DOA BELAJAR

رَضِيْتُ بِاللّٰهِ رَبًّا وَبِالْإِسْلَامِ دِيْنًا وَبِمُحَمَّدٍ نَبِيًّا وَرَسُوْلًا

رَبِّيْ زِدْنِيْ عِلْمًا وَارْزُقْنِيْ فَهْمًا

"Kami ridho Allah SWT sebagai Tuhanku, Islam sebagai agamaku, dan Nabi Muhammad sebagai Nabi dan Rasul, Ya Allah, tambahkanlah kepadaku ilmu dan berikanlah aku kefahaman"

STRATEGY OF BIOTECHNOLOGY IN PLANTS PROTECTION

Ika Afifah Nugraheni, S.P., M.Biotech.

PROGRAM STUDI BIOTEKNOLOGI
FAKULTAS SAINS DAN TEKNOLOGI
UNIVERSITAS 'AISYIYAH YOGYAKARTA

Introduction

- Biotechnology is defined by the European Federation of Biotechnology as“the integrated use of biochemistry, microbiology, and engineering sciences in order to achieve technological (industrial) applications of the capabilities of microorganisms, cultured tissue cells, and parts there of.
- The term biotechnology includes the microbiological, biochemical and gene technological application of methods to change existing traits of enzymes, cell cultures, and microorganisms to obtain the desired properties.

Introduction

Biotechnology, integrated use of:

- Biochemistry
- Microbiology
- Engineering Sciences

To create some products
Using application of method to trait enzymes, cell cultures, and microorganisms to obtain desired properties.

Introduction

- Several years ago, a typical example of biotechnology in plant pathology would have been the production and application of **pheromones** functioning as attractants or repellents of insects.
- Nowadays, biotechnology is greatly influenced by the application of **recombinant DNA** or **genetic engineering**.
- The emerging subject of “gene technology” has become the dominant part of modern biotechnology, since it allowed an increased output by unraveling the mechanisms involved and pinpointing the efforts to the actual needs.

Introduction

- By DNA transfer, plants can be created which may express genes from bacteria, fungi, or even insects to protect them at least partially against the attack of plant pathogens.
- Thus, disease-resistant cultivars can now be developed not only by conventional breeding methods but also by genetic engineering.
- Earlier, naturally occurring microorganisms were used to control plant pathogenic organisms, but increasingly genetically **engineered microorganisms or transgenic plants** are being generated that express specific defense reactions towards pathogens.

Introduction

- Another field of biotechnology in plant pathology is the development of techniques which allow **a faster and more precise detection of plant pathogens**, i.e., plant pathogenic viruses, bacteria, fungi, and nematodes.
- Biotechnology in plant protection also deals with the cultivation of beneficial organisms to combat plant pathogenic bacteria, fungi, nematodes, or insects.
- The term “biopesticide” is a general term including biochemical, microbial, and plant pesticides.

Introduction

Detection of plant pathogen, using serology or molecular techniques

Genetic Engineering

Biocontrol of Microorganisms

Pheromones

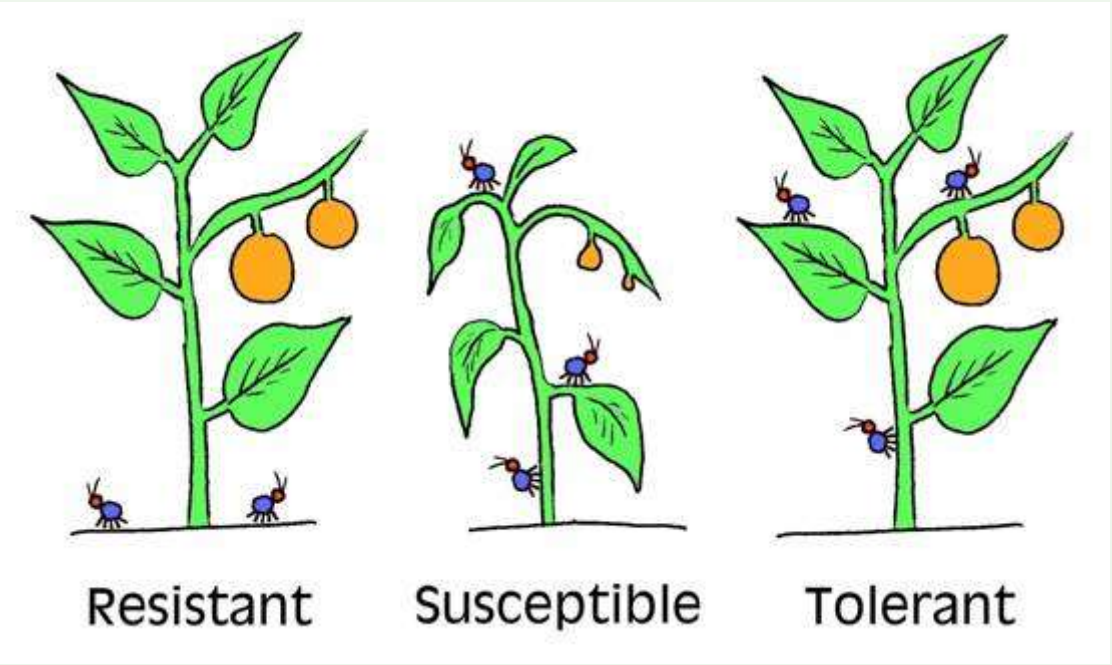
Strategy of biotechnology in plant protection

