Improving biological control of turfgrass pests in the wake of public opinion

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Connecticut Pesticide Ban
July 2010

Bumblebee incidents result in pesticide violations

VICTORY
Montgomery County, MD lawn pesticide law UPHELD!

Connecticut Pesticide Ban
July 2010
Connecticut Pesticide Ban
July 2010

- Areas affected?
  - K-8 grade school grounds
  - Day care centers

- Systematic implementation

- What's banned?
  - all EPA registered pesticides
  - Exemptions (2015):
    - microbial biopesticides
    - biochemical biopesticides
    - horticultural soaps
    - 25(b) Minimum risk pesticides

Unrestricted Management
Monitored IPM
Pesticides Banned

Impacts of Connecticut Pesticide Ban
Field quality change from IPM to pesticide-free management after 2 yrs

Bartholomew et al., 2015

Impacts of Connecticut Pesticide Ban
Practices used by turf managers under various state regulation

Wallace et al., 2016

Benefits of Biological Control:

- Reduce pest populations
- Environmentally friendly alternative to synthetic pesticides
  - Lower risk to non-target species
  - Decompose rapidly
- Less toxic to humans
- Reduce number of chemical pesticide applications
- Reduce pesticide resistance
Biological Control (Biocontrol)

**a simple definition:**

- Using beneficial organisms to reduce populations of pest organisms, or to maintain them at sufficiently low levels
  - General Suppression vs. Specific Suppression

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**General Suppression**

- Promoting a “healthy” habitat
  - Physical, Chemical, and Microbial Environment
  - Solid or foliar applied amendments
    - May contain microbes
    - Stimulate existing beneficial microbes

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**Composts**

- Enhance native soil microbe populations
- Monthly topdressing with 10 lbs/1000 ft² shown suppressing several diseases
  - Dollar spot
  - Brown patch
  - Pythium root rot
- Control varies based on target disease, type of compost, and degree to which material is composted

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**Amendment Benefits**

- Improve soil physical properties
- Soil fertility
- Alter microbiome
- Plant health

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**Specific Suppression**

- Utilizing a specific microbe for combating plant pests
- Form of suppression varies by organism
- Formulated and sold by companies

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**Biocontrol Definitions**

**Do you talk the talk?**

- **Pesticide:** any substance or mixture of substances used to kill pests or to prevent or reduce the damage pests cause
- **Biopesticide:** pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals
  - Microbial biopesticide
  - Biochemical biopesticide
  - Plant-incorporated Protectants (genetic engineered)
Biocontrol Definitions
Do you talk the talk?

• **Microbial biopesticide:**
  - Active ingredient is a living microorganism or a product made by a microorganism
  - GrubGONE
  - Rhapsody
  - Companion
  - Nemasys

• **Biochemical biopesticide:**
  - Natural compounds including plant extracts and naturally-occurring chemicals
  - Insect sex pheromones
  - Neem oil
  - Corn gluten meal
  - Potassium bicarbonate

Biocontrol Definitions
Do you talk the talk?

• **Predators:**
  - Prey on insect pests as young and/or mature bugs, beetles, flies, lacewings and spiders
  - Specialists
  - Generalists

• **Parasitoids:**
  - Seek other insects as hosts for egg laying and development, eventually kill host

Biocontrol Definitions
Do you talk the talk?

• **Biostimulant:**
  - Substance(s) and/or microorganisms that stimulate natural processes to enhance/benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, and plant quality
  - Seaweed extracts
  - Humic acids
  - Microbial inoculants

  No pest control = Not pesticide

Biocontrol Definitions
Do you talk the talk?

• **Microbial Biopesticides Mode of Action:**
  - Current products work to control pests using one or more mechanism
    - Parasitism
    - Antibiosis
    - Competition
    - Induced resistance
**How Microbial Biopesticides Work:**

**Parasitism**

- Consuming or parasitizing the pest, directly
  - *Trichoderma* spp.
  - Soil inhabiting fungi consume hyphae of pathogens
    - Obtego
    - RootShield Plus

**Antibiosis**

- Poisoning the pest: production of antibiotics toxic to pests
  - *Bacillus* spp.
    - Rhapsody
    - Companion
    - CEASE
    - Serenade
  - *Pseudomonas* spp.
    - Zio

**Dollar Spot Control in Bentgrass with**

*Pseudomonas aureofaciens (TX-1)*

- Untreated Check
- TX - 1

**Take-all Patch Decline - Wheat**

- Disease reduction – Pseudomonas spp.

