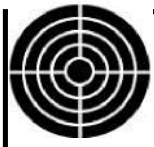
LESSON 3: PLANT DISEASES CAUSED BY BACTERIA

3.1 Introduction

Diseases caused by bacterial plant pathogens are one of the most severe constraints to agricultural productivity. Many types of crops are attacked by these pathogens every season with substantial losses occurring. Diseases caused by bacteria are important because they generally have fewer means of management compared to other types of pathogens, and therefore can pose a more serious threat to crop production. Bacterial pathogens are capable of spreading rapidly and are often detected late when plants have already been invaded and considerable harm already done. Infection may also be latent and is only detected after seedlings have been transplanted or crop produce already delivered to markets. Therefore, strengthening the capacity of farmers to identify and effectively manage bacterial plant pathogens is essential to successful and profitable farming.

3.2 Lecture objectives



At the end of this lecture of this lecture the student should be able to

1. Distinguish bacteria from other types of plant pathogens.
2. Explain the basic procedures of diagnosing bacterial crop pathogens.
3. Explain the various measures of managing bacterial plant diseases.

3.3. BIOLOGY, DIAGNOSIS AND MANAGEMENT OF BACTERIAL PLANT DISEASES

3.3.1 What is a bacteria?

A bacteria is a single-celled micro-organism, generally ranging from 1-2 µm in size. Bacterial cells occur singly or in colonies of several cells. Individual bacterial cells are too small and cannot be seen without the aid of a microscope. However, large populations of bacteria become visible as aggregates in liquid, as bio-films on plants, as viscous suspensions plugging plant vessels, or colonies on petri dishes in the laboratory.

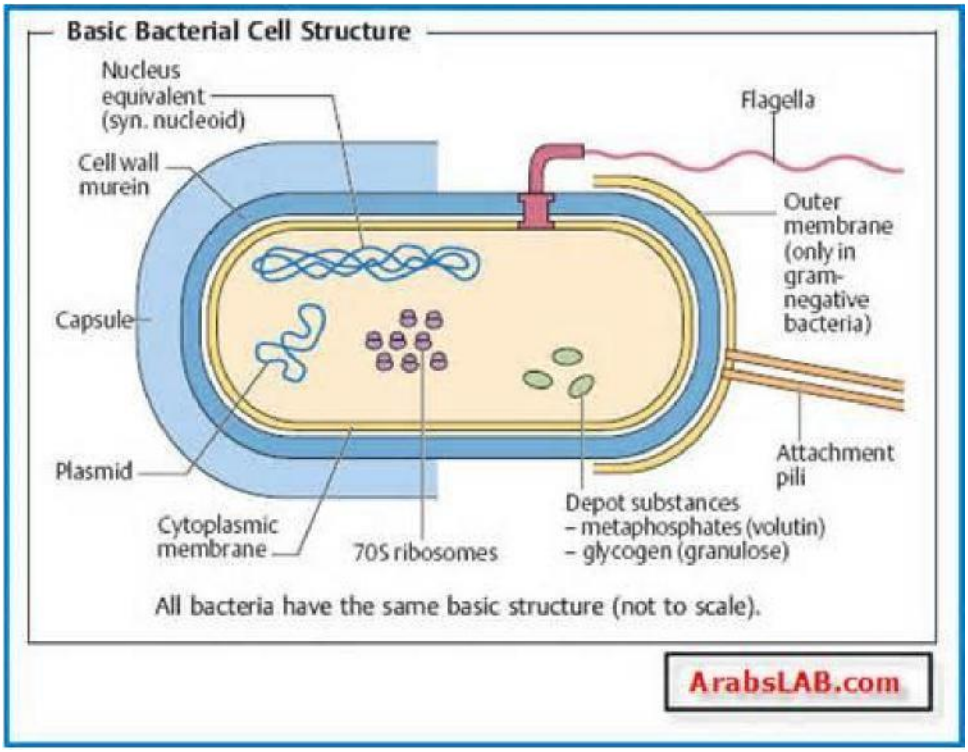


Figure 2.