Introduction

- Plant pathology in the broad sense includes diseases and pests caused by an array of diverse viruses, bacteria, fungi, nematodes, and insects.
- During a successful infection process the plant, pathogen multiplies considerably and the host plant is partially or totally destroyed.
- These severely damaged plants are called **susceptible**.
- **Resistant plants** express defense reactions against the attacking pathogens, manifested by specific biochemical, physiological or anatomical features.

Introduction

Resistant plant = the ability of a plant variety to restrict the growth and development of a specified pest or pathogen



Tolerant plant = the ability of a plant variety to grow under pest attack, but the plant is not seriously affected by the pest

Susceptible plant = inability of a plant variety to restrict the growth and/or development of a specified pest.

Biocontrol Agents

- Commercial applications of microorganisms in biocontrol will **only be successful if**:
  1. they are similar in efficacy to chemical pesticides, or
  2. in specific situations, e.g., where chemicals are not allowed to be used (like in organic farming), in cases of fungicide resistance, or if no pesticides are authorized for a particular use.
- Generally, these organisms should have high virulence and a multiplication rate high enough to survive and spread under the conditions of use → this is **challenges** in research of biocontrol agents.

Biocontrol Agents

Advantages and disadvantages of biological control agents

Advantages	Disadvantages
Most environmentally friendly and most sustainable of all IAP control methods.	Generally slow, especially initially.
Usually does not require high or long-term maintenance.	Low levels of infestation, with occasional outbreaks, will remain a feature of systems under biological control.
Relatively low cost implication over the long term.	Any use of chemicals around biocontrol agent colonies may adversely affect the potency of this control method.
	Cannot be used where the biocontrol agent would threaten commercial populations of the target species that may exist nearby. This includes community woodlots.
	Biocontrol agents are not available for all target IAP species in the eThekwini Municipal Area.

IAP (Invasive alien plants) = a plant species not indigenous to a location, area, or region, which has either been accidentally or intentionally introduced and whose presence threatens habitats, ecosystems or other species

Biocontrol Agents

- So far, application of biocontrol agents include:

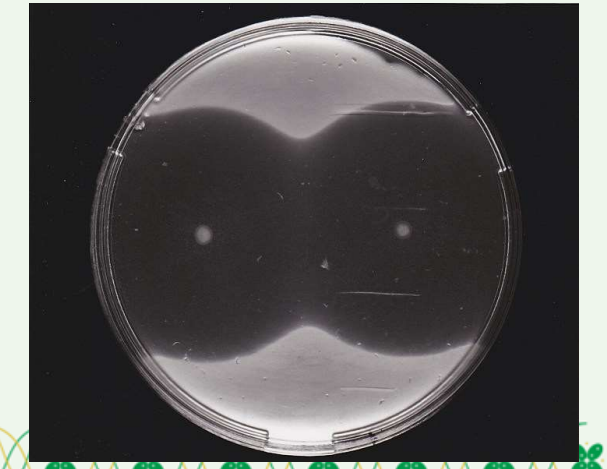
  - Bacteria used for disease control
  - Fungi used for disease control
  - Biocontrol of plant pathogenic nematodes
  - Control of weeds by bioherbicides

Bacteria used for disease control

- A major principle of biocontrol of plant diseases by bacteria is **occupation of ecological niches** in a manner of first comes first serve.
- This mechanism of occupying sites in or on plants, to prevent the settlement of plant pathogenic bacteria **(competition).**
- Example: ***Pseudomonas putida*** on potatoes, preventing an attack of ***Erwinia carotovora,*** the causal agent of black leg and soft rot of potatoes (picture on the side).

