

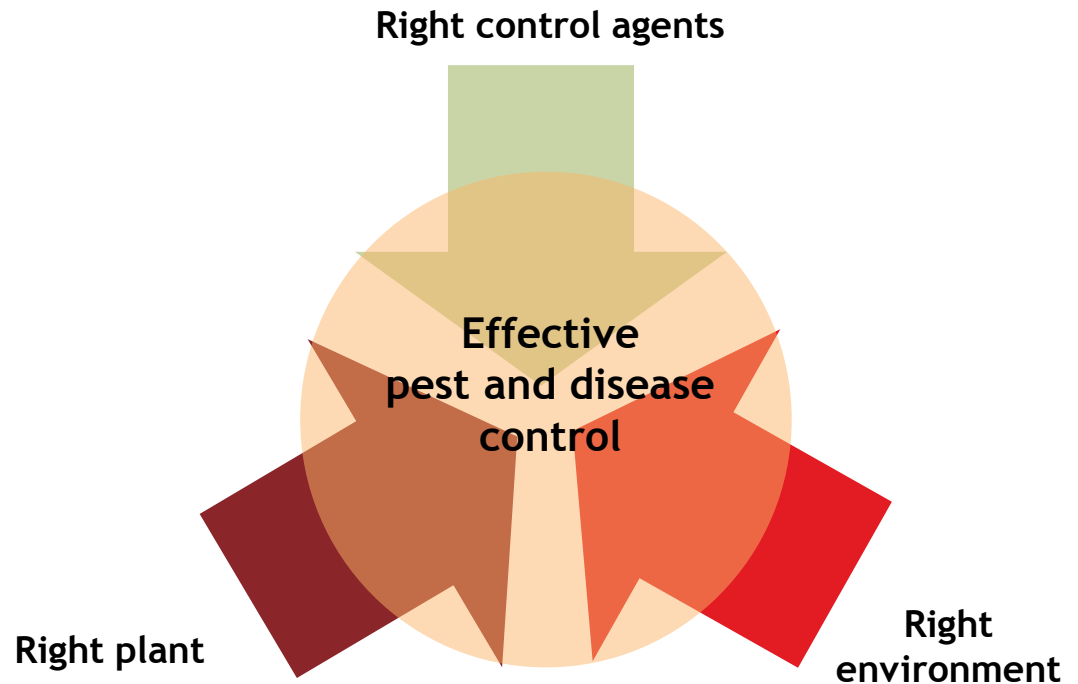
Utilizing beneficial microbes in a systems approach to plant disease management

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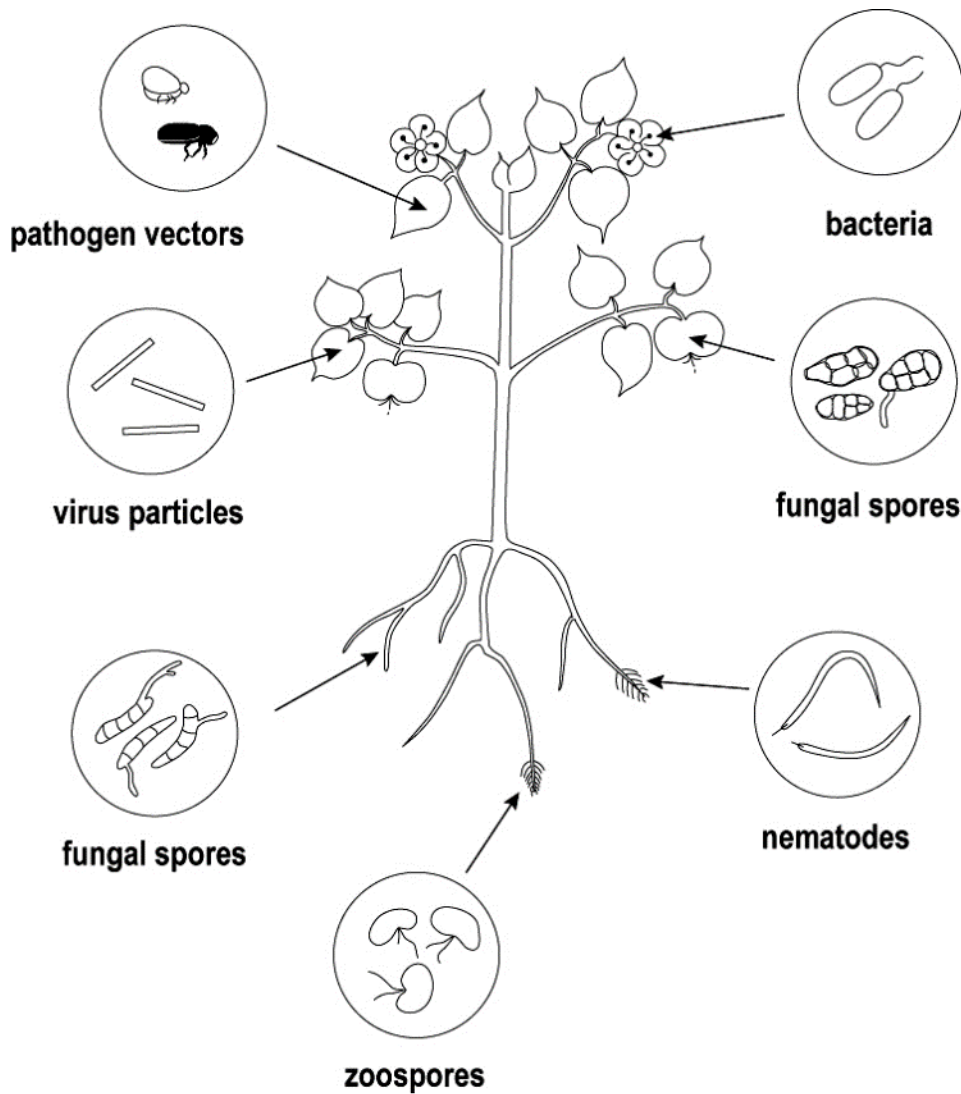
NH Joint Winter meeting
January 17, 2018



Utilizing beneficial microbes in a systems approach to plant disease management

1. Plant disease management
2. What are biopesticides?
3. How do biopesticides work?
4. What are the benefits of using biopesticides?
5. How do we use biopesticides successfully?

