Nursery levy at work: **Nursery Production Plant Health & Biosecurity Project**

Bacterial diseases in production nurseries

Background

Bacteria can cause some very destructive plant diseases. The bacterial diseases citrus canker, fire blight of apple and pear and moko disease of banana for example have caused catastrophic losses to their respective industries. Many bacterial diseases can easily be spread on nursery stock and can be difficult to control. Plant symptoms include leaf spots, blights, rots, cankers and wilts. Systemic symptoms produced by some bacteria may result from invasion of the vascular tissue. In most cases, plants infected with a bacterial pathogen cannot be cured. Even when symptoms are not present, bacteria still persist in the plant at low levels and symptoms are likely to reappear when conditions are favourable. Phytoplasmas and fastidious vascular-colonizing bacteria (e.g. *Liberibacter* spp.) that have not been able to be cultured on artificial media, but cause serious plant diseases, will not be discussed in this fact sheet.

Basic Biology

Bacteria are microscopic, single-celled organisms with a cell wall. Unlike plants and animals, bacteria do not have a true nucleus. Their genetic material is a coiled strand of DNA which floats within the cell.

Fig. 1. Bacterial leaf stripe (*Bulkhoderia* sp.) on bird of paradise (left) and bacterial leaf spot (*Xanthomonas campestris* pv. *zinniae*) on zinnia (right).

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Bacteria also have small gene carrying entities called plasmids. These influence how virulent they can be towards their host. Bacteria have several morphological shapes: rods (bacilli), spheres (cocci), spirals and tendency towards irregular shapes (pleomorphic rods). Most plant-associated bacteria are rod shaped.

Bacteria are found almost everywhere. Only a very small percentage of bacteria are pathogenic to man, animals or plants. Plant-associated bacteria may be beneficial (e.g. *Rhizobium* which fixes atmospheric nitrogen in symbiosis with plants) or detrimental. Other bacteria associated with plants can be endogenous, similar to endophytic fungi, and do not produce disease symptoms in most circumstances.

Pathogenic factors in detrimental bacteria generally fall into four areas.

- The release of enzymes (e.g. pectinase) that degrade cell walls.
- Production of toxins which damage cell membranes.
- Production of growth regulators which disrupt normal plant growth and induce tumours.
- Production of complex sugars and gums which plug water conducting tissue (xylem).

Detection and diagnostics

Diagnosis of a bacterial disease based on visual symptoms can be unreliable. One bacterial plant pathogen may cause more than one symptom, and bacterial, fungal and viral pathogens may cause almost identical symptoms. Also, plants with latent infections do not always show symptoms. Primary

Key facts

- Plant pathogenic bacteria are single-celled organisms which can cause leaf spots, vascular wilts, dieback, cankers and soft rots.
- Symptoms can be difficult to distinguish from fungal or viral diseases.
- Always use disease free propagative mother stock plants and maintain good hygiene when producing cuttings.
- Where possible, treat propagative material with a copper-based product as a protectant to reduce the chance of infection and spread of a bacterium.
- Bacterial diseases can be spread by soil, water, contaminated equipment, tools and staff.
- Bacteria are also spread on or in seeds, tubers and bulbs. Use healthy seed or treat seed with hot water.
- Avoid overhead irrigation and exposure to rainfall if bacterial diseases are a problem.
- Avoid overcrowding.
- Remove infected plants and plant debris immediately.
- Plants infected with bacterial diseases are unlikely to survive and can remain hidden within the plant for long periods, even when plants are asymptomatic. Such plants become a source of potential reinfestation in the nursery and beyond.
- Grow resistant varieties wherever possible.
- Reduce nitrogen fertilisation as much as possible while still maintaining healthy growth. Supply adequate potassium and calcium to strengthen plants.