Bacteria used for disease control

- Some bacteria produce compounds which kill other microorganisms or inhibit their growth (antibiosis).
- Generally, these compounds (i.e., antibiotics) are products of secondary metabolism.
- Example: antibiotic **Agrocin** secreted by the ***Agrobacterium radiobacter*** strain K84 to inhibits the growth of the plant pathogenic bacterium ***Agrobacterium tumefaciens,*** causing crown gall disease on woody plants (picture on the side).



Bacteria used for disease control

- A group of growth inhibitors produced by different bacteria are the **siderophores.**
- Siderophores are best studied in pseudomonads.
- The strategy is that the siderophores **chelate iron** which is essential for all microorganisms.
- The chelated iron can be taken up by siderophore producing bacteria **but not** by other microorganisms including plant pathogenic fungi.
- This protection system is active in many **rhizobacteria** protecting roots from pathogens.

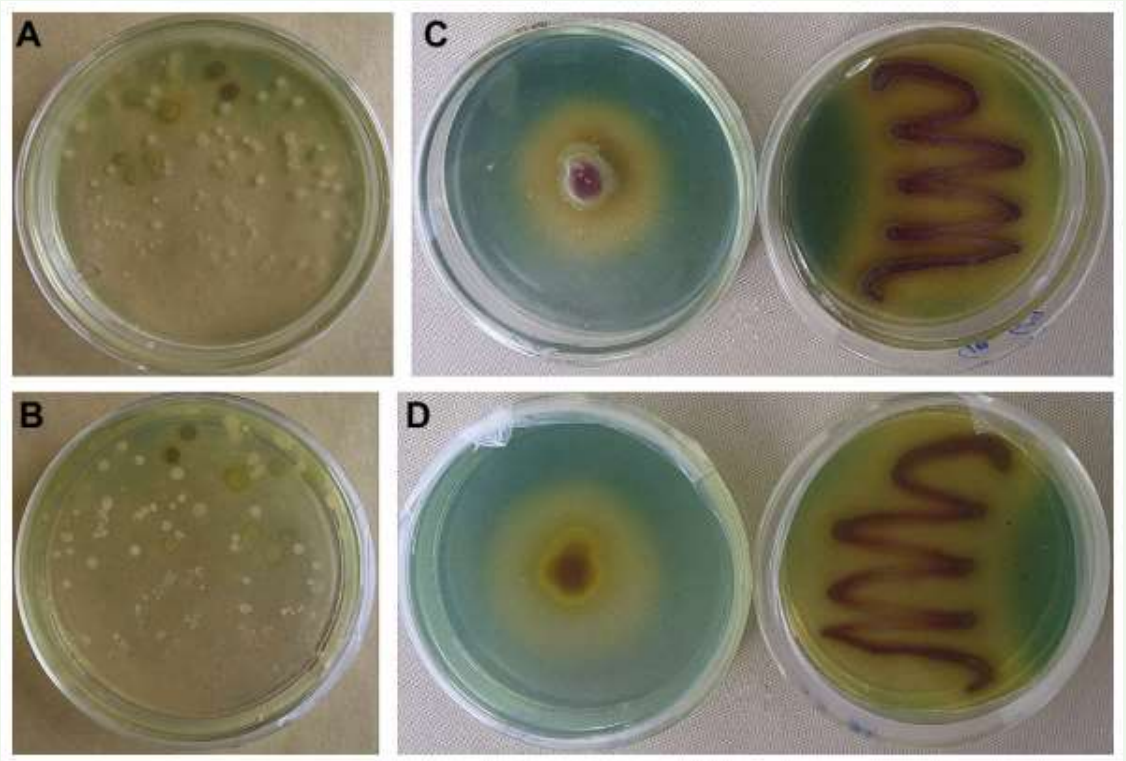
