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Joint Bachelor Course on Organic Agriculture 2014

Lecture 6: Plant protection in organic farming

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PRINCIPLES OF ORGANIC AGRICULTURE

IFOAM principles

- **Principle of Health**

Organic Agriculture should sustain and enhance the health of soil, plant,animal, human and planet as one and indivisible

- **Principle of Ecology**

Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them

- **Principle of Fairness**

Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities

- **Principle of Care**

Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment

Source: http://www.ifoam.org/sites/default/files/ifoam_poa.pdf

Photo: Stoeva, A. AUP

Plant protection

- Conventional
- Integrated
- Organic

Pieris brassicae caterpillar parasitised by Cotesia glomerata (Hymenoptera: Braconidae)

Larva of syrphid fly Episyrphus balteatus eating aphids

Harmonia axyridis, a predatory lady beetle

Plant protection

Organic

- Prevent pest, disease and weed problems through optimized cropping system as a whole
- No total destruction of pests and pathogens (economic threshold: balanced operation)
- Curative agricultural system against pests and diseases
  - Resilient, tolerant crop
  - Crop variety and rotation
  - Appropriate husbandry practices

Integrated

- Combined application of biological, biotechnological, chemical, cultural or plant-breeding measures
- Environmental consideration (useful organisms and interactions)
  - Limited chemical plant protection products
  - Substitution of harmful chemicals with less harmful “green” chemicals

Conventional

- Avoidance of plant damage by eliminating/killing pests (economic loss)
- Use of different “killing” compounds (-cide, fungicide, bactericide, insecticide, acaricide etc.)
- No agro-technical, biological and other plant protection methods

Plant protection: Conventional

- Pest → damage threshold → treatment
  - Economic threshold
    - Depending on yield and product price
  - Impact of natural regulatory mechanisms is not relevant for threshold
  - Reciprocal relation with pest and parasitoids is not relevant
  - E.g. Use of widely effective insecticide against the larvae of the cabbage moth has negative effects on parasitoids of aphids. As a result, heavy aphid infestation can build up, which makes more insecticide inserts needed (Daniel 2014)

- Approaches for organic farming?

