Lecture Supplements

Plant Bacteriology

Bacterial Disease Symptoms-Part 2

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Version 4.25

January 1, 2025

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Table of Contents

Plants get sick too!

An Atlas of plant bacterial diseases symptoms

List of plant diseases caused by bacteria
More than 160 species of plant bacteria

- Bacterial diseases of plants are more than just unsightly; they are often destructive to plants.
- The University of Minnesota explains that there are more than 160 species of plant bacteria, each with its own growth rate. While some bacteria will quickly overwhelm your plant, others will slowly ravish your plant.
- Bacterial diseases are non aggressive and cannot penetrate the foliage or stems of plants.
- However, bacterial diseases do take advantage of your plant's natural state, entering the plant through its natural and man-made wounds and opening, such as with pruning cuts, cracks and stomata.

Smith,2017

Host Plants Names (Contd.)

- Lettuce/cabbage
- Laurel
- Lilac
- Lily/Lilium/calla lily
- Loquat
- Lupin
- Mango
- Magnolia
- Melons
- Maple (*Acer* spp.)
- Mulberry
- Mushrooms
- Nectarine
- Neem
- Oak
- Oat
- Oleander
- Olive
- Orchid
- Onion
- Orange (See also Citrus)
- Palm
- Panax
- Papaya
- Peach
- Pea
- Pear
- Pecan
- Pelargonium
- Pepper
- Periwinkle
- Philodendron
- Photinia
- Pine
- Pineapple
- Pistachio
- Plane
- Plum
- Poinsettia
- Pomegranate
- Poplar
- Potato
- Primula
- Pumpkin
- Rabbit's foot fern
- Radish
- Raspberries
- Rice

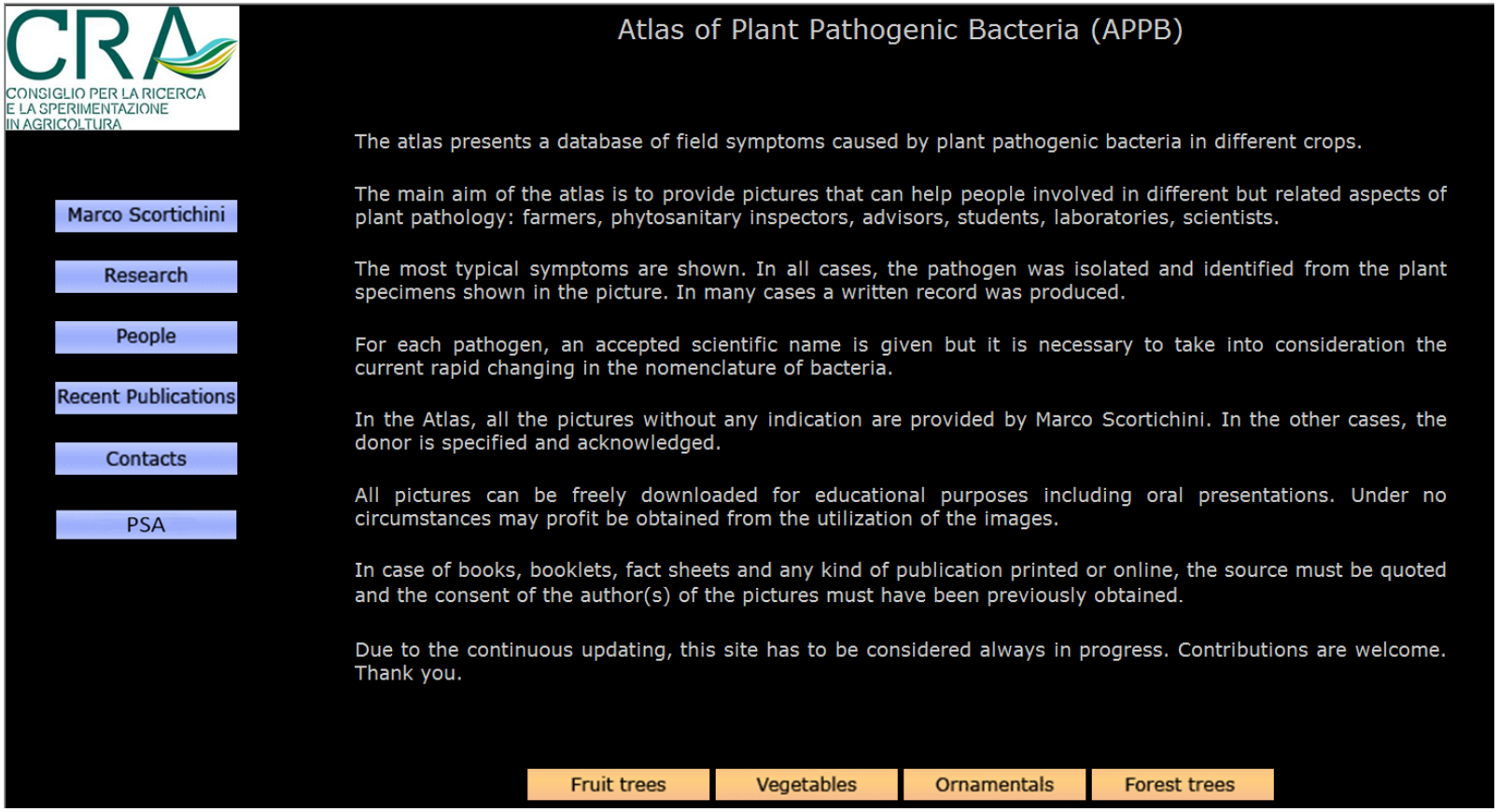
Host Plants Names (Contd.)

- Rose
- Rosemary
- Rye
- Saffron
- Sorghum
- Soybean
- Spinach
- Squash
- Strawberry
- Sugarbeet
- Sugarcane
- Sunflower
- Sweetgum
- Sycamore
- Syngonium
- Thistle
- Timoty grass
- Tobacco
- Tomato
- Tulip
- Turnip
- Vinca
- Wallflowers
- Walnut
- Wheat
- White oak
- Willow
- Wisteria
- Yarrow
- Zamiocullaf 'zanzibar gem'
- Zinnia
- Zucchini

PowerPoints/PDF files

- Allen, S.J., G.A. Constable, P.E. Reid and W.N. Stiller.2010. Breeding for cotton disease resistance in Australia. 1.34 Mb.
- Jones, J.B. 2006. Lecture 1 phytobacteriology. 19 pages.
- Sundin, G.W. 2008. Fire Blight Talk. Northwest Orchard and Vineyard Show. Michigan University, USA. 11.9 Kb.
- Hudelson, B. 2024. Plant Problems to Watch for in 2024. Plant Disease Diagnostics Clinic. University of Wisconsin-Madison Division of Extension.

Atlas of Plant Pathogenic Bacteria
APPB

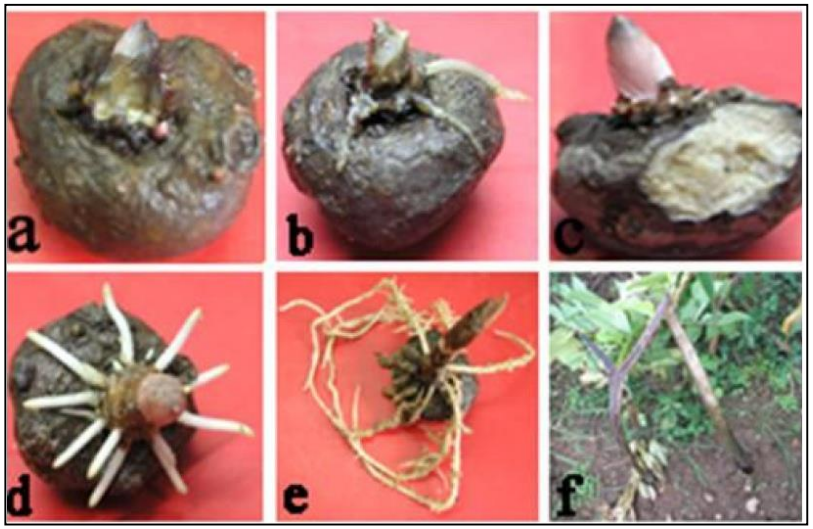


www.atlasplantpathogenicbacteria.it

Bacterial soft rot

P. carotovorum subsp. *carotovorum*

- *Amorphophallus konjac* is a perennial herbaceous species, mainly distributes throughout Southeast Asia and Africa.
- d. The corm at the bottom 2/3 was immersed in bacterial suspension for 1 h and it stayed well after 6d.
- e. The corm in d grew continually and half of the roots got rotted after 15 days.
- F. The corm in e grew continually and the petiole rot.

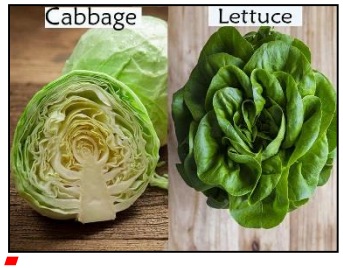


Wu *et al.*,2010

Leaf spot and shot hole

Pseudomonas syringae pv.*syringae*

Scortichini,2006



Bacterial leaf spot

Xanthomonas axonopodis pathovar *vitians*

- Bacterial leaf spot on green leaf lettuce caused by *Xanthomonas axonopodis* pv. *vitians*
- (Courtesy S. T. Koike)

Cabbage vs lettuce

Cabbage consists of a short stem and a head that forms a bulb-type shape. It is usually green in color and the outer leaves are harder to eat while the inner ones are softer. On the other hand, lettuce also has a short stem and leaves that wrap around each other. It tends to be greener than cabbage, owing to a high amount of chlorophyll. Compared to cabbage, lettuce is soft in texture and has high water content.

Riley *et al.*,2002;..

Stem rot of lettuce

E. rhapontici

Lettuce with symptoms of corky rot *Rhizorhapis* (*Rhizomonas*) *suberifaciens*

Fig. 1. Lettuce with symptoms of corky root

Vanish spot

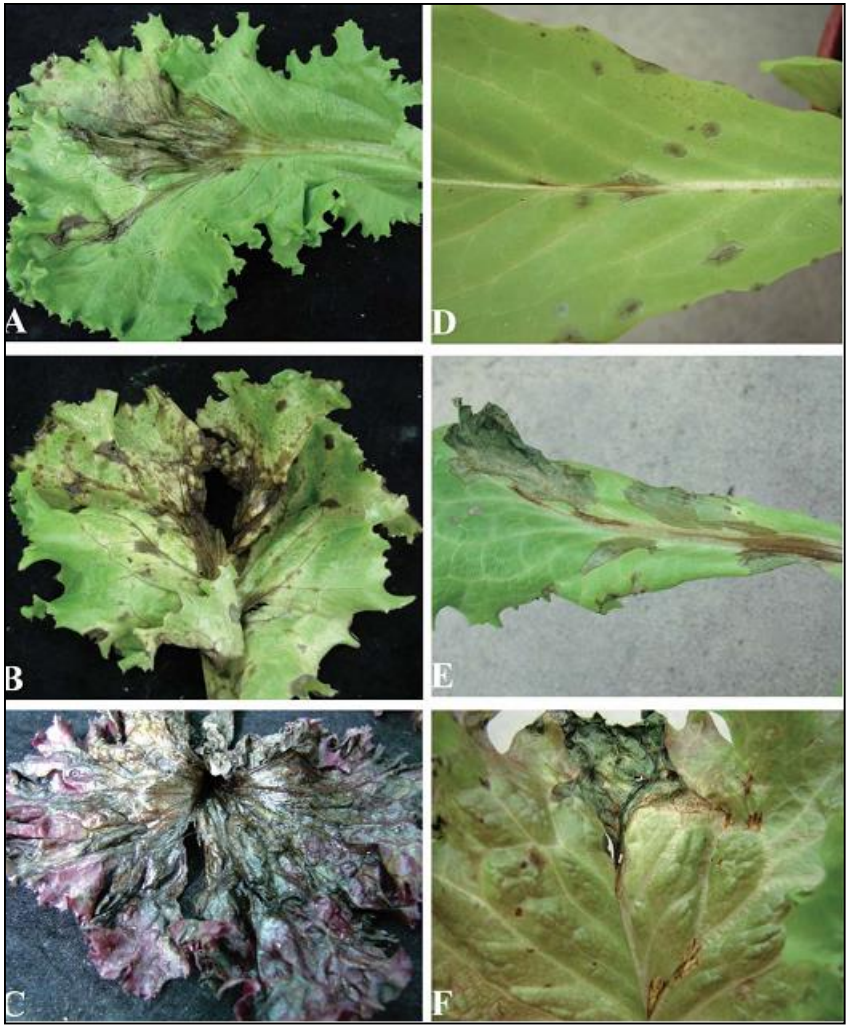
Pseudomonas cichorii

Varnish spot of crisphead lettuce, caused by *Pseudomonas cichorii*.

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Vanish spot

Pseudomonas cichorii



Rihlin,2010

Soft rot

Pectobacterium c. subsp.*carotovorum*

Soft rot of crisphead lettuce, caused by *Erwinia carotovora* subsp. *carotovora*.

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Yellowing
Phytoplasma

Aster yellows phytoplasma in romaine lettuce.

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Bacterial blight

Pseudomonas syringae pv. *syringae*

- Lilac shoots collapsing due to infection by *Pseudomonas syringae*.

Pscheidt, 2011

Bacterial blight

Pseudomonas syringae pv. *syringae*

Scortichini,2006; UC IPM Online

Bacterial soft rot diseases of true lily
P. carotovorum and *Psudomonas marginalis*

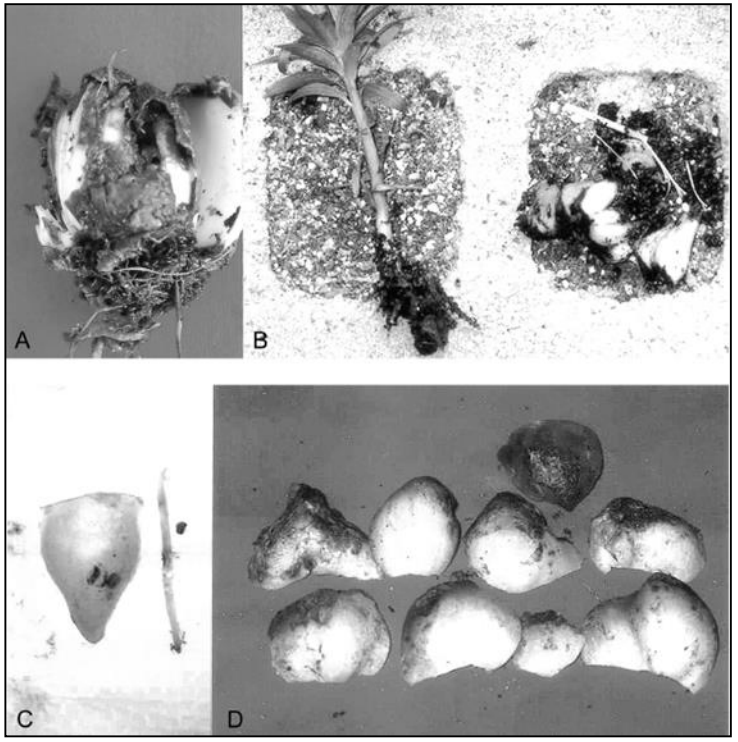
- ***Pectobacterium carotovorum* subsp. *carotovorum*:**
- Infected bulbs have a strong odor and are soft and mushy.
- Tops may appear water-soaked and collapse.
- ***Pectobacterium carotovorum* subsp. *carotovorum* or *Psudomonas marginalis*:**
- The small dark-brown lesion appeared on the bulb, and enlarged and developed into the inner scales of the bulb.
- The bulb became water soaked and gave out unpleasant odor.

Connecticut Agricultural Experiment Station, 2007; Hahm *et al.*,2003

Bacterial soft rot diseases of true lily

P. carotovorum or *Psudomonas marginalis*

- Symptoms of soft rot on lily bulbs caused by *Pectobacterium carotovorum* subsp. *carotovorum* or *Pseudomonas marginalis*.
- Typical symptoms developed on the bulbs at low temperature storage (A) or in the field (B).
- Symptoms observed after artificial pinpricking inoculationa djusted to 10^8 cells/ml (C and D).



Occurrence of rotten bulb was examined at 2, 3, 5, and 7 days after inoculation. Water-soaked lesion developed 48-72 hours after inoculation on pin-pricked bulb. The lesion was similar to the natural symptom observed in the storages or in the fields.

Hahm *et al.*,2003

Fasciation

Rhodococcus fascians

Janse,2006; Oregon Association of Nurseries,2011

Lily

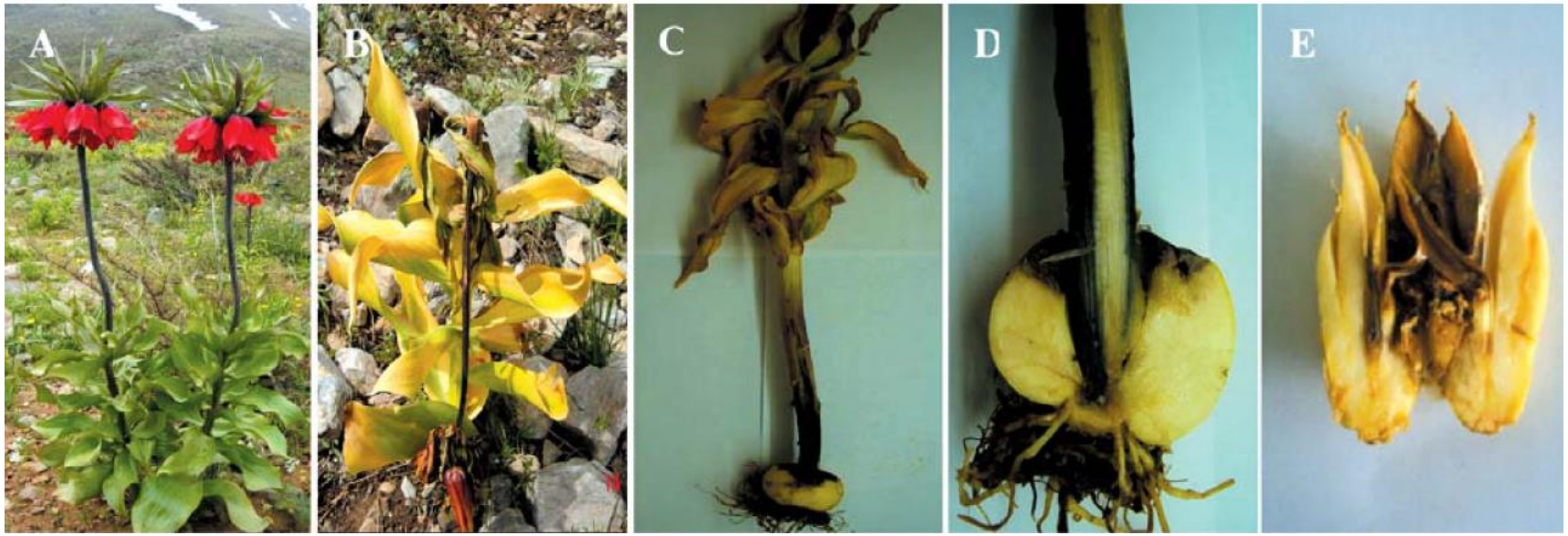
Leaf malformation and necrosis and flower bud abscission

'candidatus Phytoplasma mali'

Kamińska and Śliwa,2007

Soft-rot of crown imperial lily

P. carotovorum subsp. *carotovorum*



A, Healthy plant; B, Infectious plant in the field; C, D, symptoms of black and soft rot on bulb; E, first stage of *Pectobacterium carotovorum* subsp. *carotovorum* (pcc) soft rot on bulb.

Mahmoudi *et al.*,2007

Lily

Symptoms of stem fasciation of examined lily plants

Phytoplasma

- Apical portion of lily showing fasciation symptoms such as:
- Broadening of the main stem,
- Multiplicity of flower parts,
- Increased volume and weight.

Bacterial soft rot diseases of calla lily

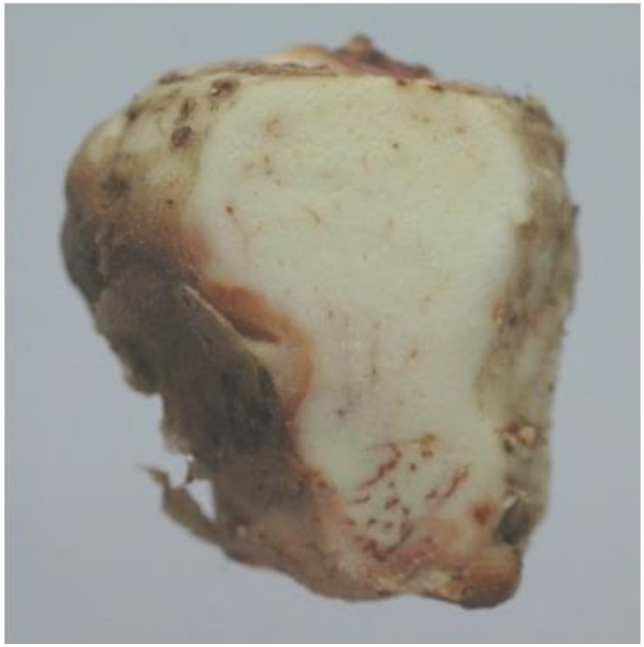
- *Zantedeschia* species are commonly called calla lilies, although they are not related to true lilies (*Lilium* spp.), which belong to the lily family.
- Calla lilies are more susceptible ornamental monocot host than true lilies.

Soft rot	***Pectobacterium carotovorum* subsp. *carotovorum*** ***P. atrosepticum*** ***Dickeya chrysanthemi*** ***Pseudomonas marginalis* and *P. putida*** ***Paenibacillus polymyxa*** ***Pseudomonas veronii*** ***P. marginalis*** ***Chryseobacterium indologenes*** ***Xanthomonas campestris* pv. *zantedeschiae***

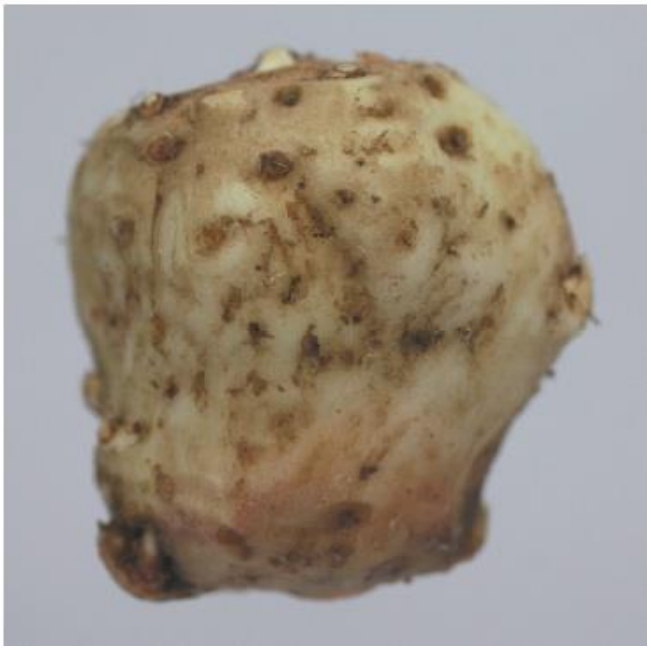
Mikicinski *et al.*,2010;…

Soft rot

Pectobacterium c. subsp.*carotovorum*



Cross-section through calla tuber showing soft rot symptom (Photo V. Krejzar).



Soft rot lesions located in the place of attachment of rhizomes to calla tuber.

Krejzar *et al.*,2008

Soft rot

Pectobacterium c. subsp. *carotovorum*

- Calla lily, ornamental geophyte (a perennial plant) cultivated for cut-flower and bulb production showing bacterial soft rot symptoms in the greenhouse:

a) Discoloration of leaves;

b) Rotting leaf petioles;

c) Leaf base and bulb rot.

Luzzatto *et al.*,2007

Soft rot

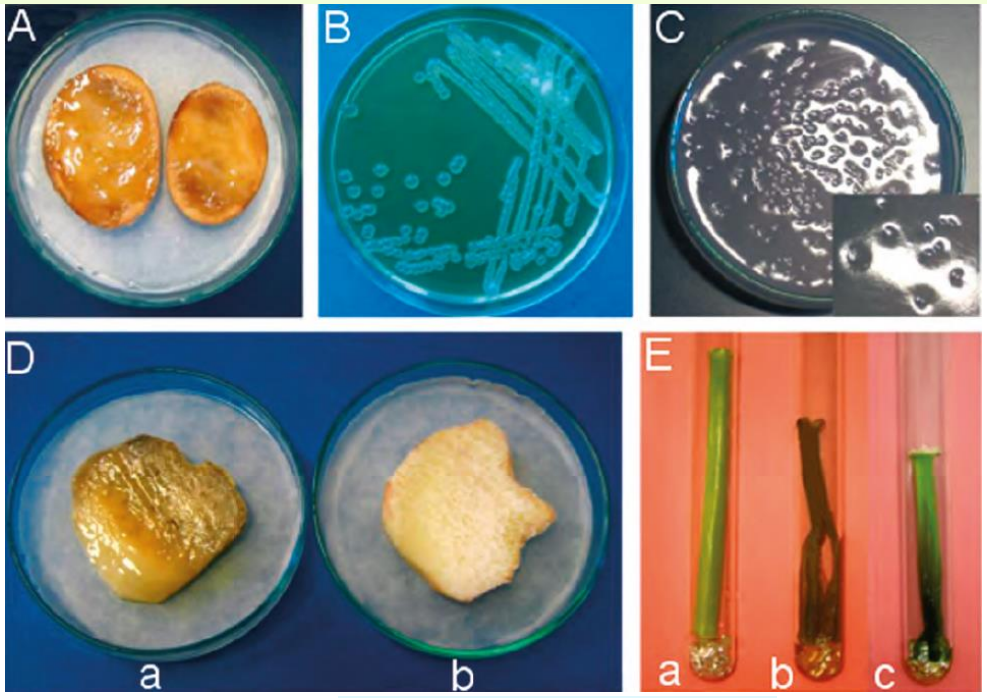
Paenibacillus polymyxa

- *Paenibacillus polymyxa* pathogen of calla lily.
- Bacterial soft rot of calla lily (*Zanthedeschia* spp.), a valuable ornamental grown worldwide, is the main limiting factor of its production in many countries.
- This is the first report that *P. polymyxa* can cause soft rot on calla lily.

Soft rot

Paenibacillus polymyxa pathogen of calla lily

A. Pectolytic activity of *Paenibacillus polymyxa* isolate 15M on potato slice 24 h after inoculation;
B. Colony morphology of isolate 15M on NAS medium.
C. Characteristic pits around isolate 15M colonies on CVP medium;
D. Rotted calla lily tuber slice 72 h after inoculation with isolate 15M (a), Water control (b);
E. Pathogenicity on calla lily leaf petiole cv. Treasure. Rotted segments 120 h after inoculation with isolate 15M (b, c); water control (a).



Mikicinski *et al.*,2010

Fire blight

E. amylovora

- Symptoms of fire blight on loquat.
- Note the infected brownish shoot tissue.

Adapted by Mary Olsen,1999

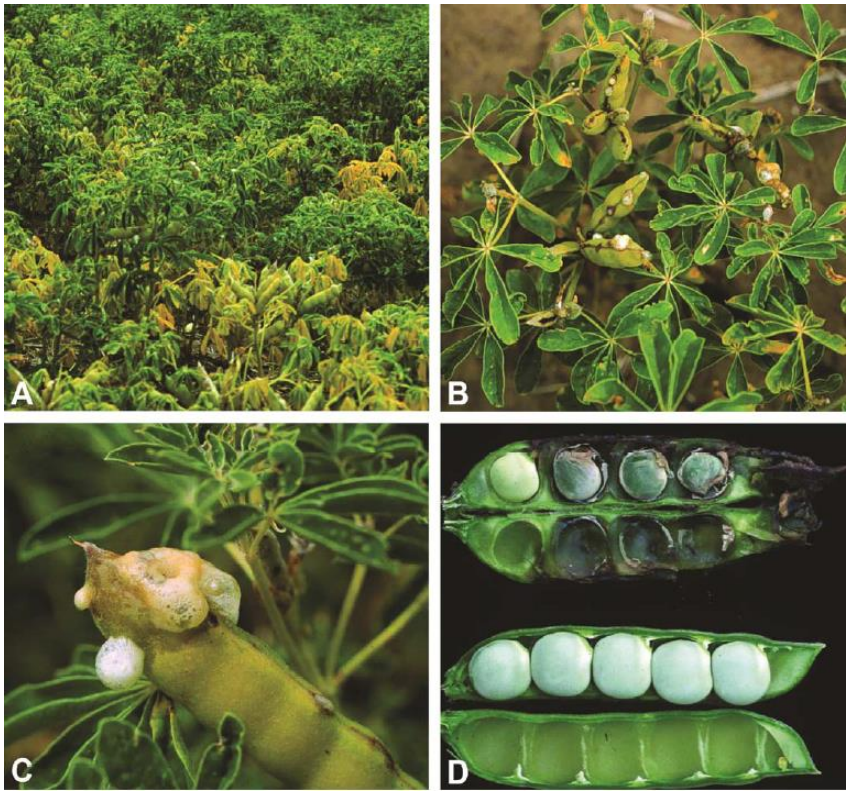
Drippy pod of Mediterranean white lupine *Brenneria quercina* pv. *lupinicola*

A. Symptoms and incidence of drippy pod disease in a field near Waitsburg, WA, in July 1987;

B. drippy pod symptoms observed from above a diseased lupine;

C. close-up view of an infected lupine pod showing profuse foaming from drippy pod infections;

D. internal drippy pod disease symptoms on a lupine pod (top) compared with a healthy lupine pod (bottom).



Lu and Gross,2010

Bacterial spot

P.s. pv. *syringae*

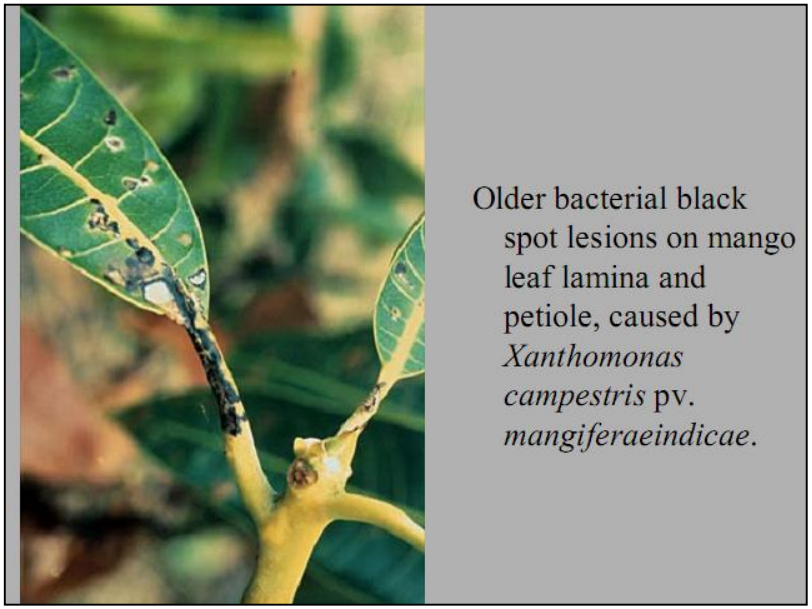
Scortichini,2006

Mango Bacterial Diseases

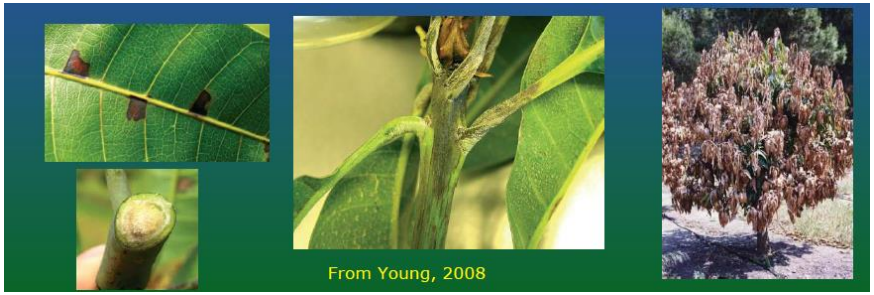
Black spot	***Xanthomonas mangiferaeindica***
Apical necrosis of mango	***Pseudomonas syringae* pv*. syringae***

Black spot

Xanthomonas mangiferaeindica



Older bacterial black spot lesions on mango leaf lamina and petiole, caused by *Xanthomonas campestris* pv. *mangiferaeindicae*.



Apical necrosis of mango

Pseudomonas syringae pv. *syringae*

- Symptoms of apical necrosis of mango caused by *Pseudomonas syringae* pv. *syringae* including:

A. bud necrosis accompanied by a drop of exudate;

B. necrosis extending outward from a bud along the central vein of mango leaves;

C. longitudinal view of necrosis extending downward from a bud through stem tissue;

D. initial symptoms of necrosis and associated exudate on flower panicles;

E. closer view of raised lesions along the central vein on mango leaves; and

F. heavy attack affecting nearly all of the branches of an infected mango tree.

- X indicates that this tree received no treatments in a disease control trial.

Kennelly *et al.*,2007

Disease symptoms

Pseudomonas syringae pv. *syringae*

- Mango tree with typical necrosis of stem tip, bud, leaf petioles and leaves caused by *Pseudomonas syringae* pv. *syringae*.
- Bars = 1 cm.

Golzar and Cother,2008

Disease symptoms

Pseudomonas syringae pv. *syringae*

- Advanced stem and apical necrosis caused by *Pseudomonas syringae* pv. *syringae*. Bars = 1 cm.

Golzar and Cother,2008

Disease symptoms

Pseudomonas syringae pv. *syringae*

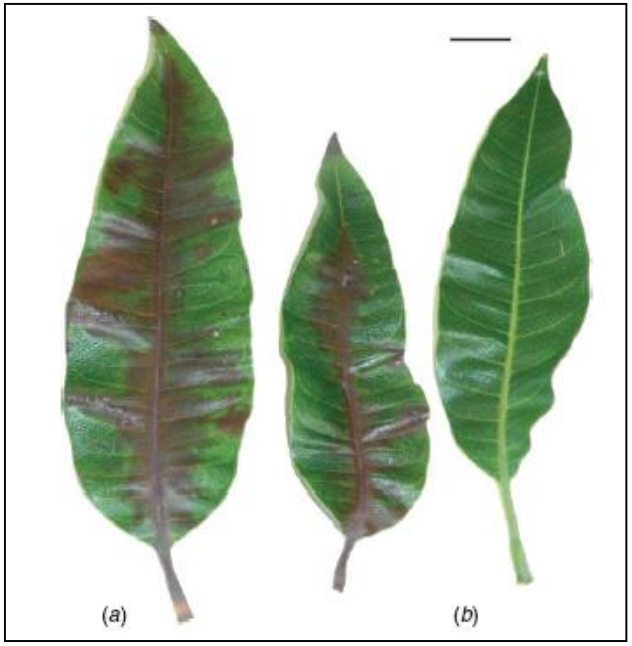
- Typical necrosis symptoms on affected flower panicles and buds.
- Bars = 1 cm.

Golzar and Cother,2008

Disease symptoms

Pseudomonas syringae pv. *syringae*

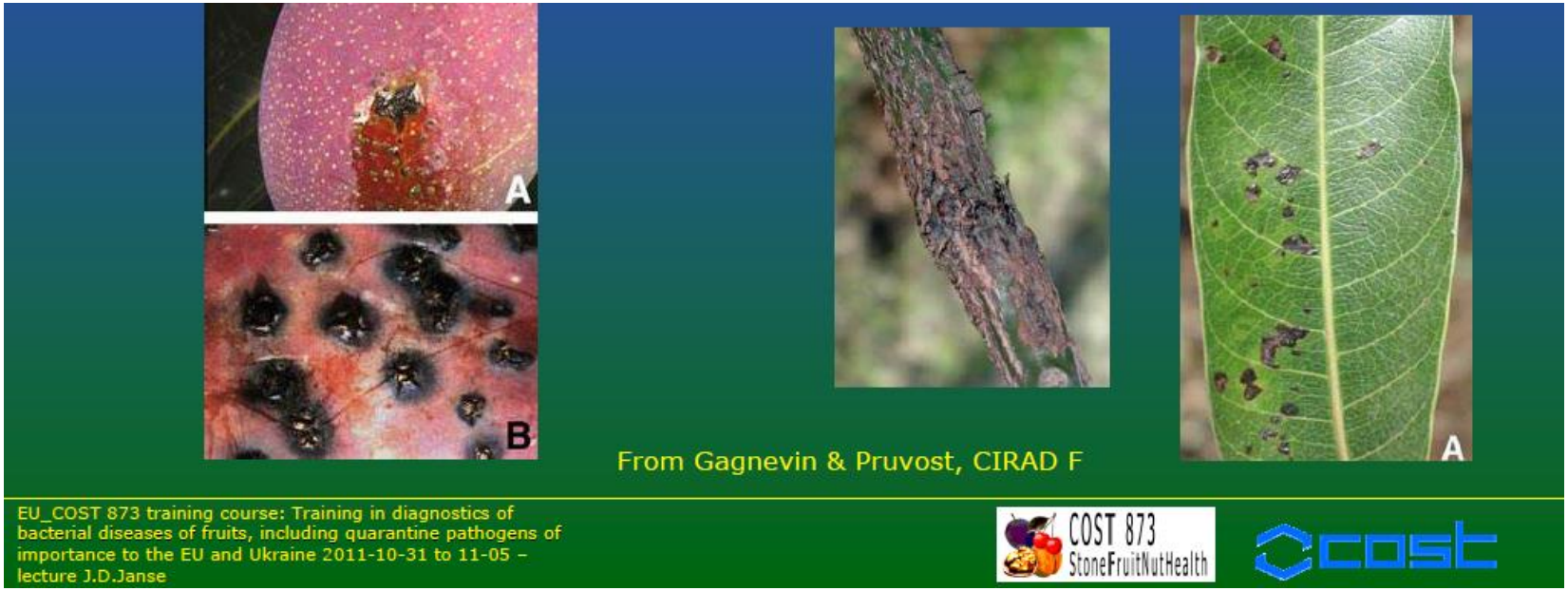
- (a) Mango leaves showing necrosis symptoms, in comparison with
- (b) A healthy leaf 7 days after inoculation.
- Bar = 1 cm.