Plant diseases

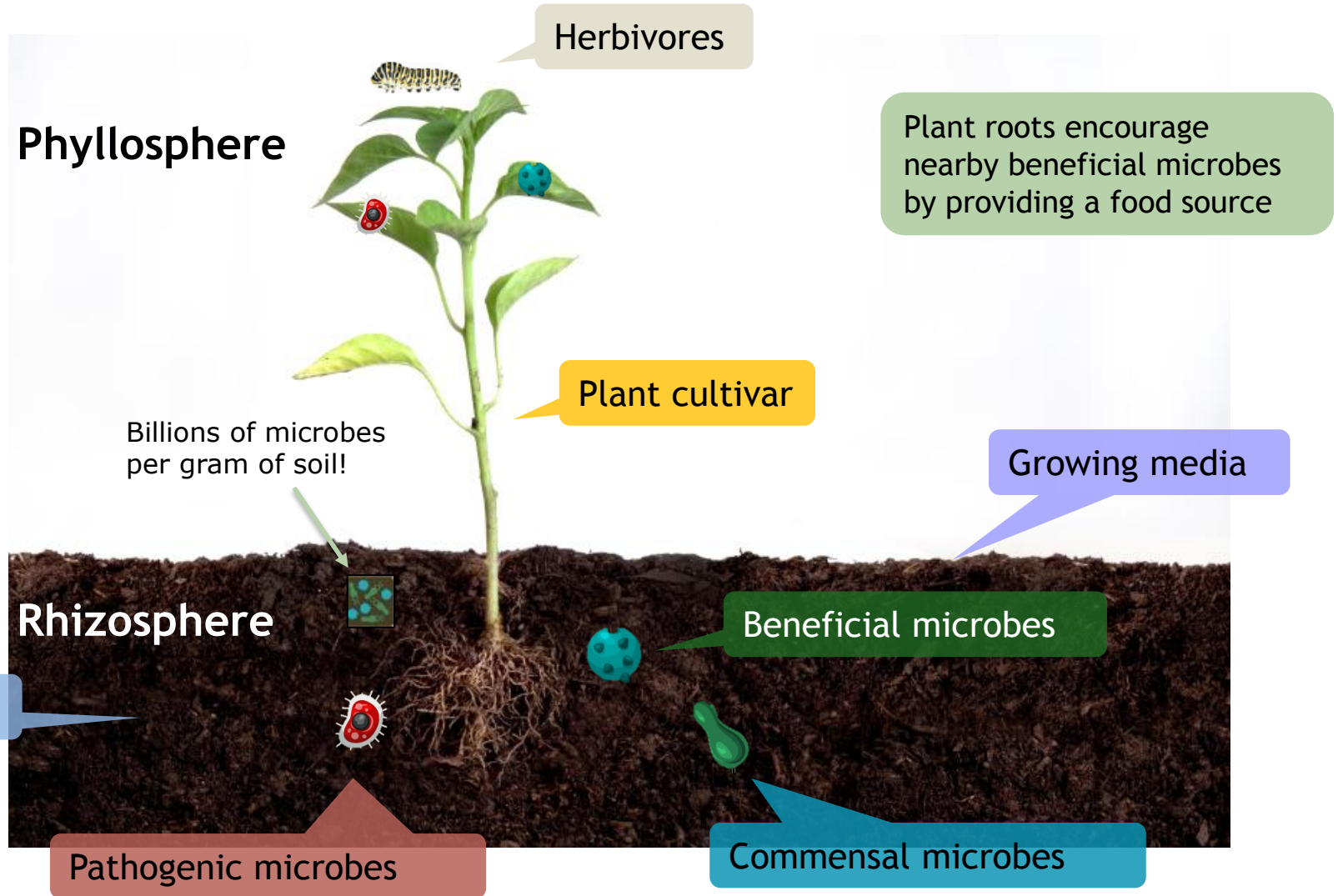


Plants are exposed to a variety of microbes

Disease is actually the exception

Many microbes are harmless

Many factors influence plant health



Plant diseases cause millions in lost revenue annually



Pathogens

- Bacteria
- Fungi
- Viruses



Sick plants

- Quality
- Yield



Lost revenue

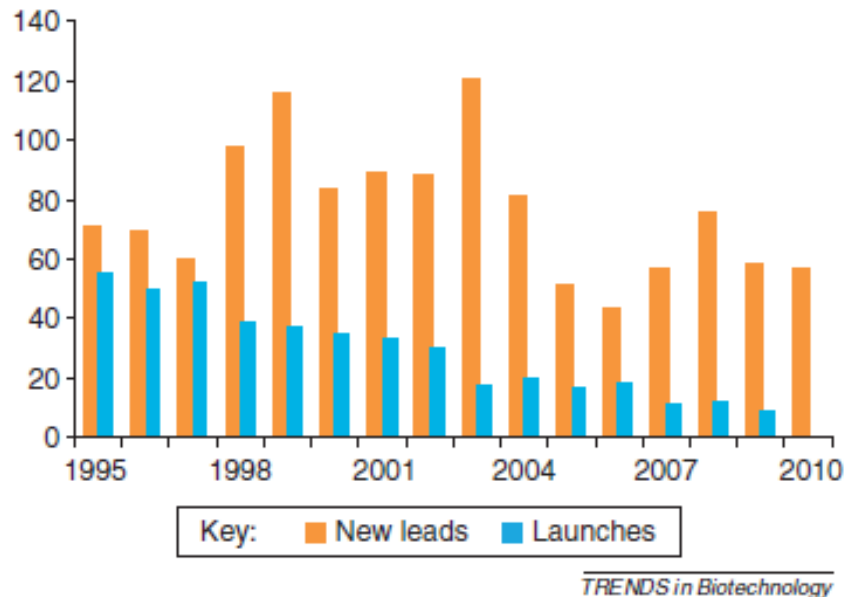
- Growers
- Retailers
- Consumers

Discovery of new synthetic pesticides has become more difficult and costly

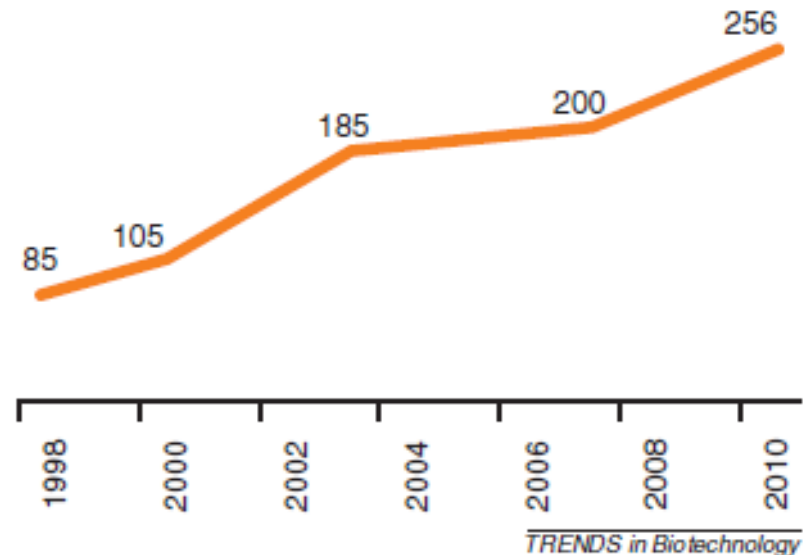
The numbers:

Synthetic pesticide = >\$259 million and 10 years

Biopesticide = \$3-5 million and 3 years



Number of new chemical leads vs number of launches



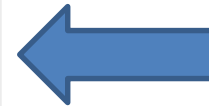
Increasing cost in \$US million over time to develop one new chemical pesticide

The biopesticide market has been growing

Key drivers of biopesticide market growth

1 = not relevant 10 = highly influential

DRIVERS	2013	2025
Residues	10	8
Regulatory	7	4
Resistance Management	4	10
Public Perception	6	6
Performance	4	9



The evolving biopesticide industry

The early years

Solely the domain of small companies

- Insufficient technical support
- Insufficient shelf life

- Under-delivered on products
- Less stringent efficacy requirements
- Many snake oil products