Plant protection strategies

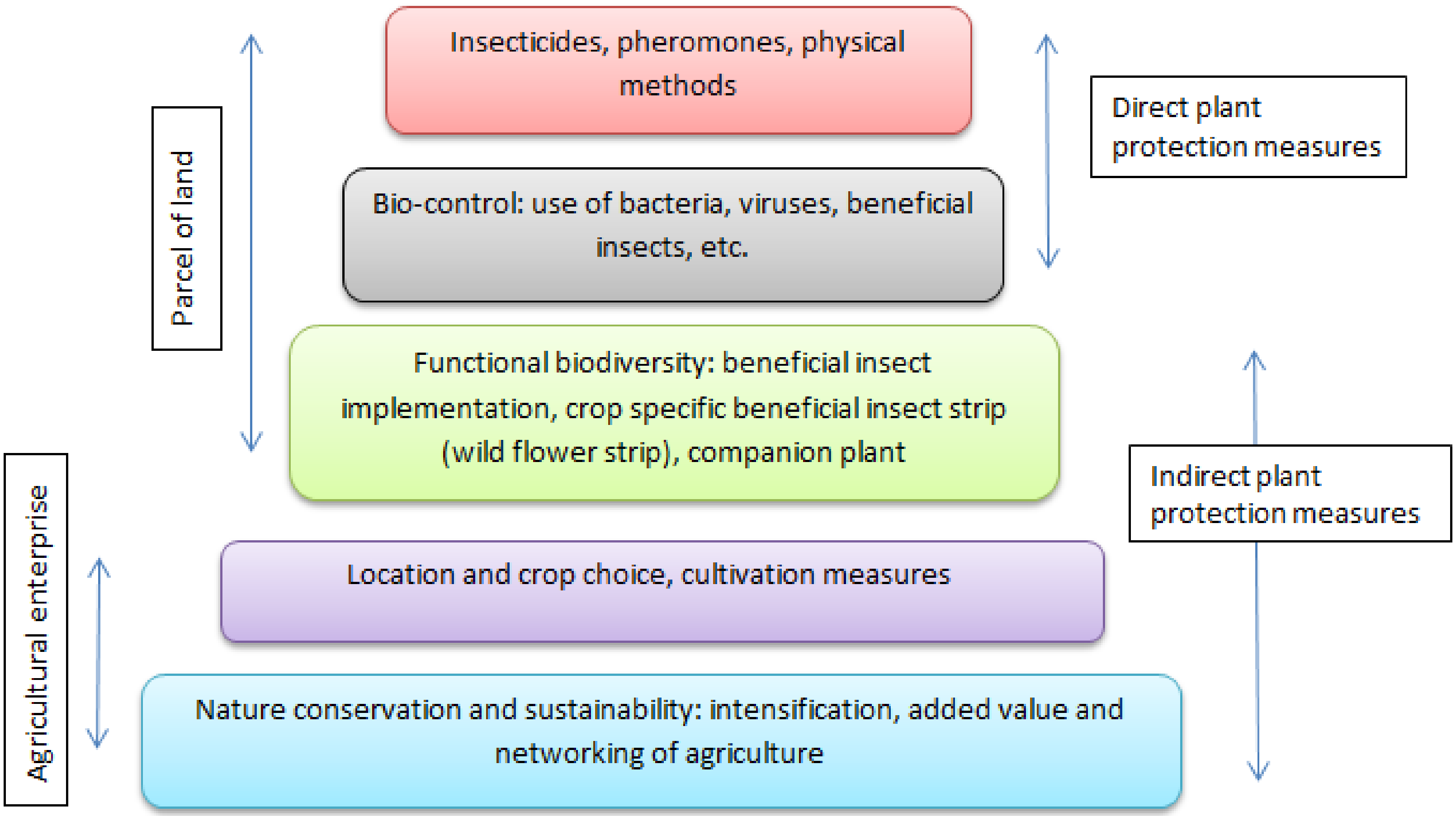
Aim of organic plant protection

- Remove reasons/encouraging conditions for occurrence of harmful organisms

- Prevention (indirect method)
  - Preventative measures and indirect methods of plant protection
  - Based on cultivation methods and selecting cultivars
  - Promoting environmentally-friendly farming system

- Protection (direct method)
  - Physical: mechanical and thermic (not selective)
  - Biocontrol

Plant protection strategies in organic farming



Source: Daniel, ETH 2014, modified

Prevention

- Suitable production site
  - Cultivating plant suitable to local soil type and climate
  - Optimal growth and development conditions
    - Careful selection of production site
      - Plant's specific demands need to be fulfilled by surrounding environment
      - Exposure, humidity, soil properties. etc.
      - Shaded, enclosed sites support development of diseases (mould, mildew, rust); Damp sites support potato cyst nematode and potato rot; windy sites are less bothered by certain pests (carrot fly *Psila rosae*)

E.g. appropriate slope for grapes.

Dry sun at slopes preventing diseases

Photo: Manolov, AUP

Prevention

Environmental conditions for crop specific development

- Microclimate
  - Soil and water conditions
  - Temperature and precipitation (duration and intensity)
- Nutrient availability and access
- Topographic conditions
  - Terrain, slopes, and valleys
- Specific characteristics of the living environment – natural ecosystem
- Organic cultivation techniques enable support of natural self-protection of crops-environment relation

Prevention: Nutrition management

- Nutrition management (balanced nutrition)
  - Determined by soil fertility and local biodiversity
- Nutrition from bio-active soils promote
  - Balanced nutrient supply (macro-/micro- and trace elements)
  - Nutrient supply through active nutrient-serving systems
    - Depending on organic matter
    - Creating stable soil structure
  - Resistance to harmful organisms/pathogens
  - Handling of disease and pest expansion
  - Natural substances for manure, green manure and compost

Prevention: Cultivation practices

Preventive impacts of soil cultivation on plant protection

- Modifying agricultural conditions for
  - Benefiting crops
  - Constraining crop-harming organisms
- Methods
  - Crop rotation
    - Balanced nutrient management
  - Intercropping
    - Under-sowing
    - Nurse crops
  - Soil tillage (frequency, applied tools, etc.)
  - Green fertilization

Sowing schedule and adequate preparation

- Rapid and uniform germination
- Moist conditions
- Uniform soil surface
- Development and uniformity of germinating seeds help the formation of healthy culture
- Allow the proper root development of the plant

Prevention: Cultivation practices

Crop rotation

- Growing different crops on the same land in a regular recurring sequence
  - Succeeding crop belongs to a different family than the previous one

- Rotating crops is one of the key principles of conservation agriculture

Advantages

- It improves the soil structure
- It increases soil fertility
- It helps control weeds, pests and diseases
- It produces different types of output
- It reduces risk

Source: http://www.infonet-biovision.org/default/ct/251/soilfertilitymanagement

Example for crop rotation

- Rotation vary from 2 or 3 years or longer periods
- Most important reason
  - To hinder the development of weeds, arthropod pests and short-persistent soil-borne diseases by reducing their population levels in the soil
  - Many of the pests and diseases that plague vegetable plants live in the soil.