**How Microbial Biopesticides Work:**

**Antibiosis**

- Poisoning the pest: production of antibiotics toxic to pests
  - *Bacillus thuringensis*
    - GrubGONE
  - Toxins active in high gut pH degrade stomach
The effect of endophyte on red thread in creeping red fescue

How Microbial Biopesticides Work: Competition
- Crowd the pest: antagonists reduce pest growth by competing for food and space
  - Bacillus spp.
  - Pseudomonas spp.
  - siderophore production

How Microbial Biopesticides Work: Induced Resistance
- Stimulating plant’s own natural defenses

Microbial siderophores
- Iron required by most living things
- Siderophores are small molecules that sequester iron from the rhizosphere
- The sequestered iron can only be used by the microbe that produced it and by certain plants

Microbial biopesticides
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GALLTROL – A®
BIOLICAL PREVENTION OF CROWN GALL DISEASE
Bacterial inoculant which aids the control and prevention of crown gall on certain fruit, nut and ornamental nursery stock (including bare-root seedlings, liners and planting stock)

Active Ingredient:
- Agrobacterium radiobacter (Strain K84) 99.00%
- 1.2 x 10¹⁵ c.f.u. plant⁻¹ (Equivalent to 1 liter of 1.2 x 10⁸ cells per ml)
- inert Ingredients: (included by FDA) 1.00%
- 100.00%

Microbial Biopesticides Mode of Action:
- Current products work to control pests using one or more mechanism

<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>Systemic acquired resistance</th>
<th>Induced systemic resistance</th>
<th>Lethal</th>
<th>stunt</th>
<th>Delayed</th>
<th>Root pressure</th>
<th>Root deformation</th>
<th>Root inhibition</th>
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Current Microbial Biopesticides for Turf

<table>
<thead>
<tr>
<th>Biofungicides:</th>
<th>Bioinsecticides:</th>
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<tbody>
<tr>
<td><strong>Trade name</strong></td>
<td><strong>Active ingredient</strong></td>
</tr>
<tr>
<td>EcoGuard</td>
<td><em>Bacillus licheniformis</em> SB3086</td>
</tr>
<tr>
<td>Rhapsody</td>
<td><em>Bacillus subtilis</em> QST713</td>
</tr>
<tr>
<td>Companion</td>
<td><em>Bacillus subtilis</em> 4B03</td>
</tr>
<tr>
<td>Zio</td>
<td><em>Pseudomonas chlororaphis</em> AF5009</td>
</tr>
<tr>
<td>Obtego</td>
<td><em>Trichoderma asperellum &amp; T. gamsii</em></td>
</tr>
</tbody>
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**GrubGONE G (Bt galleriae SDS-502)**

- grubGONE!® - 9% ai granular formulation
- Applied at 100-150 lbs/ac (9 – 13.5 lbs ai/ac)
- Cost ~$280-420/ac
- > 2 years shelf life
- OMRI approved
- Apply vs. young grubs (L1, L2)
- Most effective vs. Japanese beetle
- More variable with masked chafers and oriental beetle

**Microbial Biopesticides**

- Efficacy of microbial biopesticides variable
  - Bt applications for white grub control seem promising
  - Potential for additional insect pest controls
    - other bacteria, nematodes, fungi
  - Bioherbicides: none registered in U.S. for use in turf
  - Biofungicides: less effective turf disease control:
    - 24 Trials evaluating: *Bacillus subtilis, B. licheniformis, Trichoderma harzianum, T. virens*
    - Only 33% of trials reduced disease compared untreated

**Biocontrols Exist Naturally?**

**Isolating New Biocontrol Sources**
Isolating New Biocontrol Sources

Remember the Disease Triangle?

Inoculating Beneficial Microbes
- Microbes must be viable
  - Biological products have a shelf-life
- Need to have enough microbes to bring about a change
- Microbes must be successful in surviving and multiplying

Quorum Sensing in Bacteria
- Bacteria produce signal compounds that are perceived by other bacteria
• When the signal has been received by a certain number of cells, this is called a quorum.

**Quorum Sensing: What’s the Big Deal?**

- Density related processes
  - Pathogenicity
  - Motility
  - Biofilm formation
  - Sporulation
  - Antibiotic production
- Cross-talk exists between fungi and bacteria
  - Microbial Competition can limit disease

**Can we apply or recruit beneficial microbes to outnumber existing microbes?**

**Environmental Hurdles**

- Temperature
- Moisture
- UV light
- Other microbes
Man-Induced Hurdles

- Mowing
- Irrigation
- Fertilizing
- Pesticides

A Game of Numbers

Biocontrol Application: $1 \times 10^9$ bacterial cells per gallon

Soil bacteria: $\sim 1 \times 10^{15}$ per 1000 ft$^2$

~0.0004% alteration to population (C. Bigelow)

Traditional Biocontrol Application

Reducing Competition

Surface Disinfestant

Reducing Competition

Biological Product
Succeeding with Biocontrols

- Applications must be frequent
- Apply under favorable environmental conditions
- High rates may help
- Consider rotations with conventional fungicides
- Temper expectations

Current Best Practices for Optimizing Biocontrol Efficacy

- Accurate identification of pest problems
- Use preventively
- Utilize in IPM program
- Store carefully
- Be mindful of product compatibility
- Combine biocontrol modes of action
- Wear personal protective equipment

Developing Field Research

New project initiated with Montgomery County MD in 2019
Locations – College Park, MD
Rockville, MD
Grass Type – Tahoma Bermuda grass

Scope of Study
Year-round organic vs conventional programs evaluating disease, insect, and weed control

Thank You

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