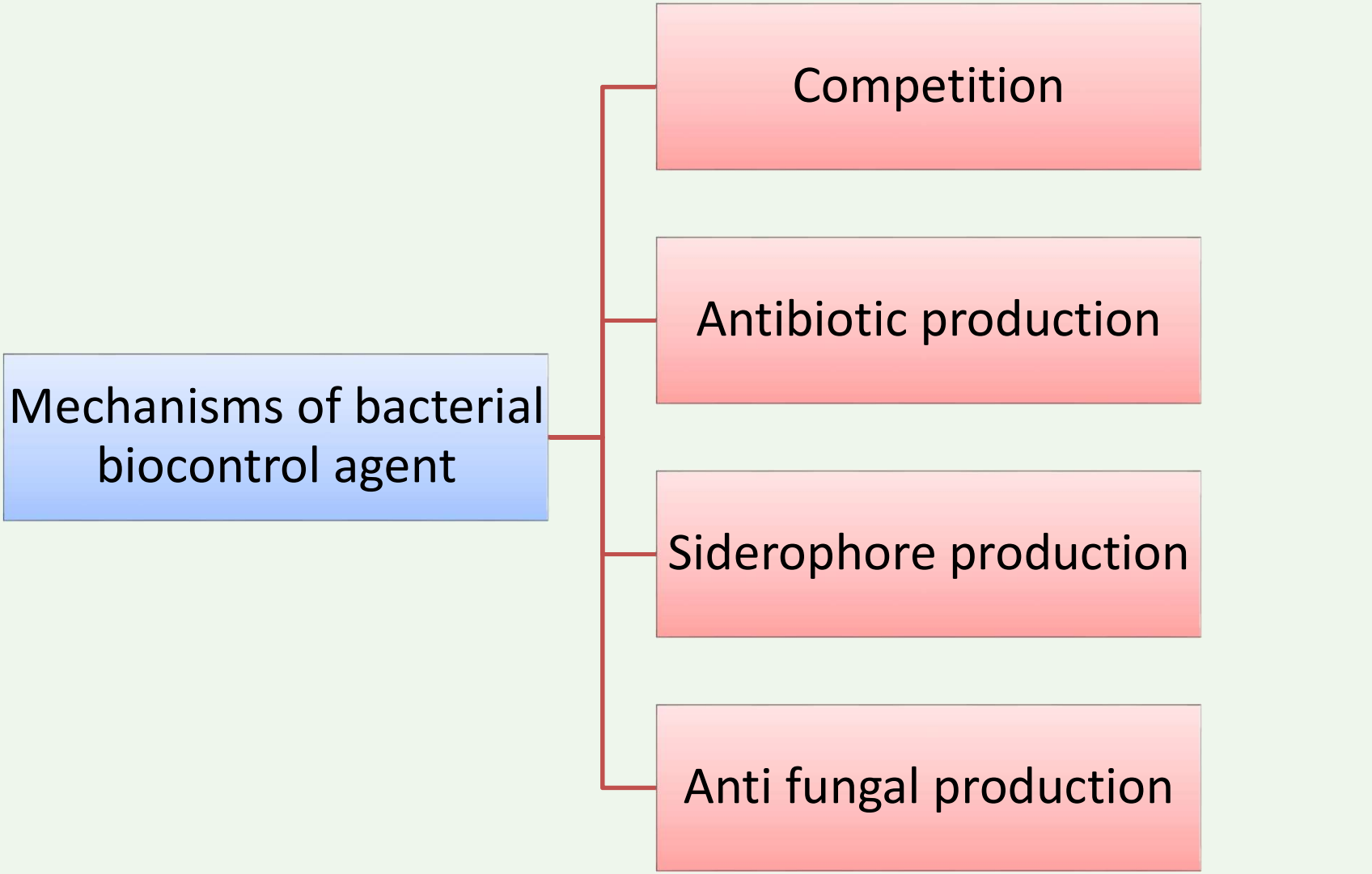


Fig. 1. The screening of siderophore-producing bacteria. A and B: the plate of preliminary screening; C and D: CAS15.

Bacteria used for disease control

- Several other **anti-fungal compounds** have been suggested to be involved in suppression of phytopathogens by rhizobacteria.
- *Bacillus subtilis* controlling common scab of potatoes caused by the actinomycete *Streptomyces scabies*.
- But also, several non-plant pathogenic *Streptomyces* species produce antibiotics which may potentially be exploited in biocontrol of fungal and bacterial diseases and even insects.

Bacteria used for disease control



Fungi used for disease control

- Fungal organisms exerting inhibitory effects on plant pathogens.
- In the case of **antibiosis,** diffusible compounds are produced which inhibit the growth of the plant pathogen.
- Fungi with a strong competing ability may cause other microorganisms to starve by limiting their nutrition or other substantial growth factors.

