Ralstonia solanacearum
Race 3 Biovar 2

Photo: USDA-APHIS-PPQ, bugwood.org #1265011

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Introduction

- Gram negative bacteria
- Causes bacterial wilt and rot
- Widespread
- Formerly known as *Pseudomonas solanacearum*

Ralstonia solanacearum colonies on TZC media

Photo: Tom Creswell, Purdue University, bugwood.org #5079060

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Ralstonia is a genus of gram-negative bacteria that can be pathogenic to both humans and plants. The plant pathogenic species include *Ralstonia solanacearum* which causes bacterial wilt and rot on a range of important crop plants.

Ralstonia solanacearum is a Species Complex

- Species complex = further split
- Race is determined by the host range of the group
- Biovar is determined by the type of food source they use
- Race 3 biovar 2 (R3b2) is the focus of the presentation

Ralstonia solanacearum colonies on TZC media

Photo: Tom Creswell, Purdue University, bugwood.org #5079060

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Ralstonia solanacearum is a species complex, which means the group is genetically classified as the same species, but there are distinct sub-groups in the species. The species complex is distinguished by “race” and “biovar”. The different races are determined by differences in host ranges. One race may attack bananas, while another race is not pathogenic on bananas. Biovar relates to the carbohydrate source that *R. solanacearum* can utilize.

Why is *R. solanacearum* R3b2 Important?

- Race 1 endemic in the U.S.
- Race 3 is pathogenic on potato and tomato
  - Potential to spread widely
  - Survival in temperate climates
  - Historically detected and eradicated
  - Recently detected in Michigan

Ralstonia solanacearum cause Southern bacterial wilt on potato

Photo: National Plant Protection Organization, the Netherlans, Bugwood.org #0725083

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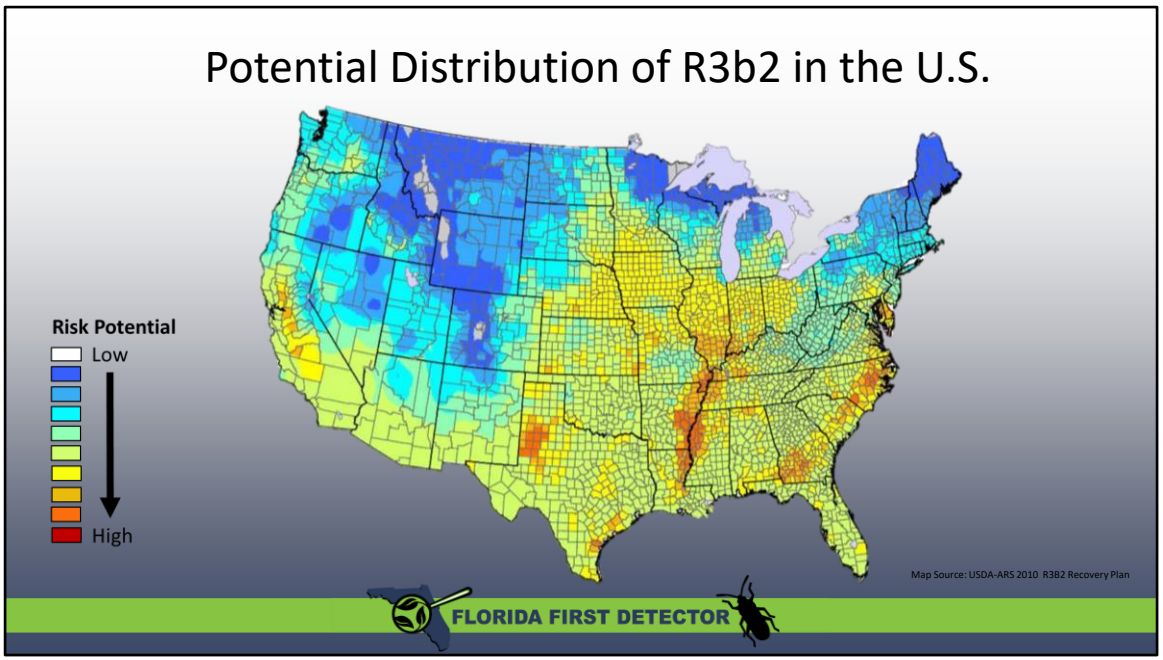
Ralstonia solanacearum race 1 is already in the United States. Race 1 can only survive in tropical climates so *R. solanacearum* race 1 is unlikely to establish in cold areas. Race 1 has an extremely wide host range, including tomato and bell pepper, and is distributed across Asia, Australia, and the Americas. It is unlikely to spread to the rest of the U.S. because of the geographic separation of seed potato production and potato production.

