Ecological Insect Management: Concepts & Practices

Seeding the Future
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Ecological Insect Management: Concepts & Practices Overview

- **Pest Management Goals, Principles and Tactics**
- **Some ecological background**
  - **Insects in food webs**
  - **Bottom-up vs. Top-down Effects**
- **Bottom-up effects: Cultural practices**
- **Top-down effects: Biological, Mechanic/Physical, Chemical**
- **Some resources**

Some Goals of Management

- Productivity and beneficial processes
- Improvement in physical, chemical, and biological properties
- Improvement of soil and plant health
- Conservation of beneficial organisms
- Suppression of pests

Principles of Ecologically-Based IPM

- Cropping system as component of larger ecosystem
- Manage system for productivity and beneficial processes
  - Plant Positive vs. Pest Negative
- Use of decision-making criteria before action (or no action)
- Integration of all suitable control techniques in a compatible manner
- Limited pesticides, only as last resort

Ladybird Beetle on mustard

Ecologically-Based IPM Tactics

- Monitor: Know your pests and beneficials!
- Keep records
- Cultural
- Biological
  - Conservation
  - Application
- Mechanical/Physical
- Biorational/allowable chemicals

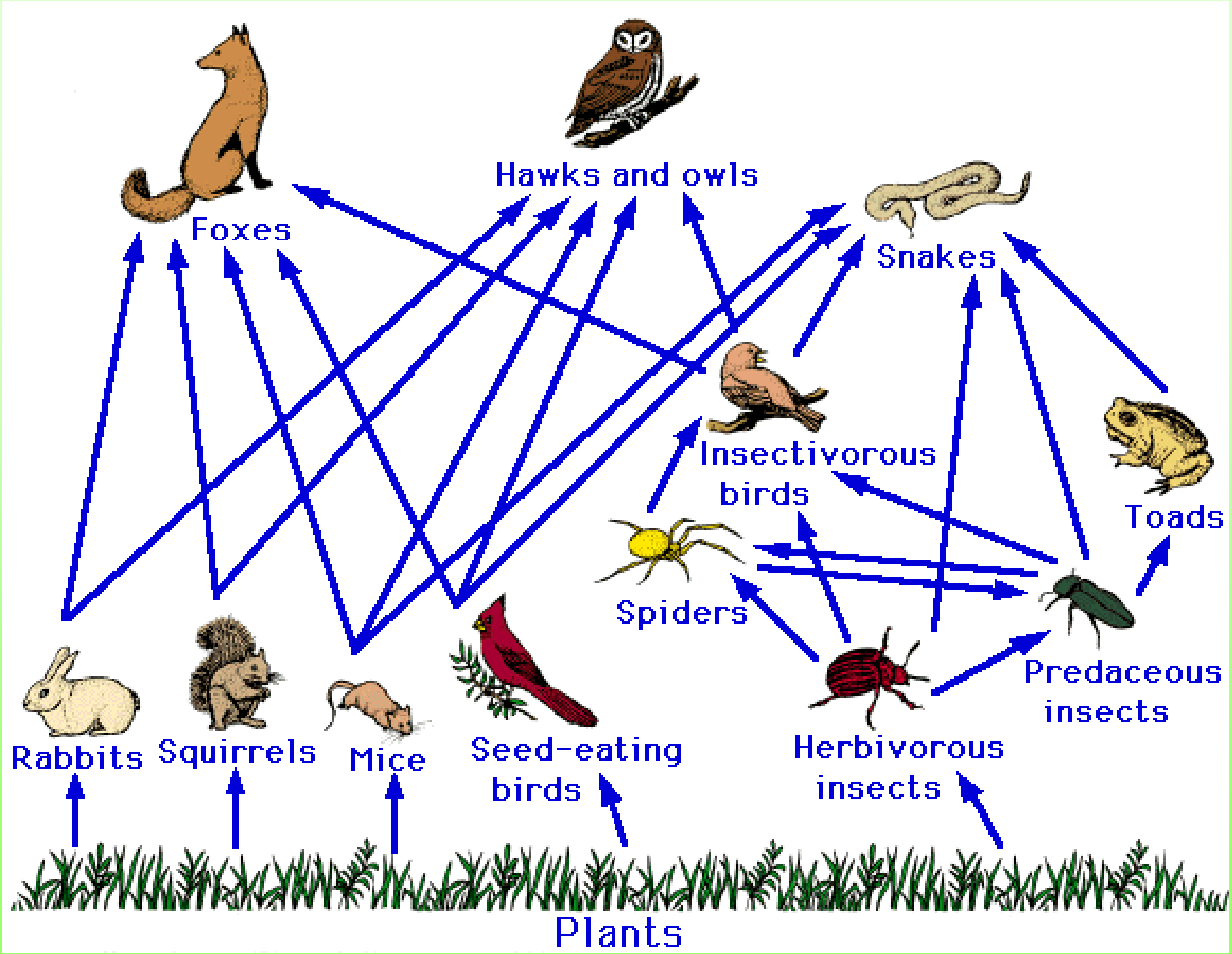
Pheromone Trap

Flea Beetle

Aphid “mummies” after parasitoid emergence

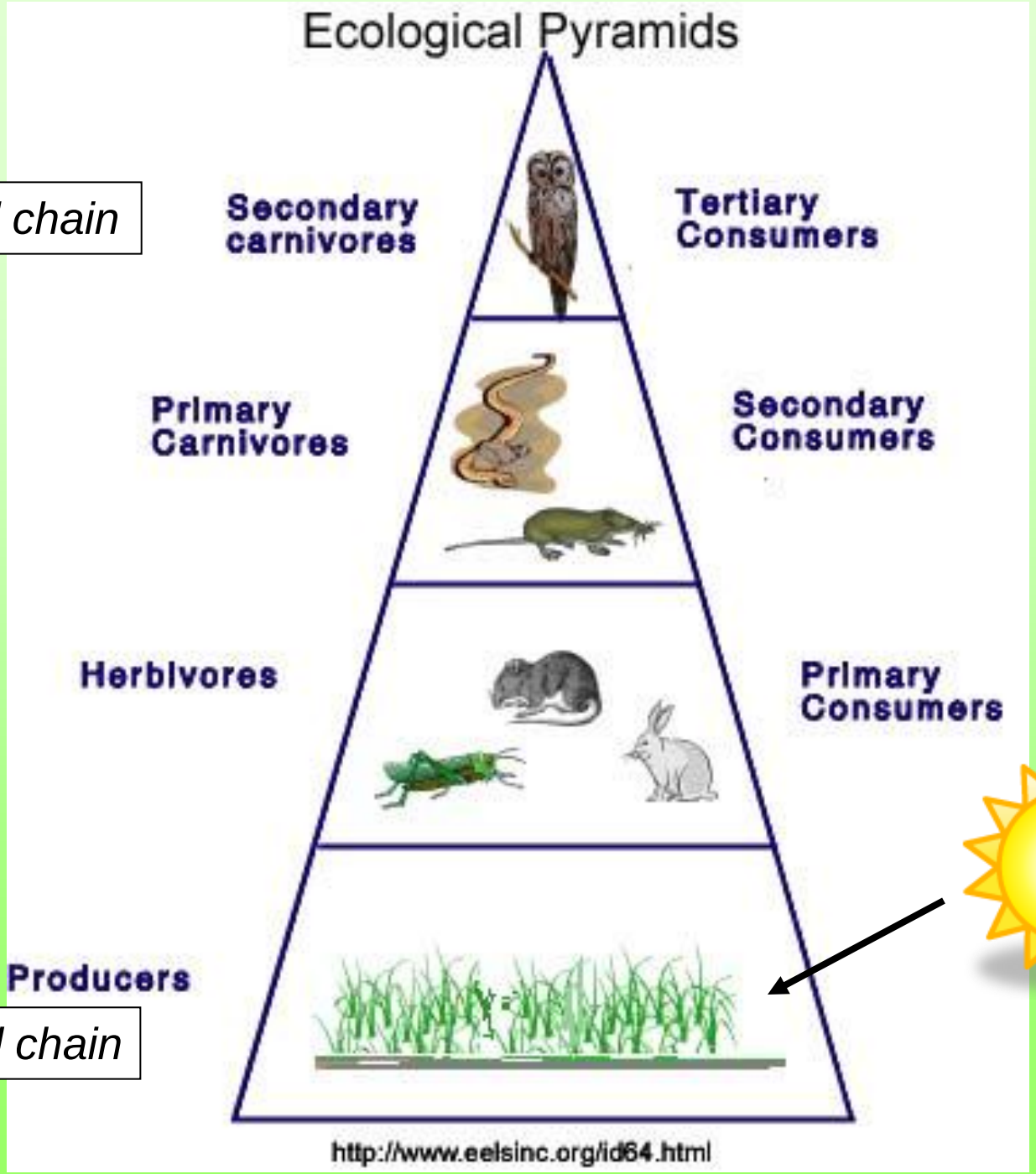
Row Cover

Zehnder et al. 2007



http://www.stephsnature.com/images/Websitelifescience/ecology/foodweb.gif

Top of the food chain



Bottom of the food chain

Simple Food Chain From an Insect's POV

Top

Herbivorous Insect

Bottom

The world is green – why?
"Bottom-up" Factors

- Plant quality
- Primary nutrients (e.g., carbohydrates, lipids, proteins, and nucleic acids)
- Plant defenses
  - Mechanical/Structural
    - Silica, lignins, wax
    - Trichomes
  - Biochemical: constitutive and induced
    - 2˚ metabolites
      - Digestibility reducers: Tannins
      - "Toxins": alkaloids, cyanogenic glycosides and glucosinolates, terpenoids, and phenolics