- Effects of crop rotation
  - Higher diversity in plant production and thus in human and livestock nutrition
  - Reduction and reduced risk of pest and weed infestations
  - Greater distribution of channels or biopores created by diverse roots (various form, size and depths)
  - Better distribution of water and nutrients through the soil profile
  - Exploration for nutrients and water of the whole soil profile by roots of many different plant species resulting in an optimal use of the available nutrients and water
  - Increased nitrogen fixation through certain plant-soil biota symbionts and improved balance of N/P/K from both organic and mineral sources
  - Increased humus formation

Source: http://www.infonet-biovision.org/default/ct/251/soilfertilitymanagement

Example for crop rotation

- Which crop should not be planted together or in rotation
  - Crops (in same group) suffering from same pest and disease problems

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Cucumber Gourds Muskmelon Pumpkin Summer squash Watermelon Winter squash	Broccoli Brussels sprouts Cabbage Cauliflower Collards Kale Kohlrabi Radish Turnip	Eggplant Pepper Potato Tomato	Beetroot Spinach beet Carrots Lettuce Parsnips	Corn Cereals	Beans Peas	Garlic Leeks Onions

Source: http://www.infonet-biovision.org/default/ct/251/soilfertilitymanagement

Example for crop rotation of vegetable crops and fodder crops

Year	Crops	Benefits
1	Alfalfa	High quality fodder, increasing soil fertility, improving the phytosanitary status of the soil
2	Wheat (spinach as a second crop)	
3	Potatoes	
4	Carrots and onion (stripe cropping)	Suppression of soil pathogens, prevention of *Psila rosae* and *Delia radicum*
5	Pepper	
6	Rye (Winter peas – second crop)	
7	Tomatoes and leek	A good practice against soil pathogens
8	Beans and peas	Enriches the soil with organic nitrogen
9	Barley (Cabbage – second crop)	

Source: Karov et al., AUP, 2013

Prevention: Cultivation practices

Intercropping, strip cropping and relay cropping

- Same advantages as rotation
- **Intercropping**
  - Growing two or more crops in the same field at the same time
    - mixed intercropping
    - row intercropping
- **Stripe cropping**
  - Planting broad stripes of several crops in the field
  - Each stripe is 3–9 m wide
  - Planting different crops breaks their life cycle and prevents them from multiplying
  - Rotating of crops annually as additional benefit
- **Relay cropping**
  - Growing one crop, then planting another crop (usually a cover crop) in the same field before harvesting the first

Source: http://www.fao.org/ag/ca/AfricaTrainingManualCD/PDF%20Files/06CROP1.PDF#page=4

Example for mixed intercropping

Crop A	Crop B	Benefits/ Protective effects against…
Basil, savory, maize	Pepper, eggplant, tomatoes	Leafhoppers, stolbur
Leek	Celery	Rust, thrips
Garlic, onion	Strawberries, parsley	Pathogens, Weevils
Carrots	Green onion, leek,	Carrot fly, Acrolepia assectella
Salad	Cabbage, turnip	Flea beetles
Celery, tomatoes	Cabbage	Cabbage butterfly
Nasturtium, horseradish	Different crops	Aphids, caterpillars,
Calendula, Tagetes, palmcrist	Different crops	Nematodes

Source: Karov et al., AUP, 2013

Prevention: Cultivation practices

Intercropping

- Measure against pest (difficult practical implementation for larger agriculture)
- Simultaneously growing agricultural diversity
- Herbivores insects (pests) in poly-cultures constraint by
  - Divers predators and parasitoids
  - Attraction to trap plants
  - Tall non-host plants
    - Obstructing movement of pest insect within cropping system
  - Visual distraction
    - Camouflage the crops
    - Herbivores tend to land on tall green plants
  - Odor distraction
    - Non-host plants confer protection to crop
    - Releasing odor masking substances
    - Crop untraceable or repelling for herbivore

Prevention: Cultivation practices

Intercropping benefits

- Plant diversity creates overall plant health
- Reduce pest pressure
  - Increased insect pest and disease resistance
  - Increased insect predator populations
- Increased weed suppression
- Sustainable soil-plant relation
  - Nutrient circulation
  - Natural soil tillage
  - Increased soil microorganism activity
- Increase yield of involved crops
  - Better use of growing area

e.g. Intercropping cereals with grain legumes reduces infection by *Orobanche crenata*

Source: Fenández-Aparicio, M. et al., 2007. Crop Protection, Vol. 26, Issue 8, Pages 1166–1172.

Prevention: Crop diversity

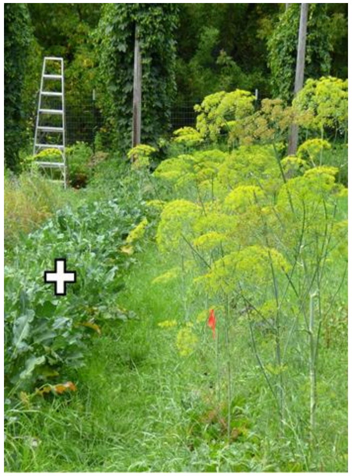
Plant species and diversification

- Organic fields
  - More species and individuals than non-organic areas
  - Birds, predatory insects, spiders, soil dwelling organisms and field flora benefit from organic condition
- Associated mixed cultures
  - Multiple plant protection effect
    - Reciprocal support for environmental and nutrition needs
    - Repelling each others pests
    - E.g.
      - Calendula in-between vegetables to combat mites/pathogens
      - Tagetes erecta or Amaranthus sp. as plant trap for nematodes

Prevention: Associated Plants

Repelling plants

- Companion plants protect target crop from pests
  - potential attractive (+) and repellent (-) properties
  - interfere with host plant location.
  - Protecting target crop via
    - masking host plant odors (spring onion)
    - visually camouflaging (marigolds)
    - Physical blocked movement - Height (Dill)