R3b2 has a more restricted host range but could cause significant economic losses especially for potato and tomato. It also has the potential to spread more widely in

Distribution of R3b2

- Probably originated in the Andes and was disseminated by potato tubers
- Worldwide, except United States and Canada

It's likely that R3b2 originated in the Andes and was then distributed further by the trade of potato tubers to the rest of locations outside of the Andes. Currently, R3b2 is not considered established in the U.S., and is currently under eradication.



Risk maps combine climate and host data to determine which areas may be most susceptible to R3b2. While the other races of *Ralstonia* are restricted to tropic climates, R3b2 has the potential to establish over much of the United States. The potential for further spread is what makes R3b2 a high phytosanitary risk.

Susceptible Crops

Eggplant

Tomato

Potato

Geranium

Photo: Tomato (Komal Sambhudas - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=88244331) ; Potato (Peggy Greb, USDA ARS, bugwood.org #1321046 ; Eggplant (Howard Shultz, Colorado State University, bugwood.org #5361660; Geranium (Wikimedia, Creative Commons Attribution-Share Alike 3.0 Unported)

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Solanaceous crops which include tomato, potato, and eggplant are hosts, as well as geranium. Geranium has been the only know infected hosts imported into the United States. If R3b2 were to establish in the US these industries would be in danger of infection with R3b2.

How R3b2 Spreads

- Infected plant cuttings
  - Geranium or tubers
- Soilborne
- Waterborne
- Weeds
- Infested machinery

R. solanacearum R3b2

Photo: Jason Brook, University of Georgia, bugwood.org #5472887

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Geranium plant cuttings and infected tubers being spread for seed potatoes can be a major form of human-mediated spread. Naturally, R3b2 can be spread through the soil water, or by waterways. In the United Kingdom, R3b2 infected the semi-aquatic plant bittersweet nightshade that led to further spread and infestation of water with the bacteria. That water was then used to irrigate a potato field, contaminating the entire field. Solanaceous weeds are potential reservoirs of R3b2. Machinery can spread the infection by picking up the bacteria from the soil and moving it across the field or between fields, if the machinery is not cleaned between fields. The bacteria could also be spread between pruning tools used to maintain ornamental plants.

Symptoms and Signs

- Symptoms are visual signals from the plant that something is affecting it
- Signs are visual signals directly from the pathogen
- Bacterial streaming is a visual sign
- After plants collapse, ooze may be seen on the stem

R. solanacearum streaming out of a tomato stem

Photo: Jason Brook, University of Georgia, bugwood.org #5472887

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Symptoms and signs are clues that can help to diagnose a plant pathogen in the field. Symptoms are the plant signaling that something is wrong. General symptoms of plants might include chlorosis, or yellowing, wilting, or necrosis. Signs, however, are seeing the pathogen directly. For example, in the photo we can see just below the cut stem a creamy stream coming out of the stem. Streaming is a diagnostic for bacterial pathogens, it will not be seen from infection with virus or fungal pathogens. If a bacterial pathogen is expected to be the cause of the disease, take the portion of the plant that is symptomatic and cut the stem. Place the stem in water and see if the bacteria stream out. To better see if bacteria is streaming from the stem you can

Symptoms of Solanaceous Crops

- Symptoms are visual signals for the plant
- Symptoms of R3B2 are yellowing, wilting and stunted growth
- Brown discoloration of the stem
- In highly susceptible plants the stems can collapse entirely