Golzar and Cother,2008

Disease symptoms

Pseudomonas syringae pv. *syringae*



Maple Bacterial Diseases

Pseudomonas Tip Blight	***Pseudomonas syringae* pv. *syringae***
Crown gall	***Agrobacterium tumefaciens***
Leaf Scorch	***Xylella fastidiosa***

Note: Leaf Scorch, a noninfectious, environmental condition, occurs when young trees experience prolonged periods of dry, windy weather, low rainfall and high temperatures with bright sunshine when the trees roots are unable to supply water to the foliage as rapidly as it is lost by transpiration from the leaves (Mansfield,2016).

Pseudomonas Tip Blight

Pseudomonas syringae pv. *syringae*

- The tip blight bacteria *Pseudomonas syringae* pv. *syringae* invade Japanese maples through mechanical or natural wounds in their bark or leaves.

Japanese maple's foliage creates a striking tapestry of color.

Crown gall
Agrobacterium tumefaciens

- Amur Maple (*Acer ginnala*) are prone to bacterial diseases like Crown gall (*Agrobacterium tumefaciens*).

Dengarden,2016

Leaf scorch

Xylella fastidiosa

- Leaves of silver maple (*Acer saccharinum* L.) showing marginal leaf scorch with distinct bands of discoloration between scorched and symptomless tissue.

Leaves of silver maple (*Acer saccharinum*).

Leaf of a maple species (*Acer* sp.).

University of Florida,2015

Watermelon Bacterial Diseases

Fruit blotch of cucurbits	***Acidovorax avenae* subsp.*citrulli***
Angular leaf spot	***Pseudomonas syringae* pv. *lachrymans***
Bacterial leaf spot	***Pseudomonas syringae***
Bacterial leaf spot	***Xanthomonas campestris* pv. *cucurbitae***
Bacterial rind necrosis	***Pectobacterium* (ex. *Erwinia*)*carnegieana*** **Reject name**
Bacterial soft rot	***Pectobacterium c.* subsp. *carotovorum***

Bacterial fruit blotch of cucurbits

Acidovorax avenae subsp.*citrulli*

	
Initial watersoaking between veins, on the underside of the cotyledon.	Later, the watersoaked area dries and dies.

Isakeit,2008

Bacterial fruit blotch of cucurbits

Acidovorax avenae subsp.*citrulli*

- Mature watermelon fruit displaying typical bacterial fruit blotch (discolored areas) symptoms including irregularly shaped water-soaked lesions with cracks.

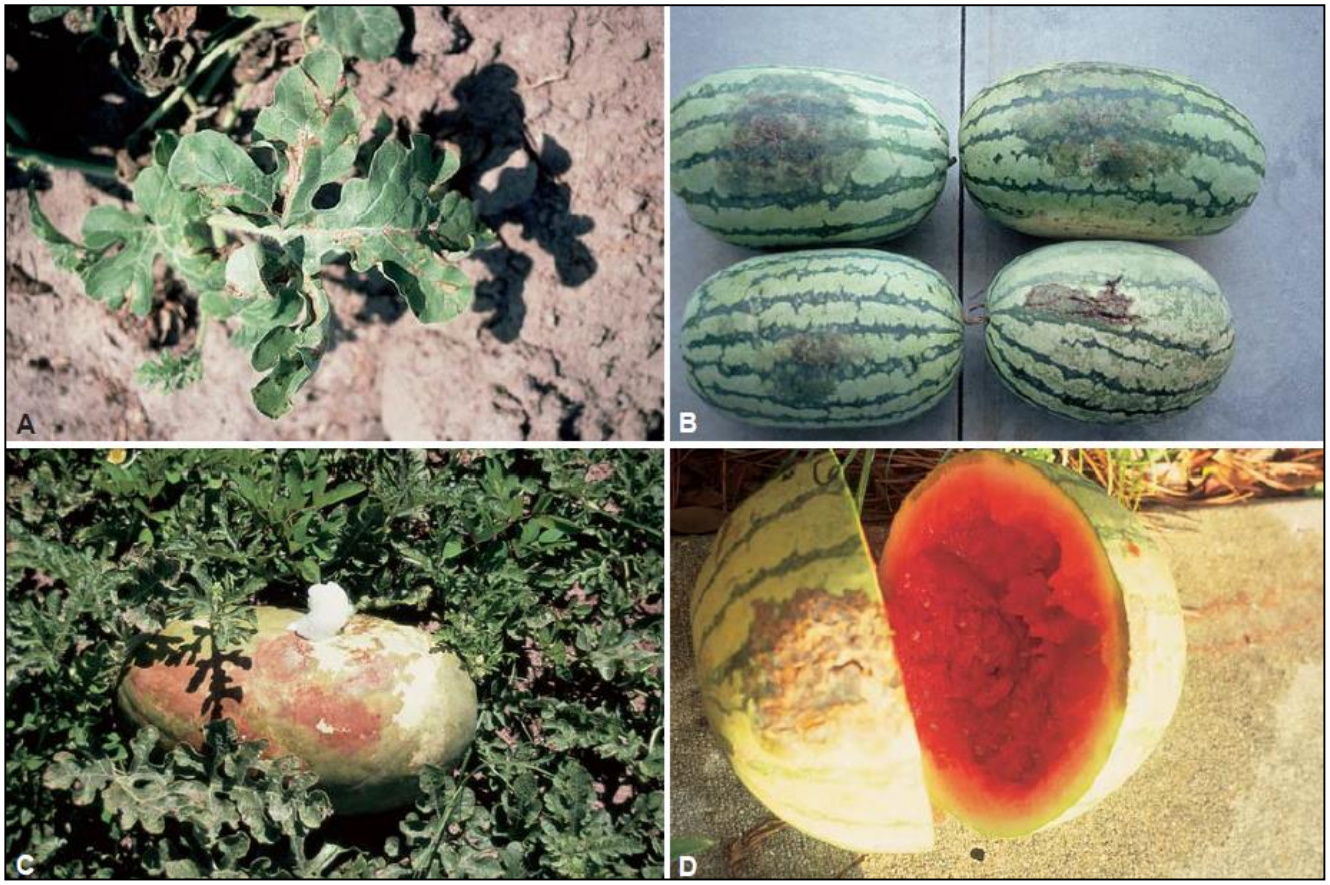
Bacterial fruit blotch of cucurbits

Acidovorax avenae subsp.*citrulli*

- The bacterium can be introduced into watermelon fields by infested seed, infected transplants, natural spread from alternate hosts or from volunteer watermelon.
- The bacterium can be a surface contaminant of seed harvested from infected watermelon.
- Bacterial fruit blotch disease development is favored by warm wet weather.

Bacterial fruit blotch of cucurbits

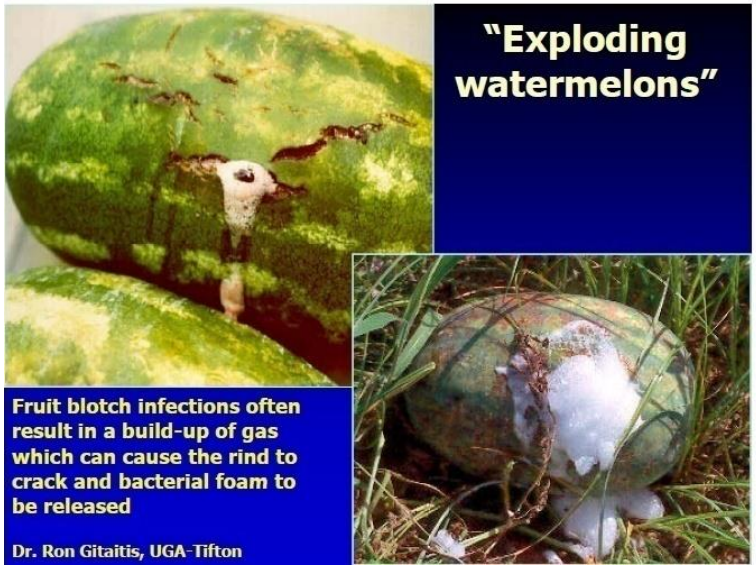
Acidovorax avenae subsp.*citrulli*

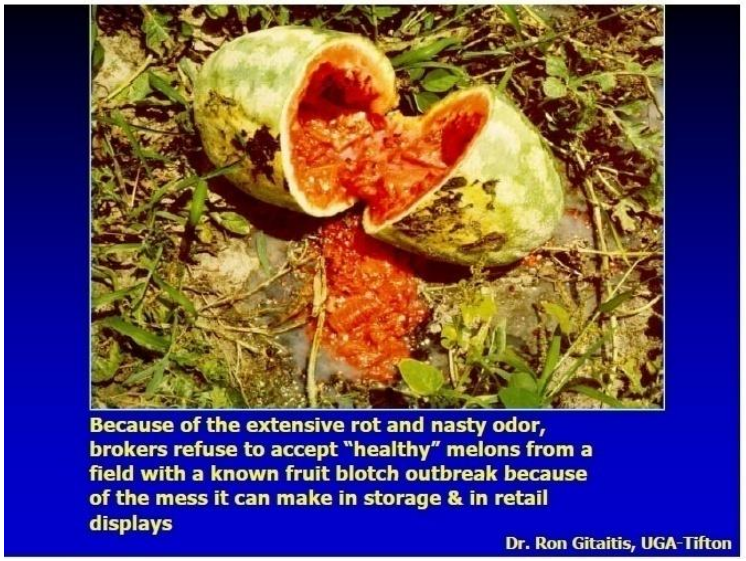


Agrios,2005

Bacterial fruit blotch of cucurbits

Acidovorax avenae subsp.*citrulli*

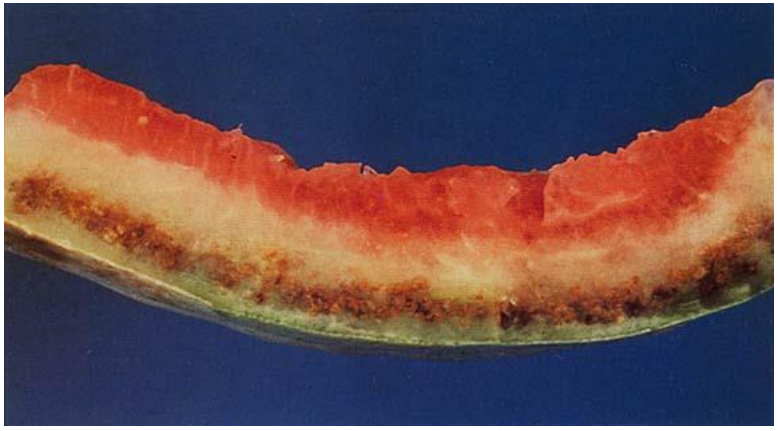




Bacterial rind necrosis

Pectobacterium (ex. *Erwinia*) *carnegieana* was rejected *Erwinia* spp.

- Hard brown patches of necrotic tissue develop on the rind of affected fruit.
- In cross section, the areas appear as corky layers occurring between the outer rind and the edible fruit tissue within.
- No symptoms on the foliage have been reported.
- In the case of severe internal necrosis, the fruit may be misshapen.



Scortichini,2006;..

Bacterial leaf spot

Pseudomonas syringae

Symptoms of the *Pseudomonas syringae* leaf spot on watermelon.

Water soaking on infected leaves.

Paret,2014

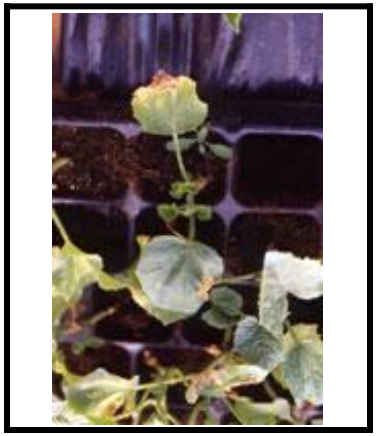
Bacterial soft rot

Pectobacterium c. subsp. *carotovorum*

Scortichini,2006

Angular leaf spot

P. s. pv. *lachrymans*



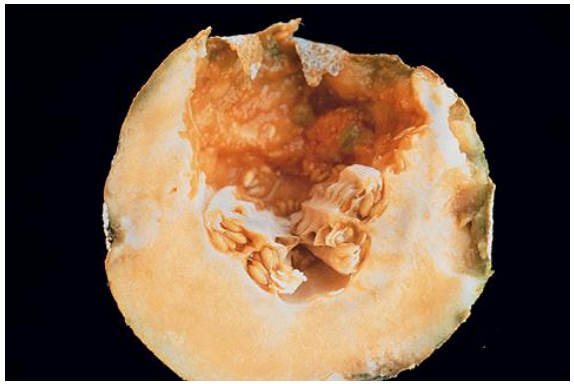
Scortichini,2006

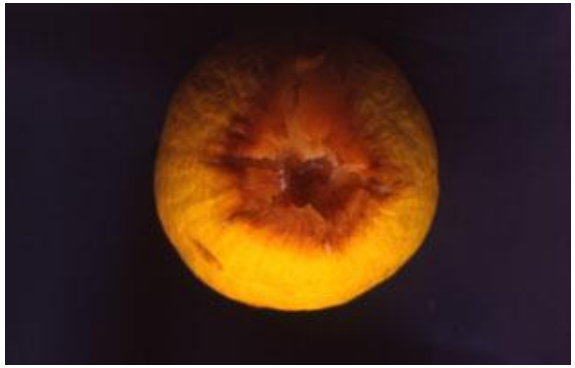
Bacterial fruit blotch of cucurbits

Acidovorax avenae subsp.*citrulli*

Bacterial soft rot of melon

P. c. subsp. *carotovorum*





Scortichini,2006

Bacterial wilt

Erwinia tracheiphila

Bacterial wilt on melon, caused by *Erwinia tracheiphila*.

Note: Watermelon is extremely resistant to bacterial wilt.

Bacterial wilt

Erwinia tracheiphila

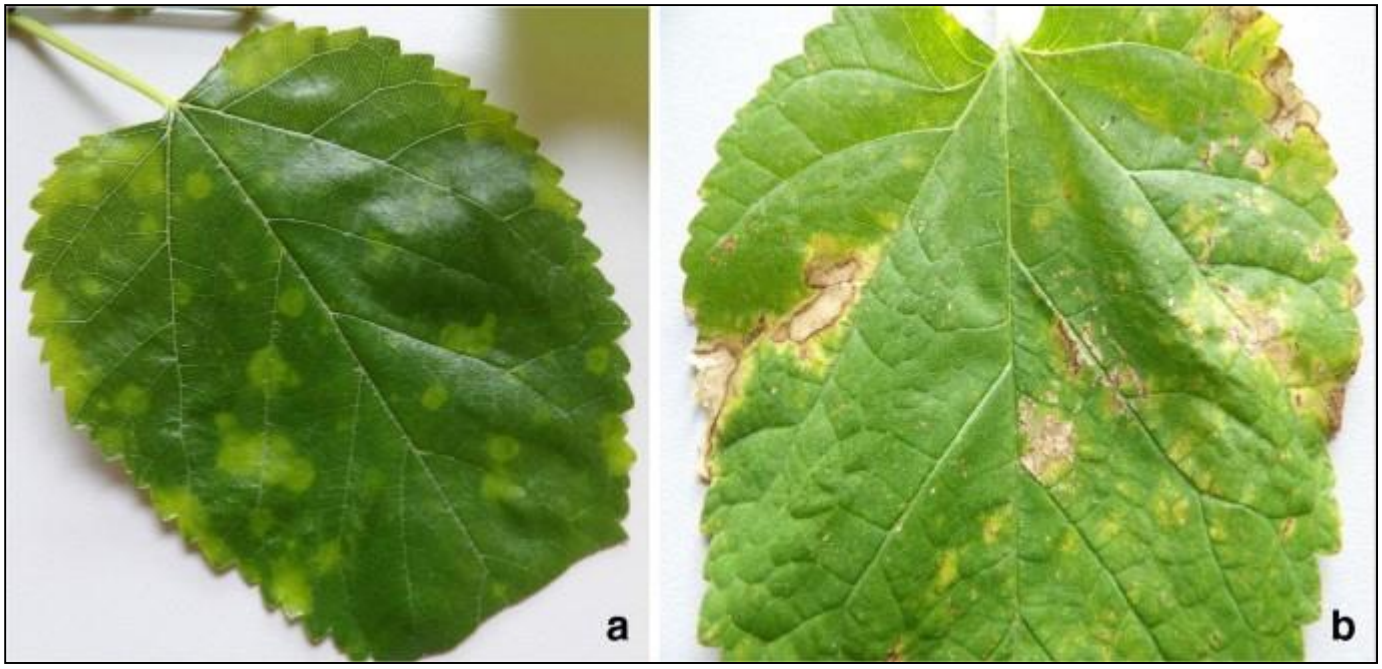
- If "stringy" sap (bacterial growth and associated resins) extends between the cuts of freshly cut sections of a stem, the plant has bacterial wilt.

Note: Watermelons are immune to this disease.

Bacterial blight

Pseudomonas syringae pv. *mori*

- Leaves of the symptomatic mulberry plants.
- A, whole leaf – early symptoms;
- b, close-up – late symptoms.



Krawczyk & Łochyńsk,2020

Bacterial mushroom diseases

Brown blotch disease	***Pseudomonas tolaasii***
Drippy gill	***P. agarici***
Ginger (yellow-brown) blotch disease	***P. gingeri***
Typical brown blotch disease	***P. costantinii***
Mummy disease	***Pseudomonas* spp.** *Pseudomonas fluorescens* Biotype G (=Biovar V)
Soft rot of mushrooms	***Burkholderia gladioli* pv. *agaricicola***
Soft rot disease	***Janthinobacterium agaricidamnosum***
Internal stipe necrosis	***Ewingella americana***

Bacterial mushroom diseases

1. *Pseudomonas reactans* (so called white line reacting organisms): Saprophytic fluorescent pseudomonads, including a diverse group of fluorescent pseudomonads referred to as *P. reactans*. Causes yellowing on oyster mushroom (*Pleurotus eryngii*).
2. Heterogenic fluorescent pseudomonads belonging to the *P. fluorescens* biovars I, II, III, or V seem to act as pathogens or as saprophytes in the bacterial community associated to cultivated mushrooms.

Bacterial Blotch (Bacteriosis)

Pseudomonas tolaasii

- *Pseudomonas tolaasii* is a Gram negative soil bacteria that is the causal agent of bacterial blotch on cultivated mushrooms.

Wikipedia,2008

Bacterial Blotch (Bacteriosis)

Pseudomonas gingeri

- Ginger blotch symptoms caused by *Pseudomonas gingeri*.

Elphinstone,2012

Janthinobacterium agaricidamnosum

Soft rot disease of *Agaricus bisporus*

- Severe rotting of button mushroom (*Agaricus bisporus*), caused by *Janthinobacterium agaricidamnosum*, stimulated by very a high (relative) humidity (88-91%) that is necessary during cultivation of the mushroom.
- The bacterium is easily spread by water and contact.

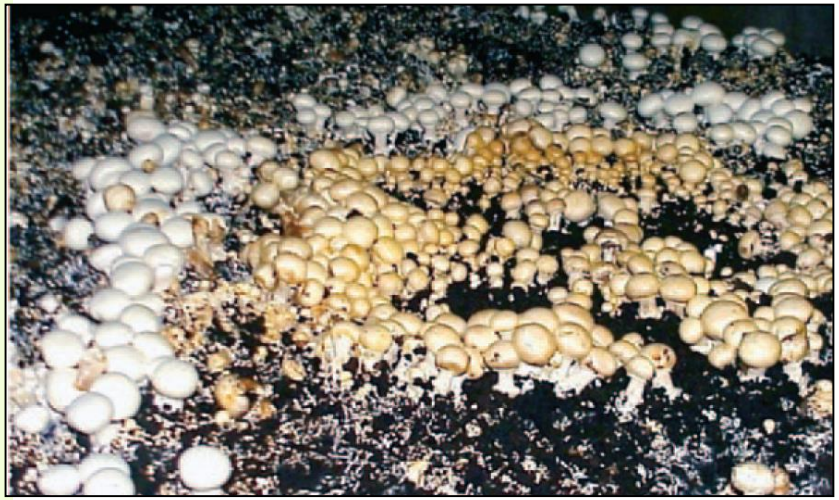
Janse,2006

Mummy disease of mushroom *Pseudomonas* spp.

- It is a serious mushroom bacterial disease caused by *Pseudomonas* spp. e.g.

1. *Pseudomonas aeruginosa*
2. *Pseudomonas fluorescens* Biotype G (=Biovar V).

- The characteristics of the diseased mushroom include the classic curved stems, tilted caps, profuse spawn growth at the base of mushrooms.



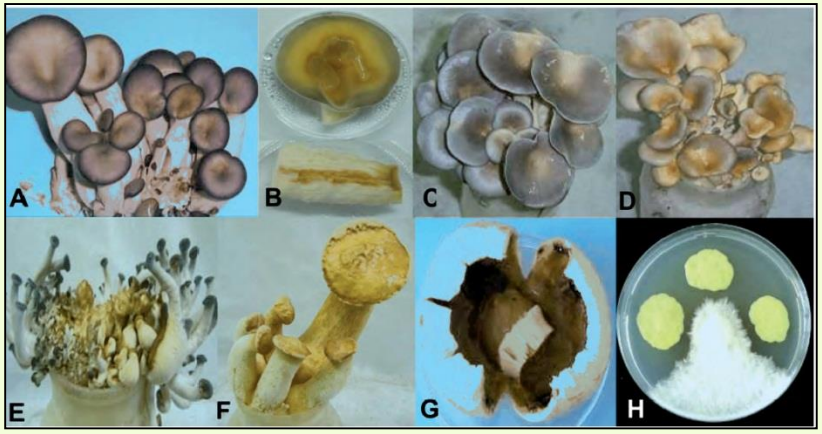
Penn State Lines; Alamy,2006

Soft rot of mushroom

Burkholderia gladioli pv. *agaricicola*

- A. Typical natural symptoms of bacterial soft rot on mushroom as observed in a mushroom cultivation farm.
- B. Tissue soft rot of mushroom inoculated by dropping a bacterial suspension on the sporocarp.
- C, D, E, F. Symptoms of bacterial soft rot on oyster and king oyster mushroom inoculated by spraying.
- G. Tissue soft rot on button mushroom injected with *B. gladioli* pv. *agaricicola*.
- H. Inhibition of oyster mushroom mycelium by *B. gladioli* pv. *agaricicola*.

See also the genus *Burkholderia*



Lee *et al.*,2010

Bacterial brown blotch disease
Mixed infections

- Major pathogen is *Pseudomonas tolaasii*.
- Bacterial brown blotch has various symptoms:
- The most typical symptom is a brown spot on the caps and stipes.
- The brown spots enlarge and coalesce with other spots, and the affected areas are sunken and covered with sticky material.
- At this stage a rotten fish smell is evident.
- *Pseudomonas tolaasii* is isolated in all these diseased mushrooms, but it is still possible that mixed infections cause these various symptoms.

Mushroom Growers' Handbook ***1***,2004

Bacterial Canker

Xanthomonas arboricola pv*. pruni*

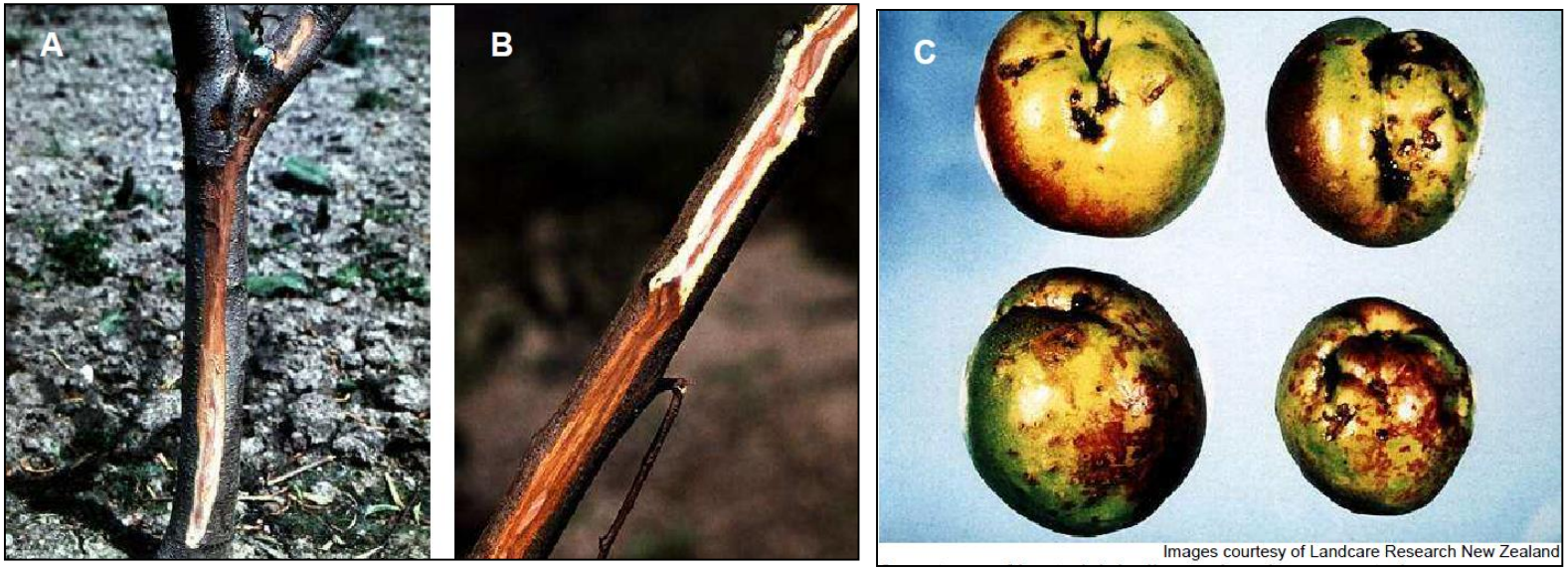
	
Pitting and gumming on nectarine fruit.	Spotting on nectarine fruit.

Plant Bacteriology Manual,2008

Nectarine

Bacterial decline and canker

P. syringae pv. *persicae*



Plant Bacteriology Manual,2008

Leaf spot & blight

Pseudomonas meliae

Scortichini,2006

Bacterial diseases of Oak

Bacterial Gall (or burl)	***Agrobacterium tumefaciens***
Bark canker and drippy nuts	***Lonsdalea* (*Brenneria*) *quercina***
Slime flux of wetwood	***Enterobacter* (*Erwinia*) *nimipressuralis***
Bacterial leaf scorch	***Xylella fastidiosa***
Acute oak decline (AOD)	***Gibbsiella quercinecans, Brenneria goodwinii* and *Rahnella victoriana***

Wikipedia; APS; Brady *et al.*,2017

Gall (or burl) on an oak tree trunk, possibly crown

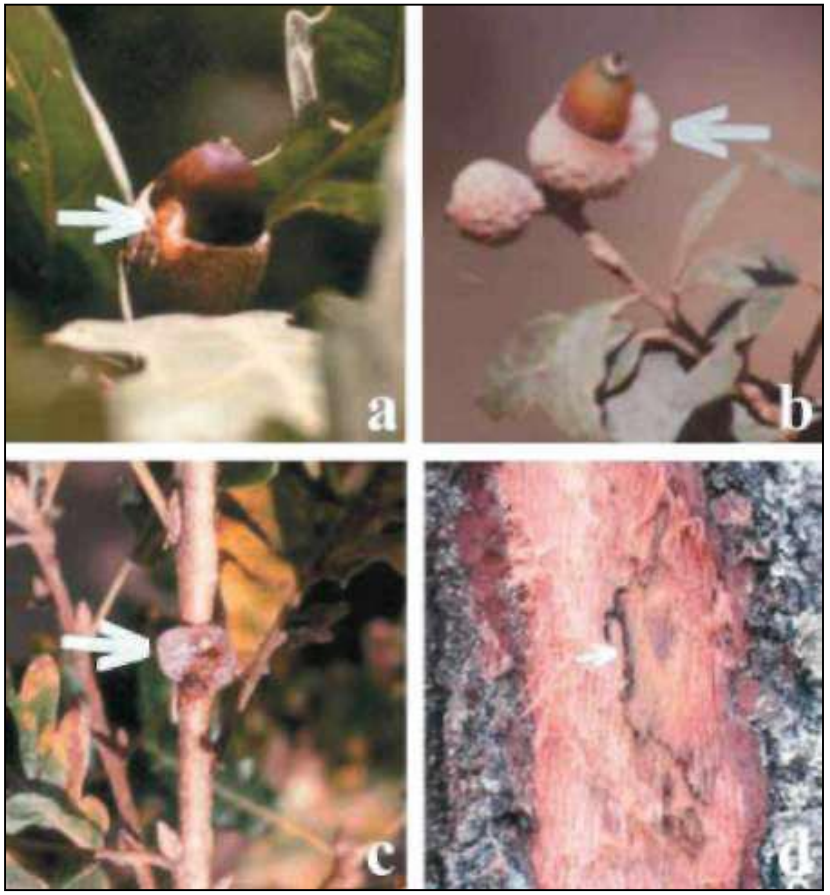
Agrobacterium tumefaciens

Alamy Stock Photo

Bark canker and drippy nuts

Lonsdalea (*Brenneria*) *quercina*

- Symptoms of drippy nut disease in naturally infected of *Quercus pyrenaica*.
- Damage and/or exudates on the tissues are indicated with arrows,
- (a and b) Acorn cup with oozing typical of the disease,
- (c) leaf bud with oozing,
- (d) detail of a 'bleeding canker'.



Poza-Carrión *et al.*,2008

Bark canker& drippy nuts

Lonsdalea (*Brenneria*) *quercina*

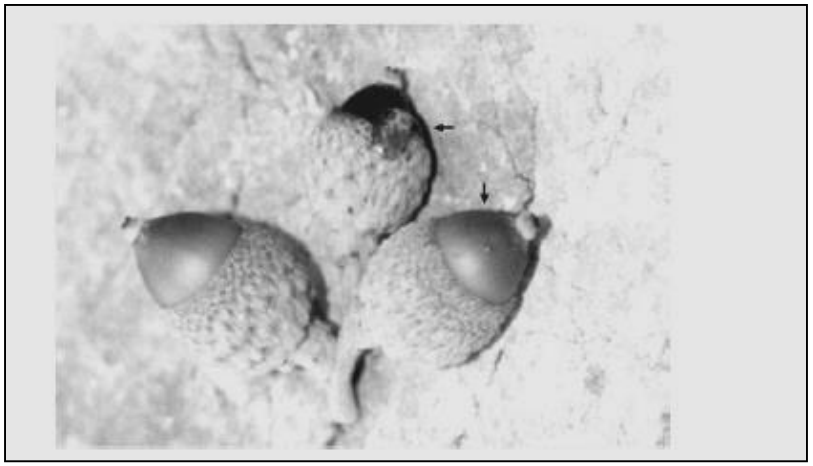
Bark canker on branch of a *Quercus ilex* tree exhibiting symptoms of *Brenneria quercina*, with necrotic lesions and dark exudates.

Biosca *et al.*,2002

Bark canker& drippy nuts

Lonsdalea (*Brenneria*) *quercina*

- Copious oozing of bacteria and sap from growing acorns of a *Quercus ilex* tree (the arrows indicate two acorns with ooze.



Biosca *et al.*,2002

Slime flux of wetwood

Enterobacter (*Erwinia*) *nimipressuralis*

Bacterial wetwood on post oak

Enterobacter (*Erwinia*) *nimipressuralis*

USDA Forest Service,2008

Bacterial leaf scorch

Xylella fastidiosa

- Leaf margins scorch, often beginning in early summer, but typically occur late in the season.
- Usually first appears on upper and outer branches, becoming more severe each year over several years.
- Appears first on oldest leaves of a shoot.
- Affected leaves usually retained until fall.
- Sapwood never streaked as with oak wilt.

University of Missouri;..

Bacterial Leaf Scorch

Xylella fastidiosa

Typical marginal leaf scorch symptoms on oak.

Don Ferrin;..

Leaf scorch of oak

Xylella fastidiosa

Symptoms leaf scorch and scald

Quercus imbricaria with leaf scorch symptoms

Source:AH Purcell

Xylella fastidiosa – an emerging threat. J.D. Janse
COST Annual Meeting Costiera, Italy, 26-30/10/2009

COST 873 StoneFruitNutHealth

cost

Janse,2009

Oak(red oak)- *Quercus rubra*

Bacterial leaf scorch

Xylella fastidiosa

Bacterial leaf scorch

Xylella fastidiosa subsp. *multiplex*

- Symptomatic native hosts of *Xylella fastidiosa* subsp. *multiplex* in the United States.
- A, Oak (*Quercus* sp.) tree with large amount of defoliation.

Almeida and Nunney,2015

Acute oak decline (AOD)

Gibbsiella quercinecans, Brenneria goodwinii and *Rahnella victoriana*

- A relatively newly described disorder affecting native oak species in Britain.
- The most frequently isolated species from symptomatic oak are members of family *Enterobacteriaceae* incl uding:

1. *Gibbsiella quercinecans*
2. *Brenneria goodwinii* and
3. *Rahnella victoriana*.

Symptoms of acute oak decline **a** external symptoms of weeping stem bleeds **b** cracked bark plates caused by necrotic underlying tissue **c** lesions in the inner bark **d** *Agrilus biguttatus* larval galleries in close proximity to necrotic lesions.

Brady *et al.*,2017

Bacterial diseases of Oats

Bacterial blight (halo blight)	***Pseudomonas syringae* pv. *coronafaciens***
Bacterial stripe blight	***Pseudomonas syringae* pv. *striafaciens***
Black chaff and bacterial streak (stripe)	***Xanthomonas campestris* pv. *translucens***

Wikipedia; APS

Bacterial Blight (Halo Blight)

Pseudomonas syringae pv. *coronafaciens*

- Symptoms: Small, water-soaked spots, surrounded by a light yellow halo, on leaves.
- Spots are green at first but change to light brown.
- Lesions may run together.
- Heavily infected leaves may dry out and die.
- Occasionally, tiny spots may be found on the hulls.

Note the necrotic spots on these leaves.

Koepsell,1989

Bacterial Blight (Halo Blight)
Pseudomonas syringae pv. *coronafaciens*

- A range of symptoms of stripe blight caused by *Pseudomonas syringae* pv. *striafaciens*.
- Stripe blight forms long, brown stripes on leaves during winter, which join into blotches that cause leaf collapse (blight).

Government of Western Australia

Oleander stem gall

Pseudomonas savastanoi pv. *savastanoi*

Bacterial galls on oleander stem and leaves.

US IPM Online

Oleander stem gall

Pseudomonas savastanoi pv. *savastanoi*

Scortichini,2006

Oleander

Leaf scorch of oleander

Severely infected oleander plant

Xylella fastidiosa

Janse,2009

Oleander

Leaf scorch of oleander

Mottling and leaf tips necrosis

Xylella fastidiosa

	
Chlorotic mottling of leaves.	**Necrosis of leaf tips and margins.**

Disease symptoms on olive

Pseudomonas savastanoi

A. Hyperplasia outgrowths (knots) on olive stems caused by *Pseudomonas savastanoi*, and

B. Extensive knot production on an older olive tree.

Kennelly *et al.*,2007

Disease symptoms on olive

Pseudomonas savastanoi

- Progressive dissection of an olive knot showing external necrosis and necrosis associated with infection of the stem.

Kennelly *et al.*,2007

Olive Knot

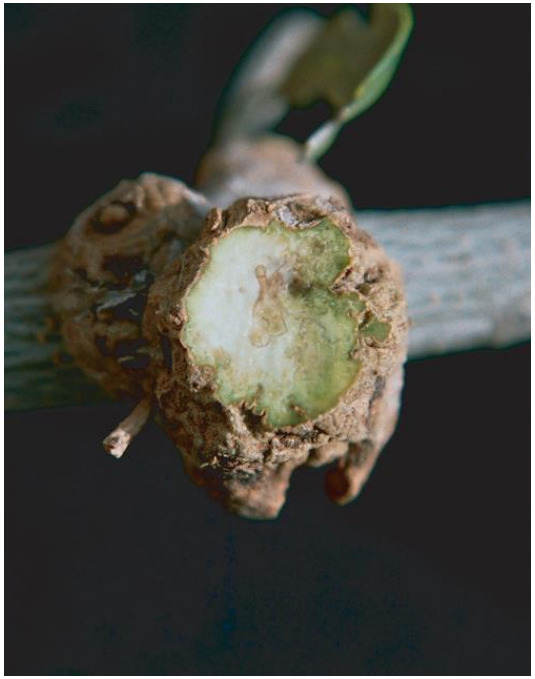
Pseudomonas savastanoi pv. *savastanoi*

- Mature, developing and young galls (right to left on bottom branch)on a naturally infected oil branch(cv. Barnea).