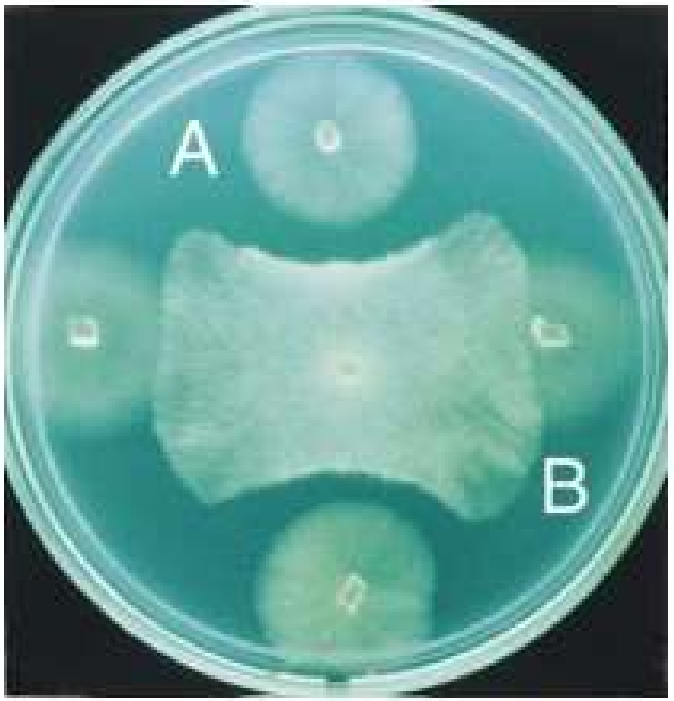
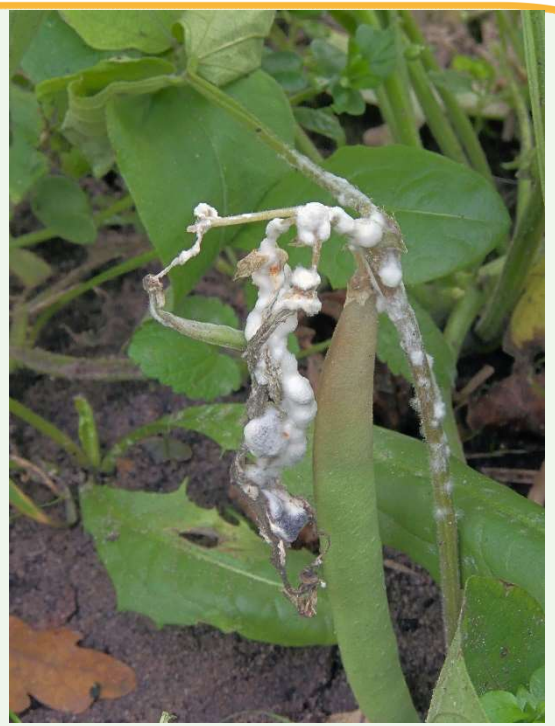


Fig. 3. Growth inhibition of *Pythium ultimum* by the *Trichoderma virens*–produced antibiotic gliovirin: A, parent strain, and B, gliovirin-deficient mutant.

Fungi used for disease control

- **Mycoparasitism** is a direct attack on fungal organs followed by the utilization of their nutrients.
- Example: principle of control of the plant pathogen ***Sclerotinia sclerotiorum*** in pepper with ***Coniothyrium minitans.***
- After its application to the soil, ***C. minitans*** parasitizes the resting structures (sclerotia) of its fungal host.



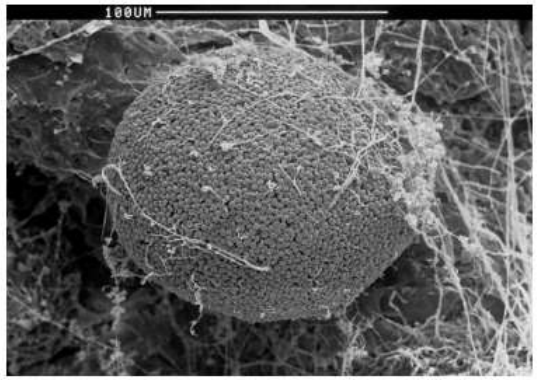


Fig. 13. Conidial droplet of *Coniothyrium minitans* present on the outer surface of the sclerotial rind of *Sclerotinia sclerotiorum* after 6 months incubation in *C. minitans* amended pasteurised soil.