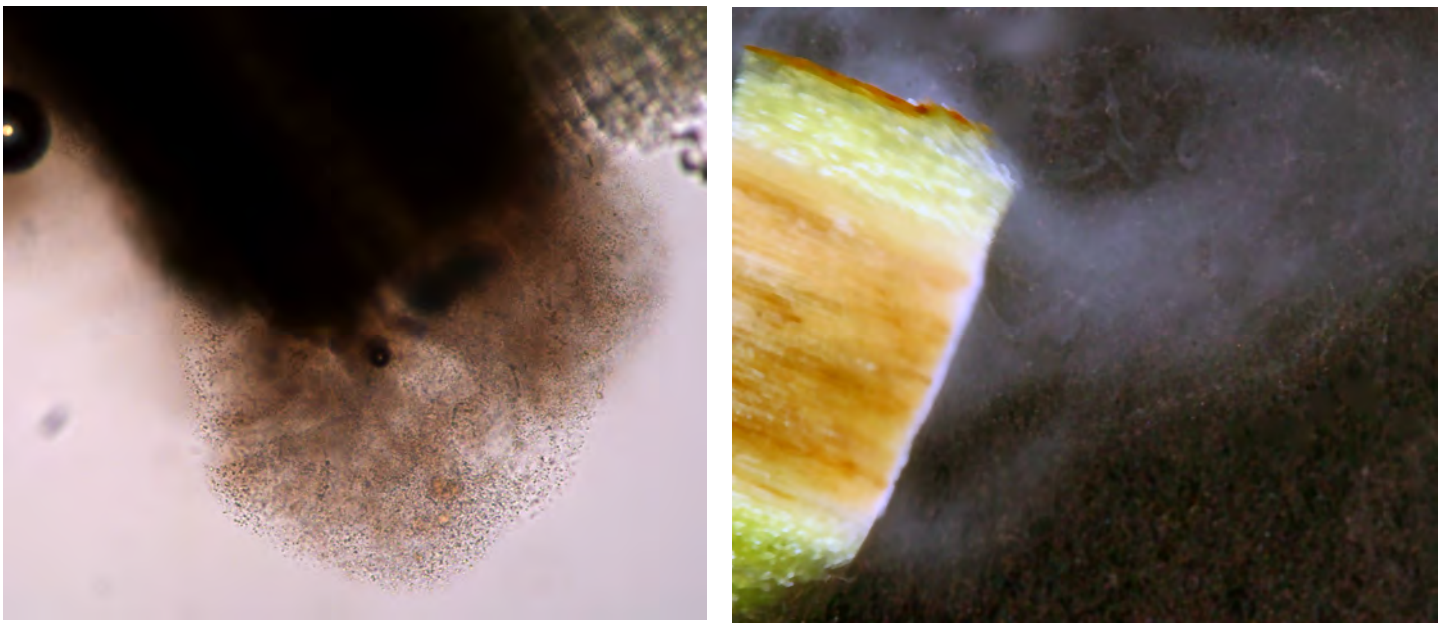

Fig. 2. Bacterial ooze streaming from plant tissue at a microscopic level (left) and visible to the naked eye in a beaker of water (right).

Fig. 3. Bacterial leaf spot (*Xanthomonas campestris*) on philodendron showing small, water soaked spots that become large, angular rotten areas (top left); bacterial leaf streak on corn caused by *Xanthomonas* sp (bottom left); bacterial leaf blight (*Xanthomonas* sp.) on syngonium showing angular, water-soaked areas on leaves that become yellow, then brown dry and papery (top right); bacterial leaf spot of bougainvillea showing orange, angular spots with pale centres (middle right); bacterial leaf blight on zamiocullaf 'zanzibar gem' (bottom right).

bacterial pathogens may be difficult to find and may have been replaced by secondary pathogens or saprophytes, that colonise dead and decaying plant tissue.

A very simple way to determine whether a bacterium is associated with a disease is to cut out a typical lesion and suspend it in a drop of water on a microscope slide. If a mass of bacteria are seen flowing from the cut tissue under the microscope (bacterial streaming) it means that a bacterium is present, but this does not always mean that the bacterium is the primary cause of the disease. The water streaming test is a rapid presumptive test for *Ralstonia solanacearum* infection and can be used in the greenhouse and field by suspending a section of infected stem in water, and observing the flow of bacteria from the cut stem.

A correct diagnosis of a bacterial disease in the nursery is essential in preventing serious losses and protecting Australia from important exotic bacterial diseases. Representative disease samples, with relevant information on the disease outbreak, should be sent to a diagnostic laboratory. The laboratory will separate the bacterium from the plant tissue and culture it on artificial media. Identification will then be based on the morphology of the bacterial colony and cells, and their physiological, biochemical and serological characteristics. In addition to these conventional methods, new identification methods are becoming available due to developments in molecular biology.