Source: http://www.intechopen.com/books/weed-and-pest-control-conventional-and-new-challenges/companion-planting-and-insect-pest-control#article-front

Prevention: Crop variety

- Suitability for ecological conditions
  - Good adaptability
  - Less demanding of soil properties, nutrients
  - Mainly regional, native varieties
  - Resistant, tolerant
    - E.g.: Apple scab disease (Venturia inaequalis) and selection of the resistant variety of apples – Freedom, Moira, Jonafree, Liberty, Dayton etc.
- Propagation material, soil and water
  - Not infected plant propagation material
  - Not infected soil and water for irrigation

Prevention: Elimination of vectors

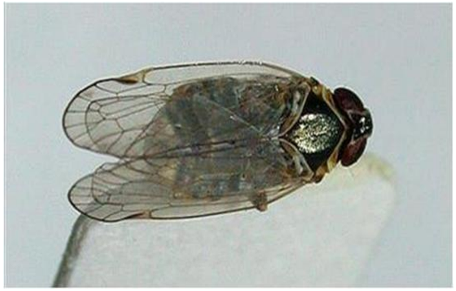
Vector

- Sucking insects (aphids, leafhoppers) can transmit diseases
  - In agriculture: decide if addressing disease or vector
- Elimination of the transmitters (aphids, weeds)
  - Aphid species
    - Impact depending on susceptibility of cultivars
    - E.g. plum pox virus transmitted by vectors (insects, aphids)
    - E.g.:Stolbur phytoplasma and its vector plant hopper (*Hyalesthes obsoletus*)

Photo WEB: http://www.chem.bg.ac.rs/~mario/scaphoideus/English/side_5_vectors.htm

Aphids on wheat

Aphids on Prunus sp.



***Hyalesthes obsoletus* Sign. (Auchenorrhyncha: Cixiidae) vector of *Stolbur* phytoplasma**

Photo: Stoeva, A. AUP

Protection (direct means): Physical methods

- Exclude/remove pests from crop system
- Required knowledge of pest biology, behavior and crop interaction

Heat treatment
- Based on different heat tolerance of crop and parasite
- Hot water (52-53^{0}C) treatment of cereal seeds
  - Historic method: fungal thread inside seeds killed
- Periodic heat treatment
  - Vegetative propagation materials (bulbs, tubers) freed of viruses

Sanitation
- Disinfection of seeds and bulbs
- E.g. Tomato seeds against *Clavibacter michiganensis* (56^{0}C/30 min), cabbage seeds against *Xanthomonas campestris* and *Peronospora parasitica* (50^{0}C/30 min), wheat seeds against *Ustilago tritici* (28-32^{0}C/4h after 54^{0}C for 10 min)

Soil solarization
- For regions with high summer temperatures
- Soil temperature above 60^{0}C
- Killing soil pathogens and weed seeds

Protection: Mechanical methods

Attraction and collection

- Mainly for monitoring
- Different methods for attracting pests

- Light traps
  - Effective tools of insect pest management
  - Mass-traps both sexes
  - Substantially reduces the carryover pest population.
- Colour traps
  - Yellow sticky boards to catch aphids, whiteflies, cherry fruit fly
  - Blues sticky boards for thrips
  - White sticky board for black plum sawfly (*Hoplocampa minuta*)
  - Low effectiveness, monitoring purpose
- Water traps
  - Utilize a flying insect's instinct to land on standing water in order to trap the bug. The water film is attractive to flying insects which will often get stuck in the water.
- Sticky bands
  - Against winter moth on fruit trees/shrubs (codling moths, geometrid adults etc.)
  - Non-woven polypropylene fleece and polythene nets
  - E.g.: protecting cabbage, carrot crops from attacks by pest Diptera - cabbage root fly, *Delia radicum*, and the carrot fly, *Psila rosae*.

Protection: Mechanical methods

Colour/sticky traps - for whiteflies and aphids
(Photo: Stoeva, A., AUP)

Water traps
(Photo: Andreev, R., AUP)

Light traps - widely used to survey nocturnal moths
(Photo: Andreev, R., AUP)

Yellow sticky traps for cherry fly
(Photo: Andreev, R., AUP)

Protection: Biological control (biocontrol)

- Definition of the biological control (Smith 1919)
  - Regulating the population densities of pests using their native or introduced natural enemies.

- Eradication of pests
  - Through its natural enemies/promoting its antagonists
  - Primarily directed against pests (insects, mites and nematodes)
  - Natural enemies
    - Predators, parasitoids or infectious agents (entomopathogens)
    - Limiting the frequency and severity of pest proliferation
- Conditions
  - Joining balanced natural ecosystem and artificial agricultural systems
  - Establishing relatively natural (balanced) agro-ecosystems
    - Healthy development of cultivated plants

Protection: Biocontrol

Discussion aspects

- As natural phenomenon – as antagonistic relationships between two organisms, when one of them is feeding or living on the other one, and thus reducing its population density.
- As human activity (a method) – an intentional use of the antagonistic relationships between harmful organisms and their predators, parasitoids or pathogens with the aim to reduce the population density of the harmful ones.