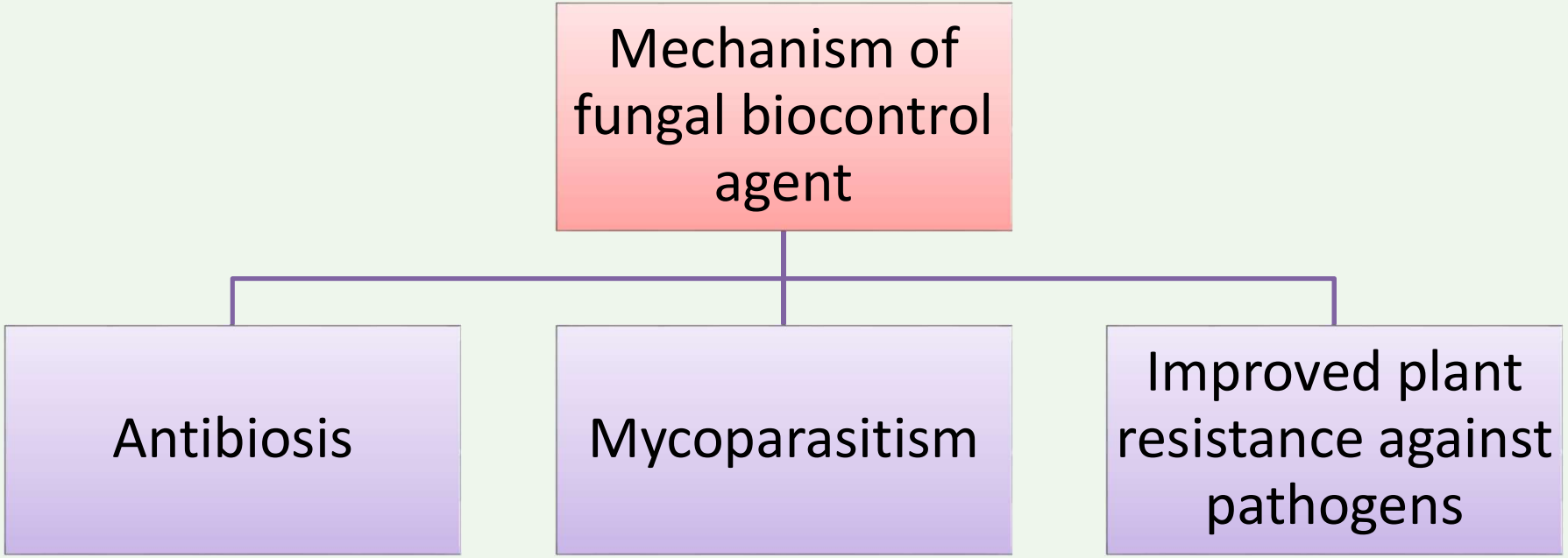
Fungi used for disease control

- **Mycorrhiza** fungi comprise a wide spectrum of species associated with plant roots.
- They have also been shown to control plant pathogens attacking roots.
- One effect of mycorrhiza is a general growth stimulation resulting in improved plant resistance against pathogens.

Fungi used for disease control

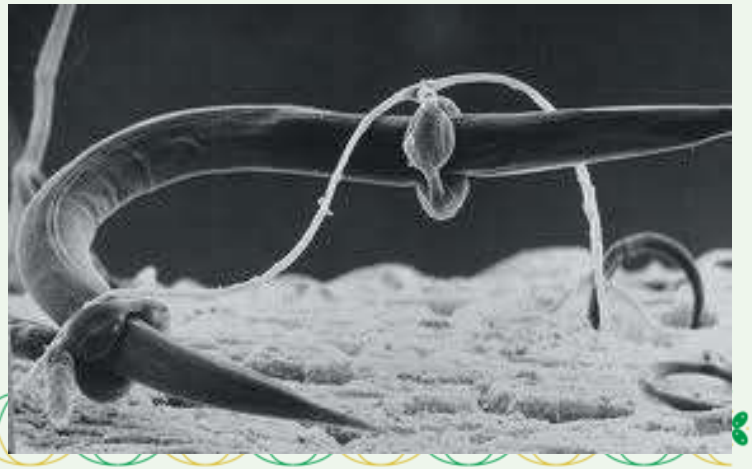
- Apparently, colonization of roots by mycorrhiza fungi sites triggers mechanisms of plant defense such as stimulation of the secondary (phenolic) pathway of the plants (formation of phytoalexins) and activation of defense related genes coding for callose, peroxidase, chitinase, or other pathogenesis related proteins the function of which is not yet fully understood.
- These effects are part of the so-called **Systemic Acquired Resistance (SAR)** which will be dealt with later.
- A challenging strategy is the biotechnological production of vesicular arbuscular mycorrhiza fungi to reduce plant diseases, and further results for application in practical agriculture can be expected from this approach in the future.