Hall *et al.*,2004

Olive Knot

Pseudomonas savastanoi pv. *savastanoi*



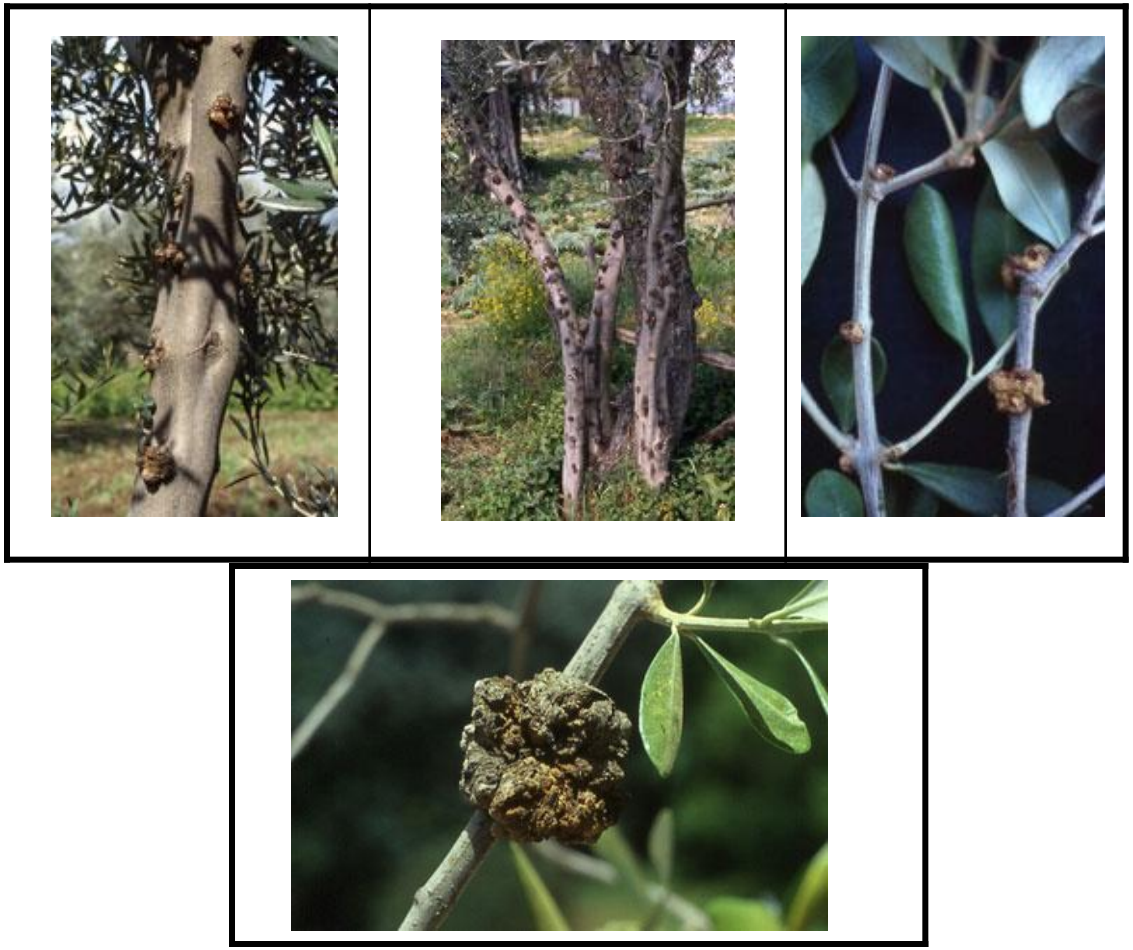
Glassy water-soaked area in a young gall. These areas produce bacterial ooze.

Necrotic areas in more mature galls, surrounded by glassy tissue.

Hall *et al.*,2004

Olive Knot

Pseudomonas savastanoi pv. *savastanoi*



Scortichini,2006

Leaf scorch of olive

Olive quick decline syndrome (OQDS)

Xylella fastidiosa

- In October 2013 the bacterium was found to be infecting olive trees in the region of Apulia in southern Italy.
- The disease was causing a rapid decline in olive plantations and by April 2015 it was affecting the whole Province of Lecce and other zones of Apulia.

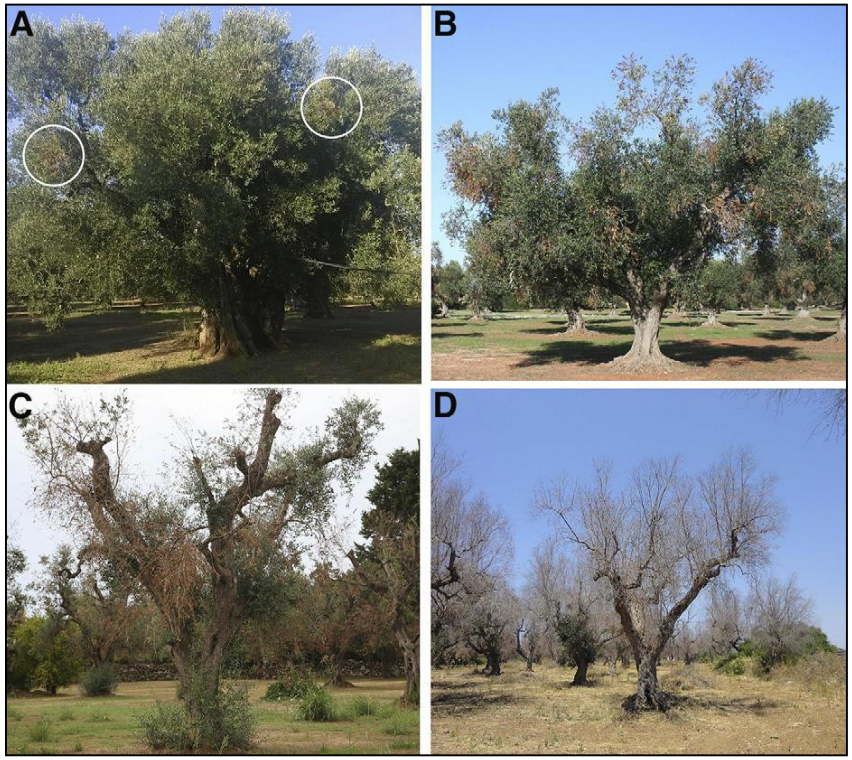
Janse,2009;Wikipedia,2017

Leaf scorch of olive

Olive quick decline syndrome (OQDS)

Scale of symptoms in olive trees in southern Italy associated with *Xylella fastidiosa*

- A, Early symptoms limited to isolated branches, likely due to independent infection events.
- B, Larger number of symptomatic branches, leading to C, heavily symptomatic plants with severe pruning used as an unsuccessful cultural practice to eliminate infections.
- D, Dead trees, which are often cut to stumps and/or uprooted.
- Koch's postulates were not yet fulfilled for the *X. fastidiosa*-olive association in Italy; therefore, the etiological agent(s) of this olive disease remained to be conclusively identified.



Almeida and Nunney,2015

Bacterial diseases of onion/garlic

Sour skin (soft rot)	***Burkholderia cepacia***
Slippery skin of onion	***Burkholderia gladioli* subsp. *alliicola***
Sour skin	***Burkholderia cepacia***
Bacterial Soft Rot	***Pantoea agglomerans*** ***Pantoea ananatis***
Yellow bud	***Pseudomonas syringae***
Bacterial leaf spot of onions	***Pseudomonas syringae* pv. *alliifistulosi***
Bacterial Soft Rot	***Erwinia carotovorum* ssp. *carotovorum*,** ***D. chrysanthemi*,** ***B. gladioli*, and** ***Enterobacter cloacae***

Sour skin (soft rot) on onion

Burkholderia cepacia

Mature onion bulb infected with sour skin
David B. Langston, University of Georgia, Bugwood.org

Wall *et al.*,2009

Slippery skin of onion

Burkholderia gladioli subsp.*alliicola*

Internal bulb rot caused by slippery skin (*Burkholderia gladioli* subsp. *alliicola*).
Howard F. Schwartz, Colorado State University, Bugwood.org

Wall *et al.*,2009

Bacterial Soft Rot

Pantoea agglomerans and *P. ananatis*

Bulb symptoms characteristic of onion surface rot.

Center rot is characterized by a single or a few discolored scales (left). Mature onion plant with several bleached and wilted inner leaves, characteristic of center rot (right).

Gugino and Pfeufer,2015

Yellow bud

Pseudomonas syringae

- Emerging leaves display intense chlorosis and older leaves exhibit extensive leaf blight.
- Yield reductions can be severe due to stand loss and reduced bulb size.
- Symptomatic plants are also more prone to freeze damage.

Gitaitis *et al.*,2012

Bacterial leaf spot of onions

Pseudomonas syringae pv. *alliifistulosi*

- *Pseudomonas syringae* pv. *alliifistulosi* pv. nov., the causal agent of bacterial leaf spot of onions.

Tsuji and Takikawa,2018

Sour skin

Burkholderia cepacia

Onion scales affected by sour skin turn soft and tan.
Photo by Ronald E. Voss

Bacterial Soft Rot

Erwinia carotovorum* ssp. *carotovorum*, *D. chrysanthemi*, *B. gladioli*, and *Enterobacter cloacae

Bacterial soft rot of onion bulb

Bacterial diseases of orchids

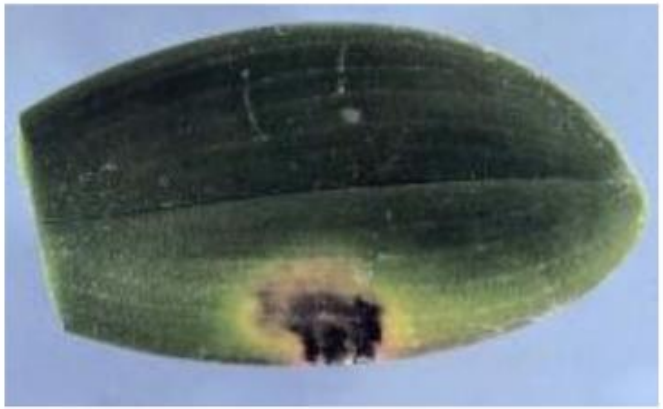
Bacterial leaf spot/rot	***Burkholderia gladioli*** **pv.** ***gladioli***
Bacterial black spot	***Robbsia*** **(ex.** ***Burkholderia*****)** ***andropogonis***
Brown rot of cypripedium (lady's slipper orchid) and other orchids	***Pantoea cypripedii*** **(ex.** ***Pectobacterium cypripedii*****)**
Bacterial leaf spot	***Bacillus*** **sp.**
Bacterial leaf spot	***Acidovorax avenea*** **subsp.** ***cattlyae***
Bacterial soft rot	***Dickeya chrysanthemi***

Burkholderia andropogonis was replaced by a new genus described herein as *Robbsia andropogonis* gen. nov., comb. nov.(Lopes-Santos *et al.*,2017).

Bacterial diseases

Erwinia and *Pseudomonas*

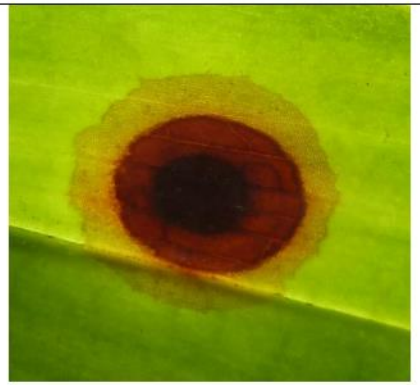
Erwinia
(bacterial rot)



Pseudomonas
(bacterial brown spot)

Newsletter of the Baton Rouge Orchid Society,2015

Bacterial diseases

		
Early stage: Translucent Lesion	Advanced Stage: Brown/Black Lesion.	Advanced Rot
		

Tsambourakis,2016

Orchid- *Phalaenopsis hybrid*

Bacterial leaf spot

Acidovorax avenae subsp. *cattleyae*

Scortichini,2006

Bacterial brown spot

Acidovorax avenae subsp. *cattleyae*

bundabergorchidsociety.com.au/orchids-diseases

Bacterial leaf rot
Burkholderia gladioli

- Natural symptoms of bacterial leaf rot caused by *Burkholderia gladioli*.

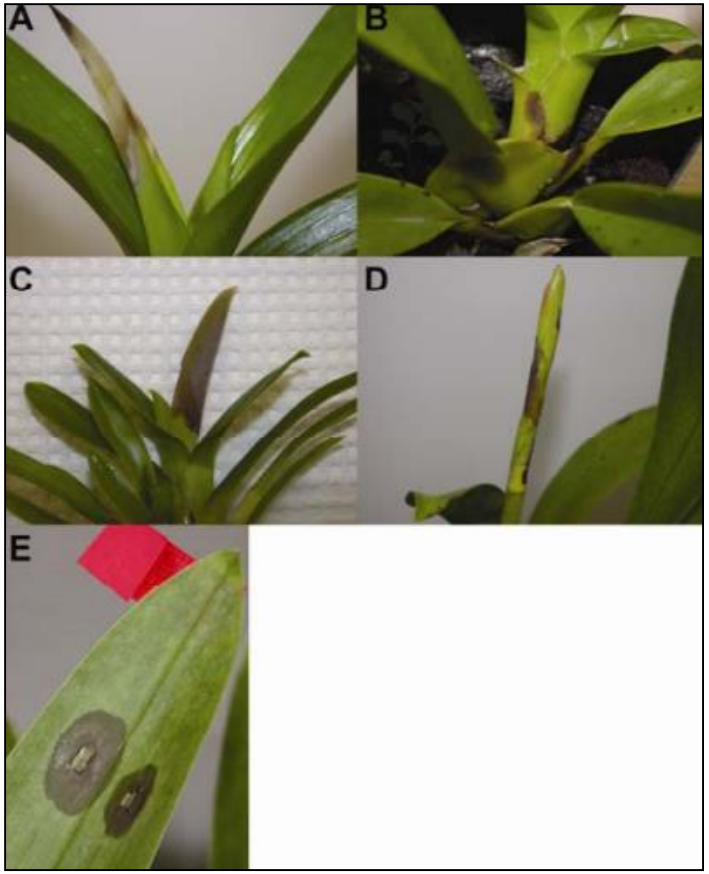
A. Dendrobium sp. leaf.

B. *Oncidium* sp. pseudobulb.

C. Oncidium sp. plantlet.

D. Oncidium sp. spike.

E. Symptoms of an artificially inoculated *Miltonia* sp. sample.

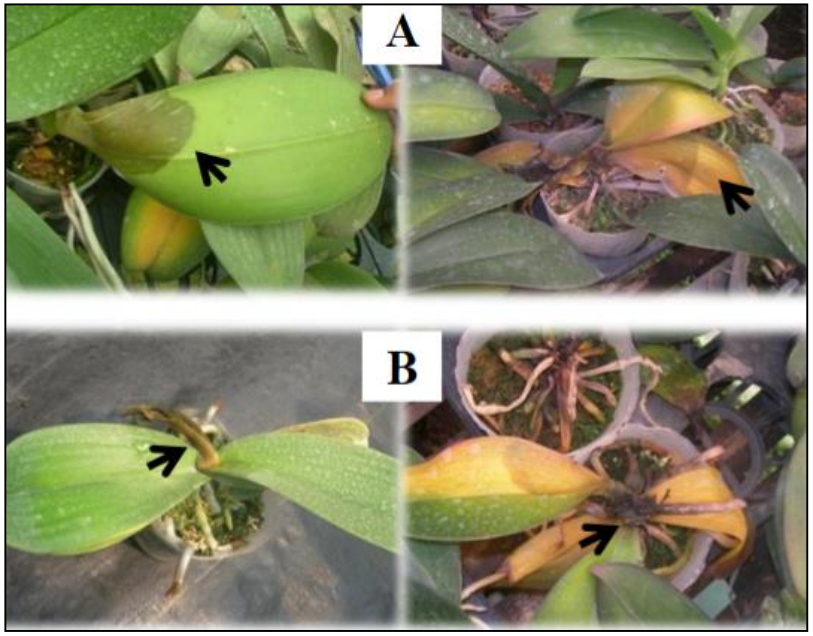


Keith *et al.*,2005

Bacterial soft-rot

Dickeya sp. and *Pseudomonas* sp.

- The symptoms of soft rot disease of *Phalaenopsis* orchids on leaf (A) and shoot (B).
- Small water-soaked lesion enlarged to either the whole leaf or plant.



Toko *et al.*,2011

Lethal yellows of palm

'*Candidatus* Phytoplasma *palmae*'

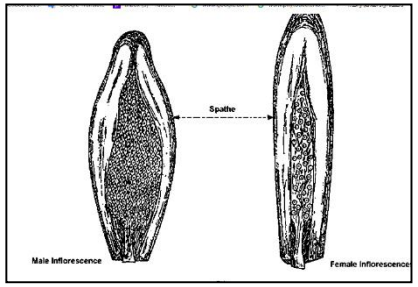
- These are all symptoms of palms infected with palm lethal yellowing strain A.
- The top left photo shows the spear leaf of silver date palm. Collapsed leaf is hanging down (right side of the trunk).
- The top right photo shows lethal yellowing *Cocos nucifera* in various stages. Healthy plants in the back.
- Palms in the front are in the early-mid stages.
- Palms to the left and right are dead and the trunk bare.
- The bottom left photo shows different leaf shades on Canary Island date palm.

https://caps.ceris.purdue.edu/dmm/1910, 2013

Pink Rot of Inflorescence

Serratia marcescens

- The symptoms of this disease were dark brown spots on the spathe cover.
- Inside these spadices affected flowers, scattered over the inflorescence, acquired pink coloration which at later stages was surrounded by pink mucous.



Riaz *et al.*,2009

Bacterial leaf blight of fishtail palm
Acidovorax avenae pv. *avenae*

Initial symptoms of bacterial leaf blight of fishtail palm (*Caryota mitis*) are small, water-soaked, translucent to light yellow banded areas running along leaf veins.

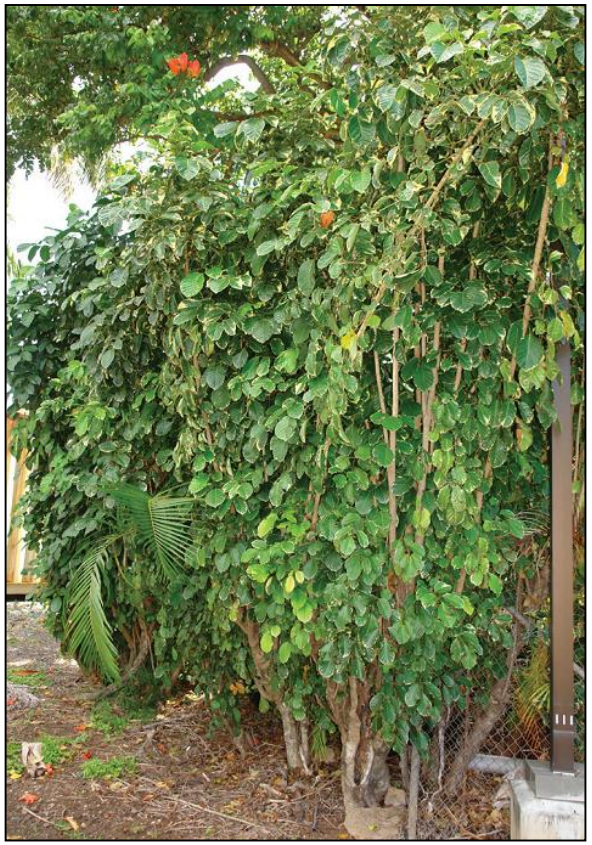
Older lesions may coalesce and develop tan to light-colored central regions that become colonized by fungi that are not necessarily pathogenic to *C. mitis*, especially under wet conditions for leaves.

Nelson,2008

Bacterial leaf blight of panax

Xanthomonas campestris pv. *hederae*

- Commonly known as wild coffee.
- Although the disease is not fatal, the lesions are unsightly, cause defoliation, and reduce plant vigor.
- This bacterial pathogen also produces leaf spot and blight diseases of English ivy (*Hedera helix*).



Nelson,2011

Bacterial leaf blight of panax

Xanthomonas campestris pv. *hederae*

The darkly colored, water-soaked, and irregularly shaped lesions often exude droplets of an amber-colored exudate from the lower leaf surface.

Severe blight causes leaves to curl, turn yellow, and fall prematurely. A purplish-red tinge surrounds the lesions as the infection expands within the leaf tissues.

Nelson,2011

Papaya bunchy top

BLO

Bunchy top of papaya caused by a rickettsia-like organism.

(A) Papaya plants showing severe bunchy top symptoms. (B) The rickettsia-like phloem inhabiting bacterium causing the papaya bunchy top disease.

Agrios,2005

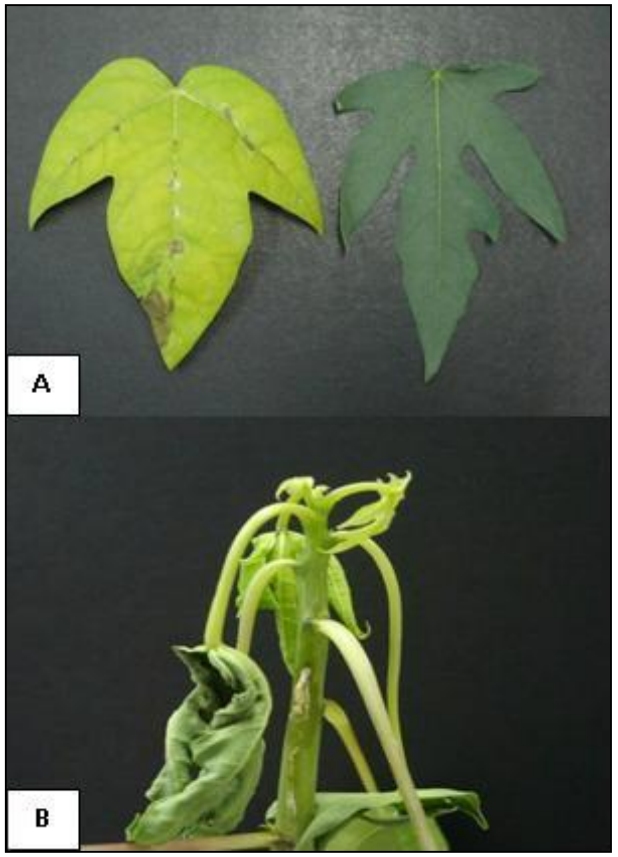
Papaya dieback

Erwinia mallotivora

- Papaya dieback symptoms caused by *E. mallotivora*.

A. Leaf spots formed along the main vein of infected leaf (left) compared to a healthy leaf (negative control: right);

B. Greasy and water-soaked lesions leading to the destruction of papaya tree (Arrow).

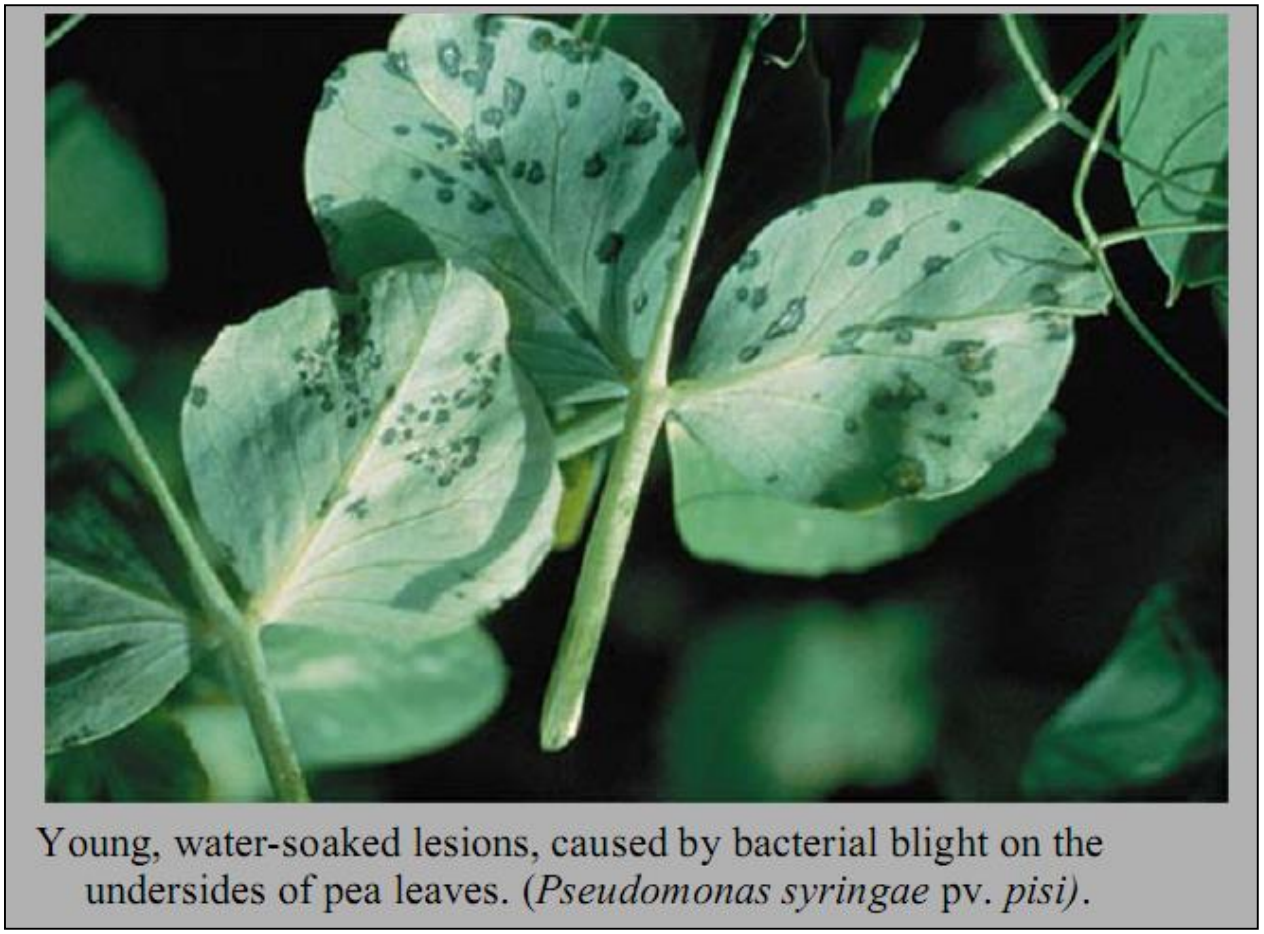


Amin *et al.*,2011

Bacterial leaf stripe on bird of paradise
Bulkhoderia sp.

Bacterial blight

Pseudomonas syringae pv. *pisi*

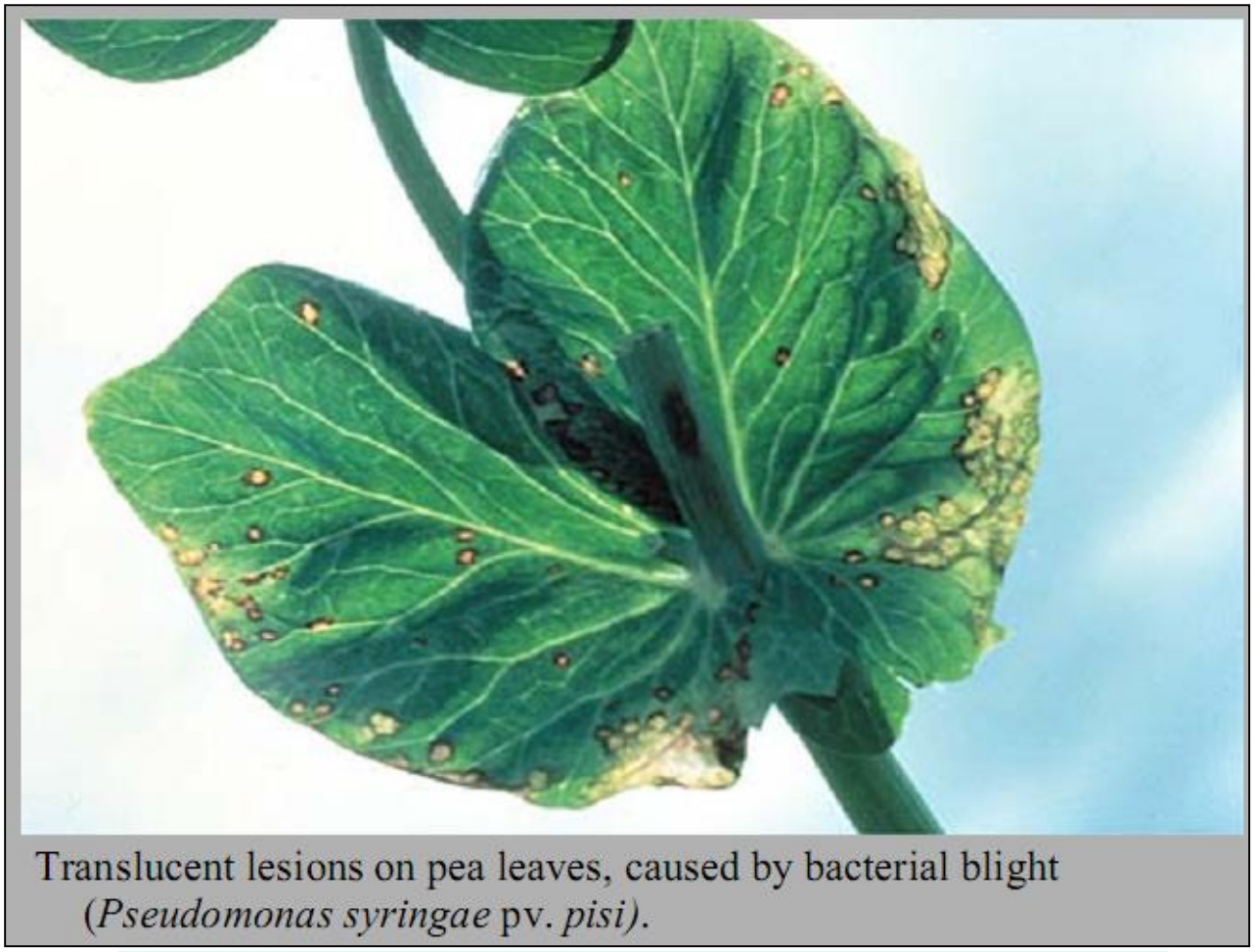


Young, water-soaked lesions, caused by bacterial blight on the undersides of pea leaves. (*Pseudomonas syringae* pv. *pisi*).

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Bacterial blight

Pseudomonas syringae pv. *pisi*

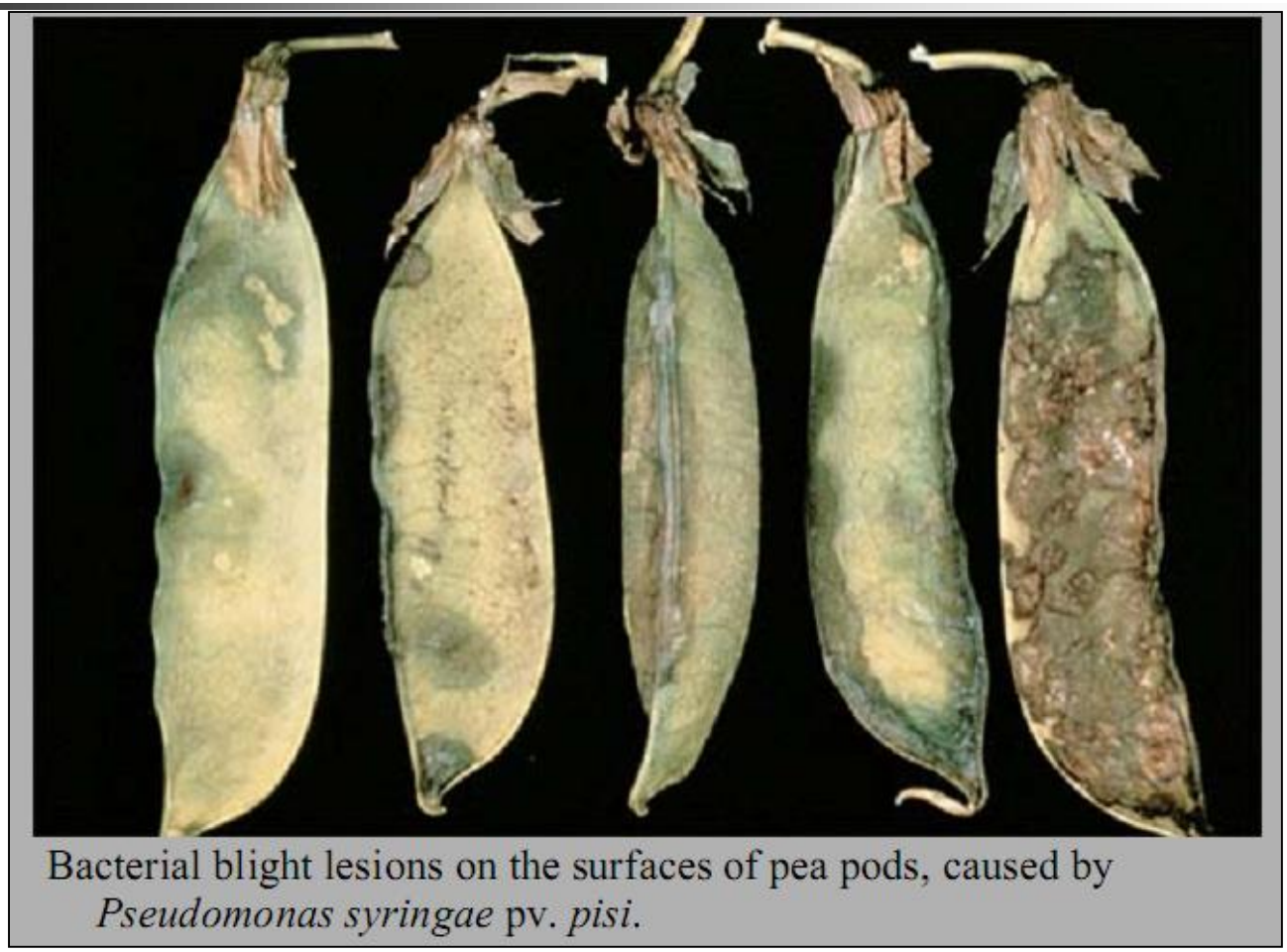


Translucent lesions on pea leaves, caused by bacterial blight (*Pseudomonas syringae* pv. *pisi*).

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Bacterial blight

P. syringae pv. *pisi*

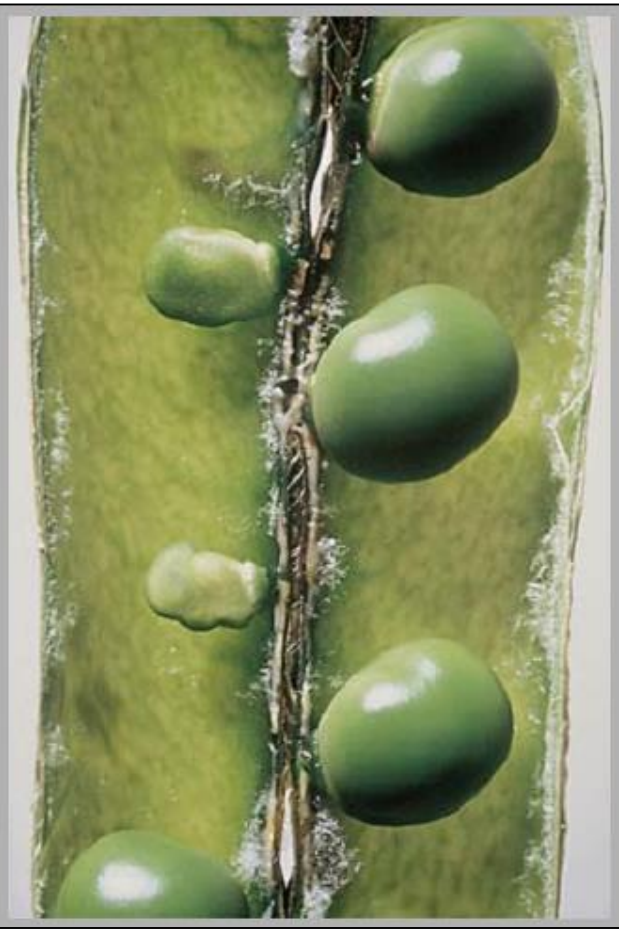


Bacterial blight lesions on the surfaces of pea pods, caused by *Pseudomonas syringae* pv. *pisi*.

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Bacterial blight

Pseudomonas syringae pv. *pisi*



Symptoms of bacterial blight of pea along the suture and infected, shriveled seed (*Pseudomonas syringae* pv. *pisi*).

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Pink seed

Erwinia rhapontici

- Pink seed of pea, bean and wheat caused by *Erwinia rhapontici*.
- Each figure show diseased seeds (left) and healthy seeds (right).

Huang *et al.*,2003

Bacterial leaf spot

Xanthomonas arboricola pv. *pruni*

- Bacterial leaf spot and shot-holing symptoms on cherry laurel caused by *X. arboricola* pv. *pruni*.
- Small wet spots on lower leaf surfaces develop into brown or black angular spots, often with yellow-tinged edges.
- Leaves become chlorotic and fall prematurely.
- Penetration occurs through stomata or lenticels.

Elphinstone and Aspin,2016

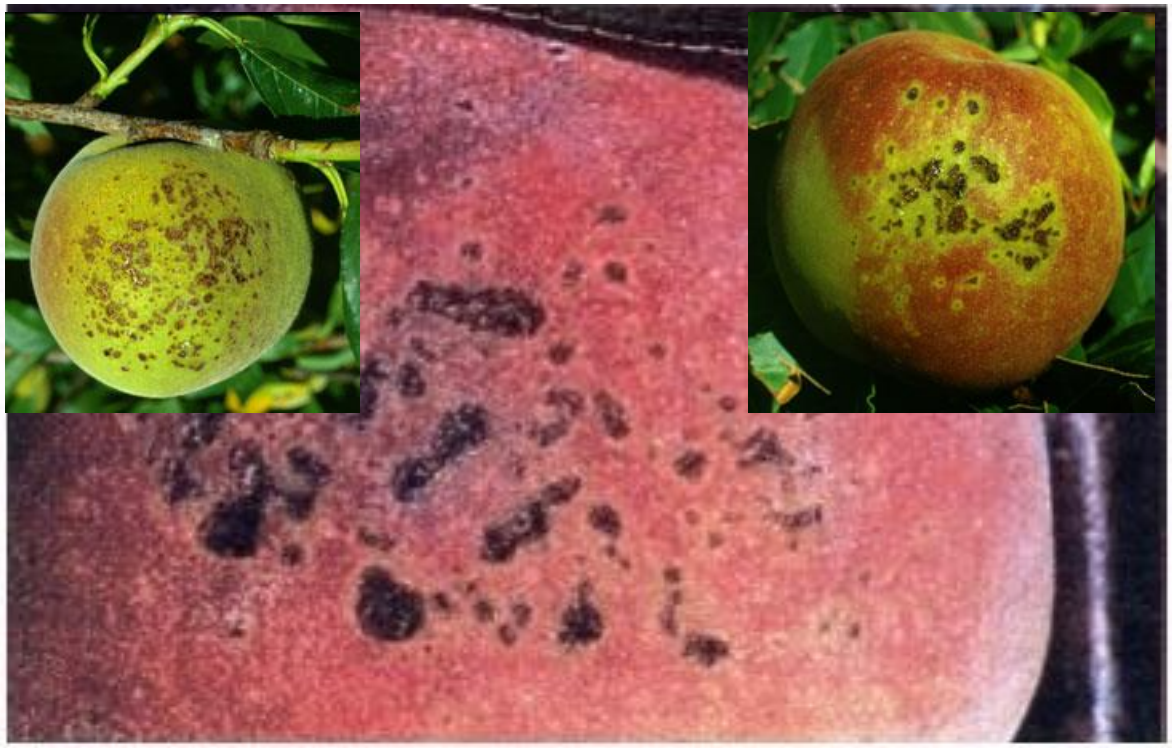
Bacterial leaf spot

Xanthomonas arboricola pv*. pruni*

Spots on two peach leaves cv. Elegant Lady.