Protection: Biocontrol

Main ways of applying biocontrol agents for control

- **Introduction** (Classical biological control)
  - Introduction a natural enemy to manage an exotic pest
- **Augmentation** (inundative and inoculative release)
  - Supplemental release of mass reared natural enemies to manage pests in a controlled setting
    - Against economically important pests
  - Inundation: immediate but non-sustainable reduction in the pest population
  - Inoculation: frequently, prophylactically, before pests become a problem
- **Conservation** (preservation of local beneficial fauna)
  - Providing habitat
  - Protecting natural enemies

Protection: Biocontrol

In each **agrocenosis** (Conservation)

- Complex of predators and parasitoids regulating pest population density
- Protect and help beneficial agents
  - Implementing of integrated pest management IPM, biological control, using selective pesticides, etc.
  - Beneficial insect wild flower strips/bushes
    - Overwintering and additional feeding

Functional biodiversity

- Ecological approach to pest management
- Process of creating habitats (the use of hedgerows, insectary plants, cover crops, and water reservoirs) to attract and support populations of beneficial organisms (giving them chances for their survival and reproduction)

Protection: Biocontrol

Augmentation

- › Biocontrol agents must be mass reared in a lab in great numbers.
- › Directed to both native and introduced pests.

Inundative release

- › Great number of bioagents used
- › To control population density of the pest quickly
  - › Not considering progeny ability of released agents
  - › Immediate but not sustainable reduction
  - › E.g. release of egg parasitoid Trichogramma pintoi against European corn borer

Inoculative release

- › Small number of bioagents used
- › To control pest also by its progeny
- › Frequently and prophylactically
- › Suitable for pests with many generations/a (aphids, psyllids, thrips)
- › E.g. Ladybeetles and parasitoids (Aphidiidae) to control aphids in glasshouses

Protection: Biocontrol

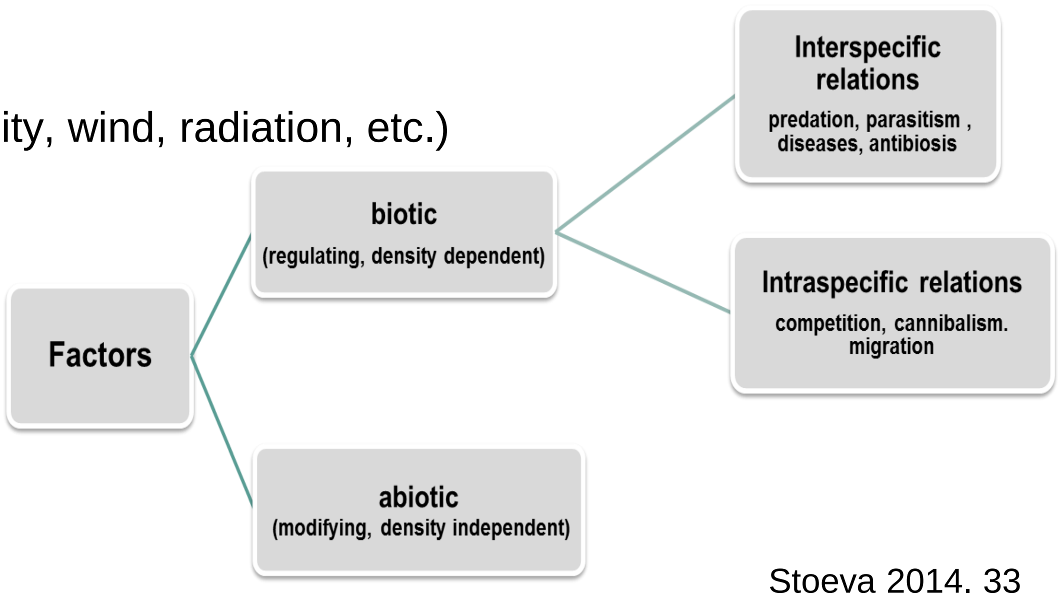
- Non-native external species introduction (classical biocontrol)
- Import of exotic biocontrol agent when there are no effective native biocontrol agents
- Alien pest (coming from another continent)

Example for introduction of a not suitable biocontrol agent – *Harmonia axyridis*

Photo: Stoeva, A.