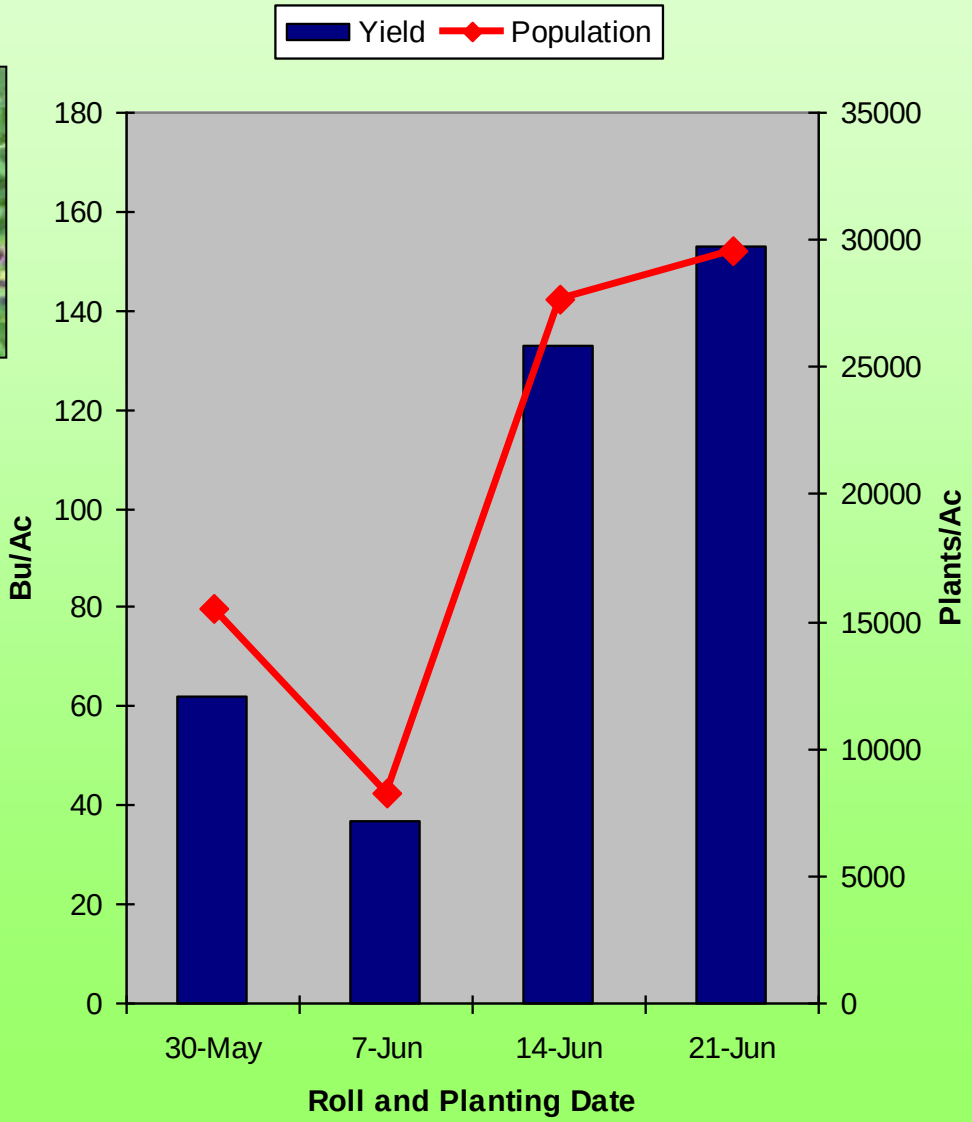
Bottom-Up Factors: Cultural Practices

- Site selection
- Appropriate plant species and cultivars
- Insect and disease-free planting materials
- Pest/disease resistant or tolerant varieties
- Planting date
- Soil and fertility management
- Diversity
  - Crop rotation
  - Species: Multiple cropping, Interplanting, Intercropping, Strip cropping, Trap cropping
  - Genetic diversity
- Sanitation

Barley undersown with red clover

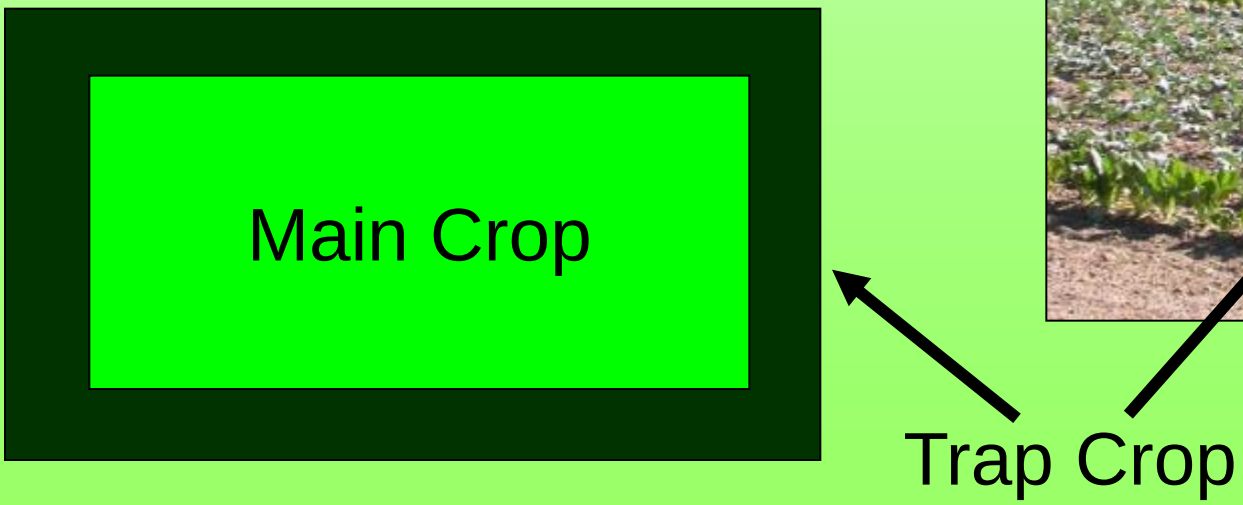
Cover Crop Management x Planting Date x Black Cutworm