Bacterial spot

Xanthomonas arboricola pv*. pruni*



Notice close resemblance to scab symptoms.

Bacterial spot

Xanthomonas arboricola pv. *pruni*

Bacterial spot on peach leaf. Note the "shot-holes" where infected tissue has dropped out.

Bacterial spot on peach fruit. Note the merging and cracking of spot.

Bacterial Canker

Xanthomonas arboricola pv. *pruni*

Cankers on peach twigs at bud break in spring.

Plant Bacteriology Manual,2008

Bacterial canker

Pseudomonas syringae

Cytospora canker

Bacterial canker on cherry. Note discolouration of wood and gumming.
Bacterial canker is similar in appearance to *Cytospora* canker.

British Columbia,2012

Bacterial canker or blast

Pseudomonas syringae

Bacterial canker is also known as "gummosis", "blossom blast"

US IPM Online,2010

Bacterial canker

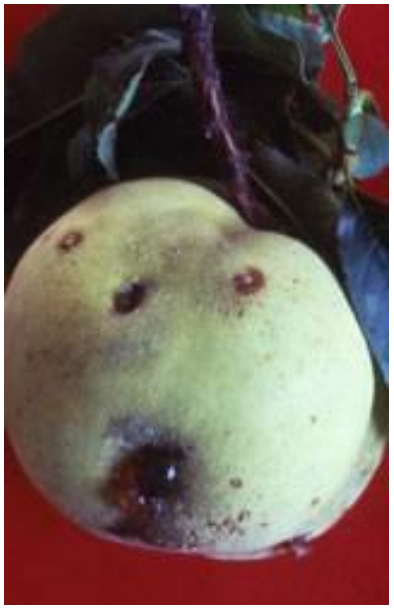
Pseudomonas syringae pv. *syringae*

Scortichini,2006

Bacterial dieback

Pseudomonas syringae pv. *persicae*



Scortichini,2006

Canker

Pseudomonas viridiflava

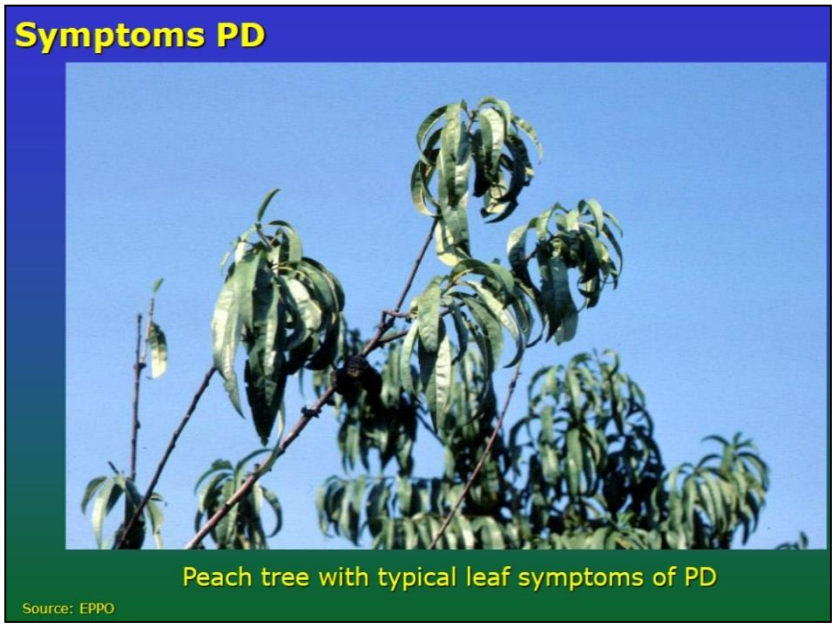
Gall

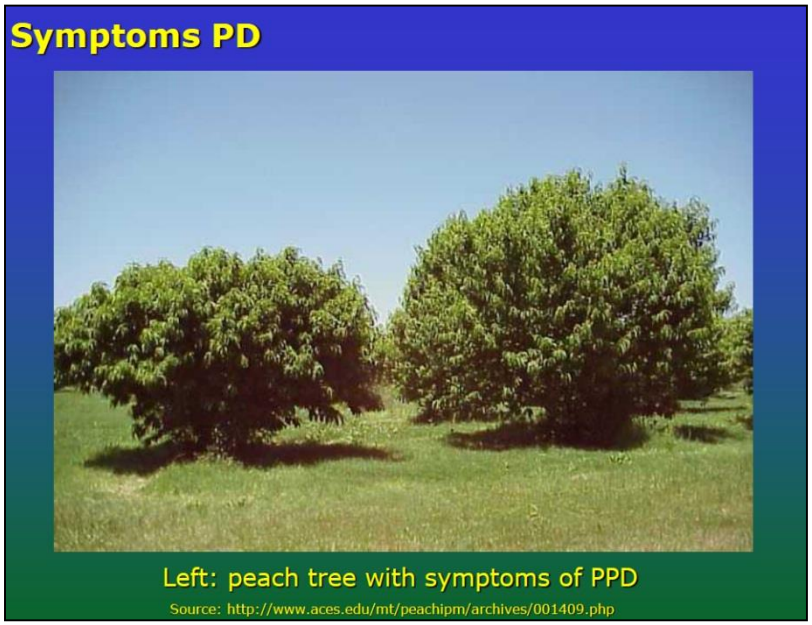
Agrobacterium tumefaciens

Scortichini,2006

Phony peach

Xylella fastidiosa





Janse,2009

Phony peach

Xylella fastidiosa

A compact growth habit and flat canopy

Peach X-disease

Phytoplasma

A. Wayadande

Bacterial canker and Bacterial spot canker

Pseudomonas syringae and *Xanthomonas arbioricola*

- Bacterial canker associated with gummosis on stone fruit caused by *Pseudomonas syringae* (left);
- Bacterial spot canker on a young stone fruit shoot caused by *Xanthomonas arbioricola* (right).

Pegg and Manners, 2014

Black stem blight of pear

Erwinia pyrifoliae

	
Necrotic symptoms caused by *Erwinia pyrifoliae*.	*Erwinia pyrifoliae* pathogenicity on immature pear.

Enterobacter pyrinus (formerly *Erwinia pirina*) was also reported to be associated with brown leaf spot disease of pear trees (Chung *et al.*,1993).

The website http://www.padil.gov.au/pbt,2011

Fire Blight

E. amylovora

	
Leaves showing typical Fireblight symptoms.	**Shepherd's Crook, a classic symptom of fireblight.**

www.agriculture.gov.ie/media

Blossom Blast

P. syringae

***Pseudomonas syringae* pv. *syringae* the pathogen of pear blast - causes leaf spots and shoot necrosis on pear trees. Blossom blast infects fruit and leaves resulting depressed black spots.**

Pear decline

'Candidatus Phytoplasma pyri'

A. Young pear tree showing symptoms of pear decline caused by a phytoplasma.

B. Disruption of phloem at and below the graft union as a result of pear decline infection is responsible for decline symptoms.

leaf scorch on pecan tree

Xylella fastidiosa

Symptoms leaf scorch and scald

Leaf scorch on pecan tree

Source: AH Purcell

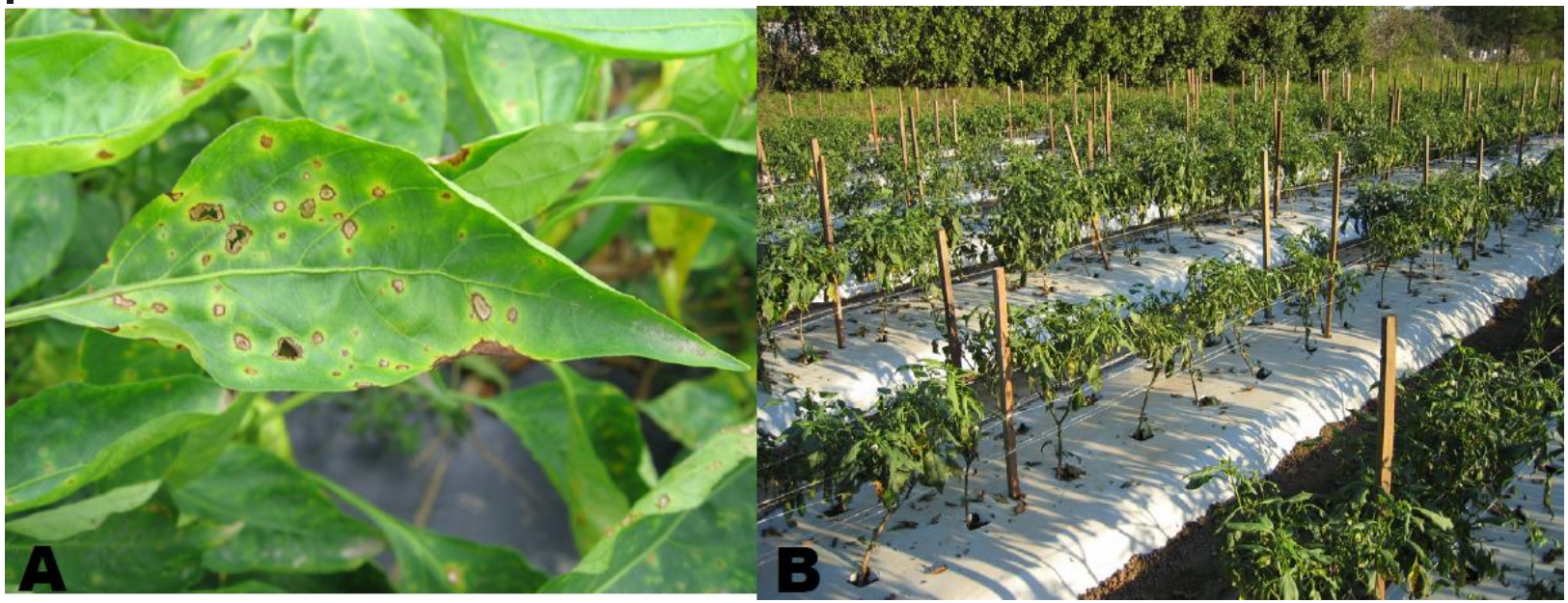
Janse,2009

Bacterial diseases of pepper

Leaf spot	***Xanthomonas campestris*** ***Xanthomonas euvesicatoria*** ***Xanthomonas perforans*** **= [*Xanthomonas axonopodis* (syn. *campestris*) pv. *vesicatoria*]** ***Xanthomonas vesicatoria*** ***Xanthomonas gardneri***
Pith necrosis	***Pseudomonas mediterranea*** **(ex. *Pseudomonas corrugata*)**
Bacterial blight	***Pseudomonas syringae***
Bacterial soft rot	***Erwinia carotovorum*** **ssp. *carotovorum*,** ***Pseudomonas viridiflava***
Bacterial wilt	***Ralstonia solanacearum***
Chlorotic leaves, spiky appearance, leaf cupping and shortened internodes and flower abortion	**'Candidatus Liberibacter solanacearum'**

Leaf Spot

Xanthomonas vesicatoria



A) Common leaf spots with necrotic center and yellow halo on infected pepper cultivar, Aristotle.
B) Devastating field infection with severe defoliation of lower leaves.

Garton *et al.*,2009

Leaf spot of pepper

Xanthomonas vesicatoria

Corky spots and scabs, water soaking margins, black necrotic lesions on the leaves with yellow haloes.

Leaf/fruit spot of pepper

Xanthomonas vesicatoria

Bacterial spot symptoms on pepper fruit.

Soft rot of pepper

P. carotovorum subsp. *carotovorum*

Soft rot of pepper

Pseudomonas viridiflava

- Fluorescent soil borne pathogen infects:

1. tomato (stem necrosis, dark blotches on pruning sites of the stem),
2. soft rot on sweet pepper,
3. the runner beans etc.

Gáborjányi,2010

Soft rot of sweet pepper

Pseudomonas viridiflava

Gáborjányi,2010

Pith necrosis

***Pseudomonas mediterranea* (ex. *Pseudomonas corrugata*)**

Scortichini,2006

Bacterial blight

Pseudomonas syringae pv. *syringae*

Scortichini,2006

Bacterial Wilt of Pepper

Ralstonia solanacearum

Browning of vascular tissues

Champoiseau,2008

Bacterial Wilt of Pepper

Ralstonia solanacearum

	
Bacterial wilt symptoms in pepper field	Bacterial ooze from infected pepper stem

Chlorotic leaves, spiky appearance, leaf cupping and shortened internodes and flower abortion

'Candidatus Liberibacter solanacearum'

- Similar tomato symptoms were reported in glasshouse capsicum:
- Chlorotic or pale green leaves
- Sharp tapering of leaf apex (spiky appearance)
- Leaf cupping and shortened internodes
- Flower abortion.

Liefting et al;

Periwinkle showing flower virescence from Colombia infected with 16SrIX-C phytoplasmas

Duduk *et al.*,2008

Bacterial leaf spot

Xanthomonas campestris

- Four bacterial diseases on four host plants:

1. Philodendron Bacterial leaf spot (*Xanthomonas campestris*) on philodendron showing small, water soaked spots that become large,
2. Bacterial leaf blight (*Xanthomonas* sp.) on syngonium showing angular, water-soaked areas on leaves that become yellow, then brown dry and papery (top right);
3. Bacterial leaf spot of bougainvillea showing orange, angular spots with pale centres (middle right);
4. Bacterial leaf blight on ZZ Plant ('zanzibar gem') (bottom right).

Pine (Monterey pine)- *Pinus radiata*

Canker

Pseudomonas syringae pv. *syringae*

M. Dick

Fire blight in *Photinia*

Erwinia amylovora

- Symptoms of fire blight in *Photinia* (*Stranvaesia*) *davidiana* caused by *Erwinia amylovora*.
- Water-soaked spots along veins and leaf margins, phloem necrosis and bacterial exudates.

Janse,2006

Pineapple flowering

Bacterial diseases of pineapple

- Pineapple is one of the five most important fruit of international trade.
- In 2002, approximately 14.8 million metric tons (MMT) were produced and 1.3 MMT traded as fresh fruit, worldwide (Contreras, 2004).
- Bacteria from the genera *Azospirillum*, *Burkholderia*,
- *Erwinia*, *Gluconacetobacter*, *Herbaspirillum* and *Pantoea* have been found associated with pineapple plants.
- Some of these bacteria have shown beneficial effects on pineapple, but other bacterial species are harmful.
- Pink disease can severely diminish the quality of processed pineapple.

Marin-Cevada *et al.*,2010

Bacterial diseases of pineapple

Acetic souring	**Acetic acid bacteria**
Bacterial fruitlet brown rot	***Pantoea ananatis* (*ex. Erwinia ananas*)**
Heart rot and fruit collapse	***Dickeya chrysanthemi***
Marbled fruit	***Acetobacter* spp.** ***A. peroxydans*** ***Pantoea ananatis***
Pink fruit	***Tatumella morbirosei*** (formerly *Pantoea citrea*) ***Tatumella ptyseos*** (formerly *Pantoea citrea*)
Soft rot	***Pectobacterium carotovorum***

The new species of *Tatumella morbirosei* and *Tatumella ptyseos* are reported to cause pink disease in pineapple (Bull *et al.*,2012).

Wikipedia;..

Bacterial diseases of pineapple

- The pineapple plant is threatened by several phytopathogenic bacteria that are responsible for diseases like fruit collapse, marbling disease, fruit brown rot, anomalous proliferations and pink disease.

Disease	Causal agent	Reference
Bacterial heart rot	*Dickeya chrysanthemi*	Johnston 1957
Bacterial fruit collapse	*Dickeya chrysanthemi*	Lim and Lowings 1979
	Klebsiella sp. plus yeasts	Korres et al. 2010
Marbling disease	*Acetobacter peroxydans* and *Pantoea agglomerans*	Rohrbach and Johnson 2003
Fruit brown rot	*Pantoea ananatis*	Serrano 1928
Shoot proliferation	Ca. *Phytoplasma asteris*	Davis et al. 2005
Proliferation of axillary buds	Ca. *Phytoplasma solani*	Davis et al. 2006
Pink disease	*Tatumella morbirosei*, *T. ptyseos*	Lyon 1915; Brady et al. 2008; 2010; Marin-Cevada et al. 2010

Marín-Cevada & Fuentes-Ramírez,2016; Rosada *et al.*,2016

Pink disease of pineapple

Tatumella morbirosei and *Tatumella ptyseos* (formerly *Pantoea citrea*)

Pink disease symptoms on pineapple fruit slices originating from a canned product. Healthy fruit (top), Diseased fruit (bottom).

Example of an immature pineapple fruit bearing blossoms that are commonly visited by flying insects.

Pink disease symptoms are difficult to observe in the field since outward symptoms are not apparent. Infections of the foliage are not usually found. Under severe invasion of the fruit by *P. citrea*, a translucent appearance of the sub-dermal fruit tissue occasionally can be observed.

Kado,2003

Marbling disease of pineapple
Pantoea ananatis and *Acetobacter* spp.

- Yellow to red or very dark brown discoloration of fruit flesh; infected tissues develop a granular texture with woody consistency and speckled color; single or multiple fruitlets may be affected; vascular system may appear speckled right down to core of fruit; symptoms develop during the last month of fruit maturation.
- *Erwinia* (*Pantoea*) is a very common bacteria in our environment and is not a disease that produces problematic toxins.

PlantVillage; Johan,2015

Marbling disease of pineapple

Pantoea ananatis and *Acetobacter* spp.

Pineapple marbling disease showing red-brown granular flesh with woody consistency

Sindhu *et al.*,2012; Johan,2015

Fruitlet rot of pineapple

Pantoea ananatis

These images are from Google images, and have not been verified by CABI.

Bacterial heart rot and fruit collapse Pineapple strain, *Dickeya* sp.)

Dickeya (ex. *Erwinia*)*chrysanthemi*

- Water-soaked lesions on the white basal sections of leaves in the central whorl which may spread to all leaves in the central whorl;
- Midportions of leaves become olive green in color with a bloated appearance; infected fruits exude juices and the shell becomes olive green; cavities form within the fruit.
- *Erwinia chrysanthemi* often forms latent infections in pineapple, as well as numerous other crops.
- *E. chrysanthemi* strains from pineapple will either be placed into a previously described or a new *Dickeya* species causing heart rot of pineapple.

PlantVillage; Alvarez,2012

Bacterial heart rot and fruit collapse (Pineapple strain, *Dickeya* sp.)

Dickeya (ex. *Erwinia*) *chrysanthemi*

- Characteristic watersoaking originating from the heart with a gas-filled blister (arrow) caused by *Erwinia chrysanthemi*.

Kaneshiro *et al.*,2008

Bacterial diseases of pistachio

Dieback or decline of pistachio	***Xanthomonas translucens* pv. *pistaciae***
Pistachio Bushy Top Syndrome (PBTS)	***Rhodococcus fascians***

Wikipedia;..

Dieback or decline of pistachio
Xanthomonas translucens pv. *pistaciae*

Xanthomonas translucens - Pistachio dieback or decline

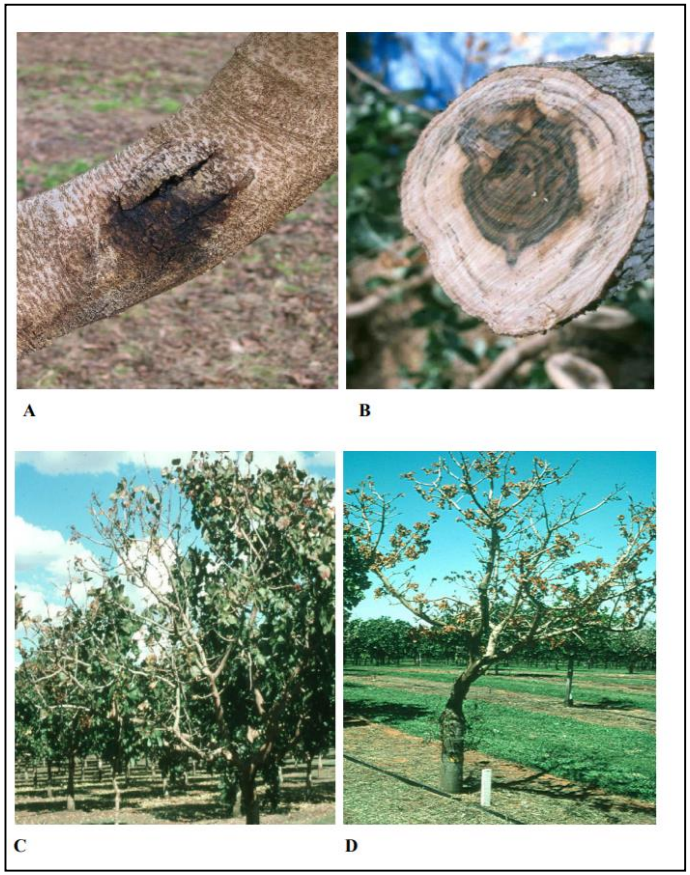
- Described from Australia in 2001 from pistachio
- Dieback of twigs, internal staining of tissues, lesions on trunk, limbs and branches, resin exudation and tree death. No fruit infection.

Photo: Univ. of adelaide, au

Dieback or decline of pistachio

Xanthomonas translucens pv. *pistaciae*

- Major limbs of the diseased tree showing black sooty patches with sunken bark.
- Discoloration of woody tissue which varies in cross-section from small, dark pin-pricks to thick and dark rings.
- The diseased tree showing dieback.
- Dead pistachio tree infected by the disease.



Marefat,2005

Dieback or decline of pistachio
Xanthomonas translucens pv. *pistaciae*

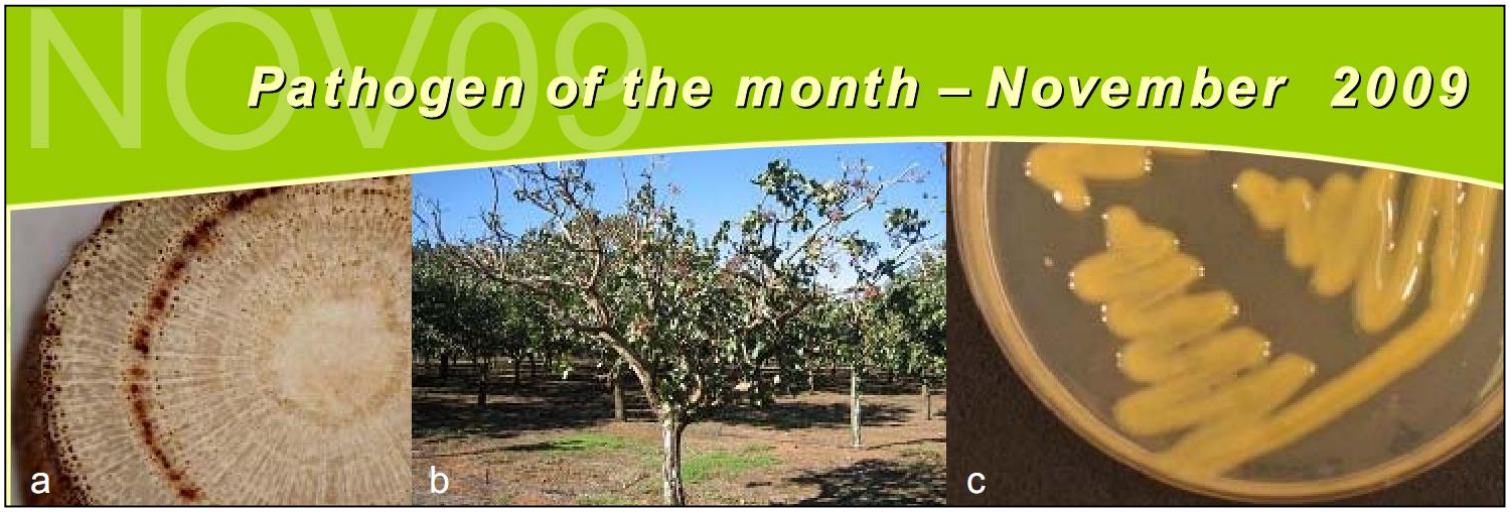


Fig. 1. Typical xylem staining (a) and dieback (b) associated with *X. translucens* pv. *pistaciae* infection in Pistachio; *X. translucens* pv. *pistaciae* on Sucrose Peptone Agar (c). Photo credits C. Taylor (a, b) and A. Salowi (c).

Giblot Ducray and Eileen Scott

Dieback or decline of pistachio
Xanthomonas translucens pv. *pistaciae*

- Typical xylem staining and dieback associated with *X. translucens* pv. *pistaciae* infection in Pistachio.
- The disease is endemic to Australia and is characterized by trunk and limb lesions, excessive resin exudates, discolouration of mature xylem, stunted growth and shoot dieback.
- Affected trees gradually decline, fail to produce marketable nuts and eventually die.
- Photo credits C. Taylor.

Giblot Ducray and Eileen Scott

Pistachio Bushy Top Syndrome (PBTS) *Rhodococcus fascians* (Rf)

- A new pistachio disease, Pistachio Bushy Top Syndrome (PBTS) has been describe.
- PBTS is caused by the infection of a bacterium, *Rhodococcus fascians* (Rf).
- Two strains have been identified and, while each is pathogenic, they act synergistically to cause more severe disease symptoms.
- Bacteria exchange DNA frequently so it is likely that new strains, probably derived from the initial two, will be found.

Klein,2015

Bacterial canker

Pss and *Pseudomonas syringae* pv. *morsprunorum* race1

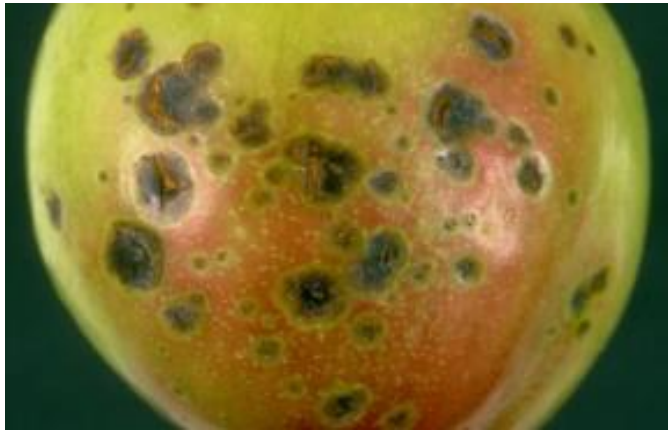
- In Belgium *Pss*, *Psm* race 1 and 2, and other sour cherry and plum *P. syringae* strains were frequently found in cherry and plum orchards (Bultreys and Gheysen, 2003; Gilbert *et al.*,2009).
- *Psm* race 1 was especially damaging to dwarf trees.

Alain Bultreys

Bacterial canker

Xanthomonas axonopodis pv*. pruni*

- Leaf spots on plum.
- Courtsey of U. Mazzucchi – Universita degli Studi, Bologna (IT)



Elphinstone and Aspin,2016

Bacterial canker

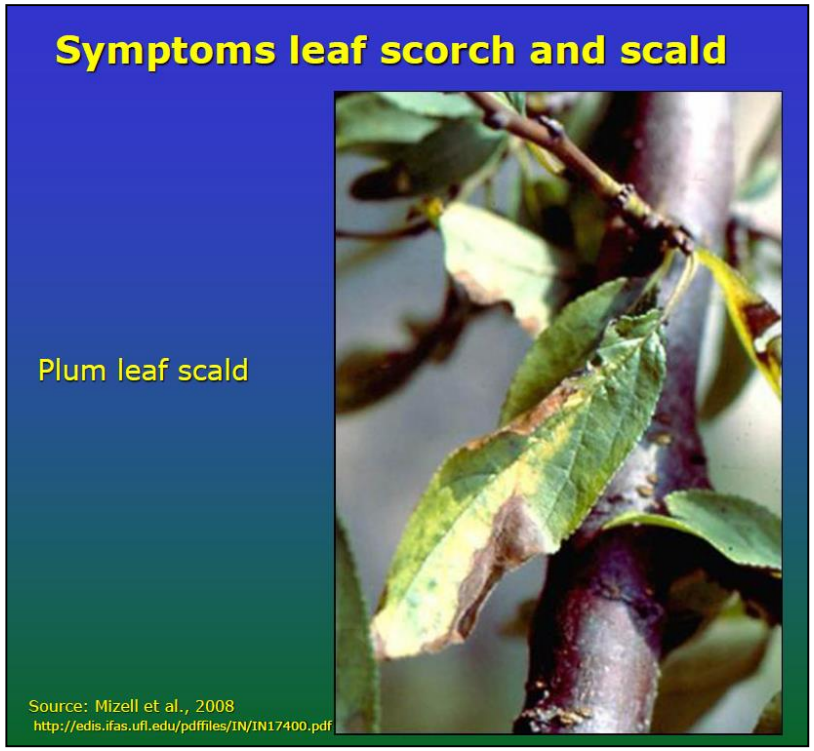
Xanthomonas axonopodis pv*. pruni*

Symptoms on Stanley plum fruit

Plant Bacteriology Manual,2008

Plum leaf scald

Xylella fastidiosa



83. Marginal necrosis and leaf roll symptomatic of plum leaf scald. (Courtesy A. J. Latham)

Janse,2009;..

Plum gall

A. tumefaceins

Crown gall on plum branch

Angular leaf spot

Xanthomonas axonopodis pv. *poinsetticola*

Scortichini,2006

Bacterial leaf spot

Xanthomonas axonopodis pv. *poinsetticola*

- The symptoms first appeared on the leaves as small spots, which quickly turned brown and were surrounded by pale yellow haloes.
- The brown spots and haloes enlarged rapidly and coalesced into irregular, yellow or brown, dry, dead areas on the leaf.

Lee *et al.*,2006

Soft rot

Pectobacterium carotovorum

Erwinia soft rot of poinsettia, caused by *Erwinia* sp.

Erwinia soft rot of poinsettia cuttings

Bacterial Blight of Pomegranate

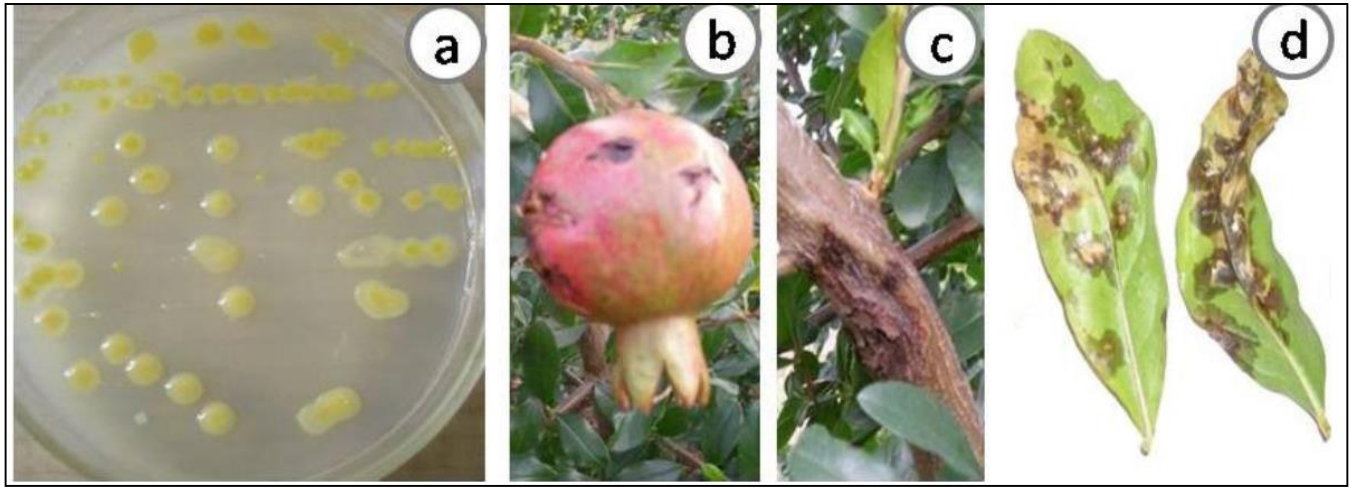
Xanthomonas axonopodis pv. *punicae*

Symptoms on naturally infected pomegranate: a) stem cankers, b) included leaf/fruit spots, and c) burst fruit.

Petersen *et al.*,2010

Bacterial Blight of Pomegranate
Xanthomonas axonopodis pv. *punicae*

a) *Xanthomonas axonopodis* pv. *punicae* colonies. Symptom may be produced:
b) on fruit
c) on stem, and
d) on leaves.



Mondal *et al.*,2012

Bacterial Blight of Pomegranate

Xanthomonas axonopodis pv. *punicae*

- Symptoms of bacterial blight on young and developing pomegranate fruits.
- Initially, spots are black and round and surrounded by bacterial ooze.
- Under favorable conditions, spots enlarge to become raised, dark brown lesions with indefinite margins that cause the fruit to crack.
- The disease may cause up to 90% yield reduction.

Benagi, APS,2014

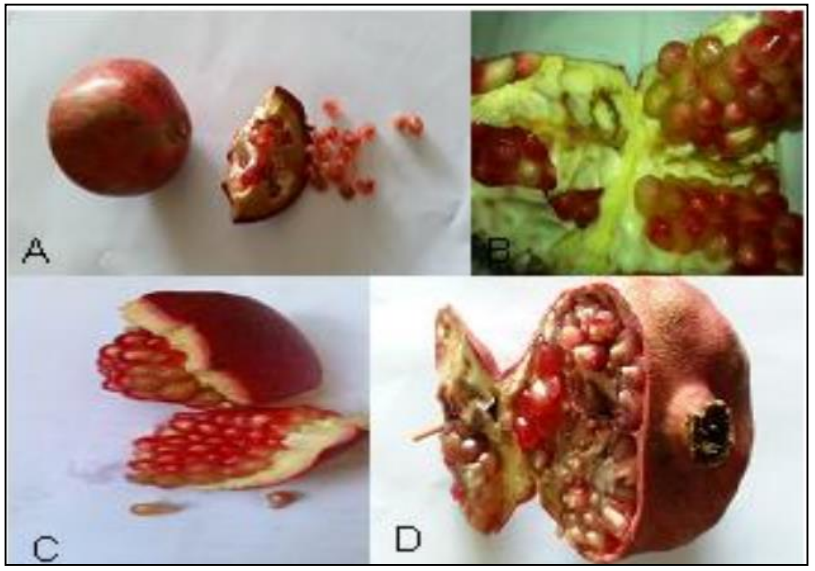
Bacterial Blight of Pomegranate

Xanthomonas axonopodis pv. *punicae*

Deshpande *et al.*,2014

Inner fruit decay of Pomegranate
Gluconobacter oxydans

- A, B, and C: natural infection at autumn 2018, 2019 and 2020, respectively,
- D: Artificial infection.



Armanious,2020

Poplar bacterial diseases

Xanthomonas arboricola **pv.** ***populi***	**Bacterial canker**
Lonsdalea populi **subsp.** ***populi***	**Symptomatic bark tissue of Populus x euramericana canker**
B. populi **subsp.** ***brevivirga***	**Symptomatic bark tissue of Populus x euramericana canker**
Agrobacterium tumefaciens	**Crown gall**

Wikipedia; Li *et al.*,2015;..

Bacterial canker

Xanthomonas arboricola pv. *populi*

- Initial symptom is small cracks in bark of one-year-old shoots, which ooze creamy slime in spring.
- Cankers may expand to girdle smaller shoots.
- On larger stems, irregular-shaped lesions break through the bark.
- Infected leaves may blacken.

Leaf scar canker caused by *X. populi* on young stem of poplar.

Bacterial canker

Xanthomonas arboricola pv. *populi*

- Canker, girdling stem of a highly susceptible *Populus tremula* tree.

Bacterial canker

Xanthomonas arboricola pv. *populi*

Artificially inoculated stem

Bacterial canker

Lonsdalea populi subsp. *populi*

- In the end of spring or in early summer white foamy mucus bleeds out from wounds of the stem.



Koltay *et al.*,2013

Bacterial canker

Lonsdalea populi subsp. *populi*

- The wounds can be on various heights of the stem.



Koltay *et al.*,2013

Bacterial canker

Lonsdalea populi subsp. *populi*

- The bark dies under the mucus, and the tissues under the bark also starts to rot. White and stinky mucus develops under the bark.

Koltay *et al.*,2013

Bacterial canker

Lonsdalea populi subsp. *populi*

- The bark becomes discoloured, with brownish-purple or black areas, and with blisters.



Koltay *et al.*,2013

Bacterial canker

Lonsdalea populi subsp. *populi*

In the next year the margins of the wound heals in, but the centre of the wound remains usually uncovered, so the degradation of the timber may start here, which leads to the death of the tree.