With the development of these new molecular techniques more information is known about the relationships between different bacteria. This has lead to name changes and the identification of some host specific plant pathogenic bacteria pathovars (pathogenic variants), biotypes and races.

Epidemiology

Bacterial plant pathogens can survive quite well in the environment even though they do not form spores. Active cells may be present as epiphytes on plants or in their root zones, or as less active cells within the plant (endophytes, latent forms). They survive in plant debris on the soil surface, in soil, in and on seed, in or on insects, and as epiphytic populations on other host plants.

Fig. 4. Vascular wilts caused by *Ralstonia* on tomato showing dark discolouration in the vascular tissue (left) and wilting symptoms in geranium (right – photo by USDA APHIS PPQ, bugwood.org).

Bacteria reproduce very rapidly by dividing in half (binary fission). The process may be repeated every twenty minutes producing millions cells per day. Infectious doses are in the order of millions of cells.

Bacteria are spread by wind, dust, rain splash, surface water, irrigation water, insects, mites, animals, soil, nursery staff and their equipment. In the field spread and infection are favoured by windblown soil and sand particles during storms that also cause plant damage. In the nursery bacteria are splashed from the soil to leaves and from leaf to leaf by overhead irrigation.

Bacteria are also spread in plant parts especially seed. Seed transmission is especially important for vascular bacterial pathogens which can infect seed externally and internally. Non-vascular pathogens can contaminate and infect the seed coat. Bacteria are also spread in tubers, bulbs, cuttings and transplants.

History of bacterial diseases

In 1866 the French chemistry professor Louie Pasteur found microscopic one-celled 'plants' causing spoilage in wine vats and disease of silkworms. He was convinced that these organisms, which we now call bacteria, were the cause of the diseases.

It was some years later that Thomas Burrill, professor of botany at the University of Illinois, proved that bacteria can cause disease in plants as well as animals. He found that fire blight of apples and pears, a disease which spread through orchards in Canada and the United States in the mid-nineteenth century "like a conflagration, blackening and blighting whole orchards; even whole valleys in a single night", was caused by the bacterium *Erwinia amylovora*.

Nurseries often have ideal conditions for bacterial diseases especially in greenhouses where there is high humidity and temperature, close planting, poor air circulation, mist beds, and overhead or flood irrigation. Bacteria cannot directly penetrate plant tissue and must enter through wounds or natural openings. They can enter leaves in water through hydathodes or stomata. They can also enter through lenticels and wounds on leaves stems and roots.

Fig. 5. Crown gall caused by *Agrobacerium* spp. on olive (left, photo by Barbara Hall (SARDI - PISA) and rose (right).

Fig. 6. Leaf and stem canker caused by the exotic pathogen citrus canker *Xanthomonas axonopodis* (top left, right and insert); bacterial canker associated with gummosis on stone fruit caused by *Pseudomonas syringae* (bottom left); bacterial spot canker on a young stonefruit shoot caused by *Xanthomonas arbioricola* (bottom right).

Symptoms

There are five basic types of symptoms associated with bacterial diseases in nurseries. They are leaf spots, vascular wilts, tumours, dieback and cankers, and soft rots. There are also some bacterial diseases that do not always present symptoms. The damage caused by these pathogens may only become evident after the plants have left the production nursery. Diseases which sometimes have latent symptoms include those caused by vascular pathogens such as *Ralstonia solanacearum* and *Clavibacter michiganensis*.

The most commonly encountered bacterial diseases in production nurseries are **spots on leaves** (Fig. 1 and 3). These spots often have a chlorotic (yellow) halo due to toxin production. They may be circular or irregular, angular when bordered by veins and longitudinal in monocotyledonous plants. Leaf spots occur on a wide range of plants including bougainvillea, dieffenbachia, philodendron and geranium.