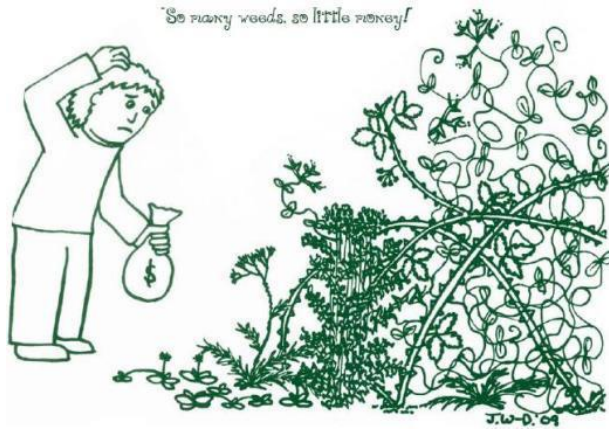
Today

Investment area for leading agrochemical companies

- Formulation improvements
- Improved technical support
- Manufacturing control

- Only the commercially viable have survived
- More cost effective and predictable products

Biological control can be used to suppress many types of pest organisms



Weeds



Insects



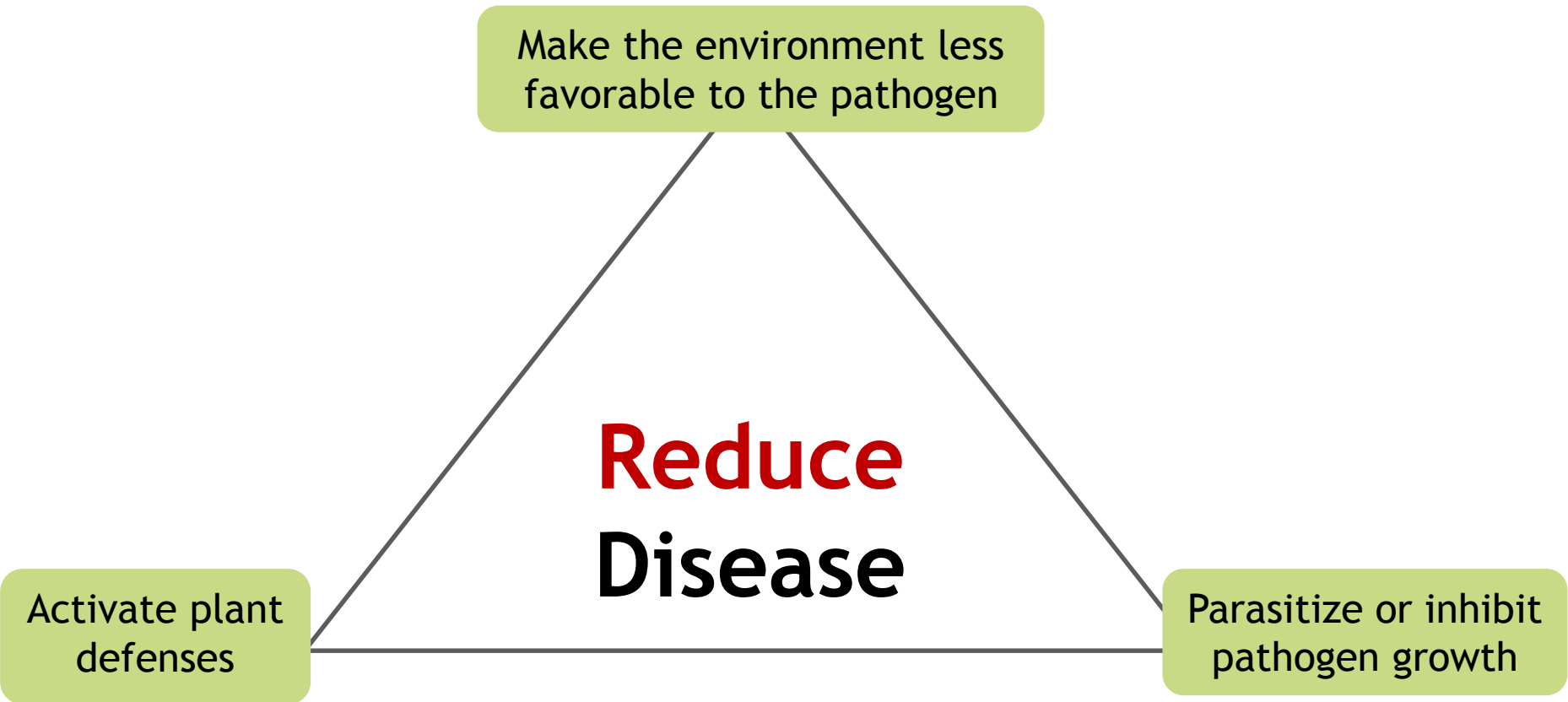
Plant pathogens

Biological control: Pathogens have pests too!



**Beneficial organisms are also present on your farm
Let's put them to work!**

Biological control: Utilizing **beneficial** organisms to suppress **pest** organisms



What are biopesticides?

“A type of pesticide derived from such natural materials as animals, plants, bacteria, and certain minerals”

Includes....

- Microorganisms (Microbial biopesticides) – Rootshield, Met52
- Microbial extracts – biochemical pesticides
- Naturally-occurring substances – MilStop
- Substances produced by plants - Regalia

What are biopesticides?

What biopesticides do

- Suppress diseases with unique MOAs
- Act preventatively
- Effective at low to moderate pressure
- Promote rooting and plant growth
- Help plants resist stress
- Enhance availability of nutrients

What they do not do

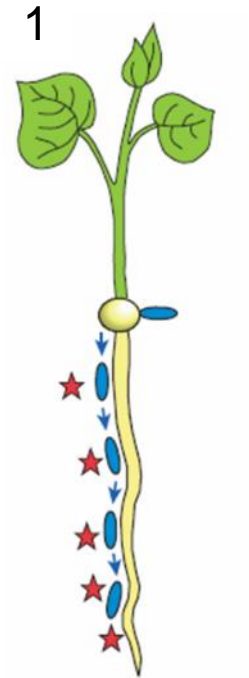
- Offer 100% protection
- Cure diseases (few exceptions)
- Effective at high disease pressure
- Last indefinitely
- Work in environmental extremes

How do biopesticides work?

Biopesticides suppress disease via one or more modes of action (MOA)

1. Antagonistic metabolites
2. Induced host resistance
3. Nutrient and niche competition
4. Predation or parasitism

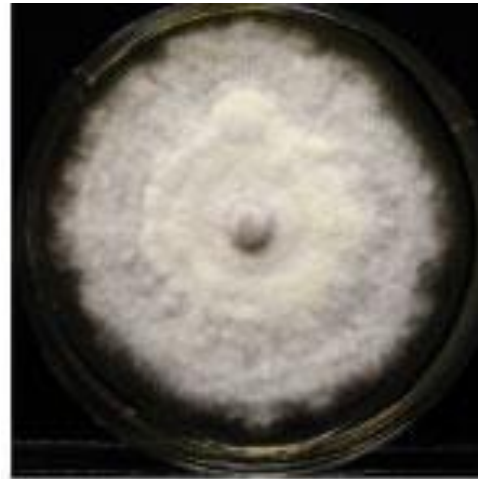
These MOAs are different from conventional fungicides