Typical structure of a bacterial cell (image: Arbslab.com)

Bacteria are classified into two main groups based on the structure of their cell wall. This distinction is easily determined using a simple staining procedure called the **Gram stain.** Gram negative bacteria stain red or pink and Gram positive bacteria stain purple but this test requires laboratory facilities to carry out. Gram stain is directly related to the chemical composition and structure of their cell walls. The Gram negative have more complex walls which is important as it protects the cells better and makes it harder to control them.

When viewed under the microscope, bacterial cells have different types of shapes. These can be rod-shaped, spherical, spiral-shaped, or filamentous. Most bacteria causing plant diseases are rod shaped.

3.3.2 Reproduction

Bacteria reproduce asexually by binary fission (one cell splitting into two). When environmental conditions permit, the binary fission method of reproduction can be very fast, giving rise to large populations of cells that help bacteria in attacking crop plants. For example some cells divide after every 20 or 30 minutes. This is one of the important characteristics that we should keep in mind when thinking of how we can effectively control these pathogens. A good strategy is to deny them the conditions that could favour their multiplication. Numbers are important in bacterial functions. For example, usually bacteria are more effective in causing disease when they reach populations of about 1 million cells per mililiter. When conditions becomes unfavourable i.e. nutrient sources become limiting the bacteria cells start dying.

3.3.3 Movement of bacterial cells

Most bacteria can move and their bodies have structures to help them in movement. This movement is important as it can help them to move from one part of the plant surface, e.g. from one point on the leaf to another. For species that attack plants the movement is important as it can help the cells to find host plants and guide them to areas where they are able to penetrate into the plant and cause infection. The movement can be triggered by specific stimulus, e.g. the presence of nutrients leaking from a plant root in the soil which attract the pathogen towards the plant. The movement can also help the bacteria to escape from harmful or threatening environments, e.g. the cell will move away if there is a toxic compound in water. Bacterial cells may or may not have appendages: flagella, usually at the poles of the cells (for movement) and fimbriae or pili, smaller thread-like appendages, usually at multiple locations. The fimbriae are believed to be helpful in attachment, somewhat like a Velcro® fastener. The flagella propel cells through films of water. That bacteria require water for movement can be exploited for their management, i.e. deny them water and you reduce their spread significantly.

3.4 Symptoms caused by plant pathogenic bacteria

Symptomatology of bacterial diseases is extremely varied, but usually characteristic for a particular pathogen. Symptoms may vary with photoperiod, plant variety, temperature and humidity, and infective dose. In some cases, symptoms may disappear or become inconsequential as the plant matures. Some common symptoms are shown below:

- Wilts,
- Leaf spots,
- Blights,
- Soft rots, e.g. caused by *Eriwinia* species in potato
- Black rot, e.g. caused by *Xanthomonas campestris* on cabbage
- Scabs

Brown vascular discolouration on tomato caused by *Ralstonia solanacearum*

Citrus canker symptoms caused by *Xanthomonas axonopodis* (Syn. *X.campestris* pv. *citri*).
Images source: Plant pathology, G. Agrios.

Crown gall, caused by *Agrobacterium tumefaciens* on roses (Plant pathology, G. Agrios)

Figure 4. Plant bacterial disease symptoms

In contrast to viruses, which invade the interior of infected plant cells, most bacteria grow in the spaces between cells and rarely enter the cell.

How then do they cause damage to the plants? This can happen through various ways:

1. Some bacteria produce toxic compounds that cause cell death
2. Some species produce enzymes that break down structural components of plant cells and their walls, e.g. soft-rotting bacteria that attack potato
3. Some species damage plants by colonizing the water-conducting (xylem) vessels thus causing infected plants to wilt and di as in the case of bacterial wilt of tomato caused by *Ralstonia solanacearum*.
4. Some species e.g. *Agrobacterium* genetically modify their hosts to form overgrowths of cells called crown gall. This is a common occurrence on rose plants in Kenya.