Koltay *et al.*,2013

Bacterial canker

Xanthomonas arboricola pv. *populi*

Infected trees in northern France

Bacterial wetwood on poplar

Enterobacter nimipressuralis

USDA Forest Service,2008

Crown gall

Agrobacterium tumefaciens

W. Jacobi; Ostry *et al.*,1989

Potato bacterial diseases

Bacterial wilt = brown rot	***Ralstonia solanacearum***
Blackleg and bacterial soft rot	***Pectobacterium atrosepticum*** ***Pectobacterium carotovorum* subsp. *carotovorum*** ***P. carotovorum* subsp. *brasiliensis*** ***Dickeya chrysanthemi*** ***Dickeya solani***
Pink eye	***Pseudomonas fluorescens***
Ring rot	***Clavibacter sepedonicus***
Common scab	***Streptomyces scabiei* (ex. *S. scabies*)** ***Streptomyces acidiscabies*** ***Streptomyces turgidiscabies***
Zebra chip disease of potato	**'*Candidatus* Liberibacter solanacearum'**
Aerial bulbs on Stolbur phytoplasma infected potato	***Candidatus* phytoplasma solani**

Wikipedia;..

Potato ring rot

Clavibacter sepedonicus

- Internal symptoms of *Clavibacter sepedonicus* on potato.
- Note the destruction of the vascular tissue and the surrounding creamy to brown coloured lesions.

S. H. DeBoer, CAB, William M. Brown Jr.

Ring rot

Clavibacter sepedonicus

Cracks in the surface of a tuber with bacterial ring rot.

Ring rot

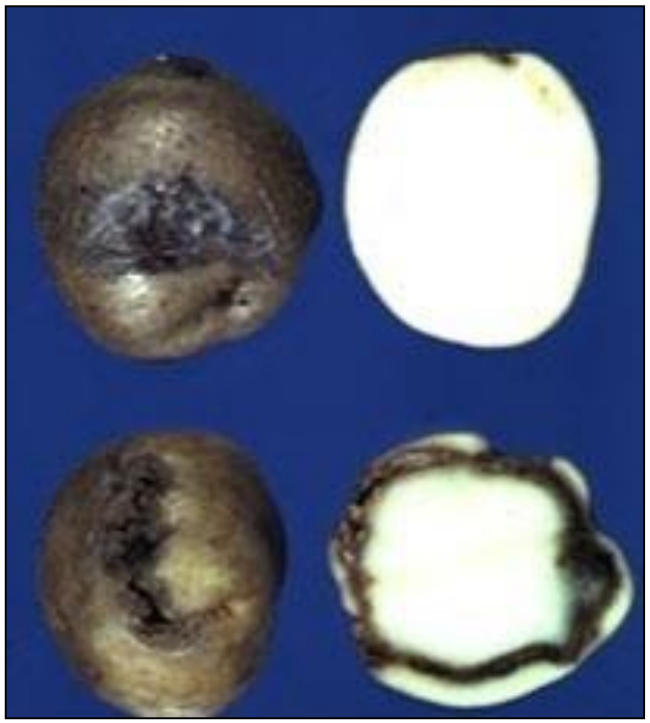
Clavibacter sepedonicus

Bacterial ring rot symptoms in an early(left) and an advanced stage(right).

van der Wolf *et al.*,2005

Bacterial ring rot

Clavibacter sepedonicus



Ohio State University Extension Fact Sheet

Ring rot

Clavibacter sepedonicus

- Ring rot causes interveinal tissue of potato leaflets to turn yellow then brown.

Bacterial Wilt (Brown rot)

Ralstonia solanacearum

- Bacterial ooze exuding from eyes of potato tuber infected by *R. solanacearum*.

Champoiseau &Allen,2009

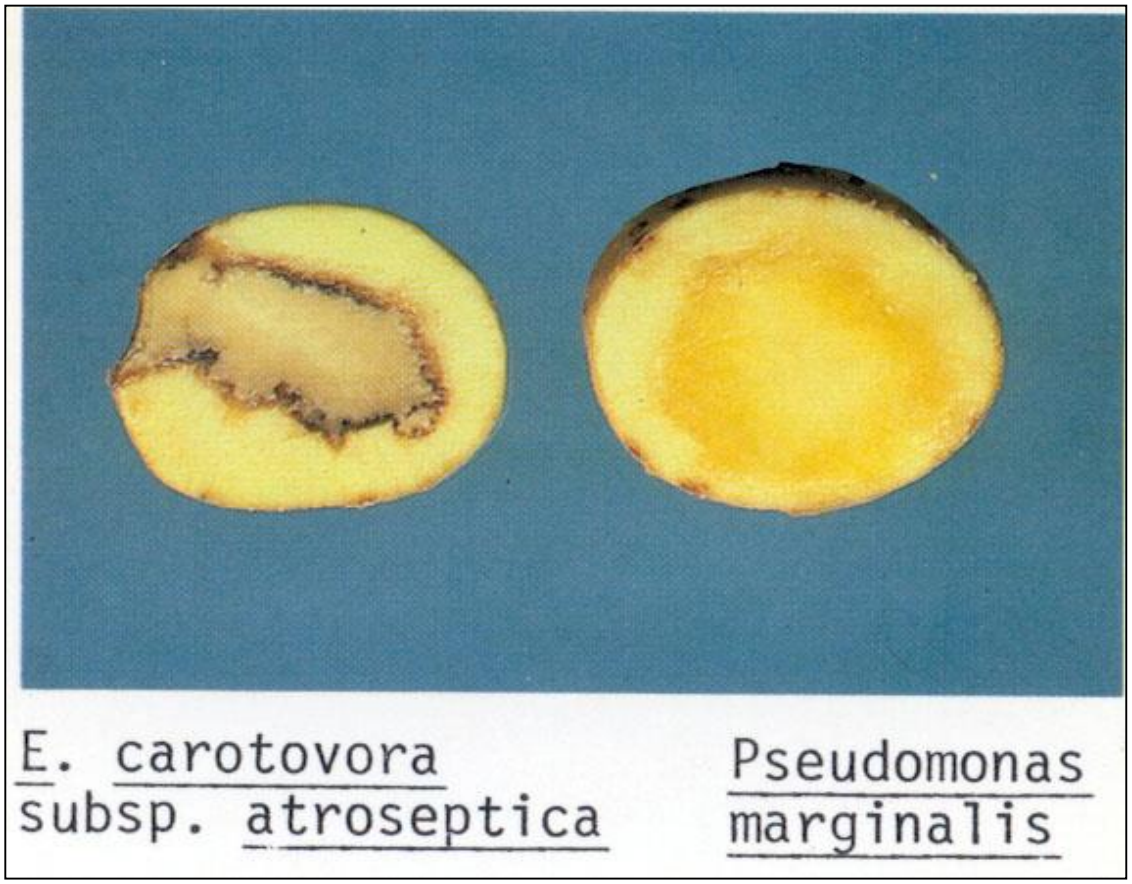
Bacterial Wilt (Brown rot)

Ralstonia solanacearum

Serious threat to potato production in Europe and U.S.

Soft Rot of Potato

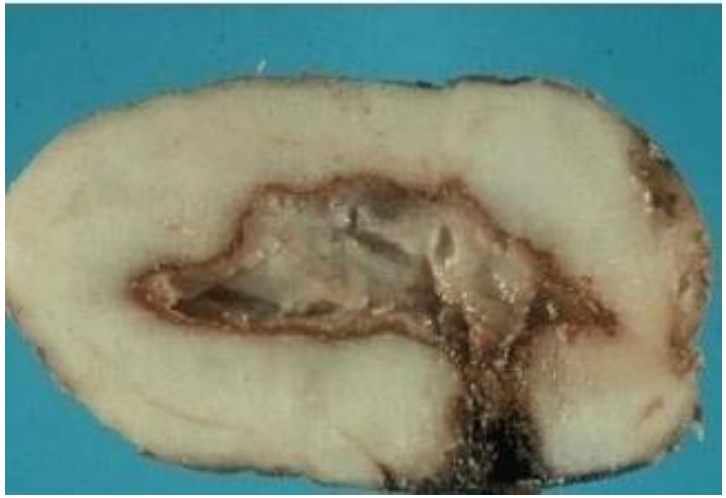
Soft rot bacteria



Potato soft rots

Pectobacteria

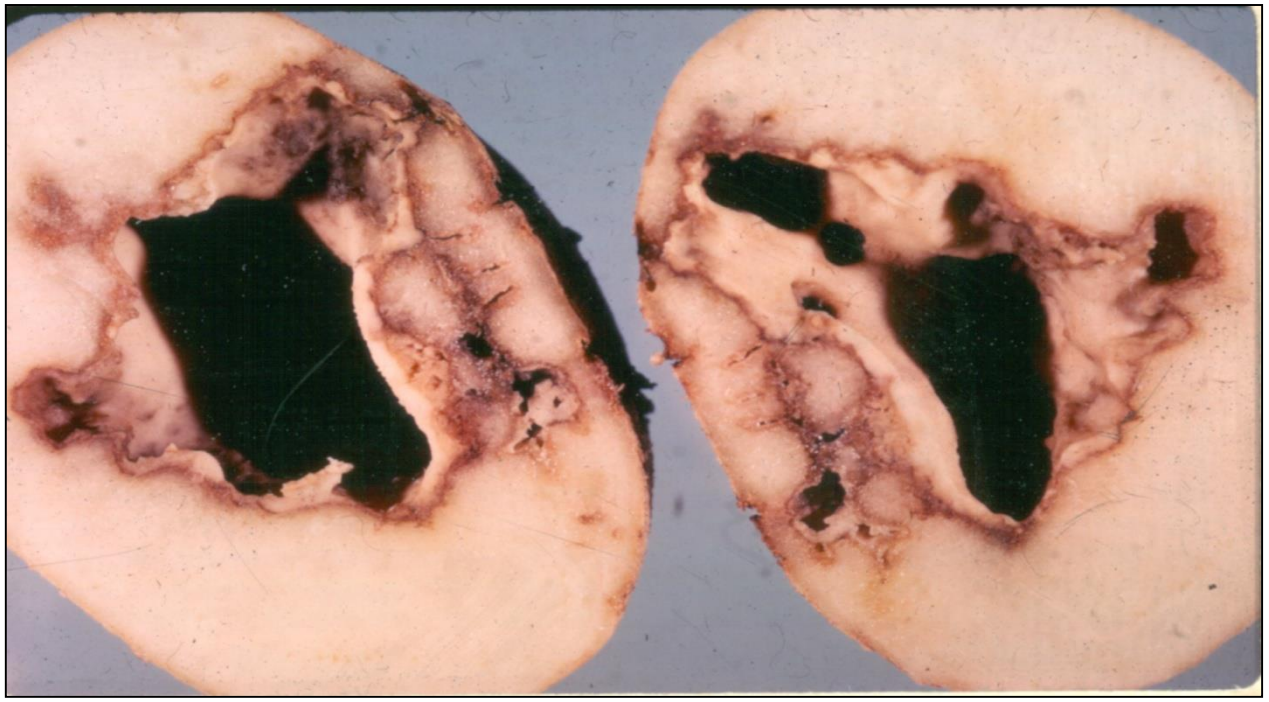
Early stage of bacterial soft rot on potato tubers. Note skin discoloration at points of infection.



Advanced decay of blackleg, soft rot entering thru wound.

Soft rot of potato

Pectobacterium spp.



Blackleg of Potato

Pectobacterium atrosepticum

Blackleg of Potato

Pectobacterium atrosepticum

Scortichini,2006

Bacterial stem and root rot

Dickeya chrysanthemi

Potato

Blackleg-like rotting (a) and internal necrosis of the stem (b)

Two *Dickeya* sp. strains

Dickeya dianthicola **is normally associated with a slow wilt with internal stem necrosis.**

Fig. 6 Blackleg-like rotting (a) and internal necrosis of the stem (b) caused by *Dickeya* sp. strains D w0443 and D w04K, respectively

Laurila *et al.*,2008;..

Blackleg-like rotting/internal necrosis of the stem/cheesy rot *Dickeya solani*

- The new emerging strains of biovar 3, with the proposed name *D. solani* cause typical blackleg symptoms on potato.
- Although disease symptoms are often indistinguishable from those of the more established blackleg pathogen *Pectobacterium* spp., *Dickeya* spp. can:

1. Initiate disease from lower inoculum levels;
2. Have a greater ability to spread through the plant's vascular tissue, are considerably more aggressive, and
3. Have higher optimal temperatures for disease development.

Toth *et al.*,2011

Blackleg-like rotting/internal necrosis of the stem/cheesy rot *Dickeya* spp.

- Disease symptoms in potato tubers and stems caused by *Dickeya* species:

a) Typical blackleg symptoms caused by '*Dickeya solani*';

b) '*Dickeya solani*' soft rot of developing progeny tuber extending from the stolon;

c) Soft rot of daughter tubers developing from the stolon;

d) Initial wilt in upper leaves;

e) Increased levels of necrosis in the upper leaves and wilt and desiccation in the lower leaves;

f) *D. dianthicola* rotting mother tuber;

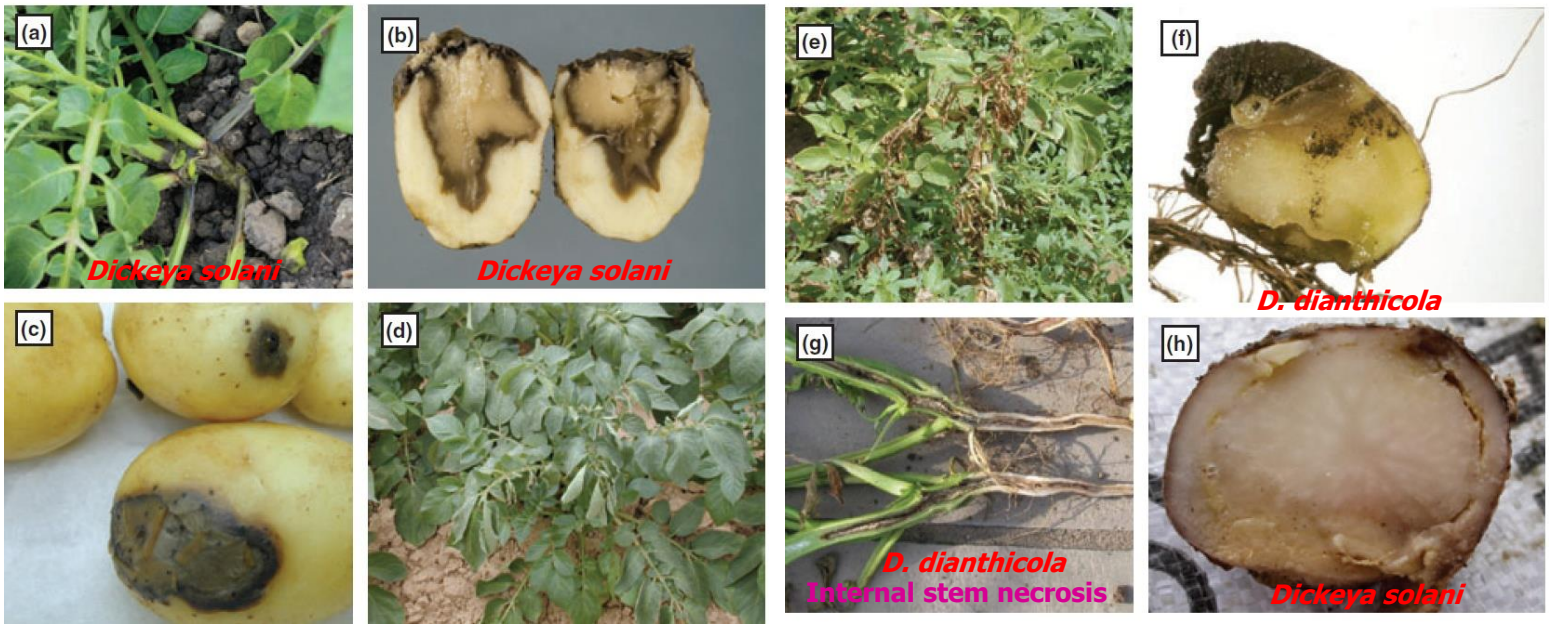
g) Internal stem necrosis or rotting extending from the stem base, but with the stem base appearing externally healthy;

h) *Dickeya solani* on imported potato causing cheesy rot and break down of the vascular ring similar to ring rot or brown rot.

Toth *et al.*,2011

Potato

Blackleg-like rotting/internal necrosis of the stem/cheesy rot *Dickeya* spp.



Toth *et al.*,2011

Potato scab

Streptomyces spp.

- Scab is a disease of potato tubers that results in lowered tuber quality due to scab-like surface lesions.
- There are no above-ground symptoms.
- Two forms of scab occur:

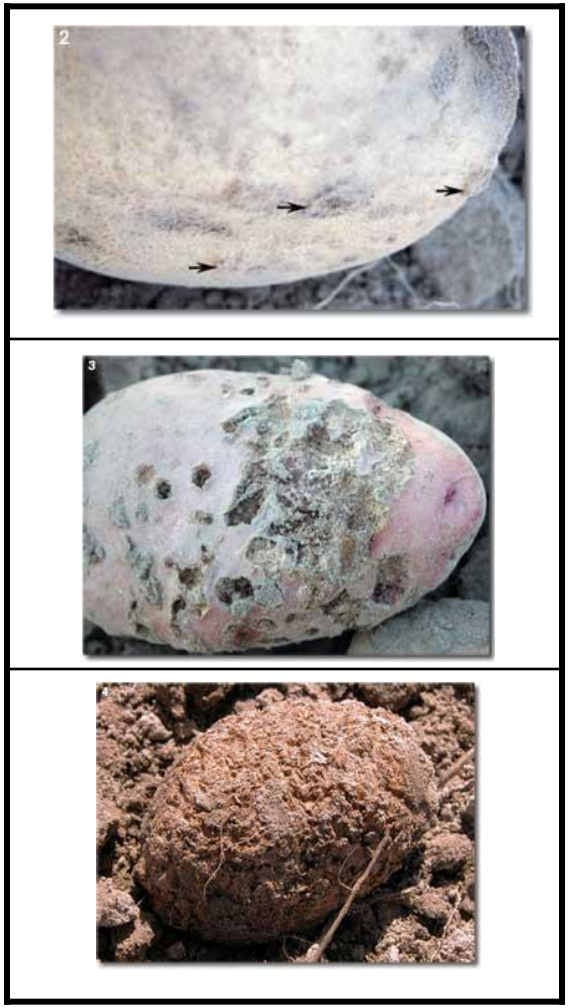
1. Common scab occurs in all production areas and is most severe in soils with a pH above 5.5.
2. Another less common form, called acid scab, is important in acidic soils (below pH 5.5).

Raised, tan to brown, corky lesions of potato scab.

Potato scab

Streptomyces spp.

- Lesions start out as small, brownish spots, which enlarge into water-soaked circular lesions within a few weeks of infection (Fig. 1).
- These circular lesions may coalesce forming large scabby areas (Fig. 3)
- Scab is most severe when tubers develop under warm, dry soil conditions with a soil pH above 5.2 (Fig. 4).



Zebra chip disease of potato

'*Candidatus* Liberibacter solanacearum'

Foliar symptoms of zebra chip(ZC) disease in field-grown potato in Pearsall, TX showing. A, chlorosis and deformation, and B, leaf curling and scorch.

Characteristic symptom of zebra chip disease in field-grown tubers showing necrotic browning in medullary ray tissue throughout the tuber.

Secor *et al.*,2009

Zebra chip disease of potato
'*Candidatus* Liberibacter solanacearum'

- A new disease of potatoes, tentatively named zebra chip (ZC) because of the intermittent dark and light symptom pattern in affected tubers which is enhanced by frying, was first found in Mexico in 1994 and in the southwestern United States in 2000.
- The disease can cause severe economic losses in all market classes of potatoes.

Liefting; Secor *et al.*,2009

Aerial bulbs on Stolbur phytoplasma infected potato

Candidatus phytoplasma solani

Gáborjányi,2010

Leaf spot

Pseudomonas cichorii

Scortichini,2006

Bacterial stem fasciation

Rhodococcus fascians

- Fasciation (flattened growth) of a pumpkin stem, which may be due to disease, a genetic condition, or injury.

Pumpkin is a gourd-like sequash of the genus *Cucurbita* and the family *Cucurbitaceae* (which also includes gourds).

Putnam & Miller

Bacterial leaf spot of pumpkin
Xanthomonas campestris pv*. cucurbitae*

- Water-soaked areas.
- Droplets of white exudate.

De La Fuente,2009

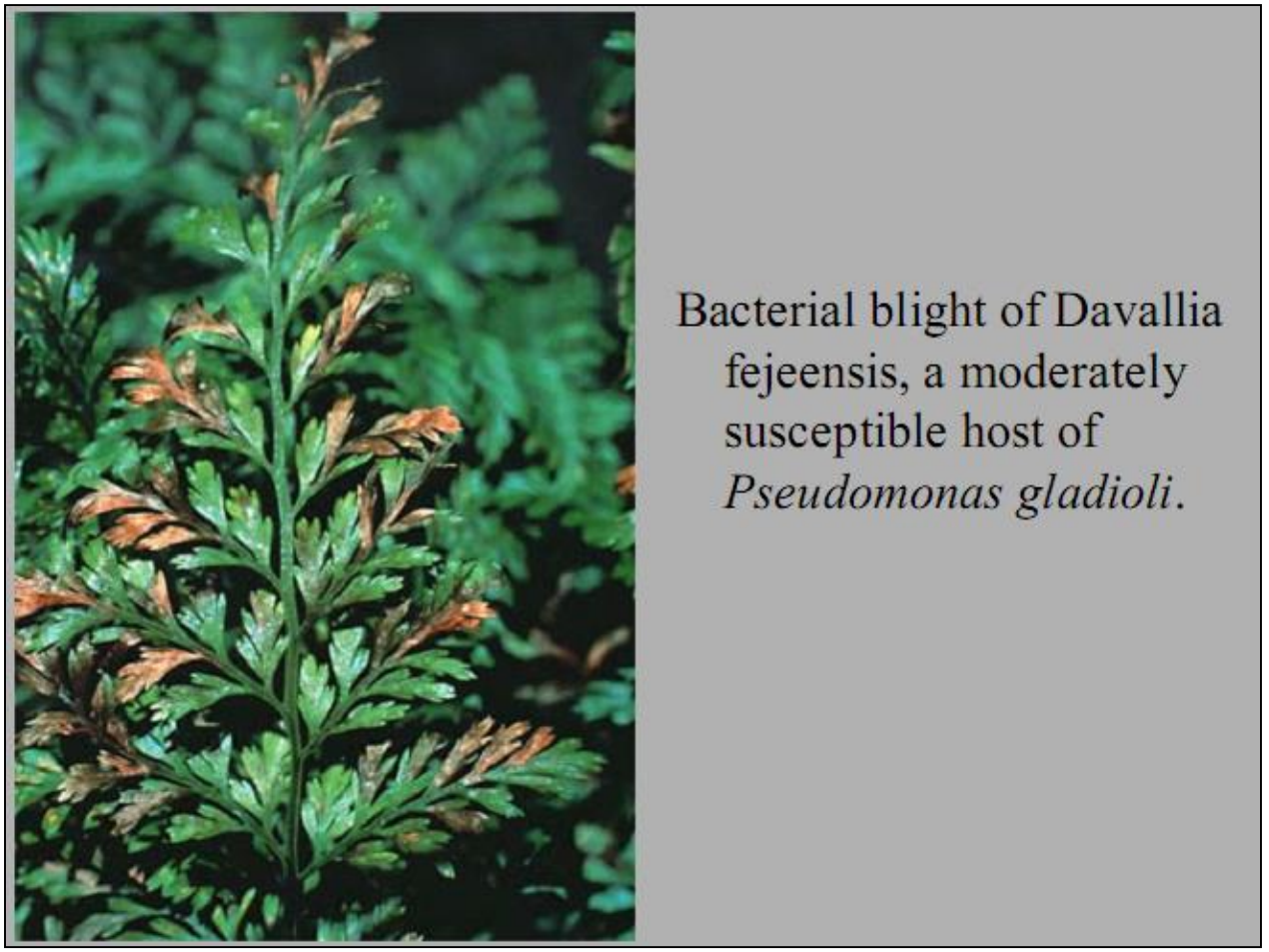
Fire blight

Erwinia amylovora

Oregon State University; RHS gardening

Bacterial blight

Burkholderia galdioli

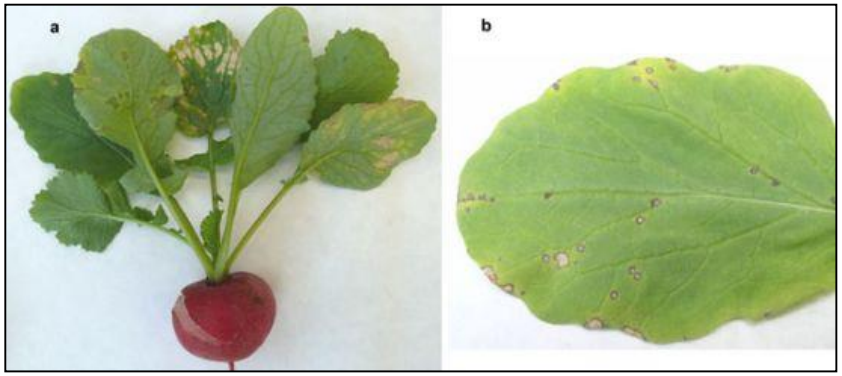


Bacterial blight of Davallia fejeensis, a moderately susceptible host of *Pseudomonas gladioli*.

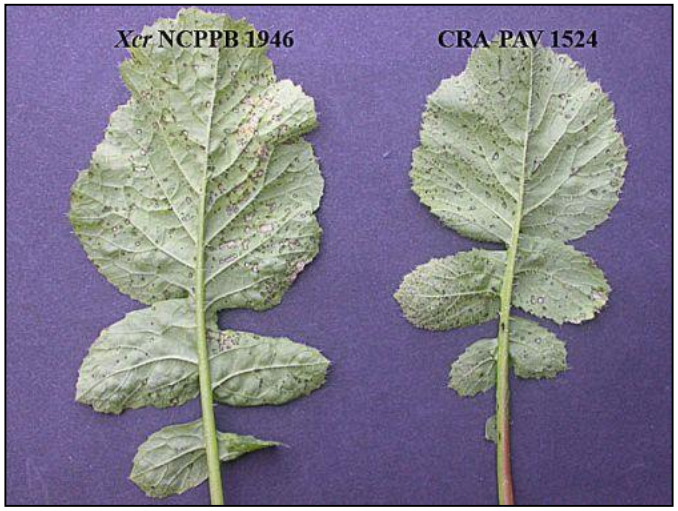
plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Leaf spot

Xanthomonas campestris pv. *raphani*



Radish plant (a) and an individual leaf (b) naturally infected with *Xanthomonas campestris* pv. *raphani* .



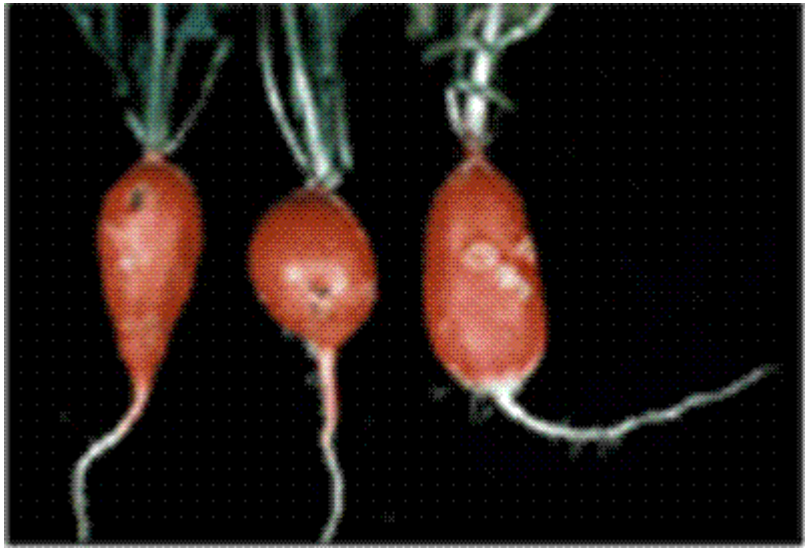
Leaf spot symptoms of radish artificially inoculated by *Xanthomonas campestris* pv. *raphani* NCPPB 1946 and CRA-PAV1524 (2 weeks after inoculation).

Loreti *et al.*,2011

Radish scab symptoms

Streptomyces scabies

Radish scab (K. Callow)



Scab on Radish (Univ. of Illinois)

Brooke Edmunds

Crown gall of raspberry

A. tumefaciens

Crown gall on black raspberry cane; young, fleshy galls caused by *Agrobacterium tumefaciens*.

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Fireblight of raspberry

E. amylovora

Heimann and Jeffers,1990

Bacterial diseases of rice

Bacterial leaf blight of rice (BLB)	***X. oryzae* pv. *oryzae***
Bacterial leaf streak of rice (BLS)	***X. oryzae* pv. *oryzicola***
Bacterial blight/Brown stripe	***Acidovorax avenae* subsp. *avenae***
Bacterial panicle blight	***Burkholderia glumae***
Sheath brown rot, grain discoloration, grain sterility	***Pseudomonas fuscovaginae***
Foot rot	***Dickeya chrysanthemi***

- *X. oryzae* pv.*oryzae* and *X. oryzae* pv. *oryzicola* can be clearly distinguished by symptoms, which reflect the differences in their modes of infection.
- The transparent streaks of BLS disease (*X.o.* pv.*oryzicola*) differentiate leaf streak lesions from those of *X. oryzae* pv. *oryzae* that are opaque against the light.

OEPP/EPPO,2007;Wikipedia;..

Bacterial leaf blight of rice (BLB)

Xanthomonas oryzae pv. *oryzae*

- The symptoms of the BLB disease include leaf blight, wilting (kresek) and pale yellow leaves. Leaf blight is characterized by wavy elongated lesions, which develop along the leaf margins.

OEPP/EPPO,2007

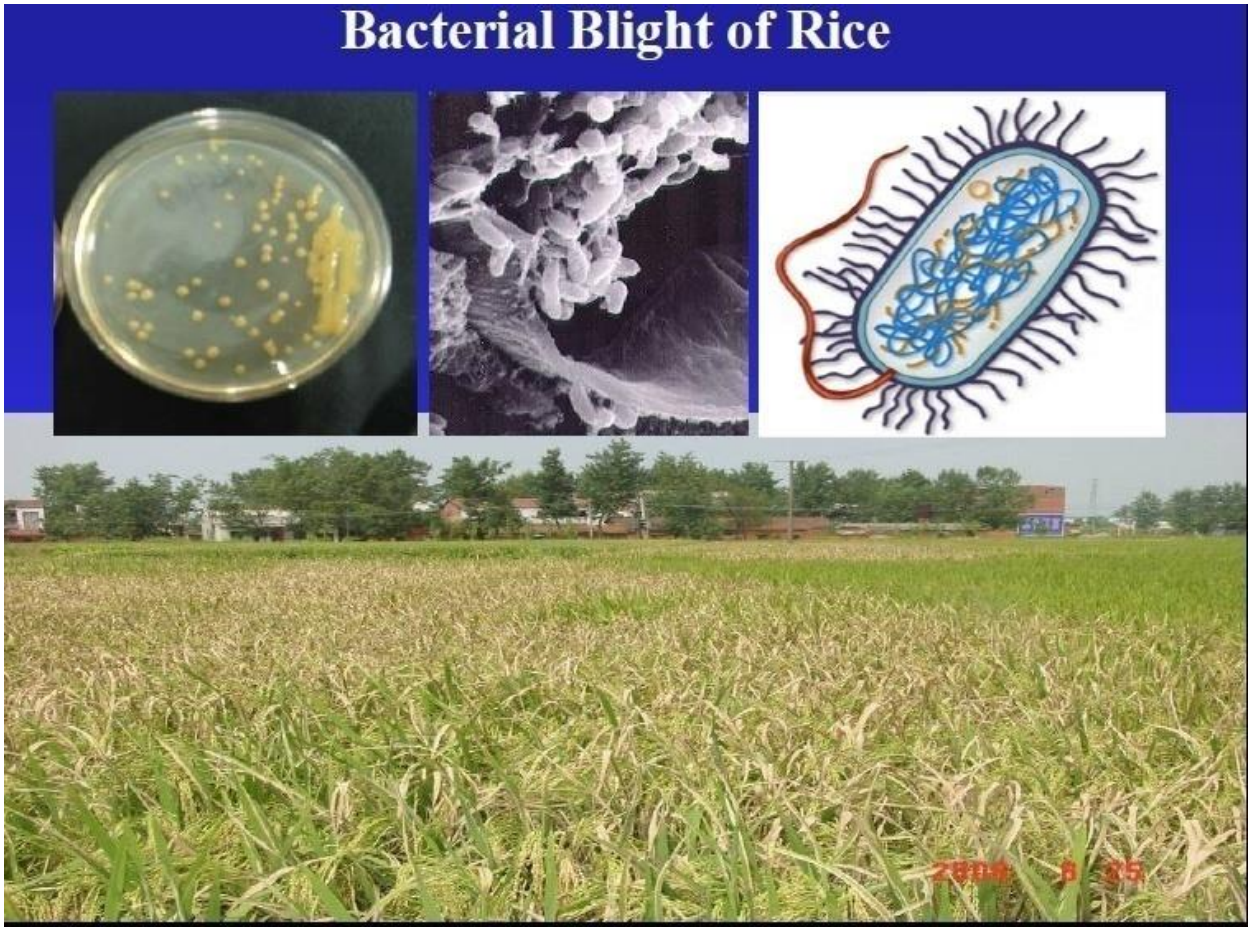
Bacterial leaf blight

Xanthomonas oryzae pv. *oryzae*

- Droplets of bacterial exudate on young lesions observed during early morning with high dew formation.

Bacterial leaf blight

Xanthomonas oryzae pv. *oryzae*



Zhaokaijun

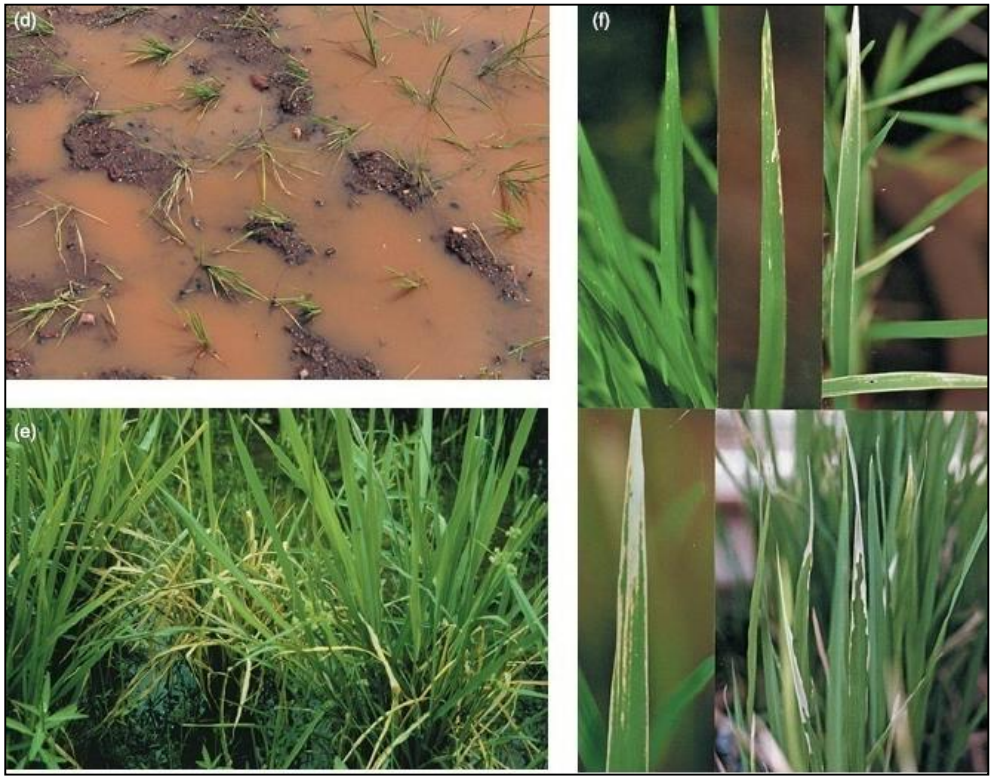
Bacterial leaf blight

Xanthomonas oryzae pv. *oryzae*

- Rice seedlings infected with *Xanthomonas oryzae* pv. *oryzae*.
- Infected leaves wilt and roll up, turning grayish-green to yellow, until the whole seedling dies.
- Plants which have survived the disease are stunted and yellowish.

Bacterial leaf streak of rice (BLS)
X. oryzae pv. *oryzicola*

- Initial symptoms of the BLS disease are small water-soaked, transparent interveinal streaks which may elongate and darken.



OEPP/EPPO,2007

Bacterial leaf streak

Xanthomonas oryzae pv. *oryzicola*

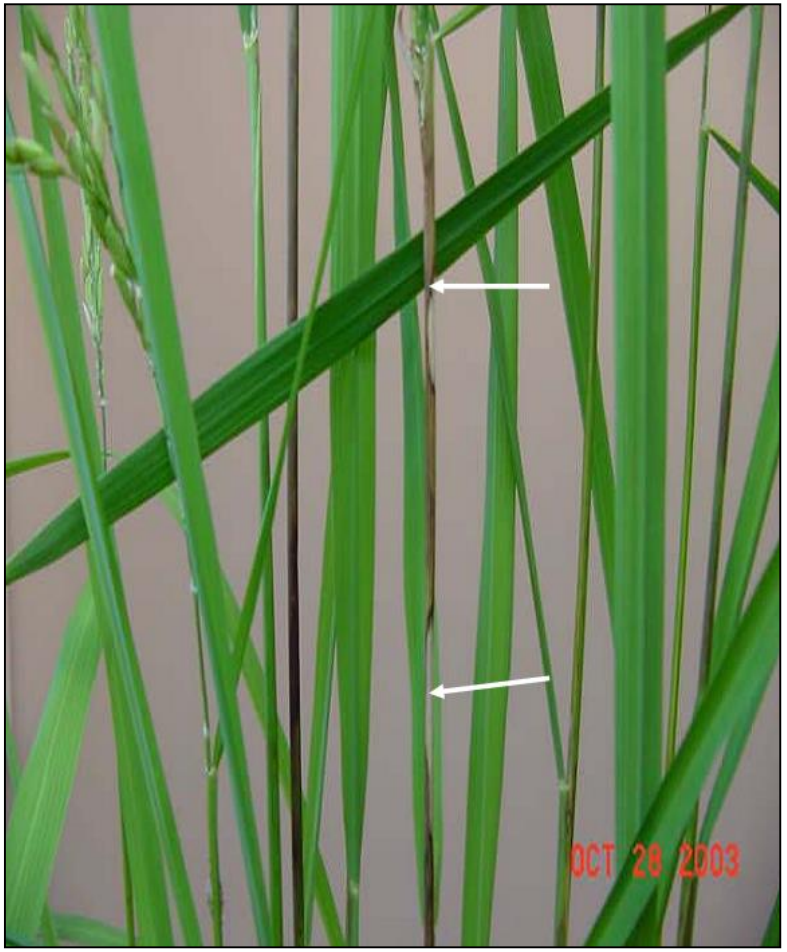
- Lesion begins as small, interveinal, water-soaked (dark green), streaks which later become translucent.
- Numerous tiny yellow beads of exudate are commonly found on the lesions.