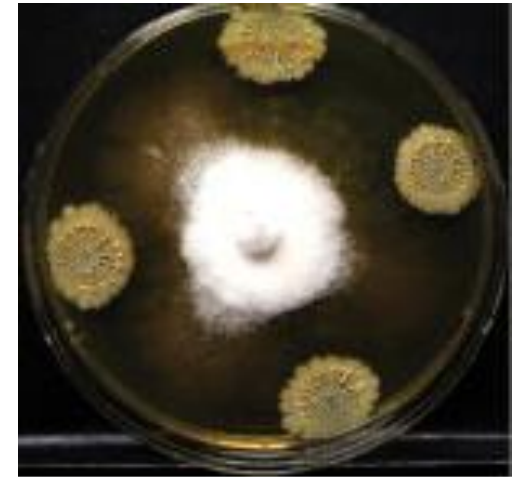
Antagonistic metabolites: Toxins or enzymes that kill or interfere with other microorganisms



<http://floriculture.osu.edu/archive/sep99/biocon.html>



Fusarium



Fusarium + Bacillus

G.S. Ali, University of Florida

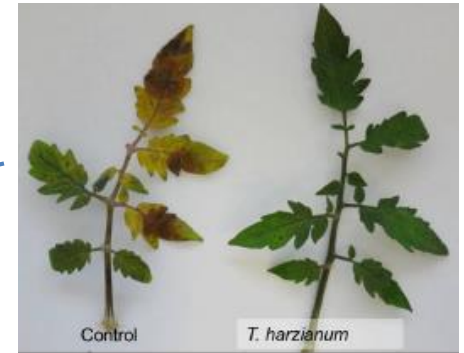
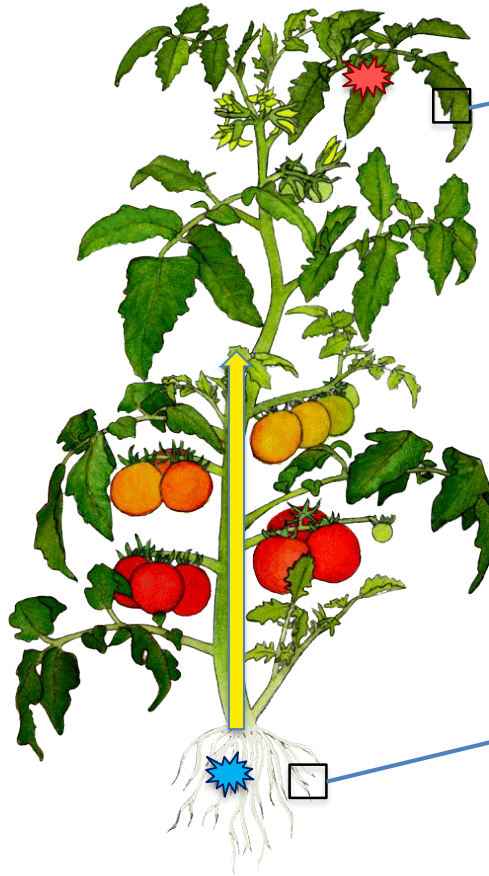
Induced resistance: Turning on plant defenses



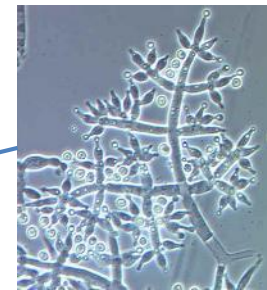
3. Activation
of defenses

2. Signalling

1. Perception



Disease protection on leaves



Trichoderma applied to roots

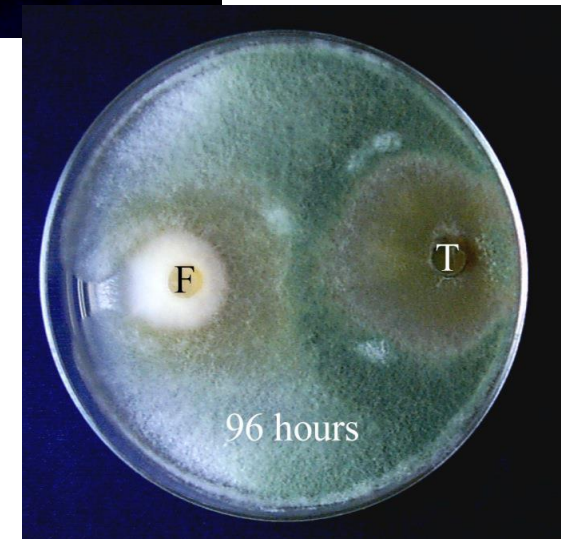
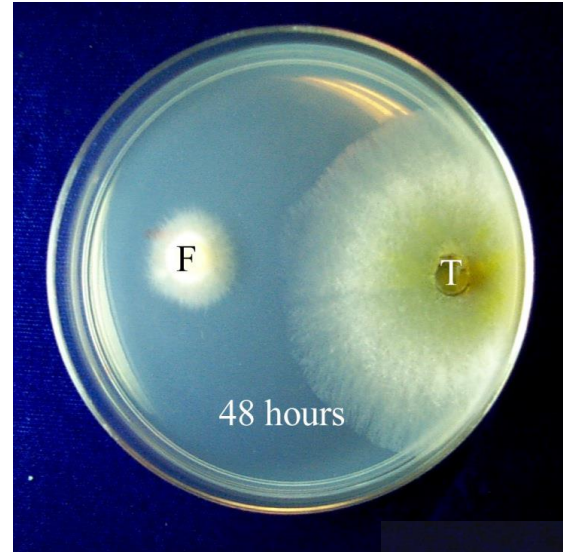
Competition: Biocontrol agent outcompetes pathogen for space or nutrients



<http://floriculture.osu.edu/archive/sep99/biocon.html>

Manage environment to
disfavor the pathogen and
favor the biocontrol agent

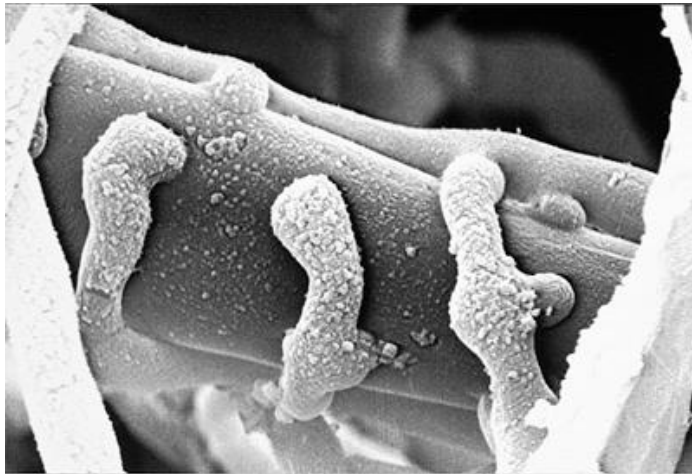
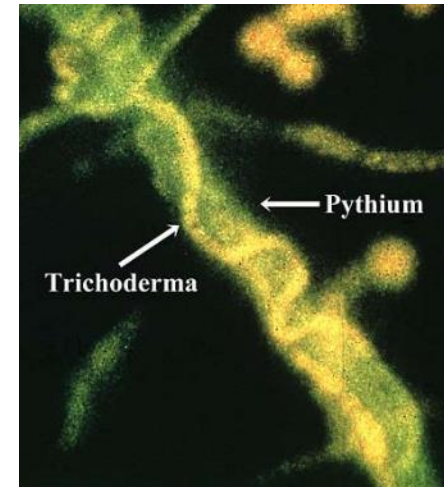
Speed is important for
effective competition