Protection: Biological control

- Biocontrol (natural control)
- Natural regulative process
  - Keeping population density small
  - Over certain time period influenced by several factors
- Factors
  - **Biotic** (regulating)
    - Predators, parasitoids, diseases, antibiosis, intraspecific relationships, and food
    - Density dependent (act in different way at low and high population density)
  - **Abiotic** (modifying)
    - Climatic conditions
      (T, precipitation, humidity, wind, radiation, etc.)
    - Density independent



Protection: Biocontrol in organic agriculture

- Use of living organisms to maintain pest populations below damaging levels
- Biocontrol agents/natural enemies of arthropods fall into three major categories:
  - Predators
    - Attacks, kills and feeds on several prey
  - Parasitoids
    - Lives or feeds in or on a host
  - Pathogens
    - Such as granulosis virus, entomopathogenic fungi and bacteria infest pests

Photo: Stoeva, A. AUP


Harmonia axyridis, a predatory lady beetle


Eggs of predatory lady beetle and larva of syrphid fly


Oenopia conglobata, a predatory lady beetle

Protection: Biocontrol

Interspecific relationships

- Predation
  - Relationship between two organisms (predator –pray)
    - Predator feeds on prey and kills or weakens it
  - Characteristics of predator
    - Bigger, stronger, faster then prey
    - usually with cryptic (protective) coloration
  - E.g. common predatory arthopods: lady beetles, carabid beetles, spiders, lacewings, syrphid flies…

Protection beneficial Insects

Ladybeetles

Ground/ Tiger Beetle

Soldier Beetle

Protection beneficial Insects

Lacewings

Predatory bug

Protection beneficial Insects

Syrphid flies

Predatory midges

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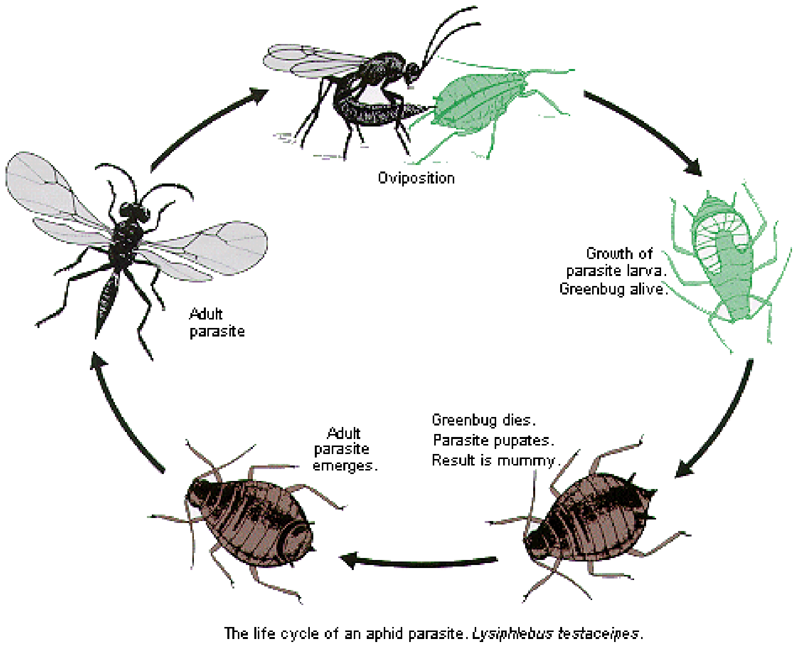
Protection: Biocontrol

- Parasitism
  - Relationship between two organisms (parasite and host)
  - Parasite feeds and lives on host
  - A parasite killing host at completion of its larval development is called parasitoid
- Parasitoids
  - Do not usually eat their hosts directly
  - Adult parasitoids lay their eggs in, on, or near their host insect
    - Larva of parasitoid uses the host as food
  - Additional source of food to their host insect (nectar, pollen)
  - **Parasitoids** categorized by
    - Place (where larvae develops)
      - endoparasitoid – at least the larva is inside the body of the host
      - ectoparasitoid – develops on the body of the host
    - Stage of host
      - Egg/ larval parasitoid, pupal, imaginal, egg-larval, larval-pupal, pupal-imaginal
    - Number of larvae in the host
    - Stage of the host parasitized

Protection: Biocontrol

Depending on number of parasitoid larvae in host

- Solitary
  - In one host only one larva may complete its development
- Gregarious
  - In one host more than one larvae of the parasitoid develop



Aphidius sp., a solitary parasitoid of aphids

Source:http://msue.anr.msu.edu/news/it_is_time_to_integrate_biological_control_into_your_reduced_risk_ipm_progr

Source: Stoeva, A., AUP

Piersi brassicae caterpillar, parasitised by gregarious parasitoid Cotesia glomerata

Protection: Biocontrol

Examples of parasitoids

- Tachinid flies
- Braconid wasps
- Ichneumonid wasps

Aphids parasitized by a species of Braconidae

Protection: Biocontrol

Pathogens

- Disease-causing organisms
- Insect-parasitic
  - Bacteria, fungi, protozoa, viruses, and EPN (entomopathogenic nematodes)
- Beneficial nematodes
  - Phyllum Nematoda
  - > 30 nematode families are known to host taxa that parasitize or are associated with insects
    - Strong biocontrol potential (7main families)
    - Mermithidae, Allantonematidae, Neotylenchidae, Sphaerularidae, Rhabditidae, Steinernematidae and Heterorhabditidae
    - Control agents of soil insect pests
  - >3200 nematodes species, connected with about 1000 harmful insects
  - Nematodes
    - Egg, larval and adult stage
    - Infection via “invasive” larva (second instar)
  - Active or passive infection