Vascular disease and wilting can occur due to the invasion of the xylem by bacteria (Fig. 4). Infection may occur through the roots, as with bacterial wilt caused by *Ralstonia solanacearum* and with *Clavibacter michiganensis* subsp. michiganensis which causes bacterial canker of tomato. Vascular disease may also be caused by bacteria such as *Xanthomonas campestris* pv. *campestris* infecting hydathodes (water pores) at the leaf margin. Vascular invasion can also result from planting infected or infested seed. Bacterial wilt affects dahlia, heliconia, Alexandra palm, strelitzia and zinnia.

Bacterial infection may produce plant abnormalities such as **malignant tumors (galls)** or distorted plant parts (Fig. 5). They are formed following infection by strains of Agrobacterium tumefaciens. The bacterium causes host cells to divide quickly. This rapid, undifferentiated cell division produces the galls. These galls can cut off flow of water and nutrients via the xylem resulting in the death of plants. Crown gall of rose is a common disease.

Dieback and cankers may also appear on trunks, stems, branches and twigs (Fig. 6). These occur when bacteria spread rapidly through plant tissues and kill them. Cankers form when a host tries to limit bark necrosis and the cambium is damaged by callus formation. These occur on woody ornamental shrubs such as azalea.

Soft rots affect nursery plants with fleshy succulent plant parts (Fig. 7), such as storage organs. Soft rot bacteria break down host tissue and release cellular fluids through the action of pectinolytic enzymes. These fluids attract secondary bacteria that proliferate and often produce an offensive odour. Soft rot bacteria may also cause cuttings to progressively rot from the cut end.

Fig. 7. Bacterial soft rot caused by *Erwinia caratovora* in lettuce (top and middle); Bacterial soft rot on *Zygocactus*.

Disease Management

It is often quite difficult for a grower to determine whether a fungus, virus or bacterium has caused the leaf spots or other diseases on nursery plants. These organisms can produce similar symptoms. If uncertain, samples should be sent to a diagnostic laboratory. This is important as an incorrect diagnosis will lead to ineffective control measures being applied.

Bacterial diseases are difficult to control with pesticides. Copper fungicides may assist in protecting healthy plants provided only very early symptoms of disease are present. There are currently no systemic chemical treatments registered for the control of bacterial plant pathogens in Australia. Therefore, management must focus on preventing plants from becoming infected.

The use of clean planting material (cuttings, transplants, seed) is of the utmost importance and propagators must maintain good hygiene standards to prevent contamination. Sanitation practices include soil/potting mix pasteurization, cleaning and disinfesting tools, benches, flats and pots. Staff should wash their hands after handling diseased plants, soil and plant debris. If possible avoid overhead irrigation and exposure to rainfall if leaf diseases are a problem. Splashing water will spread the bacteria to healthy leaves. If overhead irrigation is used, watering should be done early in the day so that plants dry quickly.

Be vigilant; inspect plants regularly and remove infected plants immediately. This will prevent the spread of the bacteria to healthy plants. If the bacterial disease is systemic and has spread through the plant, the plant will not survive and must be removed to prevent contamination of healthy plants. Unfortunately systemic bacterial diseases can remain hidden for some time and not be noticed during initial inspections, with disastrous consequences later when the disease can appear to devastate entire crops overnight. Varietal resistance, where available, is an extremely effective method of managing bacterial diseases.

Biosecurity

Many bacterial pathogens are a biosecurity threat to Australia. If an exotic pathogen is suspected to be present in the nursery, contact the nearest Department of Agriculture or Primary Industries or call the Plant Health Australia hotline (1800 084 881). There are a number of bacterial diseases present overseas, which if introduced into Australia, would seriously impact our economy. They include moko disease of banana (*Ralstonia.solanacearum*), fire blight of apple and pear (*Erwinia amyylovora*) (Fig. 8), citrus canker (*Xanthomonas axonopodis* pv. *citri*) (Fig. 6), bacterial fruit and heart rot of pineapple (*Dickeya* sp.), bacterial canker of kiwifruit (*Pseudomonas syringae* pv. *actinidiae*) and angular leaf spot of strawberry (*Xanthomonas fragariae*) (Fig. 8).

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Fig. 8. Exotic bacterial diseases including fire blight (*E.* amylovora) on firethorn (left - Florida Division of Plant Industry Archive, Florida Department of Agriculture Consumer Services, Bugwood.org) and angular leaf spot of strawberry caused by *Xanthomonas fragariae* (right).