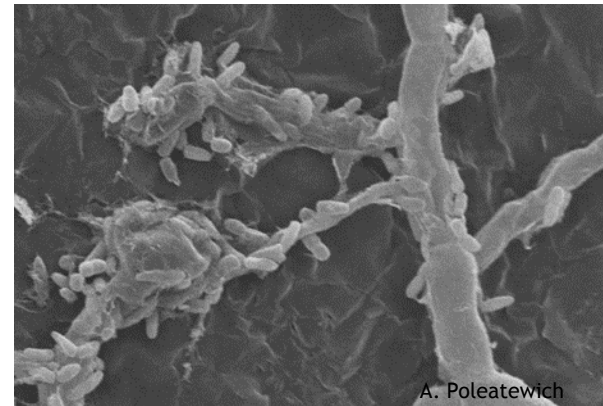
Predation and parasitism: The microbial agent attacks or consumes the pathogen



<http://floriculture.osu.edu/archive/sep99/biocon.html>



Gliocladium catenulatum (Prestop®) attaching to *Rhizoctonia solani*

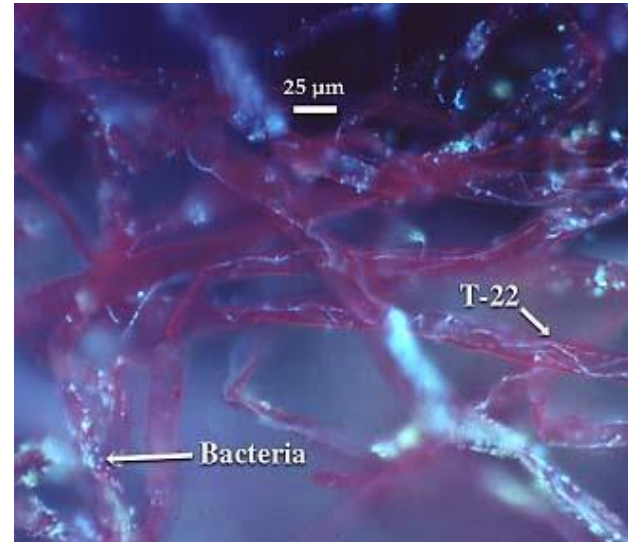


Bacillus megatarium attaching to *Colletotrichum acutatum*

Several modes of action are often at play

Example: *Trichoderma* spp. are common soil inhabitants and microbial parasites

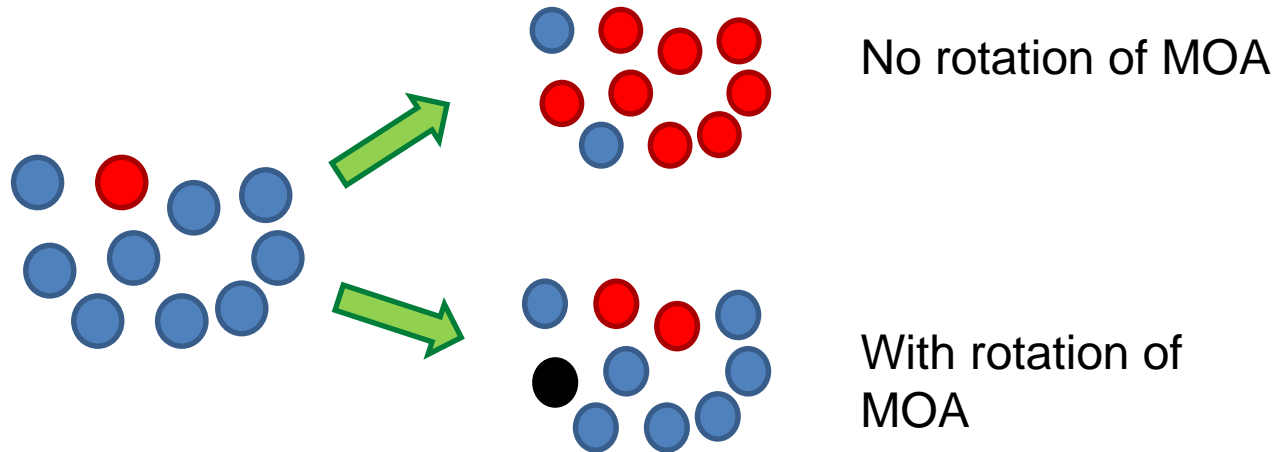
- ✓ Mycoparasite
- ✓ Competitive exclusion
- ✓ Induces host defenses
- ✓ Antibiosis



What are the benefits of using biopesticides?

1. Resistance management – alternative modes of action

- MOA = the way a chemical works
- Single site vs multisite



2. Short re-entry and pre-harvest intervals

What are the benefits of using biopesticides?

4. Most are exempt from Maximum Residue Limits (MRLs)
5. Worker safety
6. Consumer demand/perception
7. Minimal impact on beneficial organisms – predators
8. Align with market trends toward sustainability

The goal of disease management is to reduce the harmful effects caused by a disease

Control

- Completely eliminate disease
- High costs
- Reactive

Management

- Maintain disease below economic threshold
- Continual process
- Must know pathogen biology

Debunking the Myths

Manufacturers cite the following as the most common misperceptions about biopesticides:

MYTH: All biopesticides are alike.

FACT: Quality can vary widely. It's easy to see which biopesticides have value by what's being used in the marketplace.

MYTH: Biopesticides are difficult to use.

FACT: There is a learning curve, but they can deliver significant value when used properly.

MYTH: Biopesticides are intended to replace traditional chemicals.

FACT: Most biopesticides are intended for use in conjunction with traditional chemicals.

MYTH: Biopesticides are only for use in organic production.

FACT: Only about 5% of all biopesticide use is for organic applications.

MYTH: Biopesticides are not reliable.

FACT: Biopesticides are reliable when used properly. It's important to be educated before using them; a dealer should only partner with established suppliers that offer strong technical support programs.

How do we use biopesticides successfully?

Best practices

- Can deliver value when used properly
- Maximum benefits when used in an IPM program
- Learning curve
- Proper use is important
 - Know your crop, pathogen biology
 - Use registered products
 - Consult with extension specialists, product technical support
 - Apply according to the label
 - Check for compatibility

Use only registered products to manage diseases according to the label

Check label for:

- Diseases product can be used for
- Crops and usage
- Application rates, methods and mixing instructions
- Storage requirements

Triatum G Biological Fungicide

For the suppression of post-emergence damping off (*Rhizoctonia solani*, *Pythium ultimum*), fusarium root rot and crown rot (*Fusarium oxysporum*), pythium root rot (*Pythium aphanidermatum*), root rot (*Pythium ultimum*) and cavity spot (*Pythium violae*) on listed greenhouse and field crops and greenhouse ornamentals, and for the reduction in symptoms of dollar spot (*Sclerotinia homoeocarpa*) and microdochium patch (*Microdochium nivale*) on turf

COMMERCIAL
READ THE LABEL BEFORE USING

GUARANTEE: *Trichoderma harzianum* Rifai strain T-22 contains a minimum of 1.5×10^8 colony forming units per gram of dry weight

Why?

