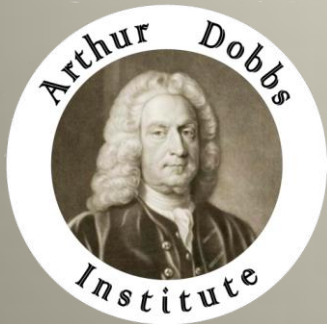
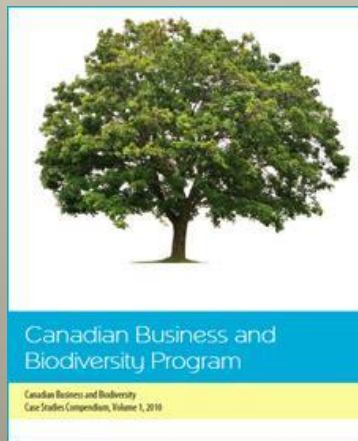


The Value of Biodiversity to Agricultural Production and AgriBusiness: Emphasizing the Example of Pollination

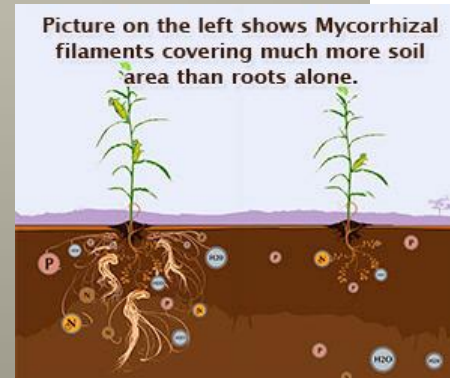
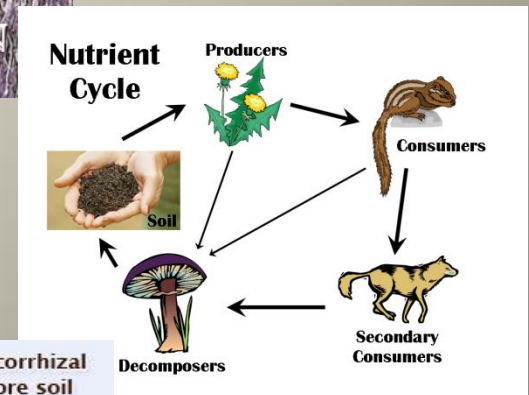
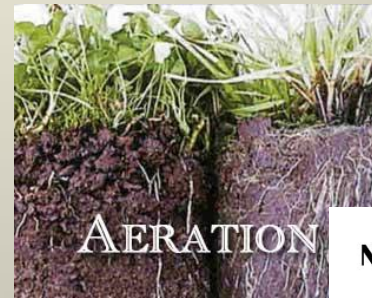


Peter G. Kevan FRSC
University of Guelph



Biodiversity in Agroecosystems

- Biodiversity for soil ecosystem services
 - Soil aeration & porosity
 - Soil nutrient cycling
 - Mycorrhizae
 - Nitrogen fixation
 - The Rhizosphere & soil erosion



Biodiversity in Agroecosystems

- Above ground biodiversity & ecosystem services
 - Natural control of pests
 - Predator & prey interactions
 - Parasites & host interactions
 - Parasitoids and host interactions
 - Natural control of diseases
 - Microbes vs. microbes
 - Microbes improving crop plant health

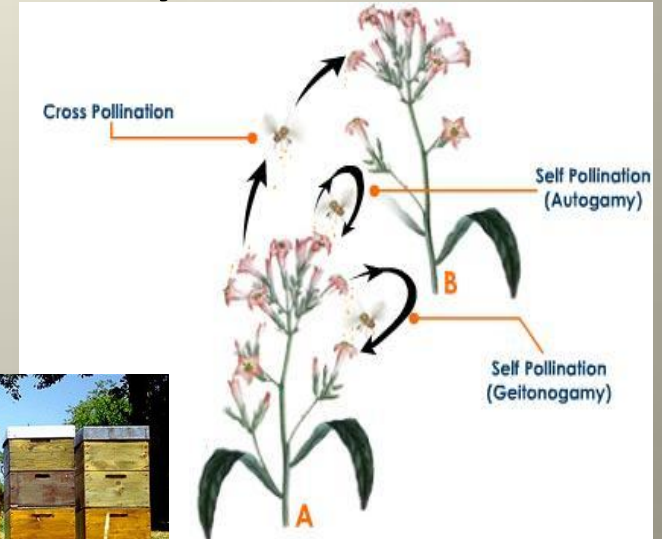


Biodiversity in Agroecosystems

- Above ground biodiversity & ecosystem services

- Pollination

- What is pollination?
- Managed pollinators
- Wild pollinators
- Pollinators in peril



