Pest Management and Sustainability

Ontario Bans Pesticides
- Announced a ban on all ‘cosmetic use’ of pesticides in the province (Apr. 22/09)
- Applies to Class 9 Pesticides
  - 2,4-D, glyphosate (Roundup), permethrin, pyrethres (Raid)
- Exceptions: gold courses, sports fields, public health applications (ex. W. Nile Virus)

Ecological Backlash
- Counter responses of pest populations or other biotic factors in the environment that diminish impact of pest management tactics
  - Usually delayed, therefore detection of effects may come too late

The Three Rs
- Major sources of backlash phenomenon
- Population ecology based phenomena
- 1- Resistance
- 2- Resurgence
- 3- Replacement

Resistance
- Most important of the three Rs
- Often associated with pesticide use but has been shown to occur with ALL pest management practices used to date
- Evolution by natural selection (preadaptive)

Resistance
- Rate of resistance development may depend on genetics of resistance factor
  - Monogenic resistance: single gene expression, therefore possibly quick development
    - e.g. House fly and DDT
  - Polygenic resistance: several genes required, therefore may be slower to develop
Resistance Development

Mechanisms of Resistance
- Biochemical
- Physiological
- Behavioural
- Not mutually exclusive from one another

Biochemical Resistance
- Insecticide usually attacked by an enzyme that detoxify it before reaching site of action

Physiological Resistance
- Reduced toxicity due to changes in basic physiology
- Often involve alterations in target site
  - e.g. knock-down resistance in House Flies to DDT involved reduction in number of target-site receptors making nerve sheaths less sensitive to toxicant

Behavioural Resistance
- Changes in behaviour that allow pests to avoid pesticides
- Limited to animal pests
  - e.g. Malaria carrying mosquitoes in Africa are composed of 2 strains - endophilic and exophilic
  - Spraying inside homes selected for exophilic strain

The Pesticide Treadmill
Management of Resistance

- **Moderation**
  - Low doses, infrequent application, low persistence, apply to adults after reproduction
  - Goal is to reduce selection pressure and conserve susceptible genes in population

- **Multiple Attack**
  - Use pesticide mixtures, apply in mosaic pattern, rotate pesticides
  - Reduce selection pressure by imposing several forces at once

Resurgence

- Pest population is suppressed but rebounds in numbers that were greater than before pesticide application

Replacement

- One pest population is suppressed and continues to be, while a second pest population previously of minor status

Causes of Resurgence and Replacement

- Reduction of natural enemies by pesticide
- Direct favourable influences of pesticides on physiology and behaviour of pests
  - e.g. homoligosis: pest organism experiences increased sensitivity and response to environmental factors
- Removal of competitive species

Loss of Natural Enemies

Release of Natural Enemies

- Insect (usually) are reared in lab
- Release may or may not be after a pesticide application
- Many available commercially
- Modern techniques involve using pesticide resistant natural enemies
Methods of Insect Control

- Cultural
  - Crop rotations, tillage, resistance
- Mechanical
  - Traps, screens, light and sound
- Chemical
  - Kill, repel, attract, disrupt physiology

Methods of Insect Control

- Legal
  - Inspections, quarantines, laws
- Biological
  - Parasites, predators, diseases, temperature, moisture, sex manipulation
- Integrated Control
  - Combination of many methods

Pest Management and Sustainability

From Pest to Control to IPM

Historically, Pest Control has been ideal
2 factors promoted shift towards Integrated Control - selective use of pesticides in order to conserve natural enemies
- Non-target effects observed in 50s-60s
- Greater understanding of ecological systems

From Pest to Control to IPM

Integrated control led to notion of Pest Management - moderate pest populations using a variety of methods
Today, the consensus is towards Integrated Pest Management - avoiding pesticides as much as is possible
- Greater reliance on natural processes
- Requires greater understanding of ecological interactions

Selective Spraying
IPM Techniques
- Insect Growth Regulators
- Reducing Crop Susceptibility
- Biological Control
- Sex Manipulation
- Genetic Manipulation
- Biocides
- Ecological Habitat Management

Biological Control
- Use of natural enemies to moderate pest population
- Not perfectly dependable or smoothly operating

Biological Control
- Parasites
  - Organism that lives on or in a host, feeding on it
  - Host is weakened or killed
  - Mostly nematodes

Biological Control
- Parasitoids
  - Insects that parasitize in their immature stages only
  - Exoparasitoid
  - Endoparasitoid