Only registered biopesticides can be legally sold and used for disease control

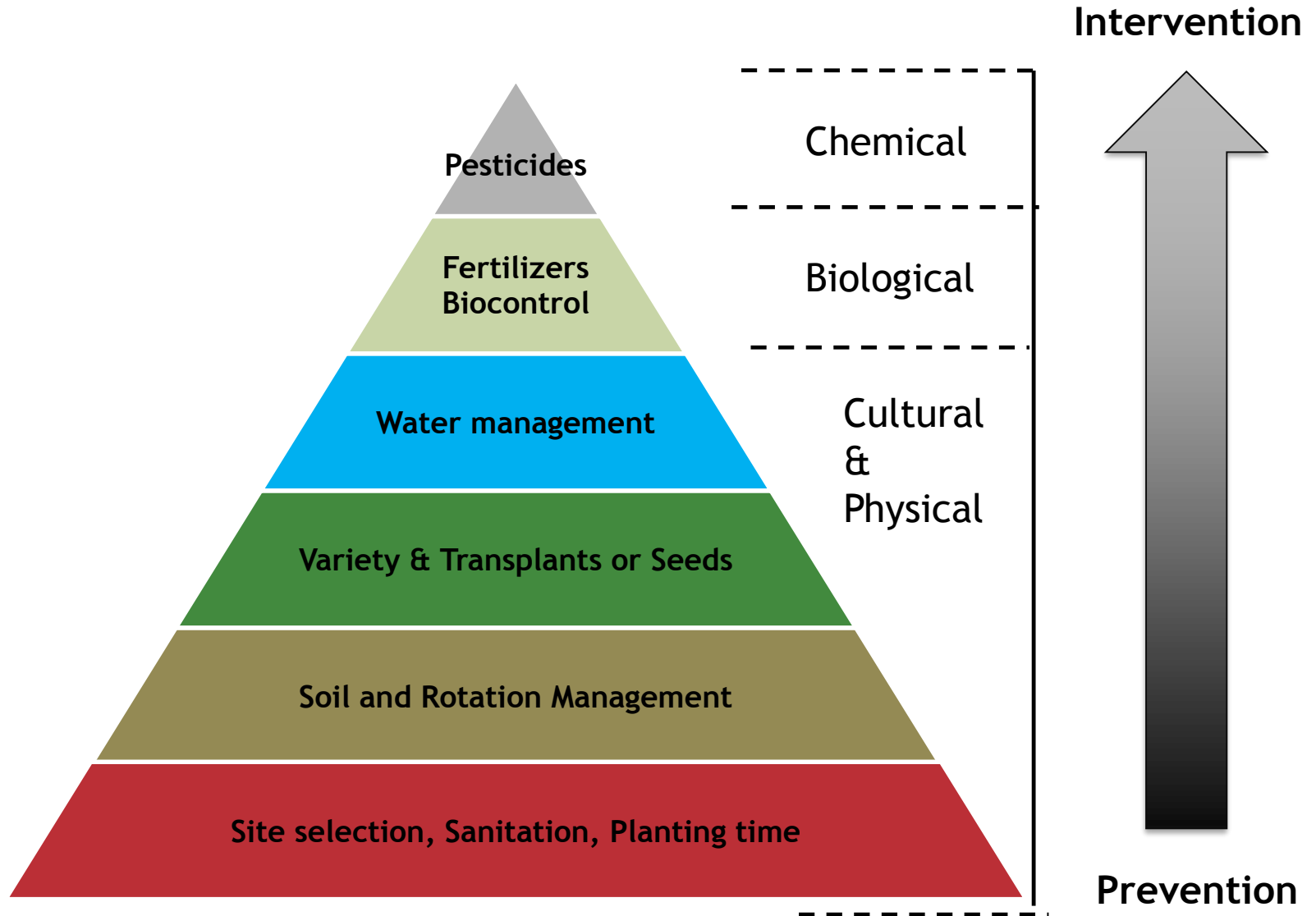
By law, biopesticide manufacturers are obliged to:

- guarantee product quality and purity
- undergo safety, environmental and efficacy testing
- Undergo federal review
- pay all independent testing and regulatory costs

Beware of unregistered disease control products

- quality control, safety, and traceability are not documented
- buyer has little to no recourse if something goes wrong

A combination of tactics provide a sound management strategy



Start with a good foundation

1. Limit pathogen spread with cultural practices
2. Limit conditions favorable for disease
3. Start early, start clean
4. Promote plant health
5. Provide proper nutrition
6. Use Resistant varieties
7. Identify the pathogen

Rotate biopesticides with other products

Check for compatibility
and synergies

Rotate modes of action
(FRAC codes)

Fungicides	
Active Ingredient (a.i.)	Brand Name(s)
Aluminum tris (O-ethyl phosphonate)	Aliette® (at 100x stock solution, use within 1 hour)
Azoxystrobin	Heritage®, Abound®, Quadris®
<i>Bacillus licheniformis</i> strain 3086	EcoGard® GN
Boscalid plus Pyraclostrobin	Pageant®
Cyazofamid	Segway®
Dimethomorph	Stature®
Etridiazole and Thiophanate-methyl	Banrot®
Fenamidone	FenStop®
Fludioxonil	Medallion®, Maxim®
Mefenoxam	Subdue Maxx®, Ridomil, Ridomil Gold®
Pentachloronitrobenzene (Quintozene)	PCNB, Terraclor® 400, Turfcide®, Penstar®. At labeled dilutions, not compatible in a 100X concentration.
Pyraclostrobin	Empress®, Cabrio®, Insignia®, Pristine®, Headline®
<i>Reynoutria sachalinensis</i>	Regalia®
<i>Streptomyces griseoviridis</i> strain K61	Mycostop® (use within 2 hours)
<i>Streptomyces lydicus</i> WYEC 108	Actinovate®
Thiabendazole	Mertect® (When tank-mixed for 4 hours or less)
Thiram	Spotrete®, Vitavax® 200

Insecticides	
Active Ingredient (a.i.)	Brand Name(s)
Azadirachtin	Molt-X®
<i>Beauveria bassiana</i> strain GHA	BotaniGard® ES, BotaniGard 22WP, Mycotrol® O
Cyantraniliprole	Mainspring
Cyromazine	Citation®
Dinotefuran	Safari®
<i>Isaria fumosoroseae</i> Apopka Strain 97	Preferal®
Pyrethrins	Pyganic
Spirotetramat	Kontos®
Thiamethoxam	Flagship®

Microbial Inoculants	
Brand Name(s)	
EM-1	

Surfactants	
Brand Name(s)	
AquaGro® 2000	
AtPlus S-12	
Bivert®	
Capsil®	
Flozine®	
Latron® B 1956	
PsiMatric	
R-11	
Silwet	
Silwet Eco	
Many other non-ionic surfactants	

Impacts on other components of your system

Impact on crops

- Test on a small area
- Use according to the label
- Dip rates are often lower than spray rates

Impact on other beneficial organisms?