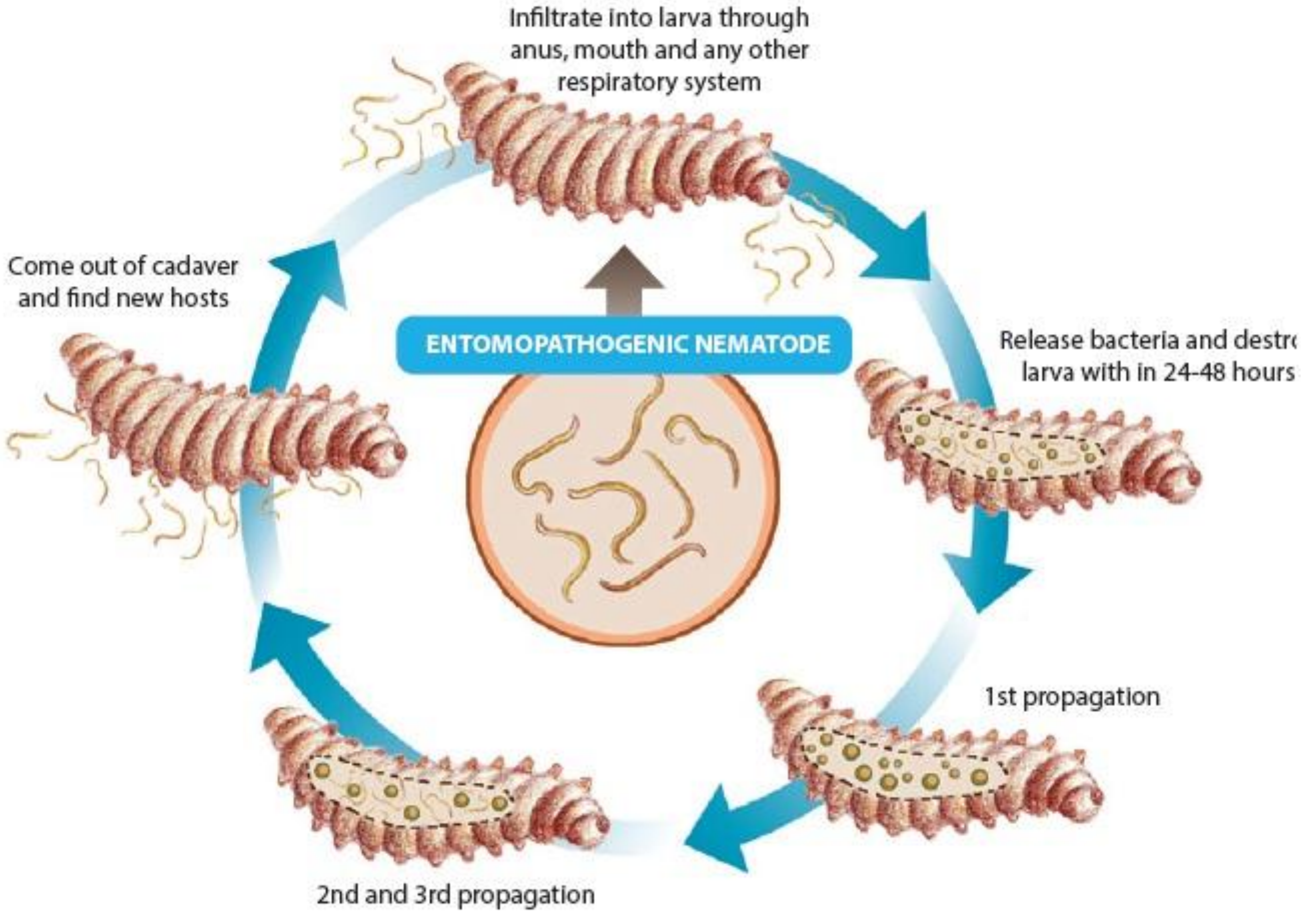
Protection: Biocontrol

- Nematodes
  - Entomoparasitic
    - Parasitic to insects
    - Organism (nematode) benefits at the insect host's expense
    - Host mortality is not necessarily a requirement for parasite's development
  - Entomopathogenic
    - Microorganism/nematode capable of causing disease in insects
    - Parasitic nematodes mutualistic-associated with bacterial symbionts
    - All life stages of nematode (except for the free-living 3rd stage infective juvenile/ dauer stage) exist inside insect host
    - E.g. Steinernematidae and Heterorhabditidae (lethal pathogens of insects)
    - Commercially mass-produced: EPN and slug-parasitic nematodes (Phasmarhabditis) to treat pest problems
    - EPN effective to kill a diverse array of insects
      - Due to a mutualistic association with bacteria in the genera Photorhabdus (for Heterorhabditidae) and Xenorhabdus (for Steinernematidae)

Protection: Biocontrol

LIFE CYCLE OF ENTOMOPATHOGENIC NEMATODES

- The life cycle is completed in a few days, and hundreds of thousands of new infective juveniles emerge in search of fresh hosts. Thus, entomopathogenic nematodes are a nematode-bacterium complex.