Bacterial panicle blight

Burkholderia glumae

Flag leaf sheath rot
Burkholderia glumae

Flag leaf sheath rot, caused by *Burkholderia glumae* on inoculated Cypress rice.



Yuan,2004

Sheath rot and grain discoloration

Burkholderia glumae

Ecological diversity within the genus *Burkholderia*

- *B. glumae*: sheath rot and grain discoloration

Cottyn, 2003

T. Coenye

Sheath brown rot, grain discoloration and grain sterility

Pseudomonas fuscovaginae

***Pseudomonas fuscovaginae*: its rise not nice for Australian rice.**

Dante L. Adorada

Crown gall of roses

Agrobacterium tumefaciens

Rose plants showing crown gall at the crown and on young stems.

Scortichini,2006

Crown gall of roses

Rose plants showing crown gall at the crown and on young stems

A. tumefaciens

Mutitu and Ngaruiya

Crown Gall

Agrobacterium radiobacter (ex. *A. tumefaciens*)

Scortichini,2006

Bacterial Blight

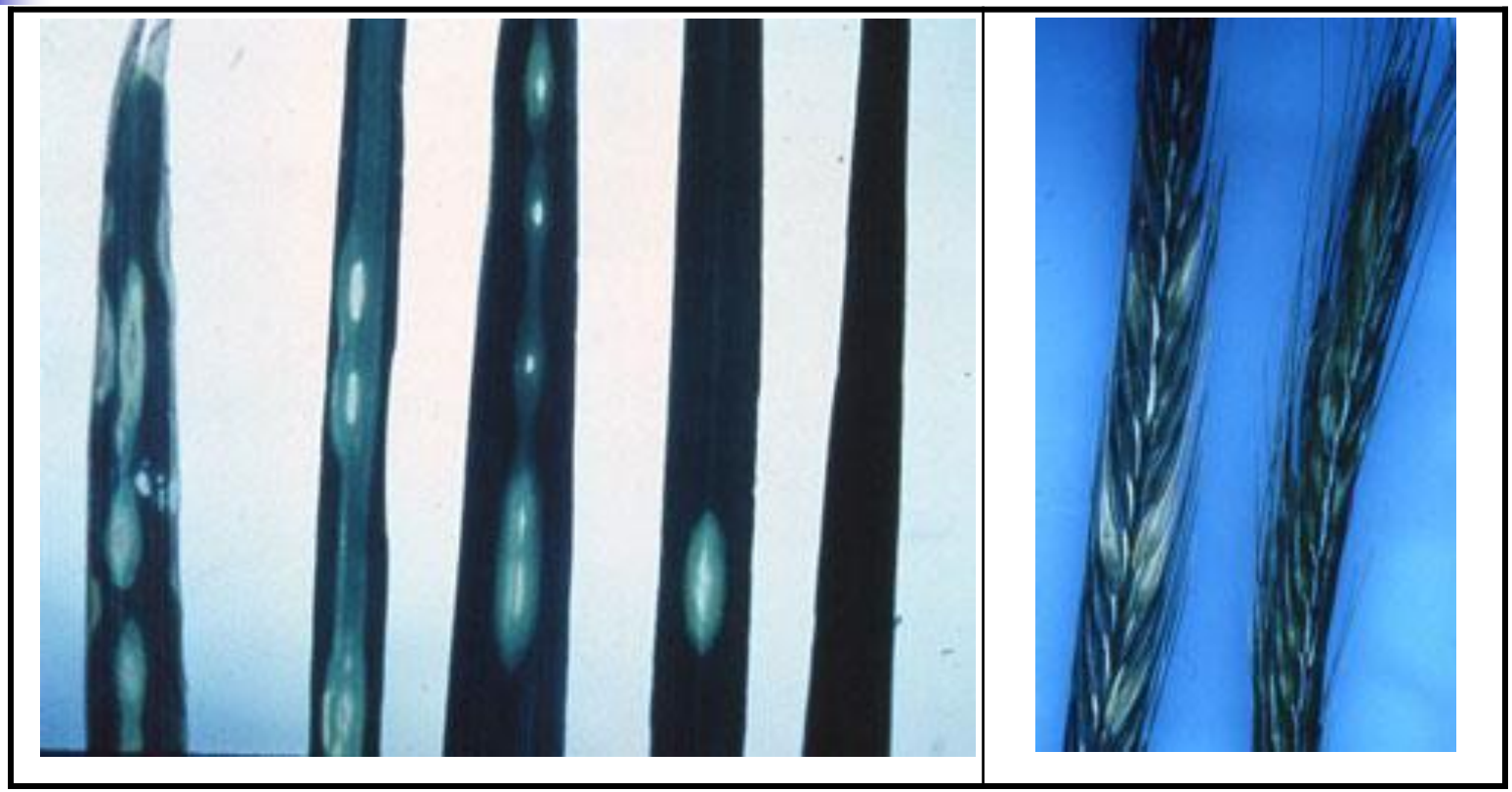
Xanthomonas translucens

- Mow infected wild grass along headlands before sowing winter rye.

Alberta,2001

Bacterial Blight or chocolate spot

Pseudomonas coronafaciens



Courtesy B. Cunfer

Bacterial soft rot

Bacillus croci and *Burkholderia gladioli* were recognized as potential saffron pathogens

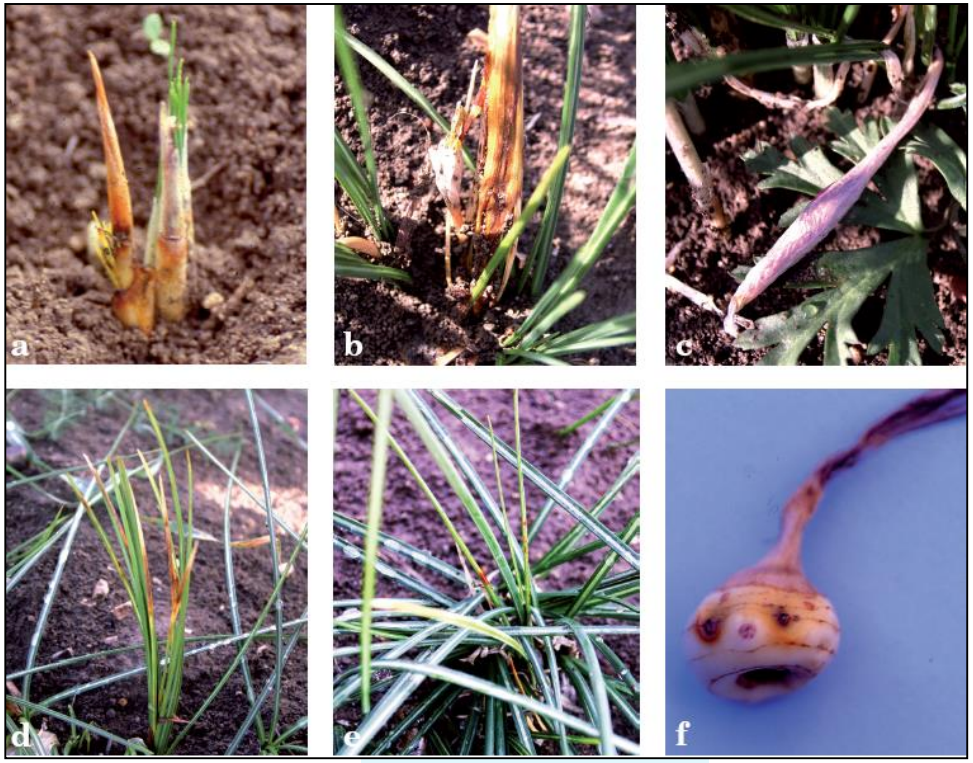
- The characteristic symptoms of the disease on saffron plants were rot of emerging shoots and leaves and spots on leaves and corms.
- In the field, the disease was destructive and reduced flowering by about 80%.

Fiori *et al.*,2011

Bacterial soft rot

Bacillus croci and *Burkholderia gladioli* were recognized as potential saffron pathogens

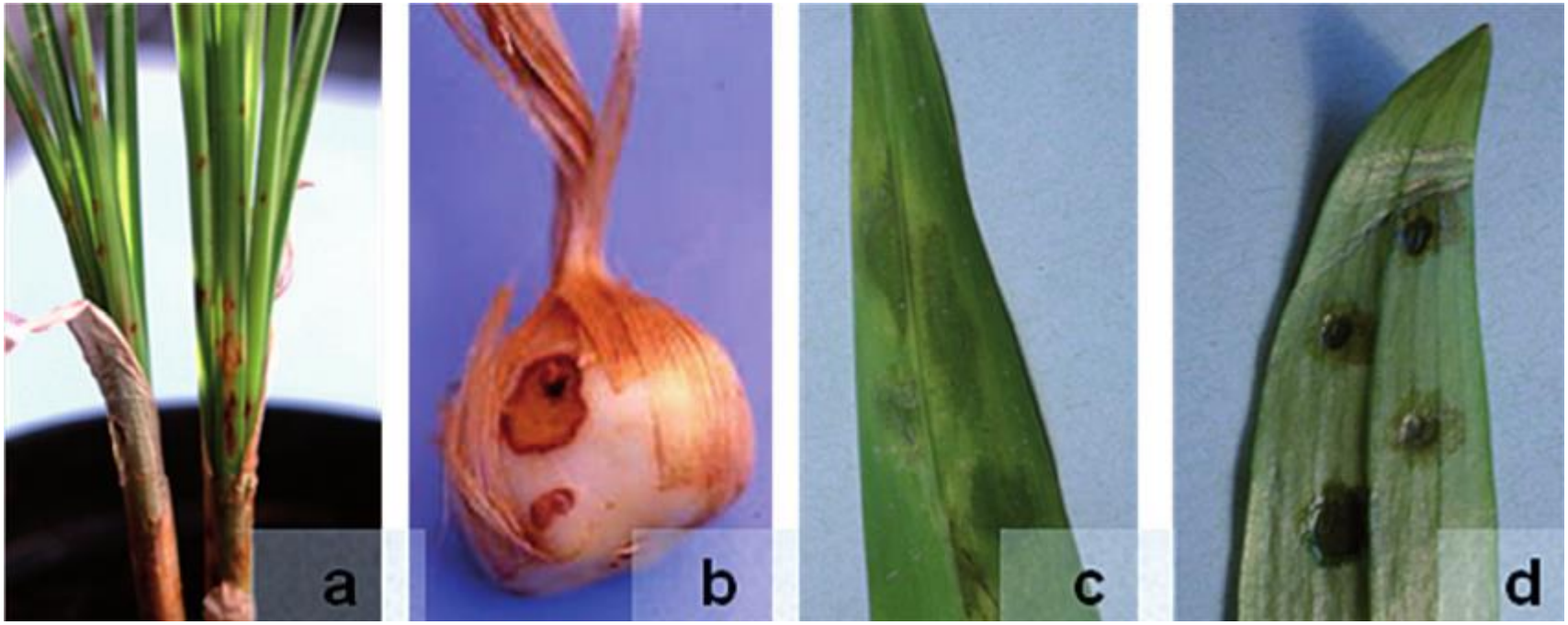
- Symptoms of bacterial soft rot in naturally infected saffron plants and corms: rot on emerging shoots, leaves and flowers (a, b and c); spots on leaves (d and e); brown marks surrounded by reddish brown halos on corm (f).



Fiori *et al.*,2011

Bacterial soft rot

Bacillus croci and *Burkholderia gladioli and B. gladioli* pv. *gladioli* were recognized as potential saffron pathogens



Symptoms of bacterial soft rot in an experimentally infected saffron plant and corm (a and b), and on gladiolus (c) and lily (d) leaves.

Fiori *et al.*,2011

Leaf spot

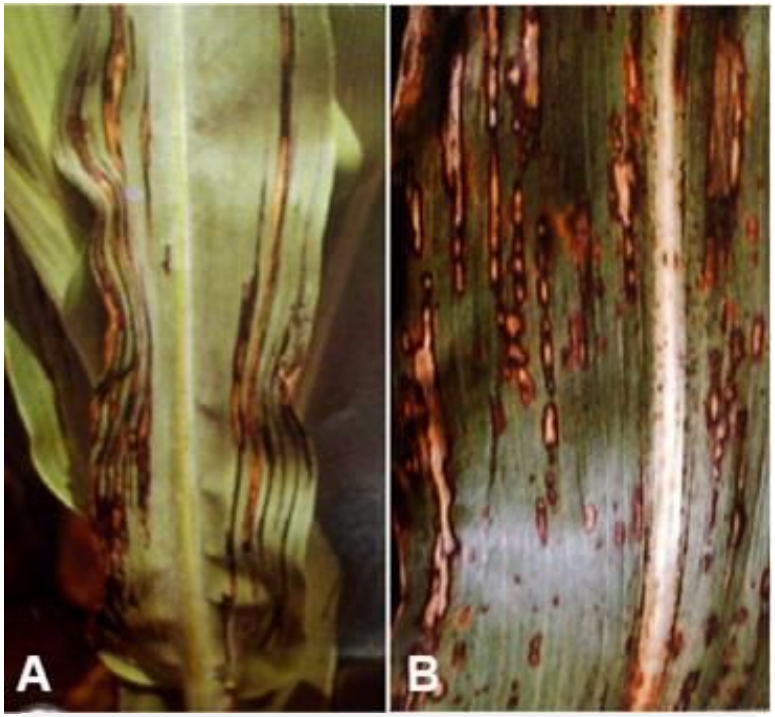
P. syringae pv. *syringae*

Bacterial leaf spot on sorghum, caused by *Pseudomonas syringae* pv. *syringae*.

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

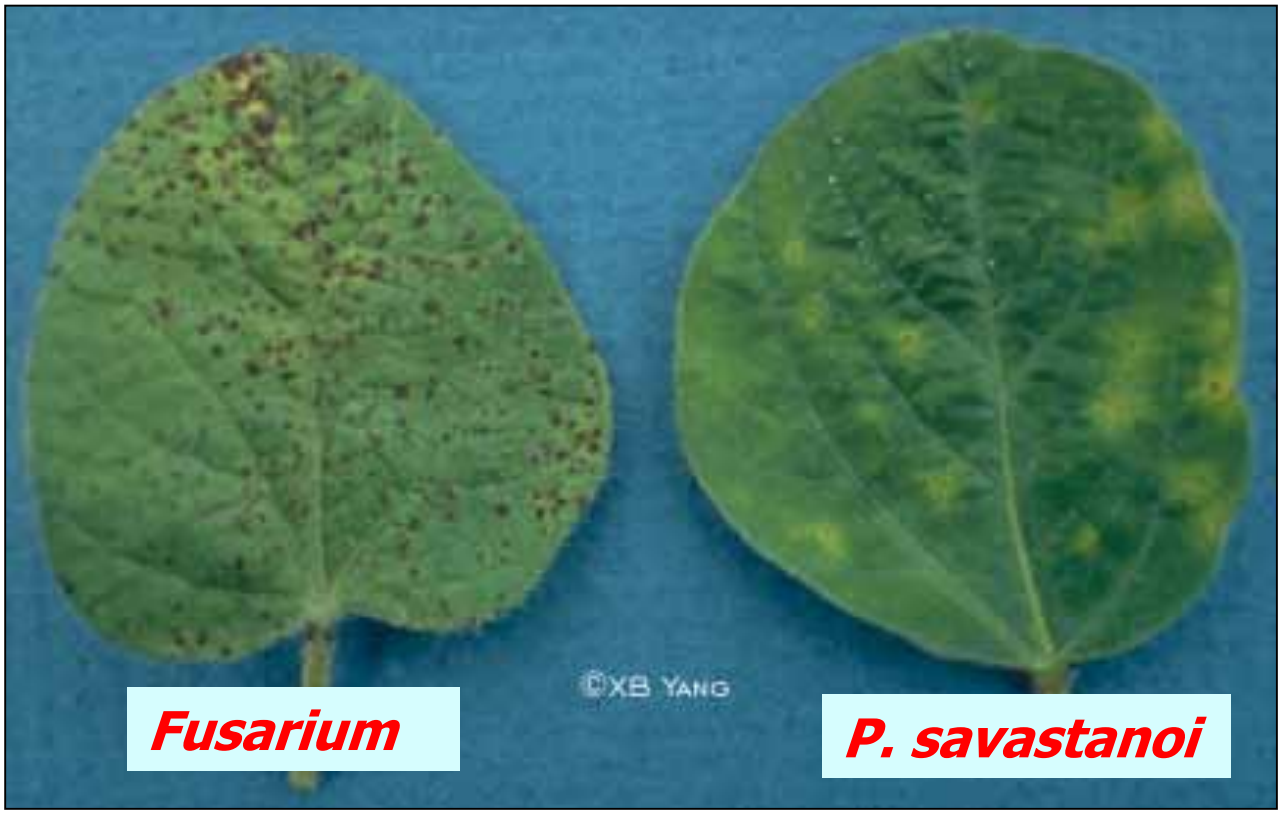
Bacterial leaf streak

Xanthomonas vasicola pv. *holcicola*



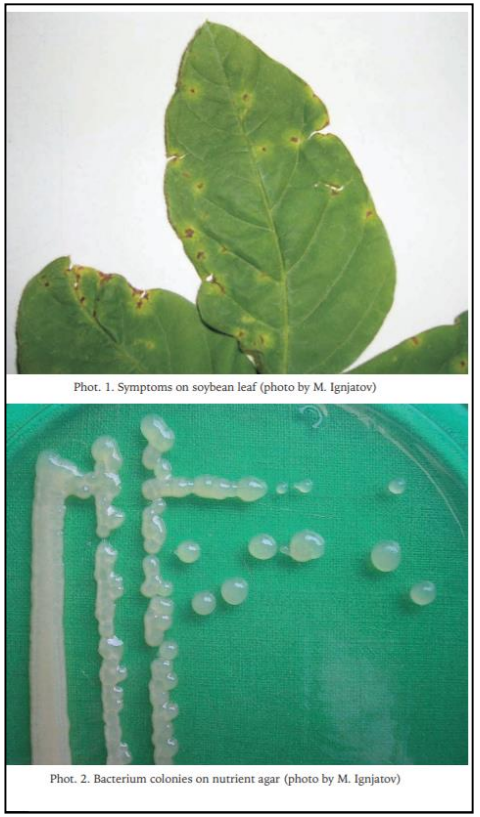
A. leaf streak and B. oval spots.
(photo: ICRISAT)

Comparison of brown spot caused by *Fusarium* and bacterial blight



Bacterial blight on soybean

P. savastanoi pv. *glycinea*



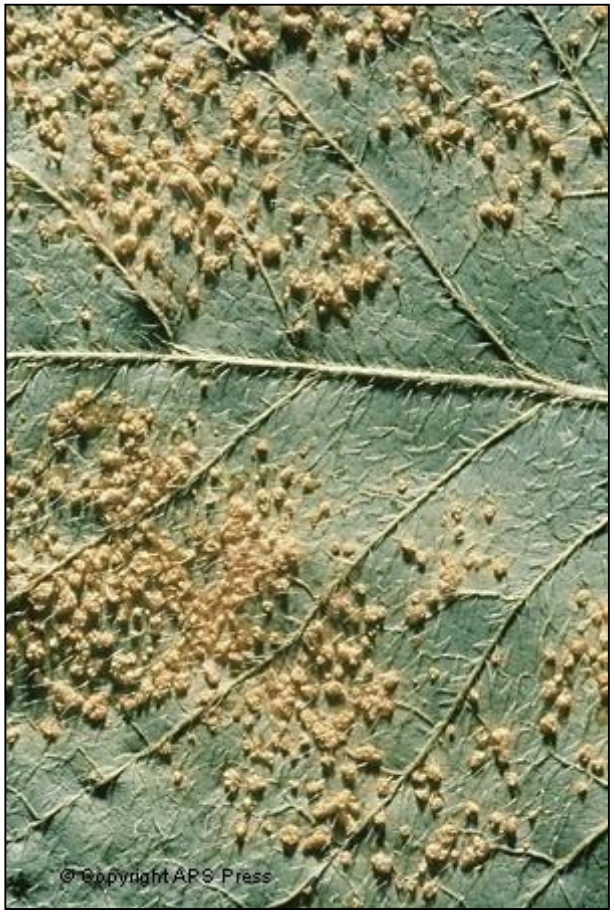
Phot. 1. Symptoms on soybean leaf (photo by M. Ignjatov)

Phot. 2. Bacterium colonies on nutrient agar (photo by M. Ignjatov)

ASGROW; Ignjatov *et al.*,2007

Bacterial pustules on soybean

Xanthomonas axonopodis pv. *glycines*



Bacterial pustules on soybean

Xanthomonas axonopodis pv. *glycines*

Bacterial Leaf Spot

Pseudomonas syringae pv. *spinaciae*

Angular, dark lesions of bacterial leaf spot caused by *Pseudomonas syringae* pv. *spinacea*.
Photo by Steven T. Koike.

US IPM Online

Cucurbit yellow vine disease

BLO

Yellowing
Phytoplasma

Aster yellows of squash, caused by the aster yellows phytoplasma.

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Bacterial diseases of Strawberry

Bacterial leaf blight of strawberry	***X. arboricola* pv.*fragariae***
Angular leaf spot of strawberry	***X. fragariae* strains**
Strawberry marginal chlorosis	**"*Candidatus* Phlomobacter fragariae"**
Fruit distortion and phyllody	**Phytoplasma**

Bacterial diseases of strawberry

Two Xanthomonas-caused diseases

1. *X. arboricola* pv.*fragariae* (bacterial leaf blight of strawberry):

- Only on some cases, induce water-soaked areas along the midribs.
- The presence of bacterial exudate was never observed.

2. *X. fragariae* strains(angular leaf spot of strawberry):

- All induce water-soaked symptoms.
- Samples with young lesions should be examined for the presence of bacterial ooze as this is the best indictor that the cause is bacterial.

Janse,2001;D. Noble

Angular Leaf Spot

Xanthomonas fragariae

Angular leaf spot lesions develop on the upper leaf as the disease progresses.
Photo by Jack Kelly Clark.

US IPM Online

Angular Leaf Spot

Xanthomonas fragariae

Scortichini,2006

Angular Leaf Spot

Xanthomonas fragariae

Bacterial ooze from *Xanthomonas fragariae* on lower leaf surface. Photo courtesy W. W. Turecheck.

IPPC,2016

Angular Leaf Spot

Xanthomonas fragariae

Angular leaf spot symptoms on strawberry calyx. Note the brown to black discoloration and drying. Photo by Michael A. Ellis.

Angular Leaf Spot

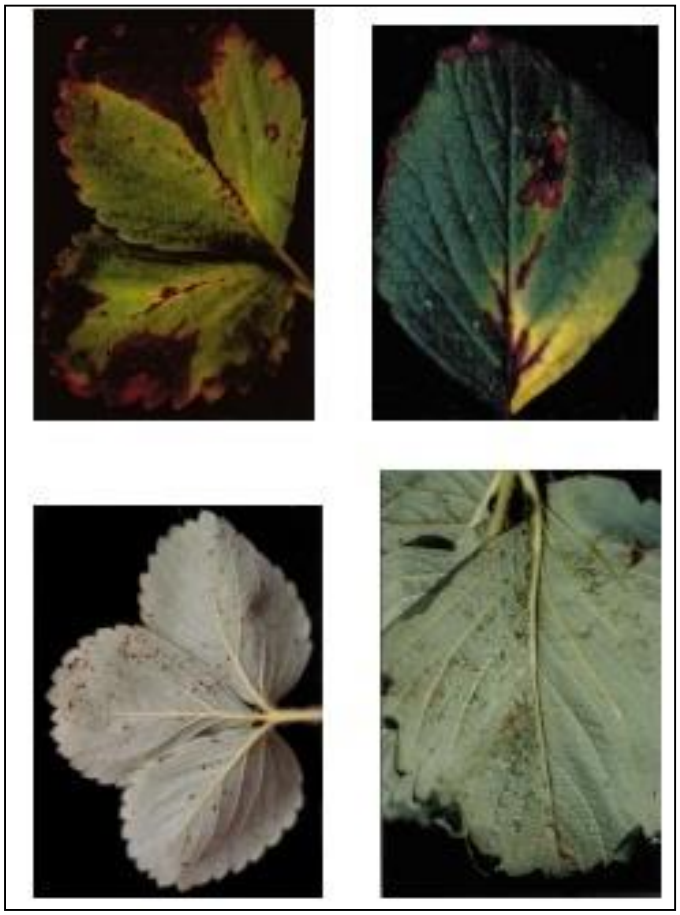
Xanthomonas fragariae

Undesirable lesions on the fruit, making it unmarketable.

Bacterial leaf blight

Xanthomonas arboricola pv. *fragariae*

- On the lower leaf surface, small, reddish-brown lesions, which were neither watersoaked nor translucent, were observed as the initial stage of the disease (Fig. 1).
- On the upper leaf surface, such lesions appeared as reddish spots.
- The presence ofbacterial exudate was never observed.
- After some time the lesions enlarged and became surrounded by a chlorotic halo.
- In some cases along the leaf margin, large brown V-shaped lesions surrounded by a chlorotic halo were also observed (Fig. 2).
- Water soaking, as found with infections of *X. fragariae* (Fig. 3).



Janse,2001

Strawberry marginal chlorosis
"*Candidatus* Phlomobacter fragariae"

Little-leaf, proliferation, malformation of fruits, and marginal chlorosis of leaves.

Tanaka *et al.*,2006

Fruit distortion and phyllody

Phytoplasma

Fruit distortion and phyllody of achenes in 'Marmolada', caused by strawberry aster yellows phytoplasma.

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Chorosis and stunting

Phytoplasma

General chlorosis and stunting of leaves in 'Redlands Crimson' strawberry, caused by phytoplasma yellows.

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Bacterial diseases of sugarbeet

Bacterial vascular necrosis and rots	*Pectobacterium betavasculorum*
Bacterial root rots	*Pectobacterium carotovorum*
Field decay of sugar beet	*P. carotovorum* subsp. *brasiliense*
Root gall on table beet	*Pantoea agglomerans* pv. *betae*
Bacterial blight	*Pseudomonas syringae* pv. *aptata*
Beet scab	*Streptomyces scabies*
Tumors on sugar beet roots	*Bradyrhizobium betae* (proposed name)
Wet rot of roots	Bacteria and yeasts
Tubercle disease/tuberculosis/ pocket disease	*Xanthomonas beticola*
Crown gall	*Agrobacterium tumefaciens*
Silvering disease	*Curtobacterium flaccumfaciens* pv. *betae*
Syndrome "basses richesses" (SBR)	SBR bacterium or SBR BLO identified as `*Candidatus* Arsenophonus phytopathogenicus

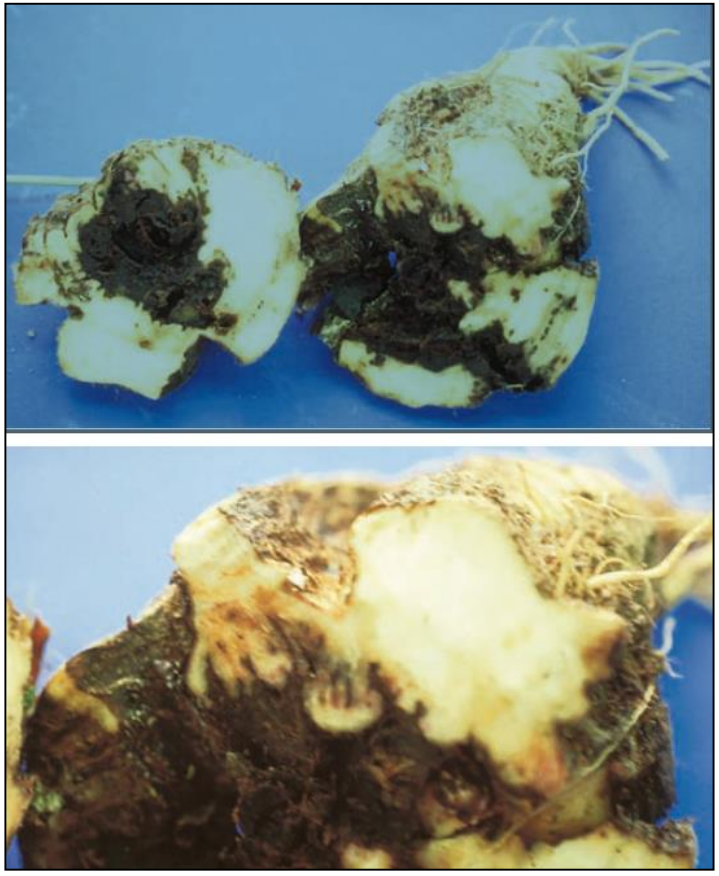
Bacterial vascular necrosis and rots (root rot)
Pectobacterium betavasculorum

- The disease is not easy to detect until the rot is well advanced.
- The vascular tissue of the root becomes discolored and a pinkish to red brown rot develops.
- Root symptoms vary from a soft rot to a dry rot; the root may become hollow without dying.
- As the disease progresses, plants wilt.
- Occasionally brown, oozing lesions occur on petioles and crown.

US IPM Online,2013

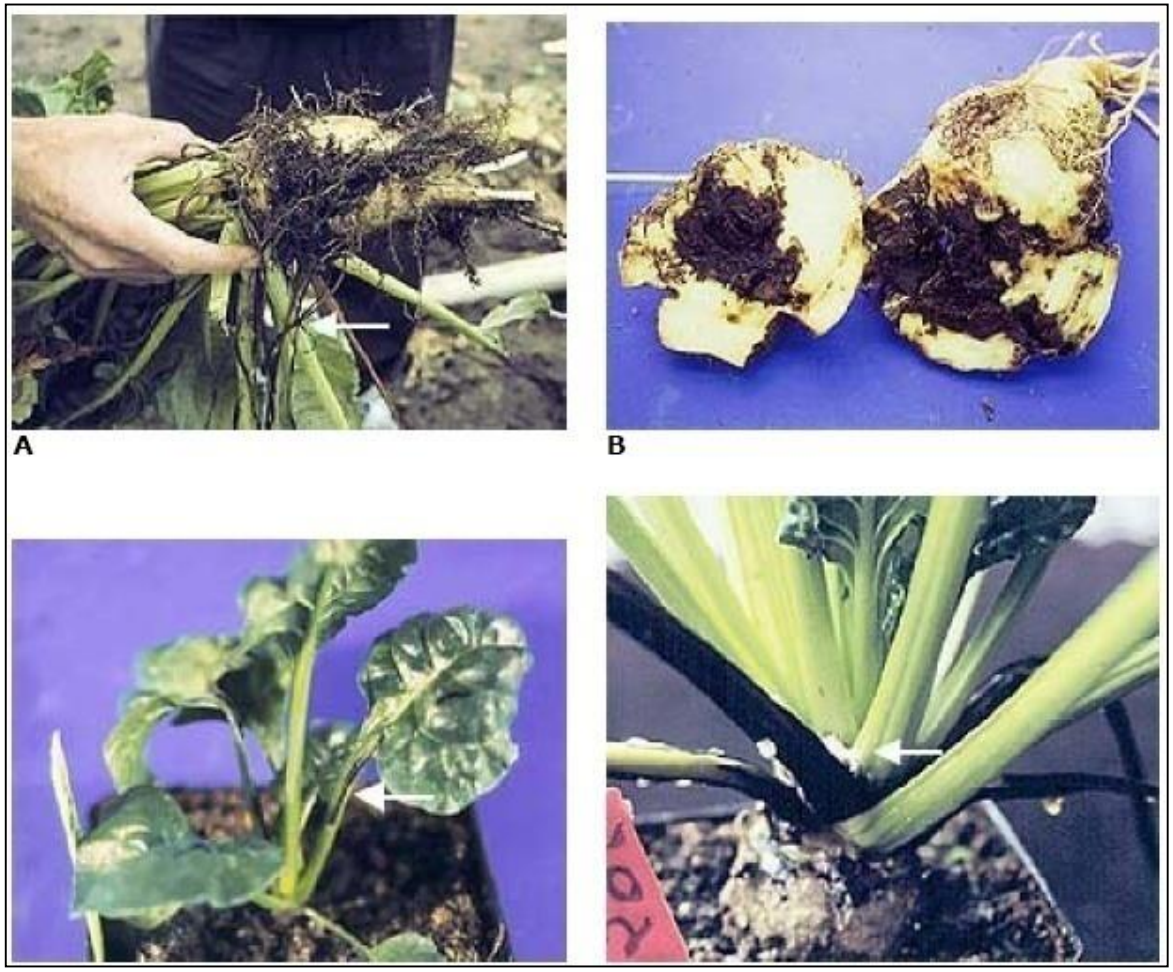
Bacterial vascular necrosis and rots (root rot)
Pectobacterium betavasculorum

- Top picture: Typical root rot symptoms of beet vascular necrosis and rot.
- Below picture: Root rot symptom and pink discoloration caused by beet vascular necrosis and rot.



Franc co-workers

Bacterial vascular necrosis and rots (root rot)
Pectobacterium betavasculorum



Zidack *et al.*,2001

Bacterial blight/leaf spot

Pseudomonas syringae pv. *aptata*

Howard F. Schwartz

Tubercle disease/tuberculosis/ pocket disease
Xanthomonas gall disease
Xanthomonas beticola

- Big galls observed on sugar beet roots, right- cross cut of the gall (Kłodawa, Poland).

The disease symptoms take the form of multiple nodules grown on the upper surface of the roots. In extreme cases, roots with a large number of tumors are strongly deformed. Occasionally the disease can be confused with the tuberosity of the roots caused by *Agrobacterium radiobacter* (syn. *Agrobacterium tumefaciens*).

Moliszewska *et al.*,2016

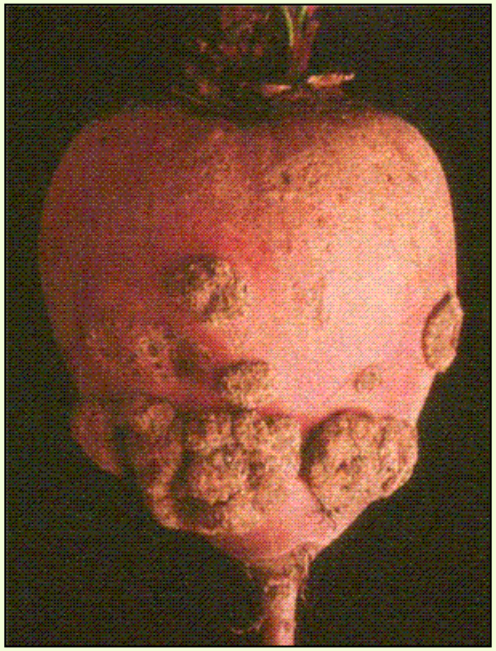
Crown gall
Agrobacterium tumefaciens

- Globular outgrowth on the upper part of the beet.

Beet scab

Streptomyces scabies

- Beet scab symptoms (Washington State Univ.).



Brooke Edmunds

Bacterial leaf spot

Curtobacterium flaccumfaciens pv. *betae*

- Symptoms of sugar beet bacterial leaf spot caused by the new pathovar, *Curtobacterium flaccumfaciens* pv. *betae*.
- A, Field symptoms; B, symptoms on leaves.

Chen and Yin,2007

Wet rot of roots

Bacteria and yeast associated with sugar beet root rot at harvest

- Bacteria:
- *Lactobacillus*, *Leuconostoc*, *Acetobacter*, *Gluconobacter*, *Enterobacter*, *Escherichia*, *Pectobacterium*, *Serratia*, *Pseudomonas*
- Yeast:

1. *Pichia*
2. *Candida*

- isolated from harvested sugar beet.

Strausbaugh and Gillen,2008

The Syndrome

"Basses Richesses" of Sugar (SBR)beet

SBR BLO or *Ca.* Arsenophonus phytopathogenicus

- The disease of sugar beet known as the syndrome "basses richesses" (SBR).
- It mainly is associated with an uncultivable phloem-restricted bacterium-like organism (BLO) called SBR BLO or SBR bacterium and identified as '*Candidatus* Arsenophonus phytopathogenicus.
- SBR symptoms appear in late summer.
- SBR causes a loss of taproot sugar content.
- A brownish discoloration of vascular tissues, seen after cutting the tap root, is the most characteristic symptom of plants affected by SBR.

Sémétey *et al.*,2007;Bressan *et al.*,2009

Bacterial diseases of sugarcane

Bacterial mottle	***Dickeya chrysanthemi***
False red stripe	***Xanthomonas* sp.**
Gumming (Yellow slime)	***Xanthomonas axonopodis* pv. *vasculorum***
Leaf scald	***Xanthomonas albilineans***
Mottled stripe	***Herbaspirillum rubrisubalbicans***
Ratoon stunt or ratoon stunting disease (RSD)	***Leifsonia xyli* subsp. *xyli***
Red streak	***Pseudomonas syringae* pv. *syringae***
Red stripe (Top rot)	***Acidovorax avenae* subsp. *avenae***
White leaf	**Phytoplasma**

Leaf scald
X. albilineans

- Leaf scald was first recognized as a bacterial disease of sugarcane in the 1920s.
- It is a vascular disease caused by *Xanthomonas albilineans*.
- The disease has been found in at least 55 countries.