D. Wilson, Rodale Institute



Bottom-Up Factor: Trap Cropping

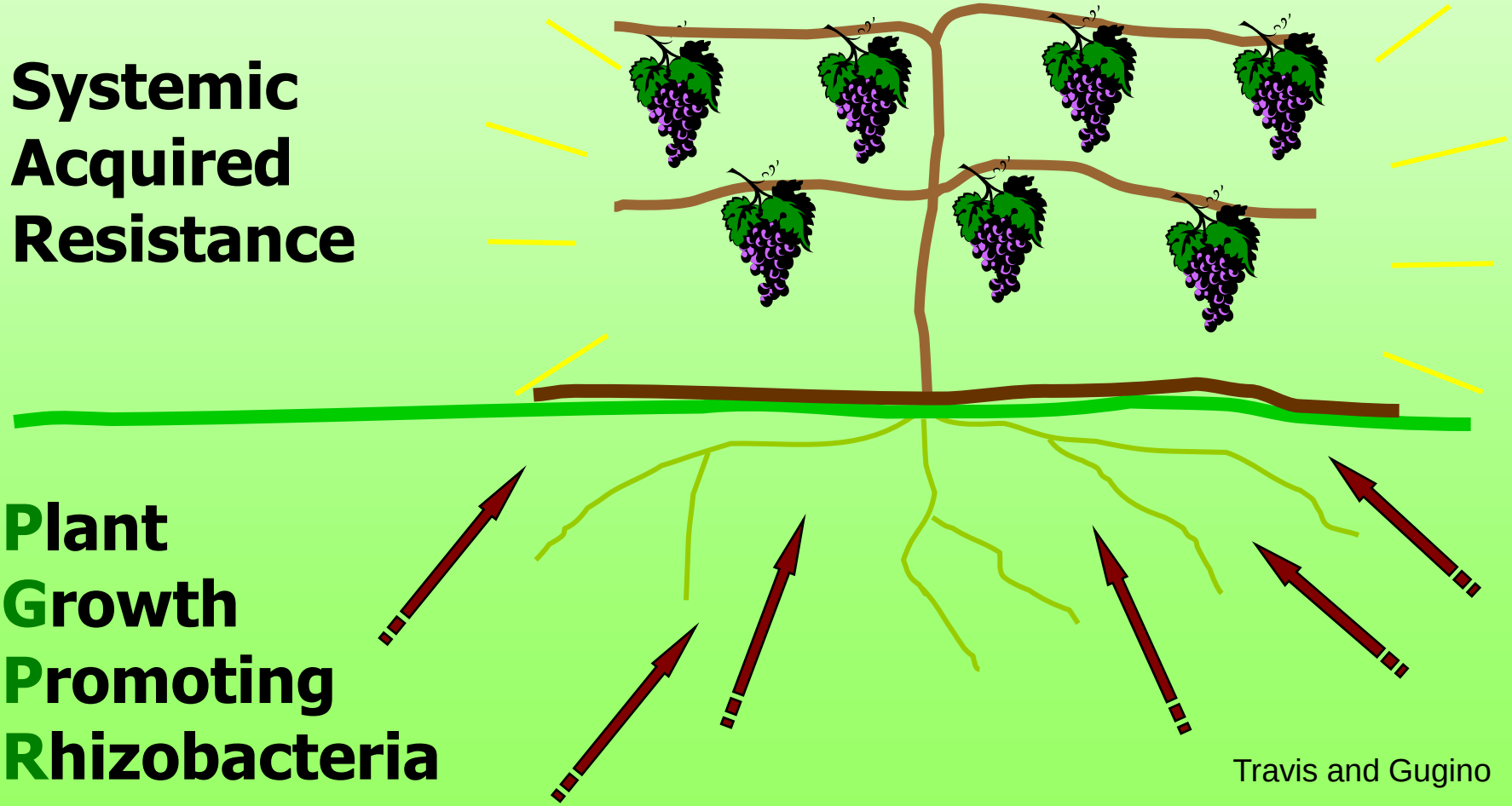
- Plant a preferred crop around the entire main crop, so that the trap crop encloses the main crop.
- Incoming pests are intercepted and concentrated where they can be killed.
- Trap crop must be present before or at the same time as the main crop to intercept pests.
- Treat trap crop as soon as pests appear



Bottom-up Factors: Induced Resistance

Induction of Systemic Acquired Resistance

Systemic Acquired Resistance



Plant Growth Promoting Rhizobacteria

Travis and Gugino

Bottom-Up Effect: PGPR-Cucumber Beetles-Bacterial Wilt

- Beetles prefer plants high in bitter cucurbitacin
- PGPR reduce bitter cucurbitacins in cucurbit plants
- Plants less attractive to beetles
- Less feeding damage, bacterial wilt

Bottom-Up Effects
Soil Fertility and Pest Management

- Organic (poultry manure) and synthetic fertilizer on cabbage insect pests
- Cabbage aphid (specialist) more abundant with manure
- Green peach aphid (generalist) more abundant with synthetic fertilizer
- Diamondback moth (specialist) more abundant and more eggs with synthetic fertilizer plants
- Nitrogen concentration was greater for conventionally fertilized
- Glucosinolate concentrations were up to three times greater on cabbage plants grown with manure

http://www.dgsgardening.btinternet.co.uk/aphidcabbage.jpg

http://images.wikia.com/gardener/images/3/3a/Broccoli_Diamond-Back_Moth_Caterpillar.jpg

The world is green – why?
"Top-Down" Factors

- **Predators** – during development consume many insects
  - Predatory mites, ground beetles, predatory bugs, spiders, daddy-longlegs, centipedes

Mesostigmatid mite

Damsel Bug

Spider

Carabid beetle

Natural Enemies: “Top-Down” Factor

- **Parasitoids** – during development consume one insect
  - parasitoid wasps, tachinid flies
- **Pathogens** - cause disease
  - fungi, bacteria, viruses, protozoa, nematodes

Parasitoid wasp

Entomopathogenic nematodes

Entomopathogenic fungi

Biological Control

Exploitation of natural enemies to hold pest below economically damaging levels

- Conservation
  - Improve environment for existing beneficial organisms
- Augmentative & Inundative
  - Purchase and release
  - Usually not long-term
- Classical
  - Imported natural enemy
  - Long-term to permanent