Biodiversity in Agroecosystems

- How to manage and encourage pollinators in agroecosystems
 - Managed pollinators
 - Wild pollinators



Biodiversity in Agroecosystems

- Examples of value added through managing pollination

Crop	Yield Boost
Apples & Pears	Insect pollination required
Stone fruits	Yes, depends on crop
Small fruit (berries)	Yes, most require insect pollination
Oil seeds (Canola, sunflowers)	15 – 20%
Forage Legumes	Most: Insect pollination required
Greenhouse tomatoes	Insect pollination required
Squash, pumpkins, melons, cucumbers	Insect pollination required

Adding Biodiversity to Pollinator Use: Crop Protection

Vectoring Biological Control Agents (BCAs) by Pollinators

- BCAs = naturally occurring agents to suppress pests & diseases (registration simplified)
- Pollinators pick up BCAs on leaving their hives through special dispensers
- BCAs are delivered to flowers & other plant parts
- Delivered BCAs infect/suppress pests & diseases by breaking life-cycles
- Crop pollinated & protected at same time = better crop & yield
- Reduced chemical spray use = less residue
- All-day, every-day delivery
- *Cost effective, Simple, Commercialized!*



Commercial dispenser with
BCA tray in Bumble bee hive




Dispenser with BCA tray displayed
on Honeybee hive

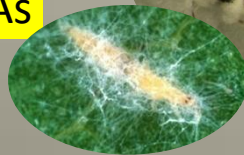


Pollinator Vectors of Biological Control Agents

Commercial Examples



Crop	Pest or Disease	Conventional Control	BCAs & Cost relative to conventional
tender fruit (Strawberry, Raspberry, Blueberry)	Grey mould, <i>Rhizopus</i> , Whiskery rot, Mummy berry	Fungicides	<i>Clonostachys</i> ~ 50 – 75% less
Tomato 	Grey mould	Fungicides	<i>Clonostachys</i> ~ 75% less
	Thrips, bugs, caterpillars, aphids, whitefly	Insecticides	<i>Beauveria</i> , <i>Metarhizium</i> , Dipel (<i>B.t.</i>) Cheaper & more reliable
Sunflower	<i>Sclerotinia</i> head rot	Fungicide	<i>Clonostachys</i> ~ 75% less









3 Insects controlled by BCAs

Under evaluation:
Apples, Canola, Peppers, other fruit ...

Tropical crops: coffee

Status of Applied Pollinator Biovectoring

Pollinator Vectoring of Biocontrol Agents for Crop Production & Protection			
<i>Progress & Potential</i>	Honey Bees	Bumble Bees	Other Manageable Pollinators
<i>Experimentally verified</i>	Yes 	Yes 	Recent Brazilian trials
<i>Demonstrated in Crop Production</i>	Yes 	Yes 	Needed
<i>Commercialized in N. America, EU</i>	Not yet	Yes 	Not applicable or still needed
<i>Used on Coffee</i>	Ecuador 	No	Possible

For more crops... Next Steps ... R & D Partnerships...

- 1. More trials disseminating biocontrol agents with honeybees*
- 2. Field trials with various BCAs against various pests and diseases*
- 3. Establish practical technology: Benefits vs. Costs*
- 4. National & International Commercial Ventures*

Economics

Canadian estimates for various crops:

Benefit:Cost Ratios depend on crop, system, problem, location.

Item	Bumblebee system	Honeybee system
Dispensers	\$5.00 (comes with each colony: incl. below): Total \$0.00	Est. \$15.00 (can be re-used)
Cartridge trays with BCA	Est. \$19.50/week/colony (depending on BCA)	Est. \$28.00/week/hive (depending on BCA)
Colony purchase/rental	\$100.00/colony good for 6 weeks	Prices set locally
Stocking rates for coffee	Est. 4 colonies/hectare	Est. 2 – 4 hives/hectare good for entire bloom
Delivery & management	Labour @ 100 hectares/day, local prices	Prices set locally
TOTAL COSTS	Est. \$480.00/hectare/week during bloom for either system (aim for saving of 20% below conventional crop protection)	
BENEFITS	More and better crop (pollination & protection), Reduced chemical use, Beekeeping, Other benefits = \$Value higher	

Biodiversity in Agroecosystems

- Other ecosystem services
 - Benefits vs. Costs
 - Similar analyses would result in similar conclusions
- Returning biocomplexity to Agriculture
 - Management through application of ecological principles
 - Ecology = Diversity, Abundance, and Activity of life
 - For agriculture, humans are central as managers & beneficiaries of agroecosystems
 - Practice and policy changes to increase biocomplexity, productivity, sustainability, and profitability to farming