3.5. Spread and dissemination of bacterial plant pathogens

Bacterial plant pathogens are spread in many ways. These include:

1. Cells oozing on plant surfaces are splashed about by rains or irrigation water.
2. Can be blown away in soil particles by wind.
3. Can be spread by vectors such as birds, insects or animals.
4. Human activity
    a. Pruning infected plants
    b. Planting infected seed or seedlings
    c. Using contaminated water for irrigation

d. Improper disposal of plant debris and residues

Two things to note:

1. Regardless of how the bacterial cells are disseminated, they require an opening to gain entry into the plant tissues. The opening could be a wound or natural opening such as stomata. It is therefore necessary to avoid inflicting injuries on plants when the risk of bacterial spread is high, e.g. during the wet season.
2. Water is a very important factor in the spread of bacteria and their ability to colonise plant tissues. It is therefore necessary to incidences of intense wetting of plant tissues when the risk of a bacterial disease is high.

For most bacterial species cell population must increase before the infection process is initiated. It is suspected that the cells in one species communicate chemically with one another (quorum sensing) and perhaps also with other species. Bacteria causing plant diseases are noted to organize themselves in dense growths of biofilms that tightly adhere to plant surfaces, serving as protectants against the adverse environmental conditions and enabling cells to produce a favourable environment for survival and spread.

3.5.1 Survival

In nature plant pathogenic bacteria can survive in various means:

i. In plant debris left on the soil surface or buried in the soil;

ii. In and on seeds,

iii. In association with other host plants, e.g. weeds or perennial crop species;

iv. Some bacteria can also survive in water

v. Some survive on inanimate objects, e.g. *Clavibacter michiganensis* subsp. *sepedonicus*, causative agent of potato ring rot, is notoriously known for surviving on machinery and packaging material.

vi. On or inside insects.

3.6. Management of bacterial plant diseases

3.6.1 Genetic Host Resistance

Growing resistant varieties is a useful strategy in management of bacterial plant diseases. It is cost effective, has no pollution to the environment, poses no hazard to the farmer and is more sustainable in the long term. Farmers should be encouraged to find out information on varieties in the market to establish the types with resistance to various diseases.

3.6.2 Cultural Practices

- Cultural practices include doing the things that farmers do regularly as they manage their crops and farms. These practices are friendly to the environment and if implemented well can lead to substantial saving of expenses. They are based on the choice that farmers make about their farming operations. They include the following:

  - Careful selection and planting of bacteria-free seed or propagation materials. Certification programs are being enforced for most crops in Kenya, especially for potato in relation to *Ralstonia solanacearum*.

- Diligent sanitation practices, e.g. cleaning of tools used in pruning; remove and proper disposal debris or other residues that may be contaminated with bacteria.

- Careful selection of crops grown with routine crop rotation to reduce pathogen propagules.

- Preventing wounding of plants that could be used by bacteria to enter.

  - Careful management of irrigation water to minimize splashing and prolonged wetting of plants.

- Prolonged exposure to dry air, heat, and sunlight will sometimes kill bacteria in plant material.

3.6.3 Chemical Applications

- Applications of copper-containing compounds or Bordeaux mixture (copper sulfate and lime). .
- Antibiotics: Streptomycin and/or oxytetracycline may also help to kill or suppress plant pathogenic bacteria if applied before infection, but they do not cure plants that are already diseased.
- Insecticides can be used to control insect vectors of bacterial pathogens, or other insects that feed on plants creating wounds that can provide points of entry.

3.6.4 Biological Control

- Competition between bacterial species can lead to suppression of some pathogenic species.The use of antagonistic or biological control products such as Blight Ban and Agrosin K84 may also be effective for managing bacterial diseases of plants.

3.6.5 Government Regulatory Measures

- The implementation of strict quarantines that exclude or restrict the introduction or movement pathogens or infected plant material.

Summary

Understanding biology of plant bacteria is important so as to know at what stage the pathogen is expected to attack the crop and also help in timely management of the pathogen.

Correct diagnosis of plant pathogenic bacteria is encouraged as wrong diagnosis can lead to easy spread of the pathogen and management become costly

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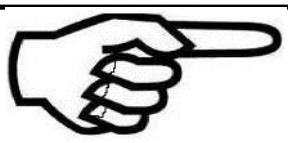

Integrated pest management is encouraged for plant bacteria pathogens as no single management option is effective on its own.

ACTIVITIES

> Visit a market place or a vegetable farm and collect samples showing symptoms of a plant pathogenic bacteria .