Wilt symptoms of the youngest leaves

Discoloration of the stem

Infected tuber discoloration

Photo: Top (Clemson University, USDA Cooperative Extension Slide Series, bugwood.org #1234078); Bottom (Clemson University, USDA Cooperative Extension Slide Series, bugwood.org #1436100)

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When R3b2 infects a host, it causes a disease. A disease is the name for the combination of a host, symptoms, and a pathogen. On tomato, R3b2 can cause tomato bacterial wilt while R3b2 on potato can cause potato brown rot. The diseases caused by R3b2 on both potato and tomato are indistinguishable from race 1 of *R. solanacearum.*

In both tomato wilt and potato brown rot disease, the youngest leaves on the plant begin wilting during the hottest parts of the day. If conditions for the disease are favorable, then the entire plant can wilt and die very quickly. Some plants will be

Symptoms on Geranium

- Causes Southern Wilt of Geranium
- Geranium imported host of R3b2
- Wilt and leaf curl symptoms subtle, may not be noticed
- Late symptoms are the blackening and collapse of stem

Pie wedge shaped symptoms on geranium

Early wilt symptoms on geranium

Photo: (Top) Margert Daughtrey, Cornell University, bugwood.org #5511639; Bottom (USDA APHIS PPQ, Bugwood.org UGA1265009

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The early symptoms of southern wilt of geranium are subtle and the wilt can be easily overlooked as over or under watering. A characteristic of the wilt is the upturning of leaf margins, which you can see in the top photo. As the disease progresses the leaf develops chlorosis and leaf scorch. These symptoms resemble other bacterial diseases, such as bacterial blight. However, other bacterial diseases may produce bacterial spots or specks in addition to the wilting. In the final stages of the disease, the stem will blacken and collapse.

Disease Cycle

- Enters plant through the roots or injury
- Colonization begins in the xylem
- Favored by temperatures 24-35˚C (75-95˚F)
- Colonizes soil and survives in host weeds over winter

Common Chickweed

Lambsquarters

Wild Mustard

Bittersweet nightshade

Photo: Common Chickweed (Chris Evans, University of Illinois, bugwood.org #5560797); Lambsquarters (Howard F. Schwartz, Colorado State University, bugwoood.org #5362600); Wild Mustards (Chris Evans, University of Illinois, bugwood.org #1380157; Bittersweet Nightshade (Steve Dewey, Utah State University, bugwood.org #1459372)

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The primary mode of infection is through the plant roots. Bacteria moves in soil water or in irrigation water. Often, lateral root damage from other organisms provide an entryway for bacteria, or by the bacteria being passed from infected roots to healthy ones. Once the roots are infected, the bacteria will colonize, and move to the rest of the plant through the xylem. The bacteria colonize most aggressively in temperatures to 24-35˚C. Once the plant dies, the bacteria can remain in the soil and survive cool temperatures by infecting host weeds such as common chickweed, lambsquarters, wild mustard, or bittersweet nightshade. They can also survive in the rhizosphere, or the area of soil that is associated with and interacts with plant roots.

Damage

- Potato major concern
- Worldwide loss $950 million
- Quarantine and eradication efforts in UK expensive
- Loss from destruction of infected plants in U.S.

Ralstonia solanacearum on potato

National Plant Protection Organization, the Netherlands, bugwood.org #0162015

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Potato is the largest concern in the U.S. for R3b2. Worldwide, R3b2 is in 80 countries and infected 3.75 million acres of potato, with damage estimated at over $950 million/year. Additionally, some fields are under quarantine or eradication measures which cause trade restrictions and unmeasurable loss. In the U.S. it is difficult to predict the amount of loss that could occur.

