Plant Health Week:

Biocontrol of plant pathogens

Chair: David B. Collinge and Convener: Rosalind Noble, BSPP
Panel: Dan Funck Jensen, SLU, Sweden; Sabrina Sarrocco, Pisa;
Mike Shaw, Reading; Dick Shaw, CABI
Biological control of plant diseases

Direct or indirect inhibition of a disease or the pathogen causing the disease by another organism (antagonist) or group of organisms

Biological control is the reduction of the amount of inoculum or disease-producing activity of a pathogen, accomplished by or through one or more organisms other than man (Baker and Cook)
Biological control – for plant pathologists

• Exploitation of a beneficial organism to control a harmful one.
  • Introduction of a biological control agent (BCA) to the cultivation system
  • Management of the ecosystem to encourage existing BCAs

• This definition does not include exploitation of other beneficial natural processes to control disease or infestation by:
  • Plant or microbial extracts to induce resistance
  • Use of pheromones to attract insects for mating disruption

Fusarium foot rot +/- BCA (© Chatchai Kosawang)

Why biocontrol?

**Advantages:**

- Environmental considerations
  - *e.g.* restricted use of chemical pesticides
- Used where fungicide resistance develops
- Can be applied in organic farming systems
- Can be used where no other control methods are available

**Disadvantages:**

- Inconsistent efficacy between locations and seasons
- Often lower efficacy than chemical pesticides
- ... or disease resistance, if available
- Problems with product quality (*e.g.* shelf-life)

But these challenges are being resolved gradually
Disease suppressive soils were the start

- *Fusarium* suppressive soils (France)
- *Pythium* suppressive soils (Hawaii)
- Mono-culture induced suppressiveness (USA, Australia)
- Suppressive sphagnum peat (Denmark, Finland, USA)
- Suppressive composted material (USA)
Mechanisms of biological control – illustrated with endophytes

More than one mechanism may operate in a specific interaction

Sclerotium of *Sclerotinia sclerotiorum* parasitised by *Trichoderma virens* I10
CF Other biocontrol with plant pathogens

Classical biocontrol of weeds

- Non-native pathogens for the permanent control of an invasive weed.
- Very high level of specificity required - Up to 90 non-target species tested in quarantine.
- Normally obligate biotrophs e.g. rusts and smuts.
- Persistence in the environment expected.
- Can be too specific e.g. Himalayan balsam releases in UK - Variable susceptibility in the field points to the need for a strain from Kashmir.
- Much higher safety requirements than other microbial control activities.
# Ecology and biocontrol mechanisms for diseases caused by fungi and bacteria

<table>
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<tr>
<th>Bacteria BCAs</th>
<th>Fungal BCAs</th>
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| **Strain K84 or K1026**
Agrobacterium *(Rhizobium) radiobacter* | Antibiosis and competition in wounds |
| **Mycostop®** *(Streptomyces sp.)* | Antibiosis and competition |
| **Serenade®** *(Bacillus subtilis strain QST713)* | Antibiosis and competition |
| **Cedomon®** *(Pseudomonas chlororaphis)* | Endophyte in embryo: antibiosis |
| **Root Shield®** *(Trichoderma harzianum strain T22)* | Competition in rhizosphere, mycoparasitism, CWDE, antibiosis, induced resistance. |
| **BinabT®** *(T. harzianum + T. polysporum)* | Competition for space, mycoparasitism CWDE, antibiosis |
| **Gliomix® Prestop®** *(Clonostachys catenulatum)* | Competition in rhizosphere, mycoparasitism, CWDE, antibiosis, |
| **Contans®WG** *(Coniothyrium mimitans)* | Mycoparasitism of sclerotia |

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Slide 9 (adapted from Birgit Jensen & Dan Jensen)
Development of a biocontrol agent

- Isolation of potential biocontrol agents
- Screening for selection of antagonists
- Production (wet or dry fermentation)
- Formulation
  - Shelf life
  - Compatibility with existing technologies
- Delivery systems
  - Seed treatment (seed coating, biopriming etc.)
  - Incorporation in growth substrates
  - Drench, broadcast, in furrow
- Risk assessment (EU, EPA etc.)
- Field performance – GEP efficacy
- Ecology of the BCA and antagonist pathogen interactions
- Market size and market introduction
- Education + Public acceptance
Strategies for isolation of potential BCAs

Isolation of antagonists from the same environment or ecological niches as where they are expected to control pathogens:

Examples:
- bulk soil*
- Endosphere
- Phyllosphere
- Rhizosphere
- Wounds

* e.g. suppressive soils
Use of a mild strain against severe disease may be appropriate against an endemic disease, impossible to eradicate;

- it was transmitted rapidly so that vector control, roguing etc. worked poorly;

- losses from the disease are large, so that some reduction in yield from a mild strain over a long period is a preferable alternative;

- there is evidence that the mild strains protect against severe, cause little damage and will (a) not interact with other viruses (b) mutate to a severe form or (c) jump hosts

Example: Citrus tristeza virus: dieback of sweet orange grafted on sour orange.
Development of BCAs - commercial aspects

- Market size and market introduction
- Public acceptance ("green technology")
- Registration costs (risk assessment and efficacy)
- Costs for development
Challenges and directions

• **Stability**
  • Colonisation is subject to environmental influence and host genotype.

• **Efficacy**
  • Control is not as effective as "vertical" disease resistance.

• **Consortia**
  • Use of mixtures of microbes to supplement each other.

• **Growth stimulators**
  • Do not need costly regulation.
The ‘low risk’ concept for plant protection products within the EU:
- a new opportunity for authorization of biocontrol microorganisms
Jørgen Eilenberg*, Ingvar Sundh, Johannes Jehle jei@plen.ku.dk

Plant protection in the EU
The European Union seeks to reduce the use of chemical pesticides and to encourage the use of non-chemical plant protection methods, with emphasis on IPM. This wish is hampered by the very long-lasting procedure for approval of, for example, microbial control agents.

Introducing a novel concept
In order to speed up the process of approval of non-chemical control like microbial control agents, the EU initiated in 2013 work to define a novel category: ‘low risk’ substances. This category of compounds should be given a possibility to be approved by a ‘fast lane’.
Risks

• Ecological risk in moving BCAs between continents
  • not possible to predict a problem in advance.
• Test for pathogenicity or otherwise harmful effects
  • May be present naturally in low amounts
  • But in large quantities after application for agronomic purposes
• Not be pathogenic towards humans, or allergenic or produce mycotoxins
• A simple screen can be – no growth at 37°C though not all are pathogens
  • But prolific at lower temperature for the supplier
• A myth that something natural is intrinsically safer than something that is artificial.
• “Low risk” is not “no risk!”
Questions

• Why do we need biological control?
• How can we achieve biological control?
• How can biocontrol be used with different agricultural practices, e.g. varietal resistance, synthetics?
• How to find appropriate organisms – where to look and how to screen for them?
• What makes a commercially appropriate organism: efficacy, robustness, persistence versus rapid disappearance?
• How to access risk – including ecological, health aspects.
• How to interpret ‘low risk’, since it does not mean ‘no risk’?
• Should we use the same criteria for viruses, fungi and bacteria?