Biological control of plant pathogens- Theory and application

Content

- definitions and principles
- mechanisms of application
- approaches to Biological
  - conservation/enhancement
  - introduction
  - augmentation

definitions

- Biological control-use of natural enemies to reduce densities of pests or inhibit pest activities
- In plant path: use of living organisms to manage disease

Biocontrol effects on disease development

- reduce pathogen numbers
- exclude or protect infection courts from pathogens (infection court=site of infection. Stomate, wound, etc.)
- reduce symptom severity

Ecological basis for Biological control

- pathogens can be inhibited by "antagonists" (no viruses)
  - habitats contain microbial communities that have members that are antagonistic to plant pathogens
  - antagonists function as a 'negative feed-back' mechanisms

Evidence that biocontrol occurs in nature

- enhancement of disease in soils upon disruption of soil microbial communities
- disease, or pathogen, suppressive soils

    - soils in which particular pathogens are prevented from establishing; or if a pathogen is present, prevented from germinating and infecting
- evidence for biotic involvement:
    - elimination of suppressiveness by sterilization
    - transfer of suppressive effect to conducive soil by transfer of biotic components

Evidence that Biocontrol occurs in nature

- succession of fungi in wood
    - fungal succession: fungi produce compounds that inhibit other fungi (strobilurins)

Antagonistic microbe-microbe interactions

- Resource competition (=preemptive utilization, preemptive exclusion)
    - one organism using up a limited resource before another can have access to it
- Antibiosis

What resources do microbes compete for?

- Nutrients (C, N)
- Minor elements
- Specific triggers for growth/reproduction
- space is not limiting
    - microbes coexist when other resources are available
- water is not limiting
    - at a microbe scale, microbial communities are either high and dry, and thus dormant, or bathed in a sea of water

Competition mechanisms

- competition for nutrients by way of rapid nutrient uptake and growth
    - E.G. prevention of fungal fruit rot using wound-colonizing bacteria
- Removal of a specific growth factor by uptake and preemptive utilization as a nutrient
    - inhibition of *Pithium ultimum* germination on seed surfaces by bacteria
- Removal of a specific growth factor by chemical sequestration

    - competition for iron by excretion of siderophores

Competition for iron via siderophores

- iron is in shore supply
- all microoganisms require ferric iron
- compete using siderophore affinities

Antibiosis

- mechanisms
    - lytic enzymes
    - antibiotics (toxins)
        - excreted antimicrobial secondary metabolites

Lytic enzymes

- serve in substrate conversion
- induced by substrate or digests of substrate
- effective antagonists produce multiple, potent enzymes, and are insensitive to their own enzymes
    - chitinases,Beta-glucanases
        - disrupt fungal cell wall structure
        - work synergistically
    - Proteases
        - important in lysis of bacteria and nematodes
    - Lipases
        - Disrupt cell membrane struture and function

antibiotics

- Antimicrobial secondary metabolites
    - produced by certain organisms against certain other organisms
    - produced only during part of growth cycle, usually when a particular nutrient becomes limiting

Competition vs antibiosis- effect on pathogens

- competition
- keeps soilborne pathogen resting structures in dormant state even when all other conditions are favorable (fungistasis)
    - temporarily halts growth of pathogens
        - no effect on pathogen viability or pathogen numbers
    - antibiosis
        - disrupts pathogen metabolism
        - disrupts pathogen structure
        - causes death of pathogen

Competition vs antibiosis- conditions

- competition more important when resources are limited or unstable over time
- antibiosis more important when resources are stable or higher in supply
    - production is nutrient/substrate dependent
    - antibiosis needed to displace existing competitors or to hold on to resources

Antibiosis is easy to see *in vitro* but its role in nature is difficult to prove

- *In vitro* conditions do not resemble conditions in nature
    - production of antibiotics and lytic enzymes in nature is site Specific
    - antibiotics and lytic enzymes are difficult to detect from natural substrata

Parasitism

- hyphae, spore and sclerotia are host structures
    - mycoparasitism (fungi on fungi)
- parasite must have direct contact with host
- chemicals (enzymes and toxins) are involved in different phases

Host mediated mechanisms

- systemic induction of host defenses
    - most beneficial organisms activate ISR, but many can activate SAR, or both

Host mediate mechanisms

- stimulation of plant growth/vigor via production of growth regulators
- Alleviation of environmental stress
- **Predisposition**: plant being susceptible due to abiotic stress

Three approaches to biological Biocontrol

- conservation/enhancement
  - modify the environment or existing practices to protect and enhance population numbers and activity of existing natural enemies
- Introduction ("classical" biocontrol in entomology and weed science)
  - introduced natural enemy to control introduced pests
- augmentation
  - add native natural enemies to control native pest

conservation/enhancement

- make use of naturally-occuring communities comprised of diverse microorganisms including antagonists
- widely employed but generally not recognized as a form of "biological control"

Conservation of antagonists

- moderating use of pesticides and other biocidal treatments to preserve antagonists
- overlaps with enhancement- removes competitors of antagonists
- Use of mild heat treatments to pasteurize growth media
  - aerated steam treatment
  - solarization
  - aerobic composting of organic material
  - leaves populations of thermotolerant fungi and bacteria to recolonize treated soils

enhancement

- addition of defined nutrients utilized by antagonists as nutrient substrate
- addition of organic matter to microbe-depleted soils
  - control of root rot of avocado caused by *Phytophythora cinnamomi*