Potential Economic Damage in FL

- Fresh market tomato production $425 million
- Pepper production $234 million
- Potato production $159 million

Tomato wilt caused by *R. solanacearum*

Photos: Rebecca Melanson, Mississippi State University Extension, bugwood.org #5593857

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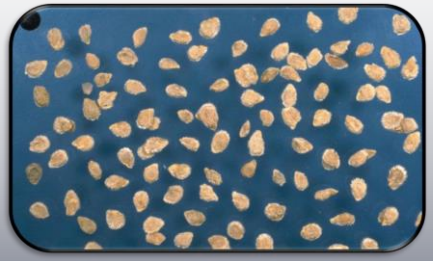
Florida has many industries that could be affected by R3b2, the largest being fresh market tomato production. Pepper and potato production would also be at risk. While total loss of the markets would not be expected, considerable losses would be possible. Additionally, quarantine of productions may occur, and the cost of management or eradication expenses would add to the loss of the industry.

Management

- Prevention is key
- Host resistance
- Seed priming
- Crop rotation



Tomato seeds

Photo: Howard F. Schultz, Colorado State University, bugwood.org #5364390

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Prevention of the bacteria in the field is the best way to deal with it. Purchasing certified pest and disease-free seeds. Once theR3b2 is in the field it will be incredibly difficult to control since the bacteria can survive in the soil and on weeds during crop rotations.

Host resistance is known in some potato and eggplant cultivars. Some tomato have moderate resistance to tomato, but R3b2 still affected them 50-60%. It will not fully protect the plant from R3b2, only provide some resistance.

Seed priming is treating seeds with by soaking. Some seeds can be primed to

require an applicator’s license!

Resources for Testing

- Plants are limited in their symptoms
- Many diseases have similar symptoms
- Testing should be done if a pathogen is suspected at your operation

R. solanacearum streaming out of a tomato stem

Photo: Jason Brook, University of Georgia, bugwood.org #5472887

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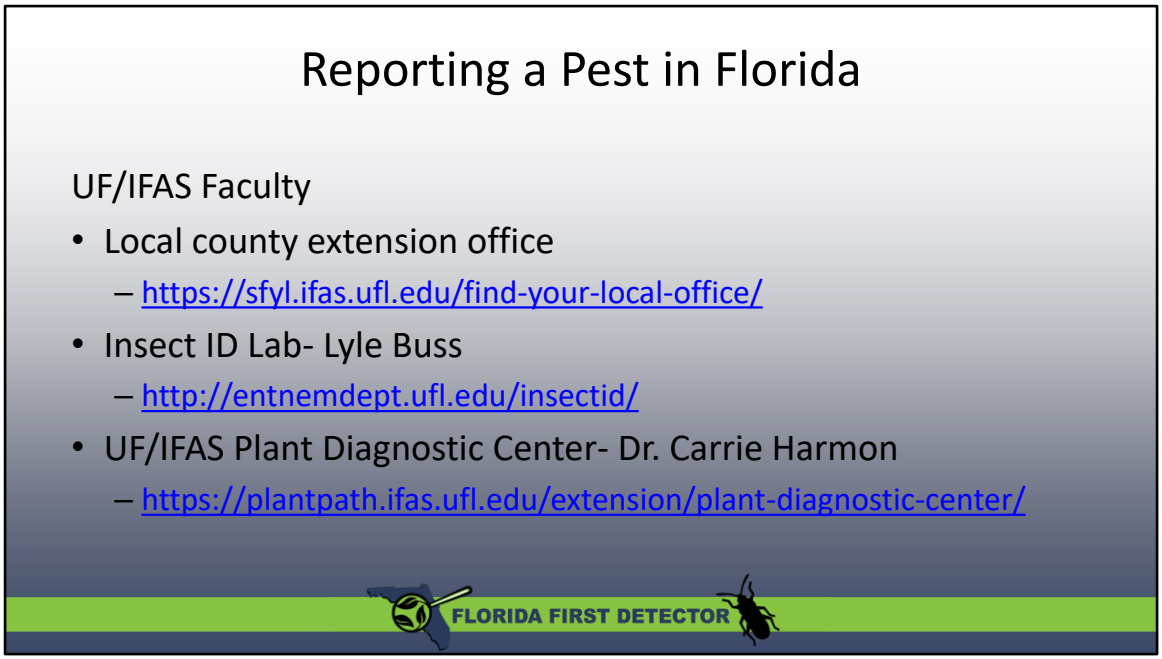
Plants only have limited symptoms that they can express to disease. Many diseases have very similar symptoms or can look like abiotic stress. If *Ralstonia solanacearum* is the suspected cause of the wilt, a sample should be sent to your local plant pathology lab. The UF Plant Diagnostic Center will be able to take your sample and test for the pathogen. It's advisable to call and speak to someone at the diagnostic center prior to sending in the sample to ensure the sample is adequate and arrives in good condition.