Biological Control
- Parasitoids - Good for 4 reasons
  - Good survival rates
  - Only one host is required for development
  - Populations can be sustained at low host levels
  - Most parasitoids have a narrow host range, therefore good numerical response

Biological Control
- Predators
  - May be mono-, oligo- or polyphagous
  - Each has advantages and disadvantages
    - e.g. polyphagous predator may switch to alternate prey when pest numbers are low. However, polyphagous predators may make poor pest controllers due to lack of preference for prey species.
**Predators**

- Predators - Augmentation
  - Any practice that increases the numbers of natural enemies
  - Usually temporary effects (one season)
- Inundative releases:
  - Releases of massive numbers of predators to have a suppressive effect on pest population
- Inoculative releases:
  - Released predators are expected to colonize the area naturally
  - Pest population suppression is effected by progeny of released predators

**Toxins from several species of Bacillus have been used**

- *B. popilliae, B. lentimorbus*
  - Highly fastidious (require host to reproduce)
- *B. thuringiensis*
  - Less fastidious, therefore easier to propagate and use commercially

**Viruses**

- 1200 insect viruses used to date, mostly on Diptera, Hymenoptera and Lepidoptera
- Nuclear polyhedrosis viruses (NPV)
- Granulosis viruses (GV)
- Cytoplasmic polyhedrosis viruses (CPV)

**Insects catch disease and wilt after dying**

- Dead larvae rupture and release polyhedra for further infection

**Sex Manipulation**

- Pheromone traps
  - Chemically synthesized and put in sticky traps
  - Affects only half of population (usually males)
  - Effect is on mating success
- Mating disruption
  - A confusion, or decoy method
  - Chemically synthesized pheromones permeate the air
  - Insects cannot locate mates and mating is disrupted
Mating Disruption

Genetic Manipulation

• Altering genetic make-up of pest population in order to:
  - Produce sterility of progeny
  - Reduce fecundity
  - Reduce survival in otherwise favourable conditions

Genetic Manipulation

• Sterile Insect Technique
  - Insects reared in laboratory are rendered sterile and released
  - Effect is on mating disruption

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Genetic Manipulation

• Sterile Insect Technique - Methods
  - Ionizing radiation (X and Gamma rays): causes point mutation before gamete formation (usually pupal stage)
  - Chemosterilization: chemicals can prevent gamete formation if applied at onset of meiosis

Biopesticides

• Taking advantage of evolutionary history between plants and pests
  - Allelochemicals and plant secondary compounds
  - Not new idea: nicotine, pyrethroids etc.
  - Now looking for new insecticidal compounds in essential oils and other plant extracts

Biopesticides
Organic Production

- International Federation of Organic Growers (www.ifoam.org)
- Method of production that aims to maintain the integrity of the soil, ecosystems and people.
- Based on ecological processes, biodiversity and is adapted to local conditions.
- In Canada, is governed by Canadian Organic Growers (www.cog.org)
  - Regulated by Canadian General Standards Board (CAN/CGSB-32.310)
  - Permitted substances also listed by CGSB (CAN/CGSB-32.311)

Organic Production

- CAN/CGSB-32.310: Permitted substances
  - All products of genetic engineering
  - Synthetic pesticides
  - Fertilizers containing prohibited substances
  - Growth hormones
  - Synthetic drugs (e.g. anti-biotics)
  - Radiation
  - For Organic certification a multi-ingredient product must contain at least 70% organic ingredients

Ecological Management

- Broadening of notion of cultural control in order to maximize benefits from ecosystem services supplied by native biodiversity
- All biodiversity levels are affected by agricultural practices
  - Pollinators, predators, parasitoids, microbes...

Ecological Mgmt

- Countering the errors committed in the past by industrialized agriculture
  - Habitat loss
  - Use of chemical pesticides
  - Introduction of exotic species
  - Introduction of exotic diseases/pests

Habitat Management for Biodiversity

- Habitat (overwintering, refuge, mating)
- Alternate food sources

Cost Benefit Analysis of Eco-Agriculture

- Ecological methods are more expensive
  - However, not subsidized
  - Loss of yield
  - Increased maintenance/human-power
  - Subsidy to chemical industries
  - BUT: Diminished costs for ecosystem services
- Market demand creates incentives
  - Higher prices per bushel on Eco-Ag (organic and others)
References