Pencil-line mark on sugarcane leaf caused by leaf scald disease.

Comstock and Lentini,2005

Leaf scald

Xanthomonas albilineans

Withered top leaves of a sugarcane stalk with leaf scald disease (*Xanthomonas albilineans*).

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Leaf scald

Xanthomonas albilineans

Characteristic white pencil lines and extensive chlorosis of emerging leaves in the chronic form of sugarcane leaf scald disease, and side shoots on a more severely diseased plant.

Acute leaf scald symptoms, including wilting, in-arching and death of leaves in sugarcane.

Birch,2001

Sugarcane Red stripe

Acidovorax avenae subsp. *avenae* = *P. rubrilineans*

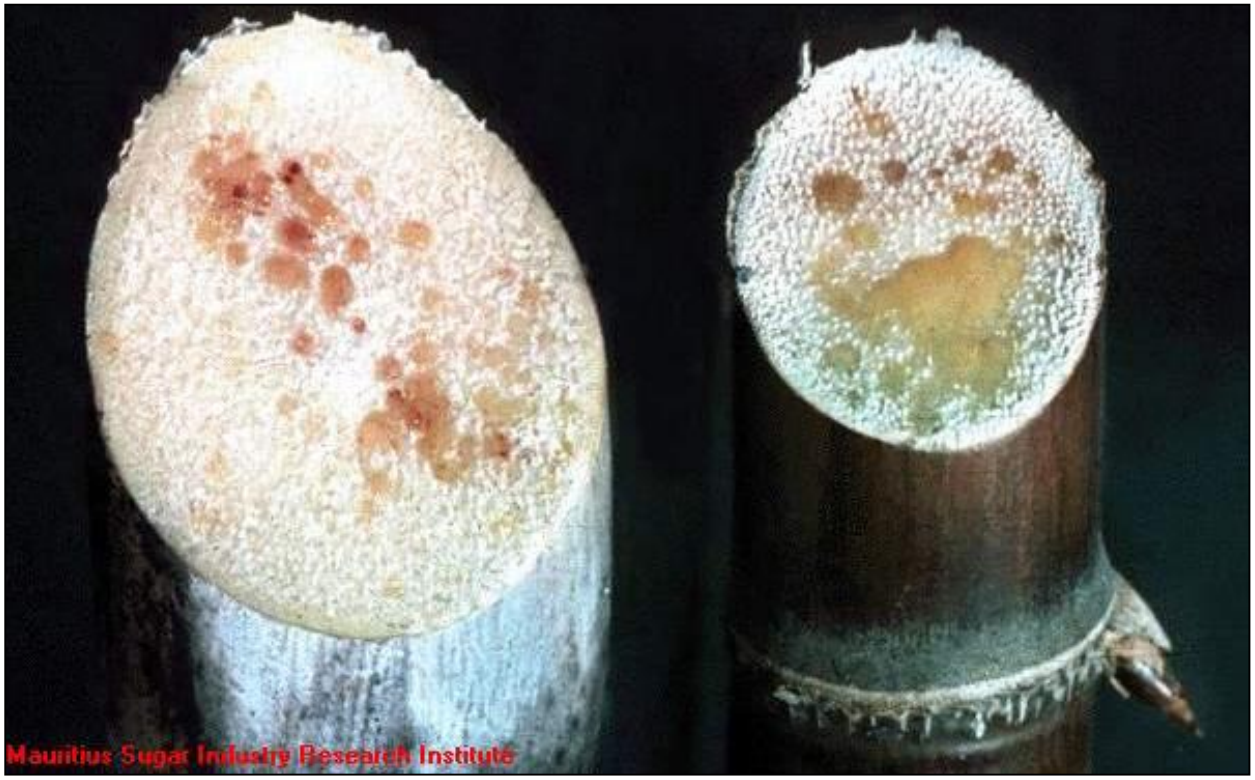
- The stripes appear as water soaked, long, narrow chlorotic streaks and become reddish brown in few days.
- These stripes run parallel to the midrib.
- Yellowish stripes develop, which later turn reddish brown.
- The rotting may commence from the tip of the shoot and spreads downwards.

agridr.in/tnauEAgri/eagri50/PATH272/lecture06/lec07;APS

Gumming (Yellow slime)
Xanthomonas axonopodis pv. *vasculorum*

Symptoms of gumming disease on sugarcane leaf: Foliar symptoms of gumming disease.

Gumming (Yellow slime)
Xanthomonas axonopodis pv. *vasculorum*



Symptoms on stalks: Yellow bacterial slime exuding from sugarcane stalks infected with *X. axonopodis* pv. *vasculorum*.

Ratoon stunting of sugarcane

RSD

Leifsonia xyli subsp. *xyli*

- Sugarcane plants issued from disease-free seed cane (left) versus sugarcane plants with reduced growth that are issued from seed cane infected by the RSD pathogen (right).

Rott *et al.*,2012

Sugarcane ratoon stunt disease

Leifsonia xyli subsp. *xyli*

- RSD produces no visible symptomes other than stunting.
- The only other visible symptoms are red-orange dots or commas in the vascular traces in the nodal tissue (which can be seen when stalks are sliced with a sharp knife).

Ibrahim and coworkers

Bacterial blight of sunflower

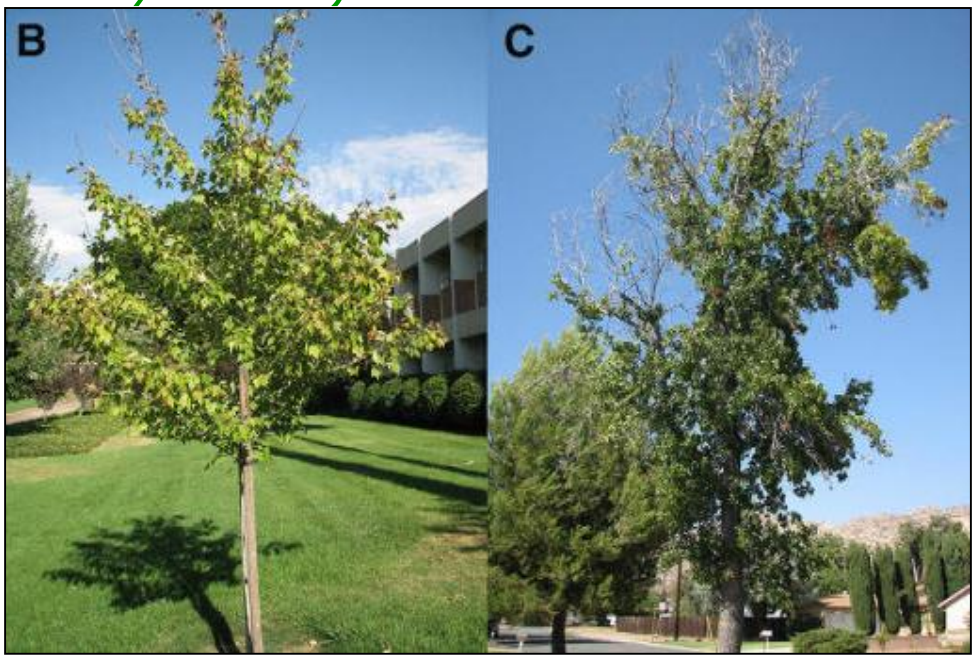
Xanthomonas campestris pv. *silvia*

Romeiro,2010

Bacterial leaf scorch

Xylella fastidiosa subsp. *multiplex*

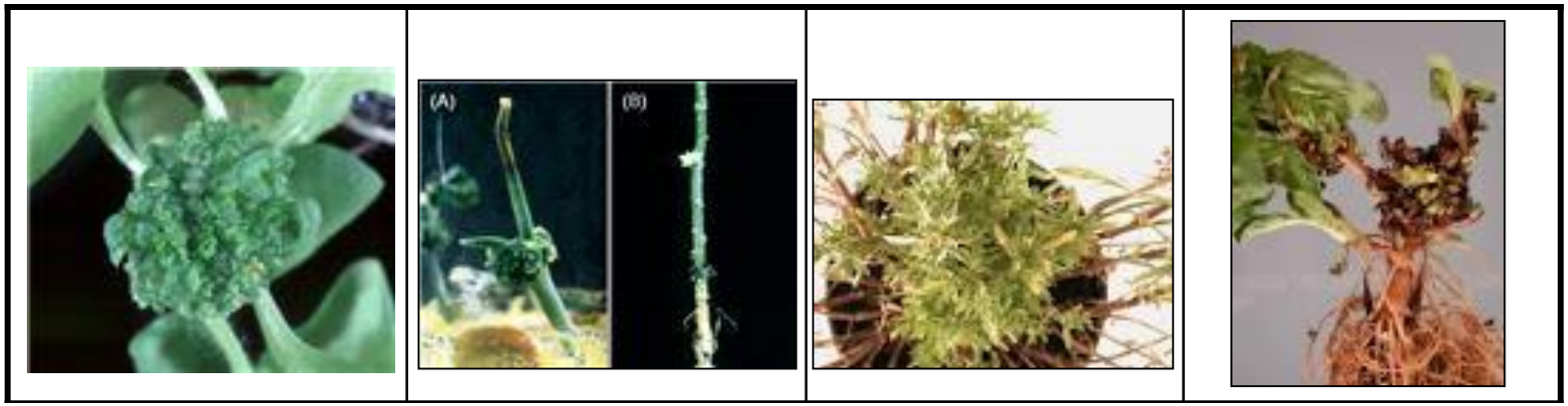
- Symptomatic native hosts of *Xylella fastidiosa* subsp. *multiplex* in the United States.
- B and C show symptomatic young and established sweetgum (*Liquidambar styraciflua*) trees.



Almeida and Nunney,2015

Leafy gall of sweet pea

Rhodococcus fascians



Sycamore with leaf scorch symptoms *Xylella fastidiosa*

- *Platanus* spp. are often known in English as planes or plane trees.
- Some North American species are called sycamores (especially *Platanus occidentalis*.
- Although the term sycamore also refers to the fig(*Ficus sycomorus*), and maple (*Acer pseudoplatanus*).

Janse,2009; Wikipedia,2018

Sycamore with leaf scorch symptoms

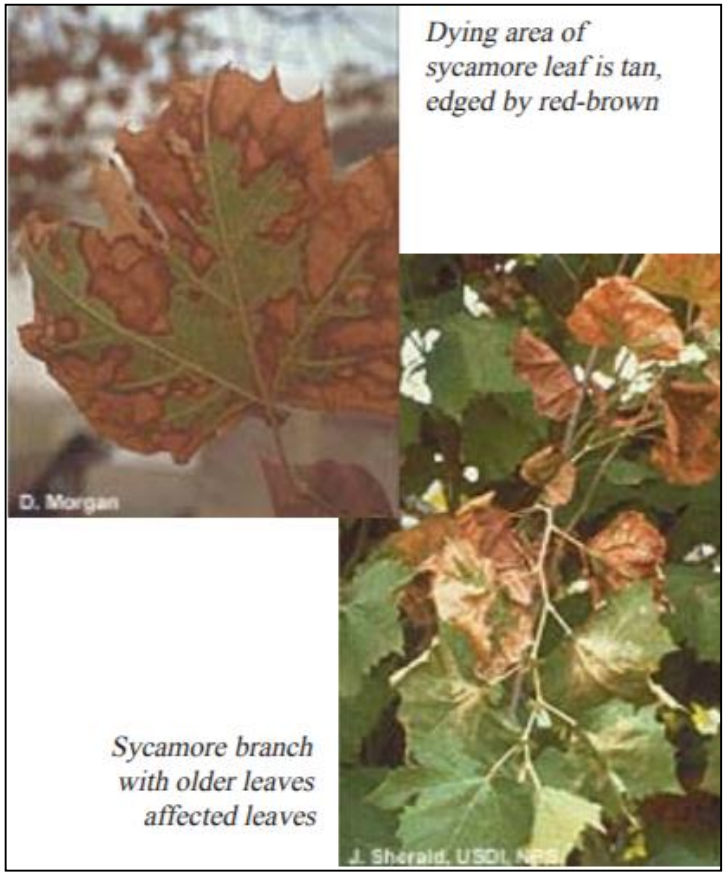
Xylella fastidiosa

- On sycamore leaves, the areas between the larger veins turn brown but veins themselves remain green. Scorched leaves often curl upward from the edge.
- On oak and sycamore, the leaves stay on the tree until fall.
- The development of scorch symptoms on the leaves is often intensified by drought and other environmental conditions.
- Over a period of several years, symptoms gradually develop on other branches of a diseased tree.
- Growth of leaf scorch-damaged trees slows and diseased limbs start to dieback.
- The decline of diseased oak and sycamore is particularly rapid.

Janse,2009; joanna@woodlandtree.com

Sycamore with leaf scorch symptoms
Xylella fastidiosa

- Initially, leaves on only one or a few branches may be affected.
- With time, symptoms may appear on other branches of the tree.
- Symptoms tend to begin with older leaves on a branch and then develop in younger leaves.
- As a result, younger leaves at the ends of sycamore branches may appear healthy.
- Over several years, entire branches may die. The resulting tree decline may require removal of the infected tree.



James L. Sherald; Clemson University,2015

Bacterial blight

Xanthomonas axonopodis pv. *dieffenbachiae*

Bacterial leaf blight (*Xanthomonas* sp.) on syngonium showing angular, water-soaked areas on leaves that become yellow, then brown dry and papery.

Bacterial blight

Xanthomonas axonopodis pv. *dieffenbachiae*

White shoots of Canada thistle

Pseudomonas syringae pv. *tagetis*

- The causal agent of this pathogen is a soil borne bacteria called *Pseudomonas syringae* pv. *tagetis* (Pst).
- It causes apical chlorosis (white or bleached-out in appearance) in Canada thistle (*Cirsium arvense*) and certain other composite weeds due to the production of tagetitoxin, a RNA polymerase III inhibitor that blocks chloroplast biogenesis.

Curran,2001

Timoty grass- *Phleum pratense*

Leaf spot

Xanthomonas translucens pv. *graminis*

A. Sletten

Tobacco bacterial diseases

Wild fire	***P. syringae* pv. *tabaci***
Granville wilt	***Ralstonia solanacearum*, race 1**
Stolbur phytoplasma disease	***Candidatus* phytoplasma solani**

Wild fire

P. syringae pv. *tabaci*

Light brown, necrotic spots surrounded by yellow halos, caused by bacterial wildfire (*Pseudomonas syringae* pv. *tabaci*).

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf; Gáborjányi,2010

Wild fire

P. syringae pv. *tabaci*

Danny Vereecke

Granville wilt

Ralstonia solanacearum, race 1

Stem pith with typical Granville wilt symptoms.

Stem pith with typical Granville wilt symptoms.

Mila,2010,

Stolbur phytoplasma on tobacco

Candidatus phytoplasma solani

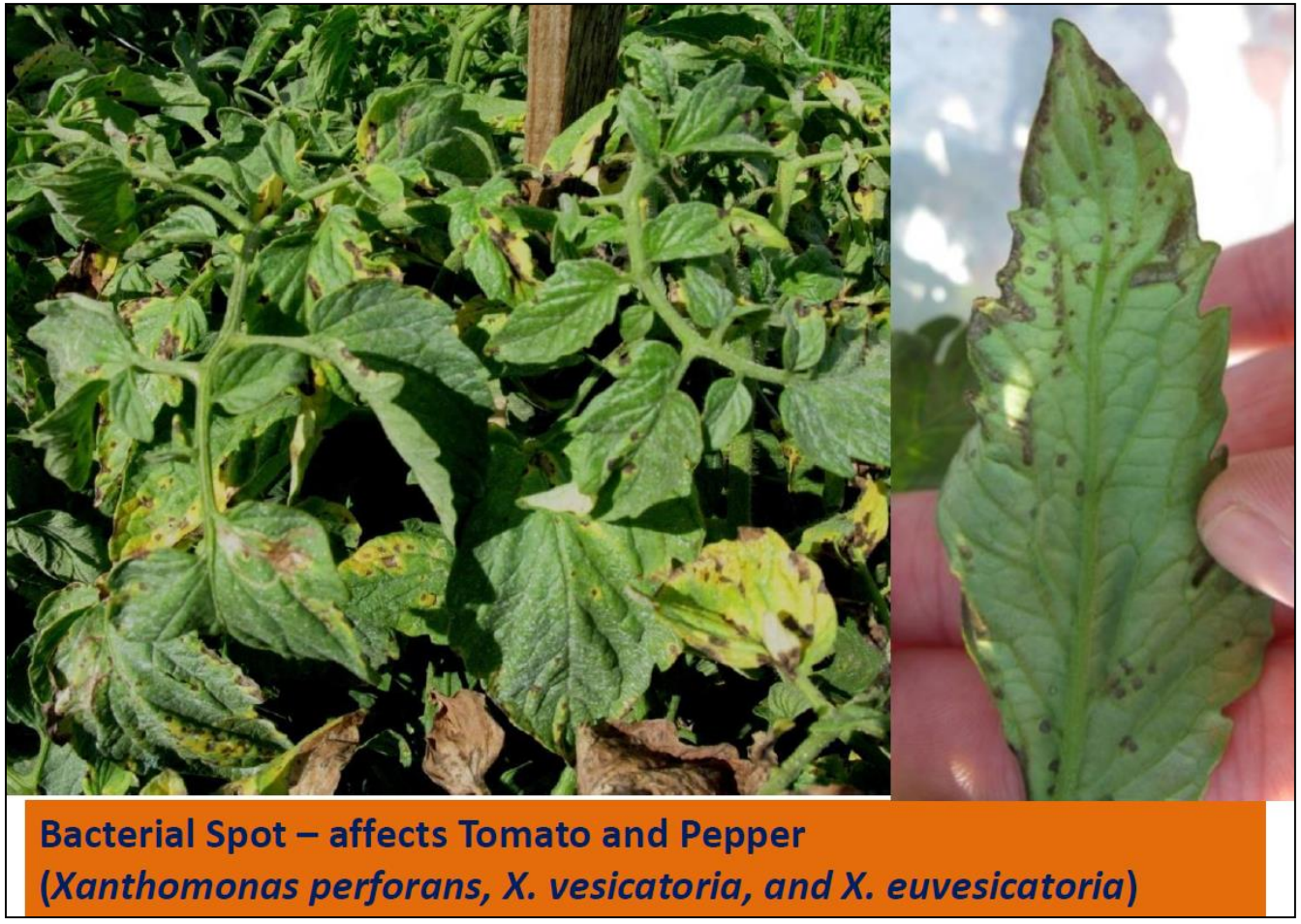
Gáborjányi,2010

Tomato Diseases

Bacterial leaf spot	***Xanthomonas euvesicatoria; X. vesicatoria; X. perforans ;X. gardneri***
Bacterial speck	***P. syringae* pv. *tomato***
Bacterial canker	***Clavibacter michiganensis***
Bacterial wilt	***Ralstonia solanacearum***
Crown gall	***Agrobacterium tumefaciens***
Pith necrosis	***Pseudomonas mediterranea/ P. corrugata***
Rot	***P. carotovorum; D. chyrsanthemi***
Tomato stolbur and tomato big-bud	**Phytoplasma diseases**

Tomato leaf spot

Xanthomonas perforans, X. vesicatoria, and *X. euvesicatoria*

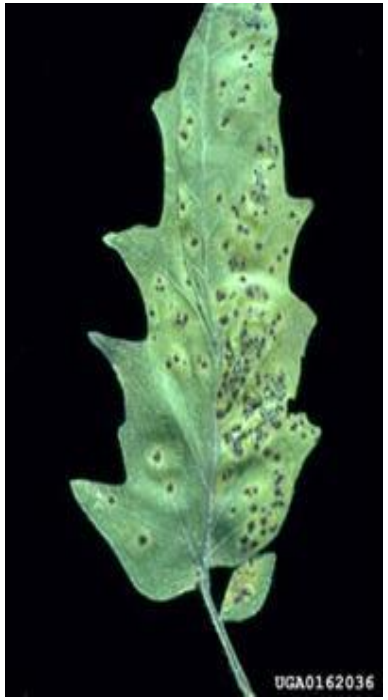


Bacterial Spot – affects Tomato and Pepper
(*Xanthomonas perforans, X. vesicatoria, and X. euvesicatoria*)

Gary Vallad

Tomato leaf spot

Xanthomonas perforans, X. vesicatoria, and *X. euvesicatoria*



- Bacterial spot of tomato caused by *Xanthomonas vesicatoria*.
- The bacterium affects all above-ground plant parts.
- On the leaves, spots are generally brown and circular.

Tomato leaf spot

Xanthomonas perforans, X. vesicatoria, and *X. euvesicatoria*

Tomato bacterial spot

Xanthomonas perforans

Bacterial leaf speck

P. syringae pv. *tomato*

Bacterial speck lesions on tomato and fruit foliage.

Bacterial leaf speck

P. syringae pv. *tomato*

Bacterial speck lesions on tomato and fruit foliage.

Leaf spot

P. syringae pv. *syringae*

- Similar leaf spots caused by a similar pathogen:
- *Pseudomonas syringae* pv. *syringae* (*Pss*).

Leaf spot

P. syringar pv. *syringae*

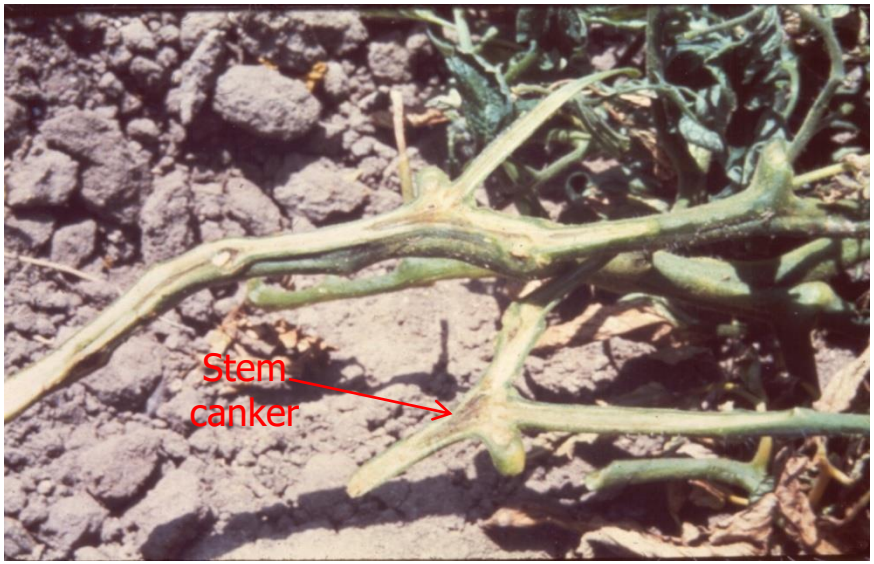
Tomato canker

Clavibacter michiganensis

- Causes tomato stems to wilt and rot.
- Survives well on stems and leaves.
- Major difference between subspecies is that Cs has many copies of an insertion element lacking from Cm.

Tomato canker

Clavibacter michiganensis



De La Fuente,2009

Wilting, stunting, yield loss, death

Tomato canker

Clavibacter michiganensis

Bacterial canker lesions on tomato fruit.

Tomato canker

Clavibacter michiganensis

Tomato canker

Clavibacter michiganensis

- Bacterial canker symptoms on tomato leaflet, showing yellow border between live and dead tissue.

Tomato canker

Clavibacter michiganensis

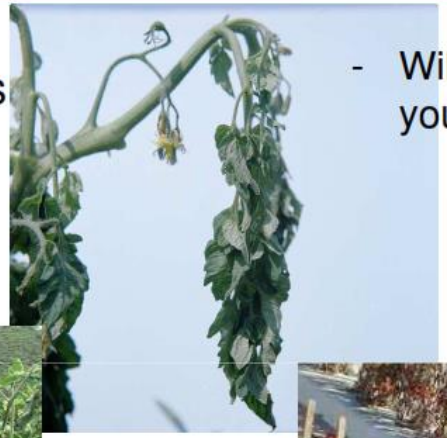
Bacterial wilt

Ralstonia solanacearum

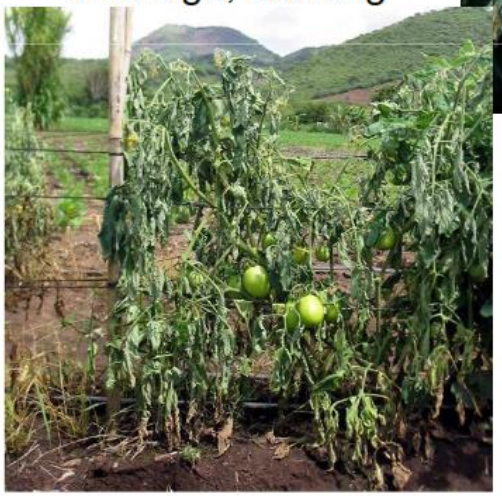
Description of the disease

- Common symptoms

- Wilting of youngest leaves



- Wilting and yellowing of foliage, stunting



- Plant death

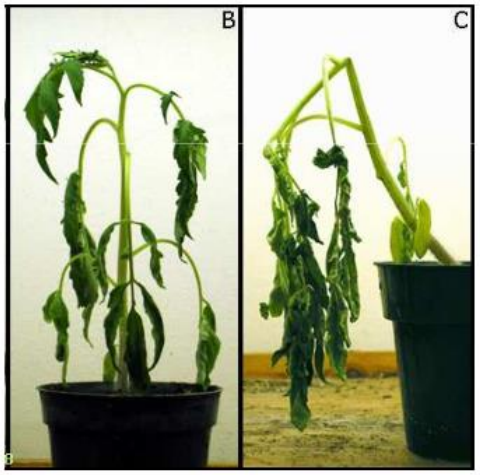
Champoiseau *et al.*,2009

Bacterial wilt

Ralstonia solanacearum

Description of the disease

- Other symptoms
  - Brown discoloration of vascular tissue



- Stem collapse (young succulent plants)

Symptoms induced by race 3 biovar 2(R3b2) cannot be distinguished from those induced by race 1 strains.

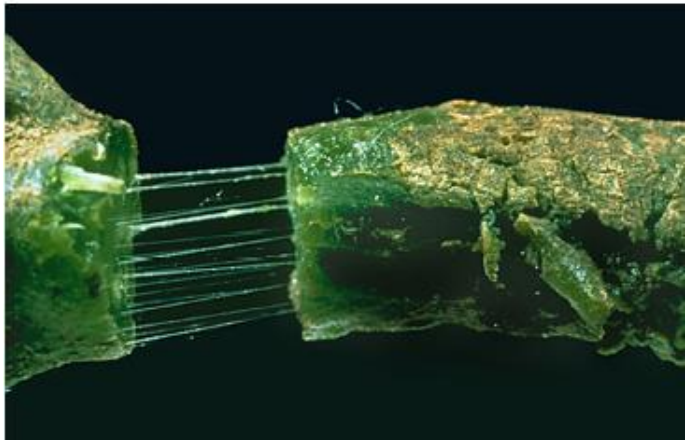
Champoiseau *et al.*,2009

Bacterial wilt of tomato

Ralstonia solanacearum

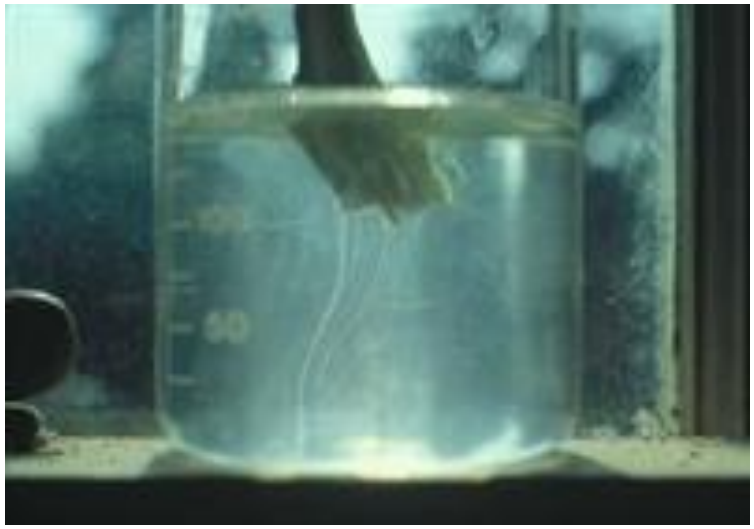
Bacterial wilt

Ralstonia solanacearum

	
The vascular system becomes dark brown as the disease progresses.	**Milky white streaming of bacteria from cut tomato stem.**

Bacterial wilt

Ralstonia solanacearum

	
Infected stem tissue.	**White bacterial streaming from the stem indicates presence of bacteria in the plant.**

Bacterial wilt of tomato

Ralstonia solanacearum

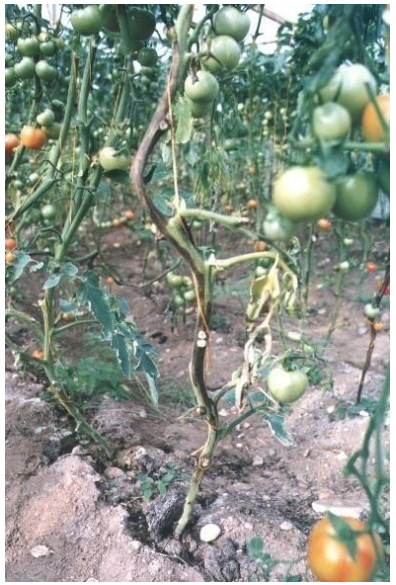
Pith necrosis

Pseudomonas mediterranea/P. corrugata

- Brown water-soaked and dry pith necrosis of the stem of tomato seedling inoculated with *Pseudomonas mediterranea*.

Tomato pith necrosis

P. corrugata, P. viridiflava & P. cichorii



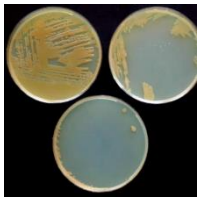
P. viridiflava - wide host range

P. corrugata - limited host range

P. cichorii - wide host range

Tomato pith necrosis

Pseusomonas corrugata



P. corrugata

Left: Wilting, drying and dying of tomato plant.

Middle: Brown to black streak along the length of the stem of tomato plant with symptoms of wilting and drying of leaves.

Right: Disintegration of the cortical tissue and its sloughing off at the base of tomato plant with symptoms of wilting and drying of leaves(Kůdela *et al.*,2010).

Soft rot

Pectobacterium spp.

Bacterial soft rot of tomato, caused by *Erwinia* sp.

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Tomato big bud

Phytoplasma

Tomato big bud causing swollen green flower buds, caused by phytoplasma.

plp3002.ifas.ufl.edu/pdfs/slides/bacterial_diseases.pdf

Tomato big bud

Phytoplasma

- The most striking symptom of tomato big bud is the large, swollen green buds that fail to develop normally and do not set fruit.

Tomato

Mottling of leaves, curling of midveins and stunting of tomato '*Candidatus* Liberibacter solanacearum'

Liefting

Mottling of leaves, curling of midveins and stunting of tomato

'*Candidatus* Liberibacter solanacearum'

Liefting

Tomato plants infected with stolbur phytoplasma and showing sepal hypertrophy symptoms

Candidatus phytoplasma solani

ÇAĞLAR *et al.*,2010

Tulip-*Tulipa* spp.
Family Liliaceae (Lily family)

Tulip bacterial diseases

- Tulips are affected by fungal, bacterial and viral diseases.
- Many tulip diseases start right at the bulb.
- Bacteria are the killer disease for tulips.

Yellow pustule and hellfire disease	***Curtobacterium flaccumfaciens* pv. *oortii***
Soft rots	***Dikeya dadantii* (*Erwinia chrysanthemi*)**
Bacterial leaf and peduncle soft rot	***Pectobacterium carotovorum***
Two postharvest diseases of tulip bulbs: **Black rot** **Brown rot**	***Burkholderia andropogonis*** ***B. gladioli* pv. *gladioli***

Morikawa *et al.*,1996; Boyraz *et al.*,2006; Tulip Facts,2015

Yellow pustule and hellfire

Curtobacterium flaccumfaciens pv. *oortii*

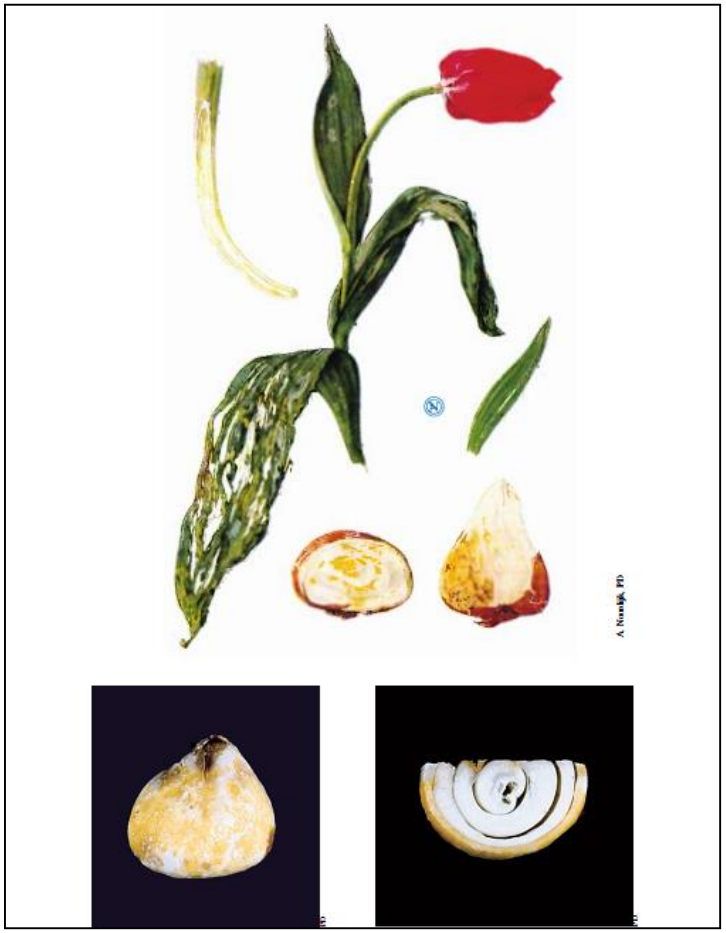
- Symptoms of the disease included 5mm long grey-white streaks along the vascular tissue of leaves and flower stems.
- The leaves turned dull grey-green, could have raised pustules, and eventually became torn.
- The leaf infection is called "tulip fire.
- Infected roots had white pustules beneath a brown covering.

Brother and Alex,1980

Yellow pustule and hellfire

Curtobacterium flaccumfaciens pv. *oortii*

- Top: Leaf symptoms: silver grey stripes and cracks along the main vein (called hell fire) and yellow pustules on the outer white scales of the bulbs. Yellow discoloration of the vascular tissue in stems and bulbs. Colour drawing.
- Bottom: Natural infection. Pustules on outer scale (left) and yellow discoloration of vascular and surrounding tissue of outer scale (right).

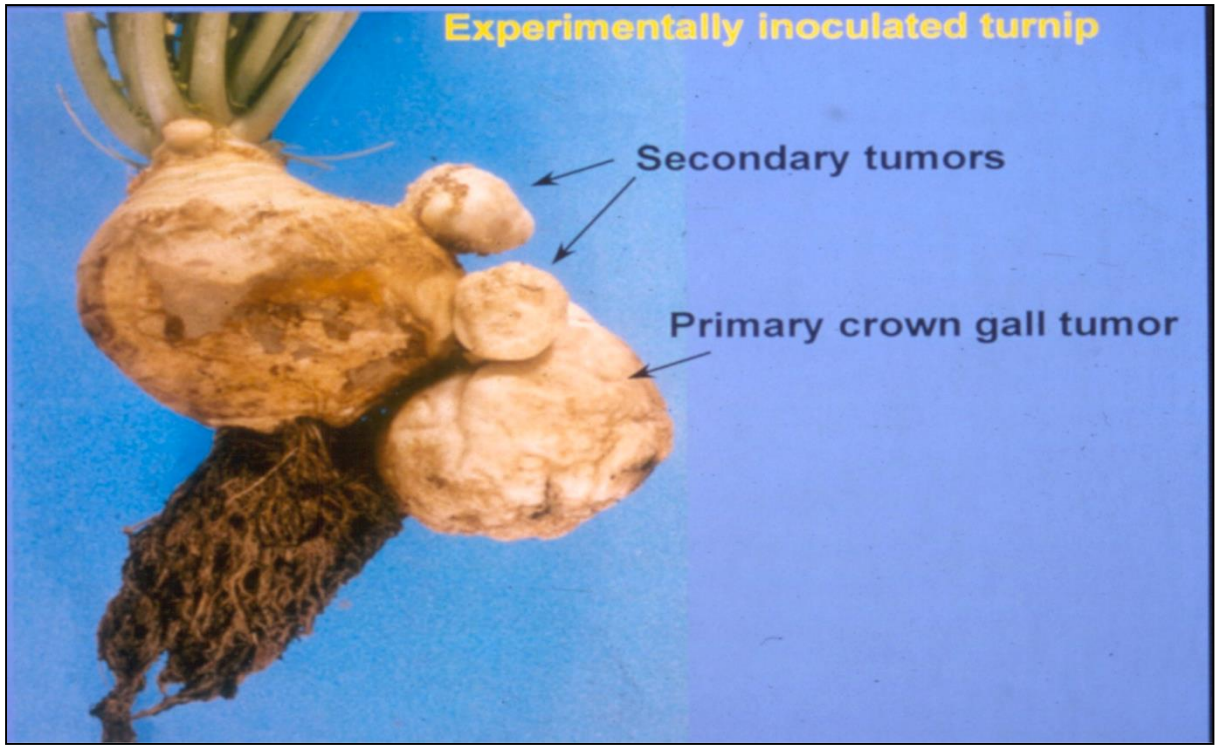


Janse,2006

Turnip, turnip or white turnip -*Brassica* subsp.*rapa*

Crown gall

A. tumefaciens



Aster yellows

Phytoplasma

Aster yellows symptoms on *Catharanthus* (Vinca).

Leafy gall

Rhodococcus fascians

- Leafy gall at the base of *Erysimum* inoculated with *Rhodococcus fascians*.