Pediobius wasp on Mexican Bean Beetle

Aphid “mummies” after parasitoid emergence

Conservation Biological Control

- Goal: Improve environment for beneficial organisms and processes
- “Farmscaping”: provide resource plants or habitats, e.g.,
  - diversity in space and time
  - cover crops
  - refuge strips of flowering plants
  - beetle banks or grassy drive lanes
  - pollen and nectar resources required by many insect natural enemies

Above-ground Dispersal of Beneficial Arthropods

Low Dispersion - (tend to s tay in field)	**Medium Dispersion (forage 1/4 mile)**	**High Dispersion (forage > 1/4 mile)**
Ground Beetles (Carabids) Lady bird Beetles (when happy) Smaller Parasitoid Wasps	Most Parasitoid W asps Predatory Wasps – Paper Predatory Bugs	Syrphids (Hover Flies) Dragonflies, Tachinid Flies Larger Parasitoid Wasps

Syrphid Fly

Big-eyed bug

Cover Crops and Pest Suppression

- Cover crops can enhance numbers of soil organisms and cause shifts in the community
- Add diversity to system
- Add food resources for beneficial insects – pollen and nectar
- Residue creates habitat for predators
- Compete with weeds

Vetch

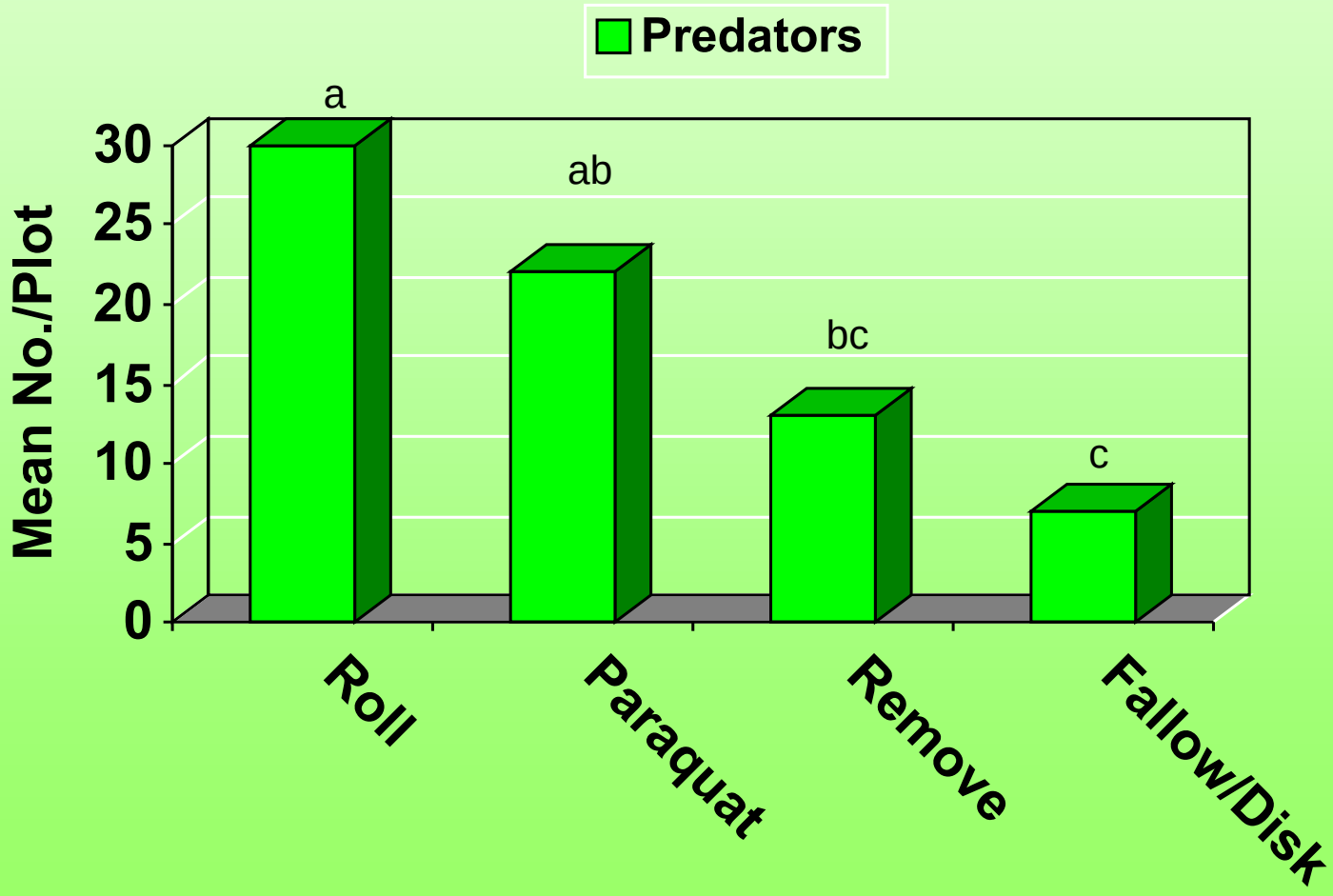
Buckwheat

Mustard

Photos: T. Pisani Gareau

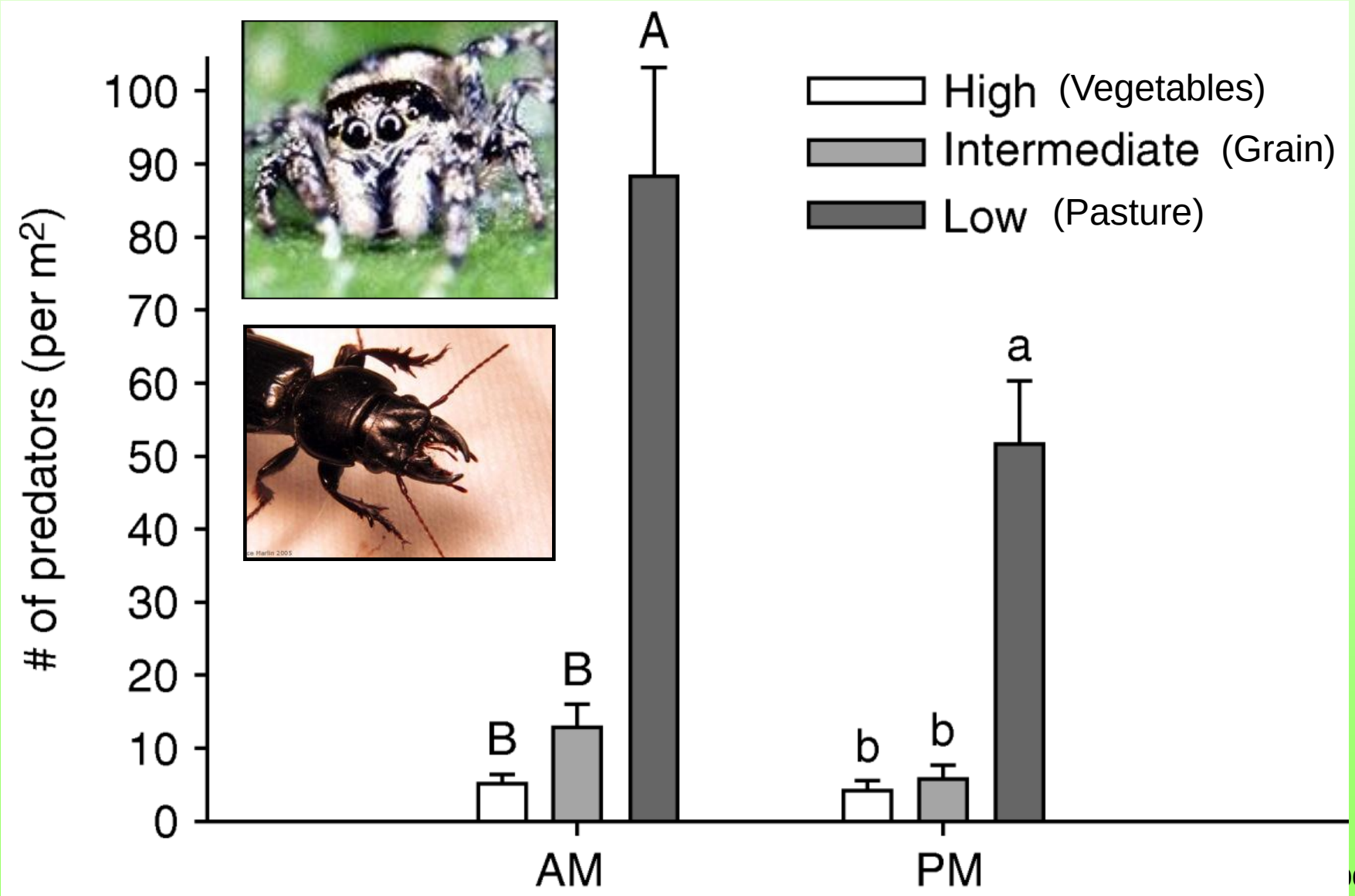
Effects of Cover Crop Rye Management in Reduced Tillage Corn

Clark et al. 1993. J. Entomol. Sci. 28: 404-416



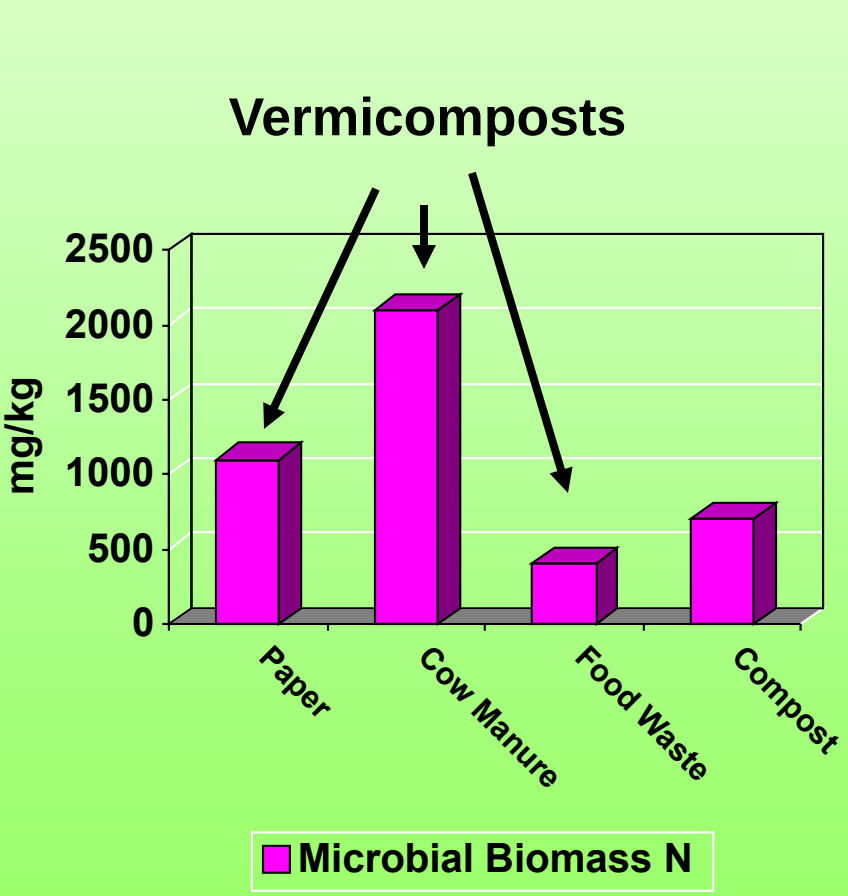
Effect of Management Intensity on Arthropod Predators