The UF/IFAS faculty is responsible for reporting diseases, insects, weeds, nematodes, or any other invasive species to the Florida Department Agriculture and Consumer Services, Division of Plant Industry (FDACS, DPI). Reporting this information is essential to protect Florida agriculture, communities and natural areas.

Local county extension agents can assist in identifying plant pest or assist in

If a diseased plant needs identification, the link to the UF/IFAS Plant Diagnostic Center run by Dr. Carrie Harmon is attached to assist in reporting and identifying the correct pest.

The diagnosticians and identifiers in each area will also provide management strategies for the pest identified to help eliminate the damage caused on the plants. If an invasive pest is found, they will send it FDACS, DPI for further testing.

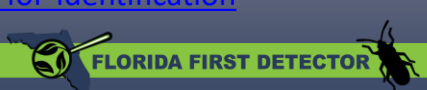
Reporting
Distance Diagnostic and Identification System

- Digital Diagnostic Collaboration
  - Extension agents
  - Laboratories
  - Clinics
  - Specialists
- https://ddis.ifas.ufl.edu/

The DDIS system connects the UF/IFAS faculty mentioned before to provide quick and accurate identification throughout Florida. This reporting collaboration tool enhances screening, early detection, monitoring, pest mapping, and rapid communication to protect agriculture. The site provides training, media of pest, equipment, and diagnostic labs in Florida.

Reporting
FDACS: Division of Plant Industry

- FDACS, DPI Responsibility
  - Announcing detection or establishment of new invasive species.
  - Reporting is a legal obligation under Florida Statute 581.091.
- Submission Form
  - http://forms.freshfromflorida.com/08400.pdf
  - https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/How-to-Submit-a-Sample-for-Identification



Florida Department of Agriculture and Consumer Services: Division of Plant Industry is a regulatory agency that detects, intercepts, and controls Florida's native and commercially grown plants. Announcing the establishment of new invasive species can affect Florida's agricultural producers and trade of agricultural products.

FDACS, DPI provides online submission forms to fill out and send into the agency for proper identification. Additionally, DPI provides useful videos of how to properly handle the specimens before shipping them for identification

FDACS, DPI Contact

- Dr. Leroy Whilby, Bureau Chief-Entomology, Nematology and Plant Pathology
  - 352-395-4661
  - Leroy.whilby@fdacs.gov
- Dr. Paul Skelley, Assistant Chief-Entomology, Nematology and Plant Pathology
  - 352-395-4678
  - Paul.skelley@fdacs.gov
- Dr. John McVay, Biological Administrator III-SES, Plant Pathology
  - McVay@fdacs.gov
- Division of Plant Industry Hotline
  - 1-888-397-1517
  - DPIHelpline@FDACS.gov

The DPI contacts provided will assist in determining the next steps if the pest found is of regulatory concern. Additionally, FDACS, DPI has a hotline with both a phone number and email for questions and concerns.

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Collaborating Agencies

- U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS)
- Cooperative Agricultural Pest Survey Program (CAPS)
- Florida Department of Agriculture and Consumer Services (FDACS)
- National Plant Diagnostic Network (NPDN)
- Sentinel Plant Network (SPN)
- Protect U.S.
- University of Florida Institute of Food and Agricultural Sciences (UF-IFAS)

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