Fungi used for disease control



Biocontrol of plant pathogenic nematodes

- A well known method to protect plants against attacks by nematodes is the use of **nematophagous fungi,** which infect nematodes.
- Several species with different infection mechanisms have been described: *Arthrobotrys oligospora* and *Dactyliaria candida* **trap nematodes mechanically** by hyphal loops, *Pleurotus pulmonaris* **lives endoparasitically**, **destroying the intestinal tract** of nematodes, or **toxin producing** fungi and fungi **infecting only the eggs** of the nematodes.



Control of weeds by bioherbicides

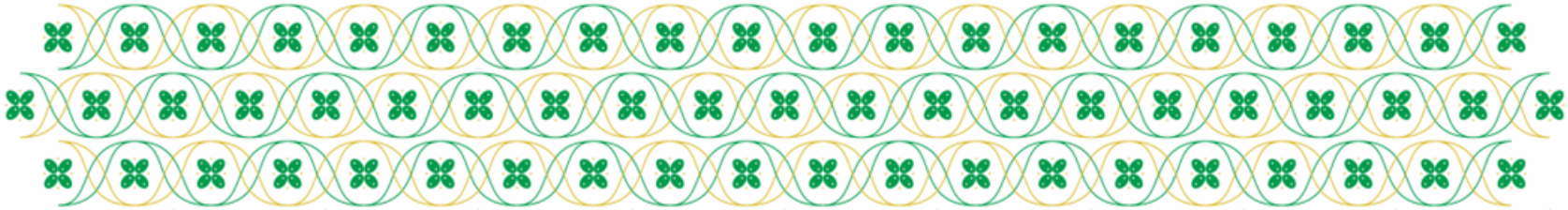
- Most of the bioherbicides damage leaves and are represented by the fungal or **“myco”herbicides.**
- The mycoherbicides can be divided into two groups:
  1. obligate parasites, colonizing their hosts by penetrating the plant cells and forming haustoria (organs for the nutritional uptake) within them (the rust, powdery and downy mildew fungi);
  2. the non-obligate fungi, invading the intercellular space of the leaves by excreting toxins and hydrolytic enzymes. The most abundantly tested fungi on weeds are *Colletotrichum sp., Fusarium sp., Alternaria sp., Cercospora sp., Phoma sp., and Phomopsis* sp.

Control of weeds by bioherbicides

- **Deleterious rhizobacteria** (bacteria, associated with roots) are also applied for biological weed control.
- Bacterial species belonging to pseudomonads, flavobacteria, erwinias, and *Alcaligenes* comprise this group.
- These bacteria can easily be applied to soils as a granulate or as a seed treatment.
- The mode of action is a decrease of the weed emergence and a delay in the growth of the weeds.
- Usually, secondary products produced by the rhizobacteria are controlling the weeds, and there is an almost abundant source of these bacteria found in all types of soils everywhere.

Control of weeds by bioherbicides

- **Natural bioherbicidal substances** are synthesized in the secondary metabolic pathway of certain microorganisms and include compounds such as curvulins, eremophilanes, or bialaphos (bilanafos).
- In the future, such compounds can be regarded as a potential to generate new herbicides because weeds are developing more and more resistance against the classical chemical herbicides.



PENUTUP BELAJAR

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

اَللَّهُمَّ أَرِنَا الْحَقَّ حَقًّا وَارْزُقْنَا اتِّبَاعَه ُ وَأَرِنَا الْبَاطِلَ بَاطِلاً وَارْزُقْنَا اجْتِنَابَه ُ

Ya Allah Tunjukkanlah kepada kami kebenaran sehinggga kami dapat mengikutinya,

Dan tunjukkanlah kepada kami keburukan sehingga kami dapat menjauhinya.