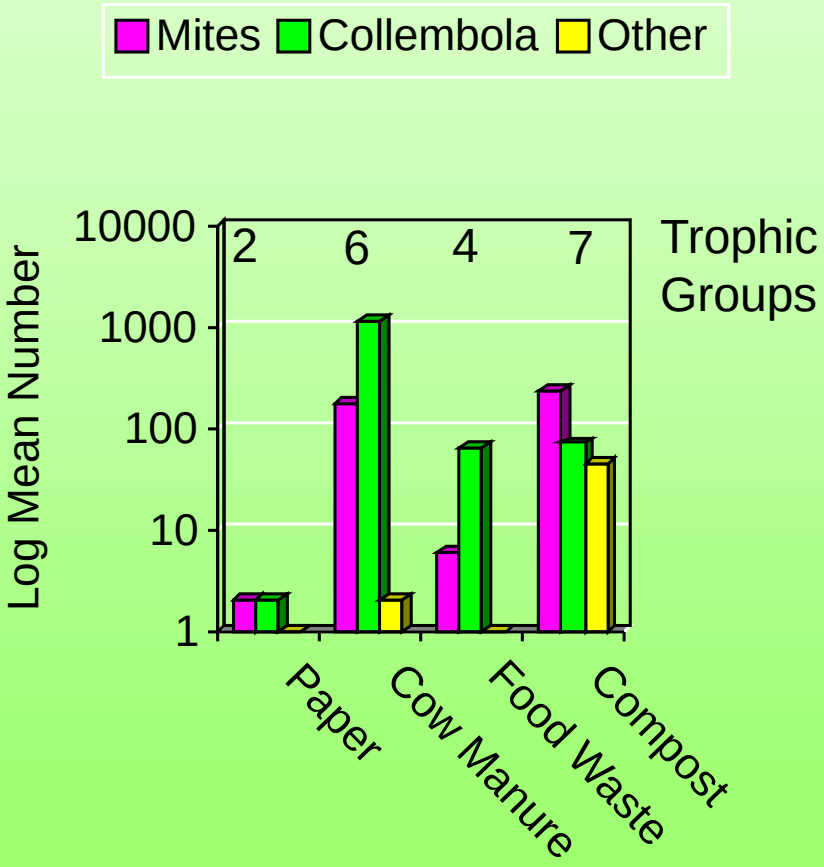
Lundgren, J. G., et al. 2006. The influence of organic transition systems on beneficial ground-dwelling arthropods and predation of insects and weed seeds. Renewable Agriculture and Food Systems 21: 227–237.



Effect of Compost Type on Microbial Biomass N and Soil Arthropods

Gunadi et al. 2002. Eur. J. Soil Biol. 38:161-165





Summary: Management for Conserving Pest Suppression

- Continuous resources
  - e.g., hay, perennial crops, mulch, cover crops
- Plant diversity
  - e.g., refuge strips, weedy fields, polycultures, cover crops
  - Rotate crops to interupt pest cycles
- Reduce physical & chemical disturbance
  - e.g., woodlands/orchards, grasslands, reduced tillage, refuges, perennial crops or cover crops
  - Reduce use of biocides

Mechanical and Physical Approaches

- Tillage
- Flaming
- Flooding
- Soil solarization
- Row covers
- Mulching
- Traps

When all else fails… considerations for pesticide use

- Substitution vs “Holistic” Management
- Organic Systems Plan: How and when you will react to a pest outbreak
- What quality does your market require?
- Decide in advance your ‘action threshold’
- Where possible, use biological controls
- Know your organic pesticide choices: what’s allowable, what’s labeled, what works, cost

Flea beetle

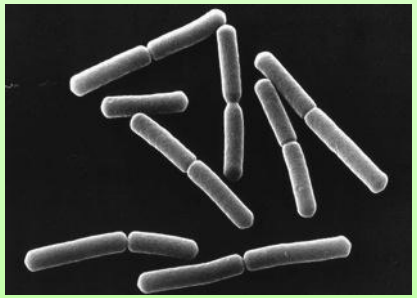
European Corn Borer

Considering Beneficials When Using Chemicals

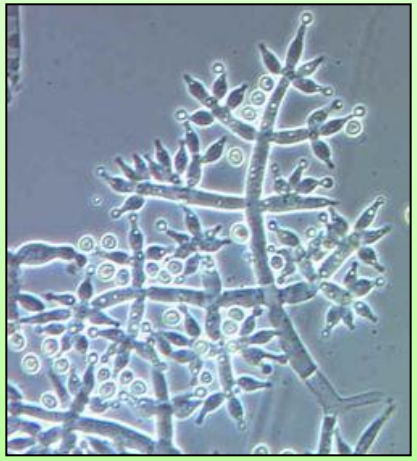
- Can be used therapeutically (in contrast to preventively)
- Short half-life
- Selective for specific pests or life stages of pests
- Low environmental exposure, e.g., baits
- Low volume application rates
- Applied when beneficials not active or present

