations.—Inoculated African violet, tobacco (Fig. 1-B), and petunia plants rotted and died after 3-5 days. Pepper, Irish potato, and soybean (Fig. 1-C) plants collapsed after only 2 days. Chrysanthemum, daisy, cabbage, and tomato plants (Fig. 1-D) wilted after 5-7 days, and the inoculated stems and petioles often collapsed after 10 days. Black veins were present several centimeters above and below the inoculation site. Eggplants reacted differently depending upon the strain; strain A-15 and A-20 produced a soft rot and collapse of the tissue; strain A-21 produced hyperplasia and strains A-19 and A-22 produced no symptoms. With strain A-17, the newest leaves of corn plants collapsed and rotted after 5-7 days; older tissues were not damaged. No other strain infected corn. *Dieffenbachia picta* showed slight blackening above and below the inoculation site; no soft-rotting was evident. The stems of morning-glory and *Cuscuta* sp. became soft, rotted, and collapsed after 3-5 days. Peanuts and snapdragon plants showed no symptoms after 14 days. By 21 days, however, galls approximately 2-3 mm in diameter began appearing on petioles of snapdragon leaves several centimeters above the inoculation site. *Erwinia chrysanthemi* was easily isolated from the galls.

Results of inoculation of chrysanthemum, corn, pepper, tomato, tobacco, and petunia with strains of *E. chrysanthemi* from sources other than sweet potato varied with the strain (Table 4).

Effect of temperature and moisture on symptom development.—At 32 C and high humidity, stems and petioles of sweet potato plants inoculated with the sweet potato bacterium became black, soft-rotted, and collapsed after 5 days. At 32 C and low humidity, no stems or petioles collapsed; the tissue at the site of inoculation blackened only slightly after 10 days. All plants showed a slight blackening at the inoculation site after 10 days at 27 C; no soft-rotting was evident. No symptoms were observed on plants at 22 C or on plants injected with sterile distilled water. When two of the plants held at 22 C and 27 C for 10 days were placed at 32 C and high humidity, both collapsed within 5 days. The two other plants kept at 22 C and 27 C remained healthy.

DISCUSSION

Field symptoms of the bacterial wilt disease of sweet potato were similar to those of Fusarium wilt. However, the earlier symptoms of bacterial wilt were easily distinguished from Fusarium wilt on the basis of the soft-rotting produced by the causal bacterium.

The bacterium responsible for the wilt and root rot disease of sweet potato was not *E. carotovora,* as previously suggested (15), but instead was *E. chrysanthemi.* Our results, showing that the soft-rotting erwiniae can be distinguished by a few biochemical tests, agreed with the results of Bonnet (4). Our results disagreed with the original report (6) that *E. chrysanthemi* does not produce indole, but instead agreed with the positive results obtained by Dye (9).

The sweet potato strains infected several hosts of *E. chrysanthemi,* including chrysanthemum, Shasta daisy (6), and African violet (14), but not *Dieffenbachia picta* (17). Although results of host-range test studies showed that tobacco, petunia, tomato, pepper, eggplant, Irish potato, cabbage, and morning-glory plants were infected and often killed at a high temperature and humidity, the presence of the disease in these hosts under field conditions has not been determined. Results of inoculating chrysanthemum plants with the sweet potato bacterium were similar to results obtained with *E. chrysanthemi* (3, 4, 6, 14). Plants usually died above the inoculation point, but survived by producing new shoots from axillary buds below that point. The hyperplasia produced in snapdragon and eggplant was not observed in any other plant tested and has not been previously described for *E. chrysanthemi.* The lack of a correlation between host of origin of *E. chrysanthemi* strains and their host range (Table 4) suggest that the pathogenicity of this bacterium is highly variable. However, our data do suggest that chrysanthemum is a common host to all strains. More detailed studies are needed to determine the existence of pathogenic varieties of *E. chrysanthemi.*

Our results agreed with Martin and Dukes (15) that cuttings of Georgia Red and Georgia Jet are highly susceptible and that Red Jewel is highly resistant to bacterial soft rot. We further found that cultivars Bunch Porto Rico-M2, Jasper, and 73-Red Jewel-OP-1 were resistant at a low inoculum concentration but not at high inoculum concentration. Although we rated the four cultivars as resistant, we do not know the response of roots of mature plants. For example, the fact that 23 of 56 apparently healthy roots collected from symptomless Red Jewel plants eventually rotted suggests that the response of vine cuttings is not representative of the plants' resistance.

A requirement of a high temperature and humidity for disease development may explain the sudden appearance of the disease in the field during June, and also the absence of the disease in drier climates. Preliminary epidemiological data indicate that the pathogen is spread from the plant bed to the field by infected, symptomless vine cuttings. The presence of the pathogen in "seed" roots for propagation collected in the plant bed and the failure to isolate the pathogen from soil suggest that roots play an important role in the survival of the pathogen. However, since we did not determine the percent recovery on MS agar of *E. chrysanthemi* added to soil, it is possible that the bacterium can survive in soil in small numbers. The possibility of avoiding the disease by growing sweet potatoes for seed in a drier climate should be investigated.

Observations that the causal bacterium was present in the vascular system of roots with no external symptoms or signs indicate that a rigid field inspection and/or laboratory detection scheme is needed.

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