- Check the label, ask supplier or specialist
- More research on biofungicides is needed

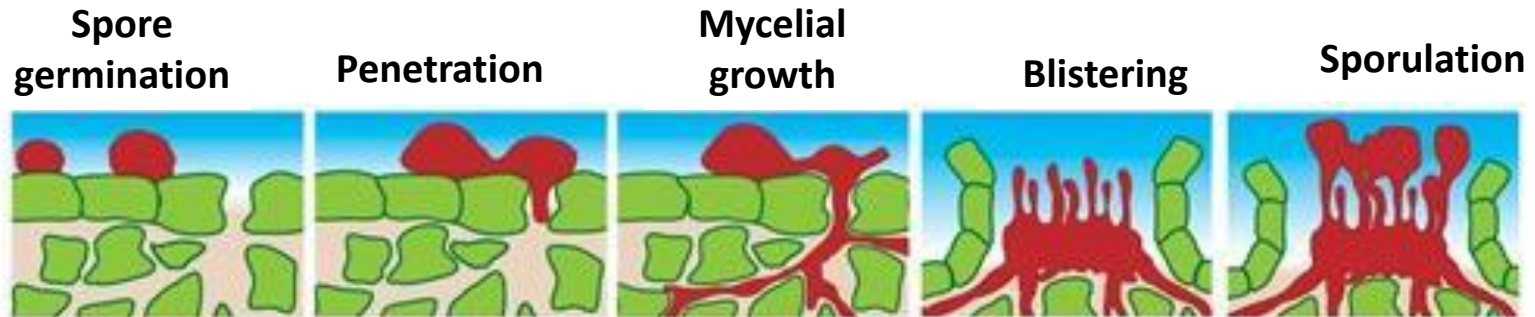
Most biological controls are preventative.....they must be applied before symptoms appear

Applications should begin...

- Before disease symptoms appear
- At first sign of disease

The sooner applications begin, the more likely you can gain control

Most biological controls are preventative....they must be applied before symptoms appear



	PREVENTATIVE	CURATIVE	ERADICANT
Zone of activity	Stops spore germination on the leaf surface to prevent infection.	Stops early pathogen development inside the plant.	Stops pathogen development when disease symptoms are visible and prevents further spread.
Application timing	Best applied just ahead of periods of high disease risk and before disease infection.	Apply at periods of high disease risk, when infection could have occurred, but before symptoms are visible.	Apply when the first signs of infection are identified.

Re-application is often needed

- Frequency of application is related to residual time, or time to degrade
- Biochemicals may be “washed” away after root growth and irrigation
- Microorganisms can grow within the root zone and can persist for longer
- Re-apply when transplanting – colonize new substrate
- Most often regular applications are best

General characteristics of microbial based active ingredients

	Fungal	Bacterial	Notes
Example	<i>Trichoderma</i> spp.	<i>Bacillus</i> spp. <i>Streptomyces</i> spp.	
Re-application rate	Longer intervals, every 12 weeks	Shorter intervals, every 4 weeks	Depends on mode of action
Environmental Diversity	Broad pH, soil temps, moisture	Narrow pH, soil temps, moisture	Can be variable, check label
Compatibility	Typically broader	Somewhat limited	Some can be tank mixed, check label
Shelf life	Typically up to 1 yr	Up to 2 yrs	Temperature dependant

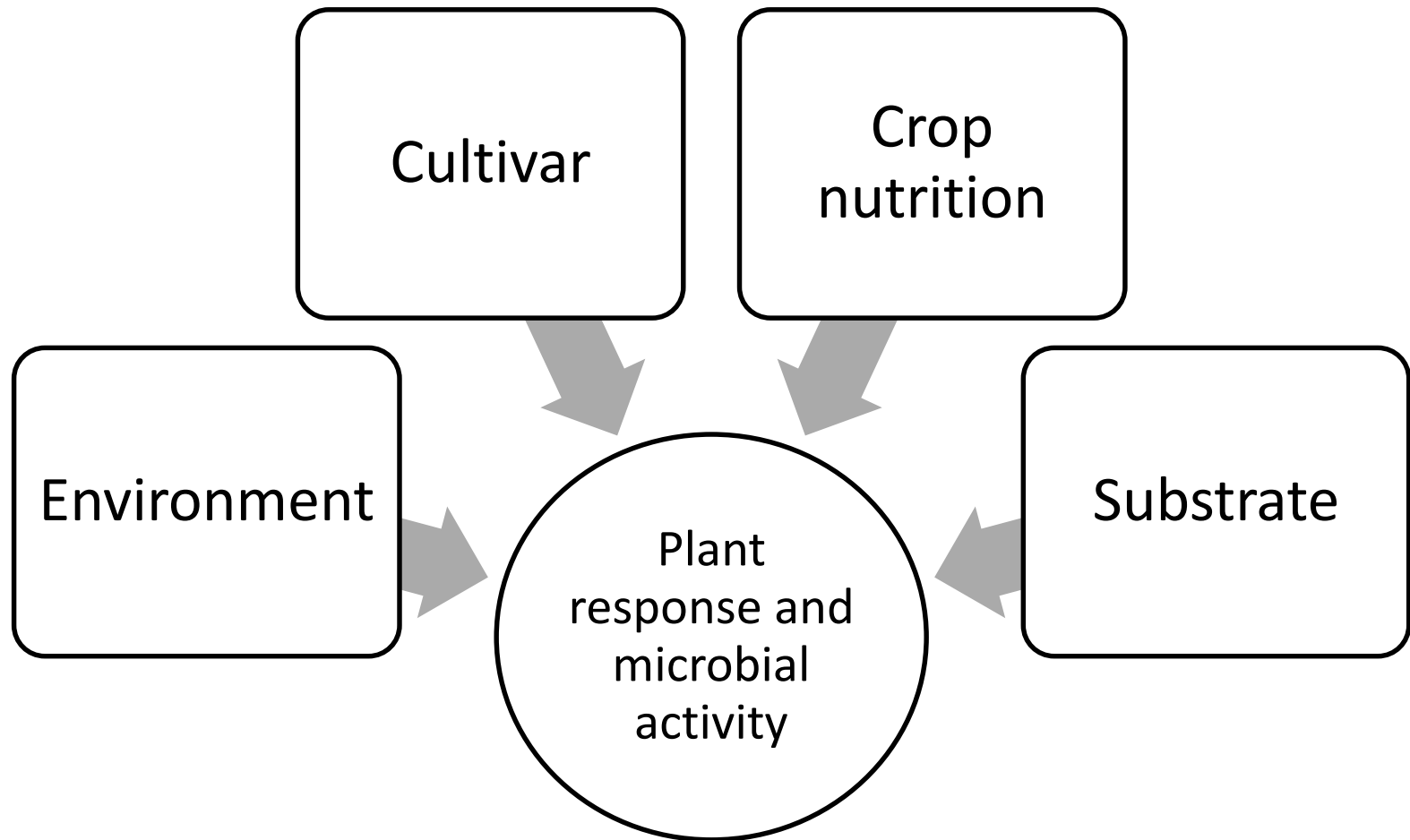
Factors that influence diseases and biocontrol