Biorational “Chemicals”: Microbial Control

- Plant Disease
  - *Bacillus subtilis* (Kodiak)
  - *B. pumilus* (Sonata)
  - *Trichoderma harzianum* (RootShield, PlantShield)
- Insects
  - *B.t. var. kurstaki*
  - *Beauveria* spp. (Mycotrol)
  - Insect viruses



B. subtilis



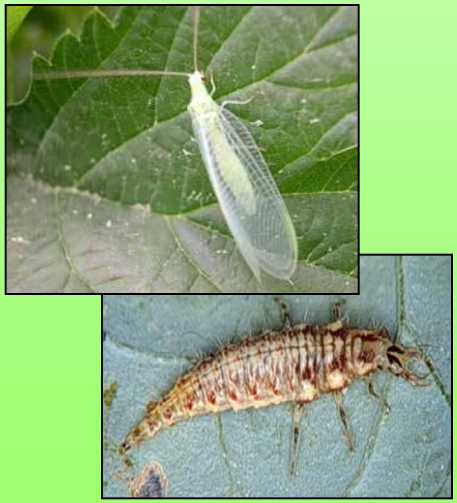
Trichoderma harzianum

Insect Virus

Beauveria

Biorational “Chemicals”: Inundative Biocontrol

- Apply large number of organisms in same manner as a pesticide
- Introduces large numbers of organisms for relatively fast-acting control
- May or may not become established



Some Allowable Pesticides in Organic Systems

(OMRI - 2007)

Allowed

- Insecticidal soap
- Diatomaceous earth
- Bicarbonate (potassium or sodium)
- Spinosad (Entrust®)
- Various microbials
- Particle films: bentonite, kaolinite (Surround®)
- Plant extracts and oils
- Pheromones

Restricted

- Dormant and summer oils (narrow range petroleum, fish, plant)
- Sulfur compounds
- Copper compounds
- Botanicals
  - Pyrethrum (PyGanic®)
  - Ryania
  - Sabadilla

Example Pesticide Surround WP^{tm}

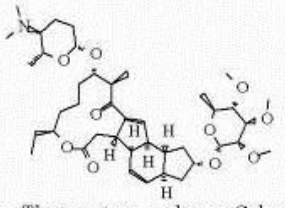
- Kaolin clay particle film
- Registered on pome, stone and citrus fruits, berries, grapes, and row crop vegetables
- Insects, mites, fungi, bacteria, and environmental stress such as solar effects
- Prevents insect feeding and oviposition
- Approved for organic production

Example Pesticide Entrust^{tm}

http://www.dowagro.com/ca/prod/success.htm

- Spinosad
- Produced by fermentation of bacteria (*Saccharpolyspora spinosa*).
- Lepidoptera larvae (cabbage looper, army worms, earworm, corn borer, horn worm), thrips and leaf miners
- Labeled for cereal grains, cole crops, corn, tomatoes, okra, peppers, eggplants, leafy vegetables, strawberries, succulent and dry beans and peas, tree nuts, cucurbits, potatoes, turf and ornamentals

SPINOSAD



TRADE NAMES : DE105

CLASSIFICATION : Naturalyte

MODE OF ACTION : Unique But Unknown

SPECIES SPECTRUM : Lepidoptera, Diptera, Thysanoptera, and some Coleoptera and Hymenoptera

TARGET CROPS : Cotton, Vegetables, Tree Fruits and Nuts

USE RATES : 50-180 Gms AI/Ha

IPM FIT : Safety to beneficials leads to fewer sprays for secondary pest outbreaks in cotton and tree fruits. It is also safe to mammals, birds and fish.

*TRADEMARK OF DOWELANCO

Crop Rotations
Know Your Pest and Beneficials
Reduce Pest Habitat
Provide Beneficial Habitat
Minimal Pesticide Use

→ Above-Ground Diversity

↓

Pest and Disease Suppression

Healthy Plants!

Healthy Soil

↑

Below-Ground Diversity

←

Build Organic Matter
Crop Rotations
Improve Soil Tilth
Optimize Fertility
Minimize Pesticides

Some Pest Management Resources

- **ATTRA, https://attra.ncat.org/pest.html**
- **Integrated Pest Management: An Overview for Market Growers.** http://www.cias.wisc.edu
- **Scouting vegetables for pests**, K. Delahaut. 2004. http://www.cias.wisc.edu
- **Natural Enemies of Vegetable Insect Pests.** M. Hoffman and A. Frodsham. www.cornell.edu/ent/biocontrol/manual.html
- **Biological Control of Insects and Mites: An introduction to beneficial natural enemies and their use in pest management**, D. Mahr et al.. 2008. http://learningstore.uwex.edu

Some Resources

- **Manage Insects on Your Farm: A Guide to Ecological Strategies.** M. Altieri and C. Nicholls. 2005. SAN, www.sare.org
- **Natural Enemies Handbook: The Illustrated Guide to Biological Pest Control**. M.L. Flint and S. Dreistadt. UC Press. www.ipm.ucdavis.edu
- **Greenhouse IPM with an Emphasis on Biocontrols.** 2005. PA IPM. http://paipm.cas.psu.edu/
- **Resource Guide for Organic Insect and Disease Management**. 2005. Caldwell et al. www.nysaes.cornell.edu
- **NYS IPM/Cornell Organic Production Guides 2011** http://www.nysipm.cornell.edu/organic_guide/

Photo by M. Greenwood: Nematode on astigmatid mite