Oregon Association of Nurseries,2011

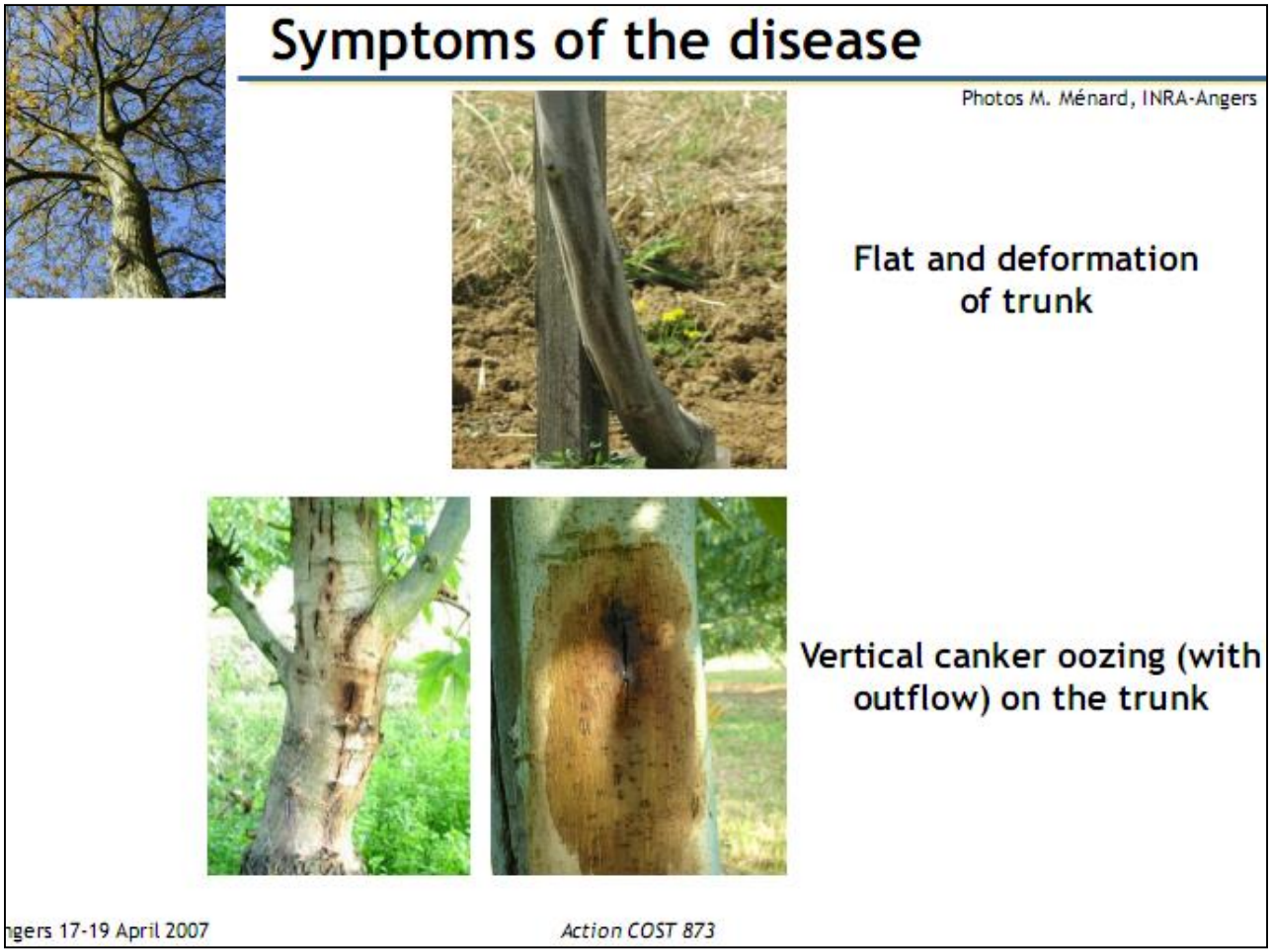
Walnut bacterial diseases

Walnut blight (vertical oozing canker, OVC)	*Xanthomonas arboricola* pv. *juglandis*
Deep bark canker	*Brenneria rubrifaciens*
Shallow bark canker	*Brenneria nigrifluens*
Crown gall	*Agrobacterium tumefaciens*
Walnut witches' broom phytoplasma	Phytoplasma
Nursery stock only	*Xylella fastidiosa*

- Brown Apical Necrosis of Walnut (BAN) causes premature fruit drop and yield losses.
- A number of organisms have been associated with BAN on walnut: *Xanthomonas juglandis*, *Fusarium* spp., *Alternaria* spp., and *Pantoea agglomerans*.

Walnut blight

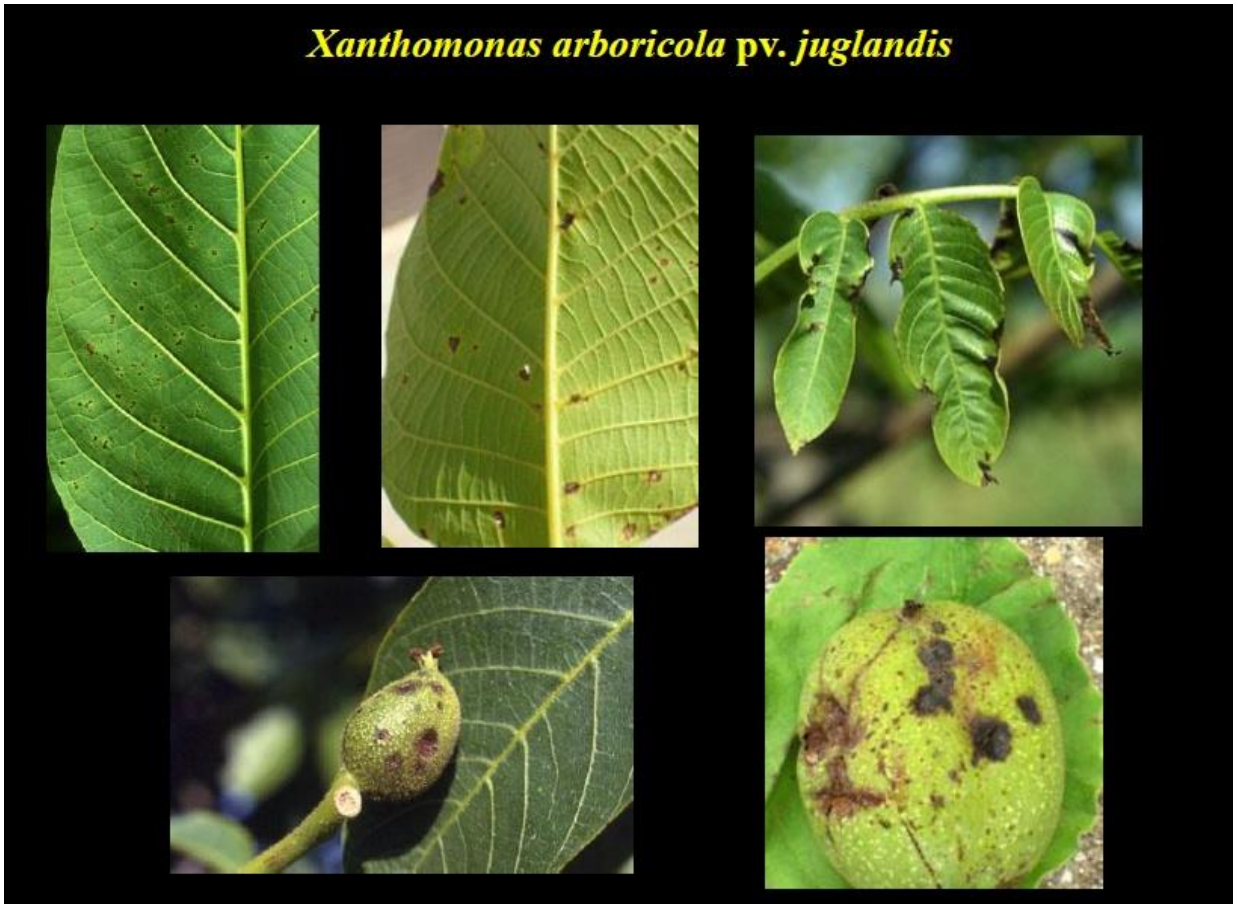
Xanthomonas arboricola pv. *juglandis*



Meyer *et al.*,2007

Walnut blight

Xanthomonas arboricola pv. *juglandis*



Scortichini,2006

Walnut blight

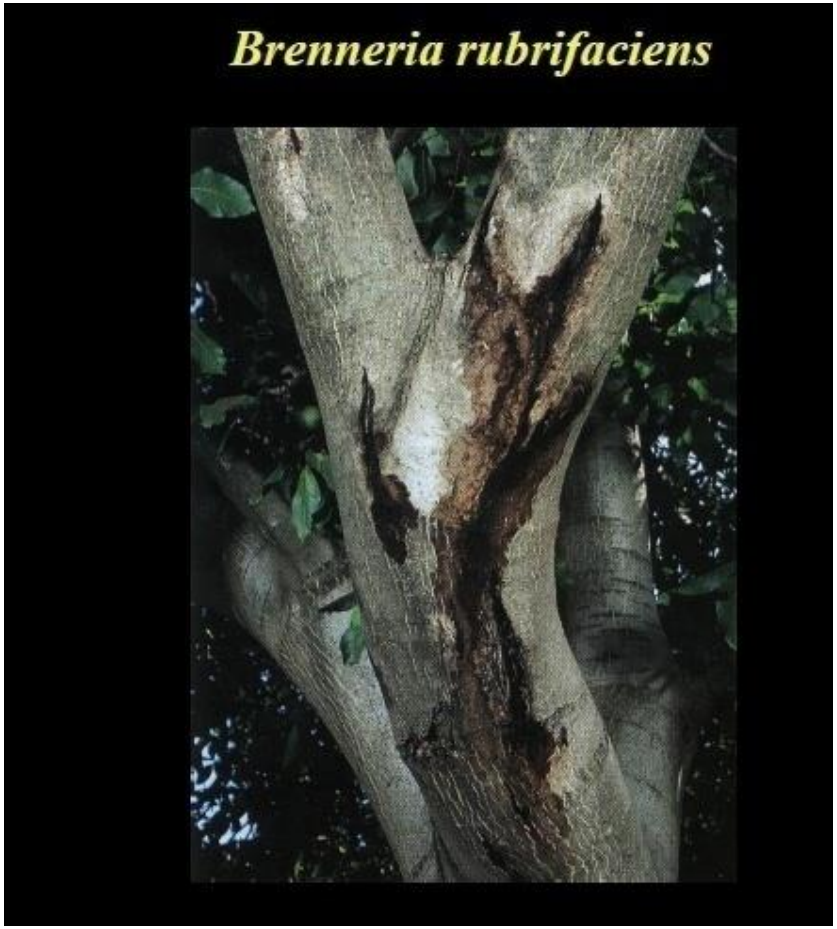
Xanthomonas arboricola pv. *juglandis*

Sunken spots on new fruits.

Transverse section of fruit showing necrosis.

Deep bark canker

Brenneria rubrifaciens



Scortichini,2006

Shallow bark canker

Brenneria rubrifaciens

1. Pits in the wood and streaks in the inner bark of a walnut tree with deep bark canker, caused by *Brenneria rubrifaciens* (left).
2. Reddish brown exudate flowing from cracks in a branch of a walnut tree with deep bark canker, caused by *Brenneria rubrifaciens* (right).

- Both images courtesy of J.K. Clark, University of California, USA.

Juglans Post-Entry Quarantine Testing Manual, New Zealand,2008

Shallow bark canker

Brenneria rubrifaciens

- Necrosis of the outer bark of a walnut tree infected with shallow bark canker (left).
- Scattered blotches of dark brown exudate on the bark of a walnut tree infected with shallow bark canker (right).
- Both images courtesy of J.K. Clark, University of California, USA).

Juglans Post-Entry Quarantine Testing Manual, New Zealand,2008

Shallow bark canker

Brenneria nigrifluens





Scortichini,2006

Crown gall
Agrobacterium

- Crown gall appears as rough, abnormal galls at or below the soil surface on roots or trunk.
- Live galls are not hard but soft and spongy.
- The centers of older galls decay.
- Young trees become stunted.
- Older trees often develop secondary wood rots.

Crown gall

Agrobacterium

Crown gall on walnut (Image: Larry, W. Moore, courtesy of CABI)

Stead,2008

Brown Apical Necrosis of Walnut (BAN)
Mixed infections(Bacterial and fungal)

- Brown Apical Necrosis of Walnut (BAN) causes premature fruit drop and yield losses.
- Reported from Europe, Turkey and China.
- A number of organisms have been associated with BAN on walnut:

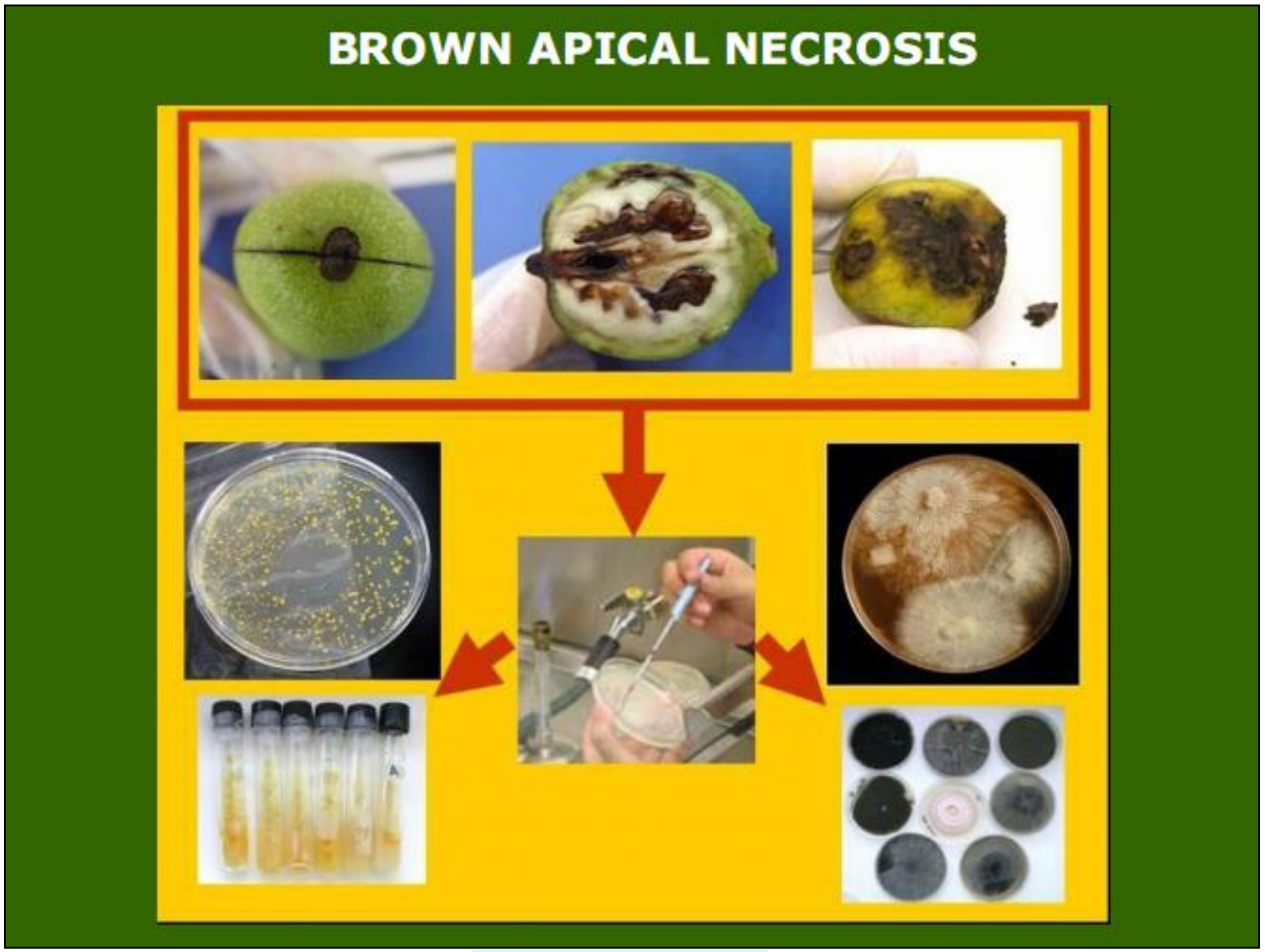
1. *Xanthomonas juglandis* (main pathogen),
2. *Fusarium* spp.,
3. *Alternaria* spp., and
4. *Pantoea agglomerans* (reported from China).

Yang *et al.*,2011; Moragrega and Özaktan,2010; Delgado,2011

Brown Apical Necrosis of Walnut (BAN)
Mixed infections(Bacterial and fungal)

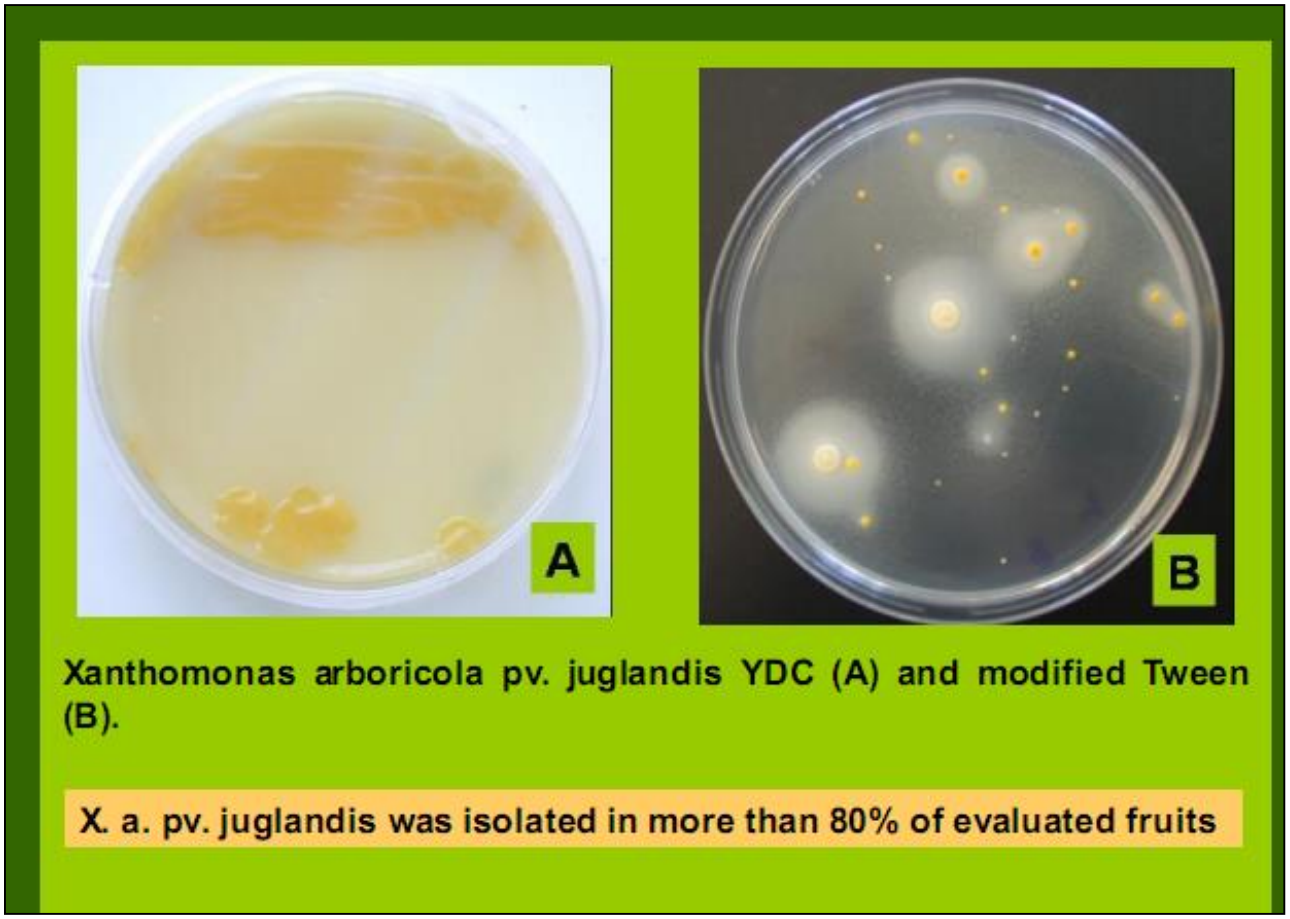
Delgado,2011

Brown Apical Necrosis of Walnut (BAN)
Mixed infections(Bacterial and fungal)



Delgado,2011

Brown Apical Necrosis of Walnut (BAN)
Mixed infections(Bacterial and fungal)

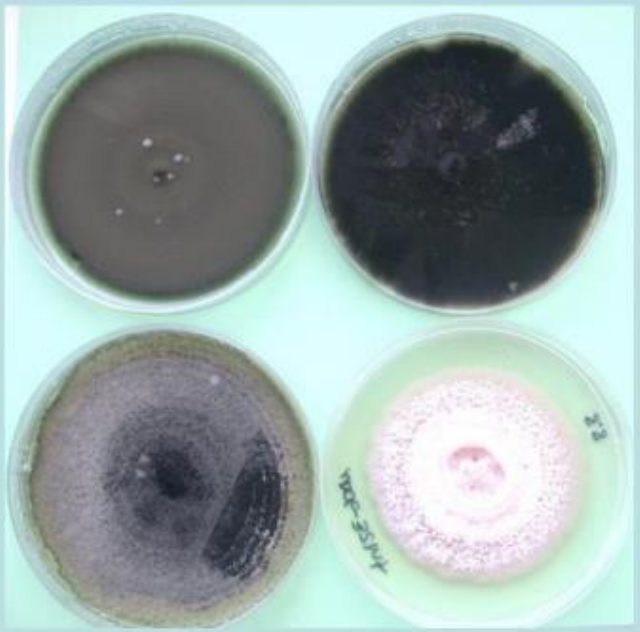


Xanthomonas arboricola pv. juglandis YDC (A) and modified Tween (B).

X. a. pv. juglandis was isolated in more than 80% of evaluated fruits

Delgado,2011

Brown Apical Necrosis of Walnut (BAN)
Mixed infections(Bacterial and fungal)



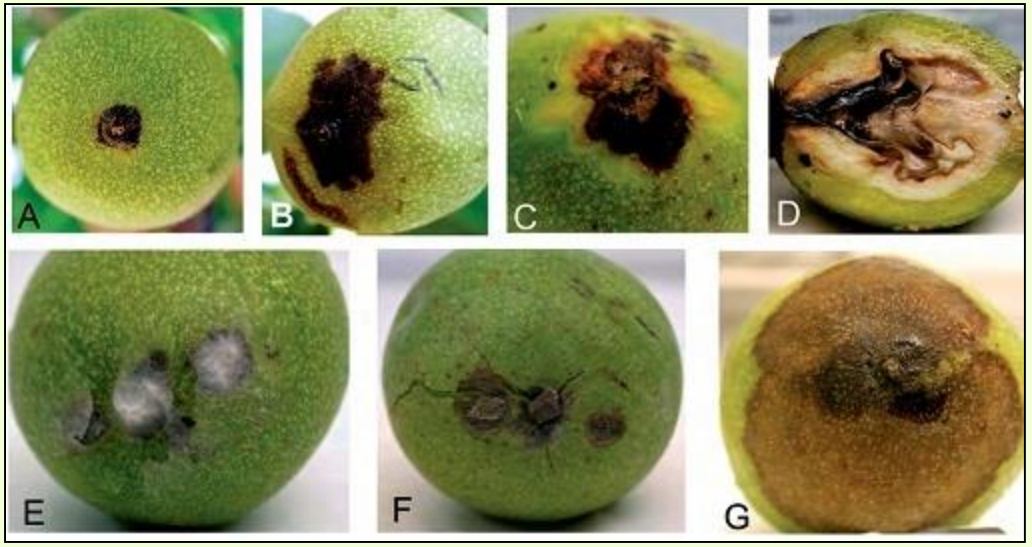
PDA cultures of fungi isolated from BAN affected fruits (A). (B) Conidia of ***Alternaria sp.***

The most frequently isolated genera was ***Alternaria sp.*** (50-80%). ***Fusarium sp.*** (10-20%) and ***Cladosporium sp.*** (10-40%) were found in lower frequency (Figura 8). *Fusarium* was not identified in 2006 samples.

Delgado,2011

Brown Apical Necrosis of Walnut (BAN)
Mixed infections(Bacterial and fungal)

- External (A, B) and internal (C, D) symptoms of "apical necrosis" on cv. Hartley fruits.
- External symptoms on young cv. Chandler fruits inoculated with *Alternaria* spp. (E), *Fusarium* spp. (F) and *X. a.* pv. *juglandis* (G) isolated from "apical necrosis"affected fruits.



Moragrega and Özaktan,2010

Witches' broom of Walnut

Walnut witches' broom phytoplasma

- Witches' broom symptoms on a walnut tree infected with walnut witches' broom phytoplasma.
- (Courtesy C.J. Chang, University of Georgia, USA).

Wheat bacterial diseases

Black chaff = bacterial leaf streak of cereals such as wheat, barley,.. The diseases are called black chaff when on the glumes (spikes). i.e. Due to the darkening of the glumes, infection of the heads is often referred to as black chaff disease.	*Xanthomonas translucens* pvs. *undulosa* and *cerealis.* The causal agent was named Bacterium translucens because of the translucent lesions on symptomatic leaves.
Bacterial mosaic	*Clavibacter tessellarius*
Bacterial leaf blight	*Pseudomonas syringae* subsp. *syringae*
Bacterial shheat rot	*Pseudomonas fuscovaginae*
Basal glume rot	*Pseudomonas syringae* pv. *atrofaciens*
Pink seed	*Erwinia rhapontici*
Spike blight = gummosis	*Rathayibacter tritici*

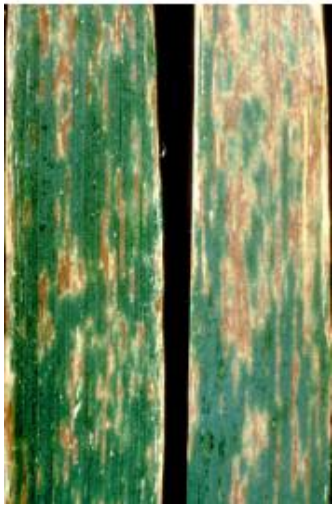
Bacterial Leaf Streak and Black Chaff
Xanthomonas translucens

- Wheat spike showing typical black chaff symptoms:
- Discoloration of the peduncle, and
- Alternating bands of healthy, and
- diseased tissue on the awns.

Duveiller *et al.*,1991, Cimmet

Bacterial Leaf Streak and Black Chaff

Xanthomonas translucens

		
Early stage infection of wheat leaf with water-soaked lesions.	Late stage infection of wheat leaves with interveinal brown streaks and blotches.	Wheat glume with brownish black streaks and blotches (Black chaff).

Bacterial Leaf Streak and Black Chaff

Xanthomonas translucens

Figure 2.3 a. Fresh milky exudates of *Xanthomonas translucens* pv. *undulosa* and water-soaking observed in the morning on a triticale leaf. b. Spreading exudates cause flakes to form on triticale leaves with bacterial leaf streak lesions.

Duveiller *et al.*,1991, Cimmet

Bacterial Leaf Streak and Black Chaff

Xanthomonas translucens

Triricate spike infection showing moist gray lesions on the glumes.

Duveiller *et al.*,1991, Cimmet

Bacterial Leaf Streak and Black Chaff

Xanthomonas translucens

Translucent lesion in the middle of a durum wheat leaf where de remains longer in the morning.

Inconspicuous blotches caused by *Xanthomonas translucens* pv. *undulosa* on wheat leaves.

Duveiller *et al.*,1991, Cimmet

Leaf Streaks

X. translucens pv. *undulosa*

- Streaks caused by *Xanthomonas translucens* pv. *undulosa* can be found on other Gramineae such as canarygrass.

Duveiller *et al.*,1991, Cimmet

Basal glume rot

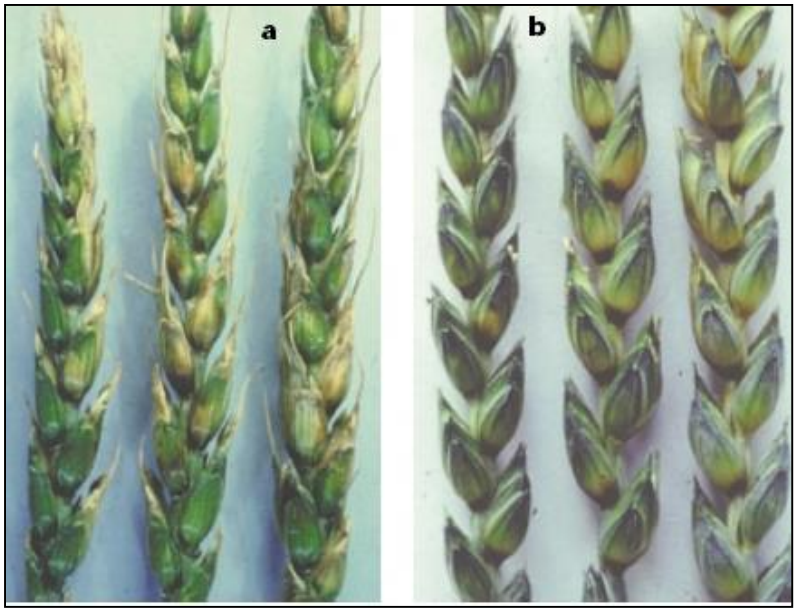
Pseudomonas syringae pathovars

a. Basal glume rot caused by *Pseudomonas syringae* pv. *atrofaciens* on wheat spikes;

- Natural infection.

b. Of basal glume rot caused by *P. s.* pv. *atrofaciens* on wheat spikes;

- Artificial inoculation.



Basal glume rot

Pseudomonas syringae pv. *atrofaciens*

Figure 3.2. Symptoms of basal glume rot caused by *Pseudomonas syringae* pv. *atrofaciens* on wheat grains. (Photo: K. Rudolph.)

Discoloration starting at the base of the glume that turns dark brown to black is typical of basal glume rot. Photo: CIMMYT.

Leaf necrosis

P. syringae pv. *syringae*

Haghighi and Taghavi,2014;..

Bacterial disease on wheat and other plants of the family Gramineae

Pseudomonas syringae pv. *atropurpurea*

Bacterial spike blight

Rathayibacter tritici

- A deformed culm and sticky exudate on the spike are symptoms typical of infection by *Rathayibacter* (*Clavibacter*) *tritici*, a bacterium associated with bacterial spike blight.

Spike gummosis

Rathayibacter tritici

Note Yellow slime on upper parts.

Bacterial mosaic

Clavibacter tessellarius

A.K. Vidaver; S.M. Ries

Bacterial sheath rot

Pseudomonas fuscovaginae

- The sheath brown rot disease reduce spike exertion.

Duveiller *et al.*,1997, Cimmet

Bacterial sheath rot

Pseudomonas fuscovaginae

Sheath brown rot symptoms on seedling.

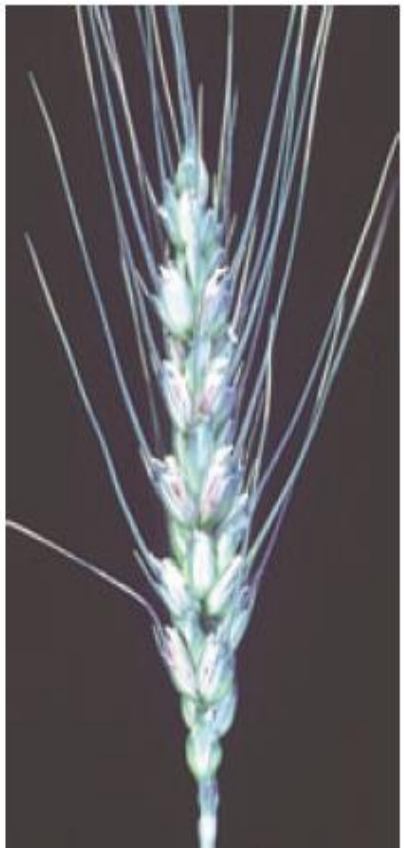
Early infection at the booting stage.

Late infection at the booting stage.

Pink Kernels on a wheat spike

Erwinia rhapontici

- Symptoms are distinct light pink kernels, slightly shrunken when compared to healthy grains.
- Pink seeds do not germinate well.
- Growth inhibition in wheat depends upon proferrosamine A Concentration.

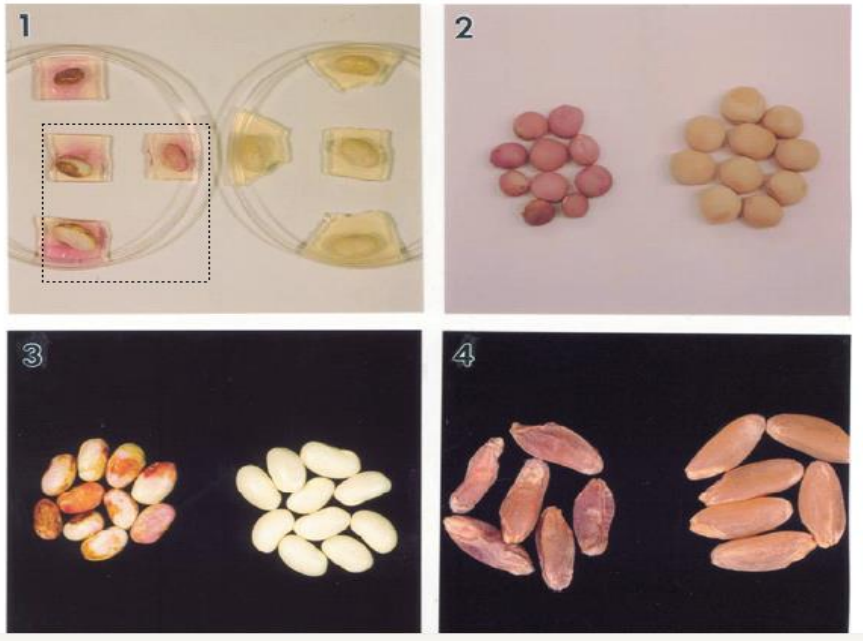


Duveiller *et al.*,1997, Cimmet

Pink seed

Erwinia rhapontici

- Pink seed of pea, bean and wheat caused by *Erwinia rhapontici*.
- Each figure show diseased seeds (left) and healthy seeds (right).



Huang *et al.*,2003

Blight

P. syringae pv. *syringae*

Dieback of new shoots due to *Pseudomonas*.

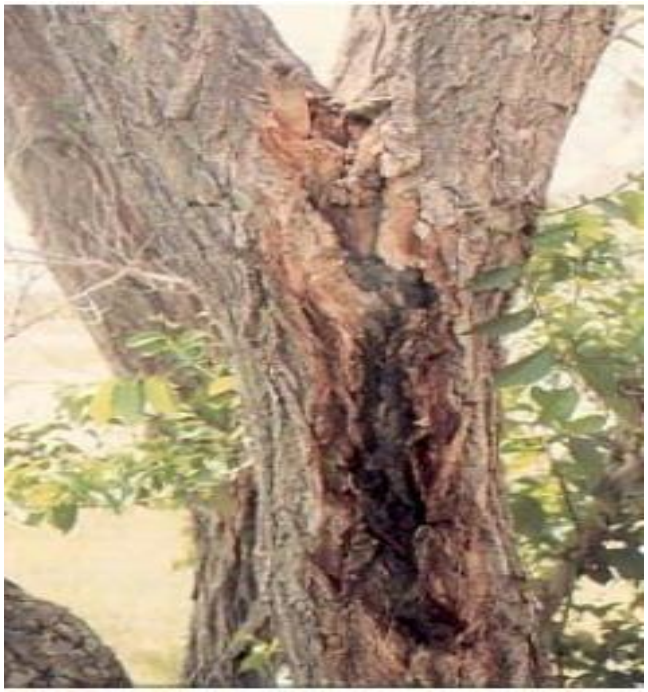
Note dark, black areas on these twig.

Putnam,2000&2008

Watermark disease

Brenneria salicis

- The watermark disease is a vascular wilting disease that causes great losses among willow populations.
- The bacterium *Brenneria salicis* formerly *Erwinia salicis*, is the causal agent of this disease and occurs mainly in the xylem vessels of the host plant.
- Infected willows show wilted, dried, brown-colored leaves and a watery, transparent color of the wood.
- Infected cuttings do not show any internal or external symptoms of the watermark disease.



Typical external wetwood symptoms. The prolonged oozing of slime has injured cambial tissue and stained the bark.

Crown gall

Pantoea agglomerans

M. Goto

Tumor

Agrobacterium tumefaciens

- A tumor formed at the base of an *Achillea* inoculated with *Agrobacterium tumefaciens*.

Oregon Association of Nurseries,2011

Bacterial leaf spot

Xanthomonas campestris pv. *zinniae*

- Spots reddish brown to dark brown, angular and with a prominent yellow halo form on leaves.

Angular leaf spot

Pseudomonas syringae pv. *lachrymans*






Soft Rot

Pectobacterium carotovorum subsp. *carotovorum*

Scortichini,2006

Bacterial wilt

Erwinia tracheiphila

Scortichini,2006

Terminology

- LEAF SPOTS: Discolored, distinct spots on leaves.
- LEAF BLOTCHES: Blotchy dead or discolored areas on leaves.
- BLIGHTS: Rapid death of plant parts or entire plant.
- GALLS: Tumorous tissue on plant.
- CANKERS: Sunken dead areas on surface of stem.
- ROOT ROTS: Softened, blackened or brown tissue in the roots.
- LESIONS: Small local area of malformed tissue.
- NECROTIC LESIONS: Dying and dead tissue; blackened, holes.
- CHLOROSIS: Yellowing of tissue.
- WILTING/FLAGGING: Foliage on all or part of plant wilted, dying.
- VASCULAR STREAKING: Discolored streaks in xylem and phloem.

Allen,2009

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