The host plant

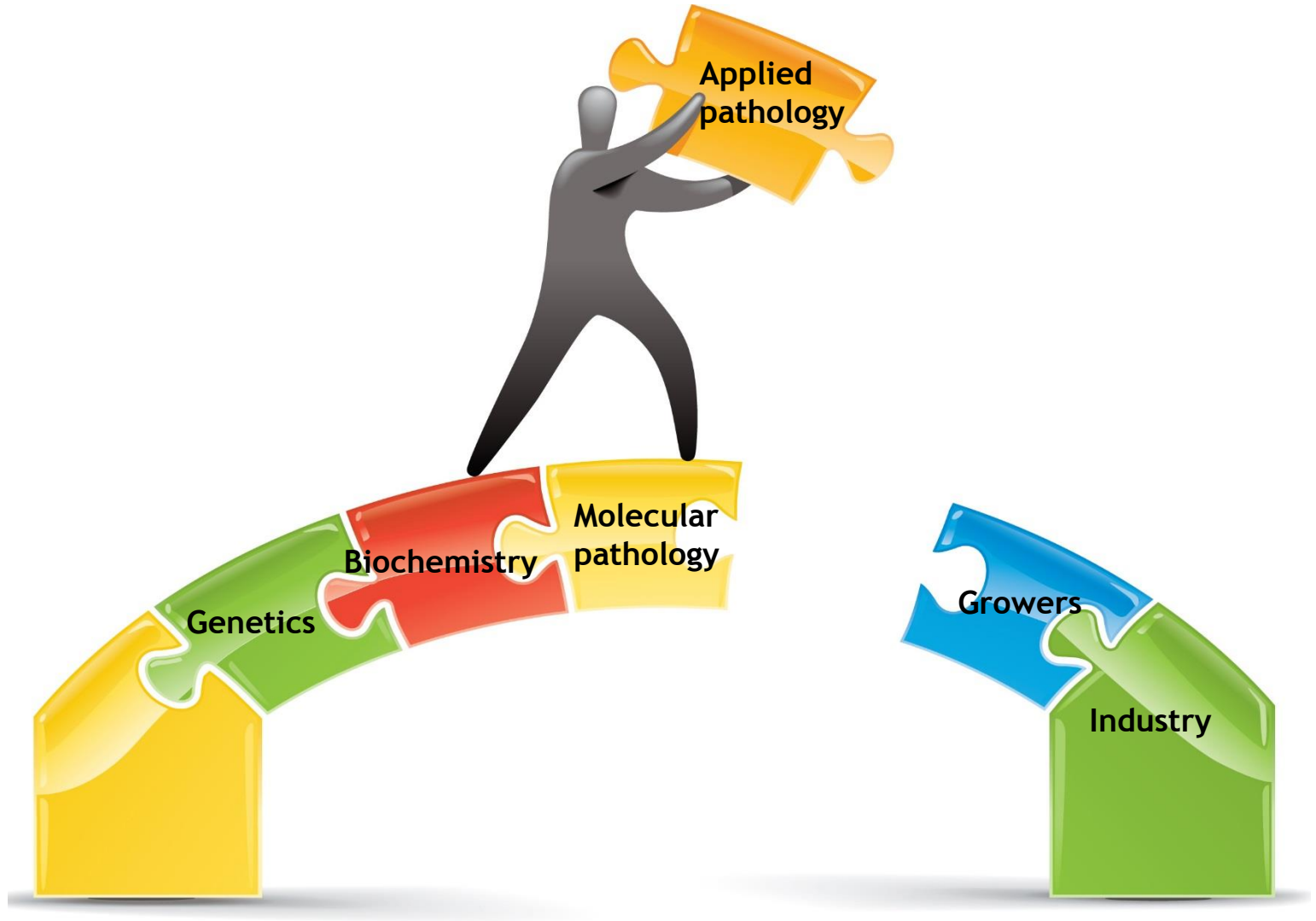
- Provides microenvironments for microbes
- Living and dead plants provide food for microbes (pathogens and beneficial)
 - Root, fruit and leaf exudates
 - Dead plant tissues
 - Live plant tissues

Results in the field don't always match success in lab

Several factors influence microbial activity and plant responses



Limited knowledge of how commercial cultivars and growing systems compare with lab-based models



Best practices for biocontrol in production

Grower questions

- Which product should I choose??
- How and when should I use it?
- Are two better than one?
- What is best for my system?
- Non-target effects of induced resistance?



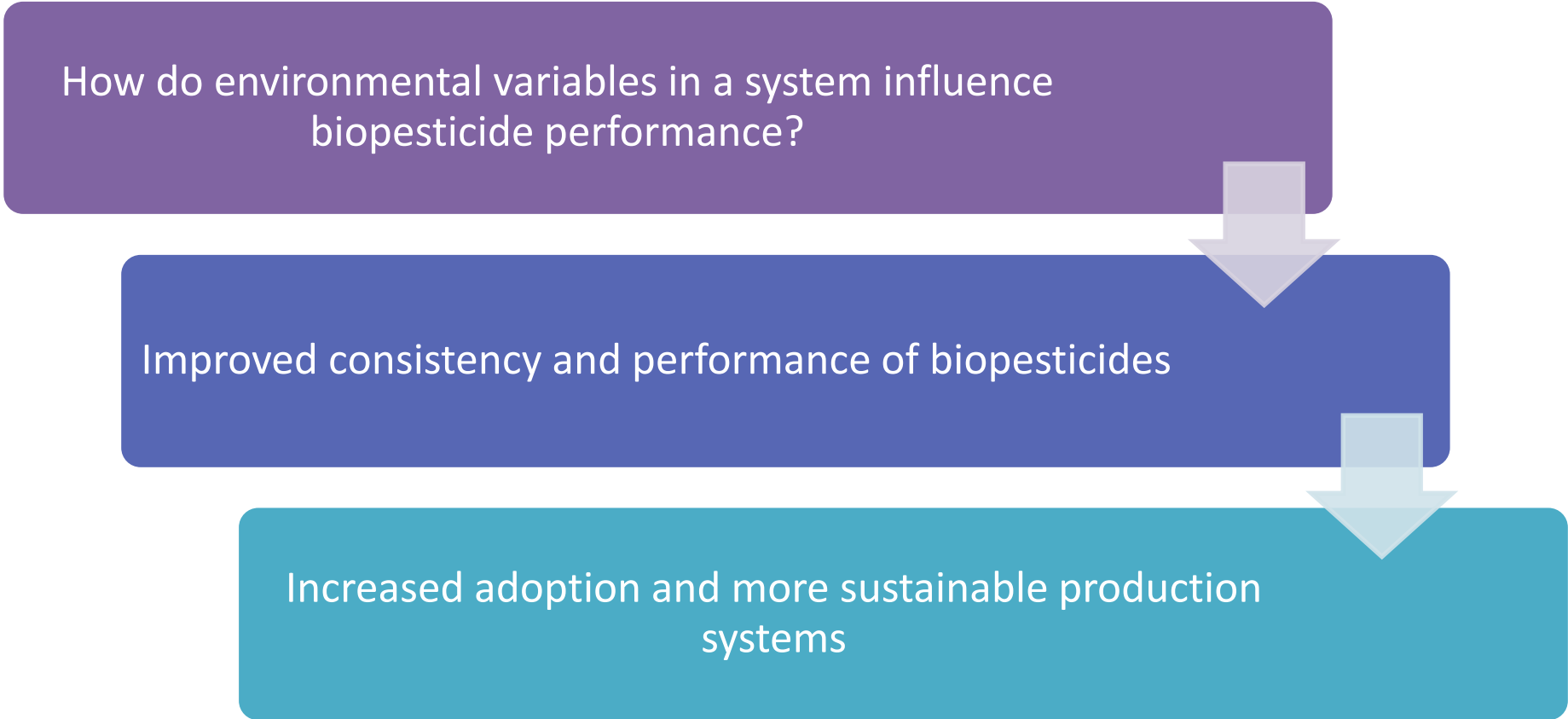
Research questions

- How do biopesticides perform under commercial conditions?
- What the effect of substrate?
- What is the effect of cultivar and grafting?



Can we develop best practices tailored to specific production systems?

How do environmental variables in a system influence biopesticide performance?



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graph TD; A[How do environmental variables in a system influence biopesticide performance?] --> B[Improved consistency and performance of biopesticides]; B --> C[Increased adoption and more sustainable production systems];
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Improved consistency and performance of biopesticides

Increased adoption and more sustainable production systems