Source: http://vegalab.com/larva-bio-control/

Protection: Pheromones

Pheromone (semiochemicals in OA)

- Biologically active substances released by organisms
  - Low concentrations influencing other organisms
  - From another species – allelochemicals
  - From same species – pheromones
- Allelochemicals
  - Repellent effect to disturb feeding, to attract other organisms, to be toxic, etc.
- Pheromones
  - Act on individuals of same species
  - Provoking: alarm pheromones, aggregation pheromones, trail pheromones, social pheromones, sex pheromones etc.
  - Sex pheromones (highly specific) regulate the sexual behavior of insects
    - > 900 important pests on market

Protection: Pheromones

Synthetic sex pheromone used as

- Pheromone traps
  - Mainly for trapping males
- Dispensers
  - Containing extremely high concentrations of sex pheromone and disorientating males while searching females
- Electrostatic powder
  - Males attracted by pheromone to traps
  - Electrostatic powder sticks to males' abdomen and (female smell)
- Combined with chemosterilant
- Combined with color sticky trap

Protection: Pheromone traps

Photos: Andreev, R., AUP

Pheromone delta trap for oriental fruit moth

Pheromones and other chemical attractants used for

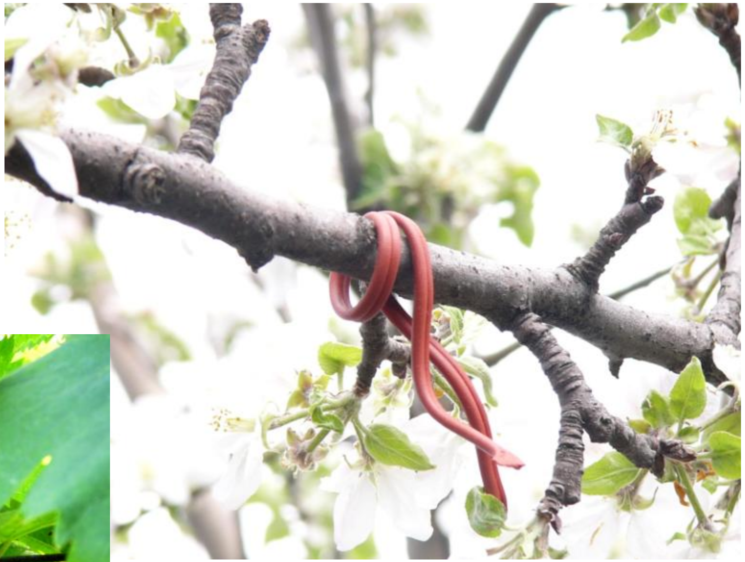
- Mainly for monitoring pests
- Direct plant protection
  - Disrupting mating
  - Capturing large number of adults (mass trapping)

Pherocon 1C trap and ICP trap

Protection: Pheromone dispensers

For mating disruption

- Method of confusing males
    - Mostly used against vine moth and grape berry moth in vineyards, codling moth in orchards and some other pests



Different systems of disorientation

- Grape moths (left)
- Codling moth (right)

Protection: Products for organic agriculture

Operative EU Regulations Legal framework for organic production

- Chemical, mineral and organic substances
- Regulation (EC) No 834/2007
  - Organic production and labeling of bio-products
- Regulation (EC) 889/2008
  - Detailed rules' definition for the implementation of Regulation of the Council (EU) No 834/2007

Biopesticides vs Chemical pesticides

	Advantages	Disadvantages
Biopesticides	› less toxic › generally affect only the target pest and closely related organisms › effective in very small quantities › often decompose quickly › difficult for insects to develop resistance to these pesticides	› slow effect › lack persistence and wide spectrum activity › rapidly degraded by UV lights › not available easily
Chemical pesticides	› high efficacy › low cost › easy application	› broad-spectrum activity and environmental persistence › effects on non-target organisms › secondary pests › pesticide resistance › toxicity

Source: Bailey, A., et al., 2010

Source: http://www.seedbuzz.com/knowledge-center/article/bio-pesticides-benefits-barriers

Protection: Products for organic agriculture

COMMISSION REGULATION (EC) No 889/2008

Fungicides – mainly chemical and mineral substances	
Copper in the form of copper hydroxide, copper oxychloride, (tribasic) copper sulphate, cuprous oxide, copper octanoate	Fungicide (up to 6 kg/ha per year)
Lime sulphur (calcium polysulphide)	Fungicide, insecticide, acaricide
Mineral oils	Fungicide, insecticide (only in fruit trees, vines, tropical trees)
Potassium permanganate	Fungicide, bactericide (only in fruit trees, olive trees, vines)
Sulphur	Fungicide, acaricide, repellent
Calcium hydroxide	Fungicide Only in fruit trees, including nurseries, to control *Nectria galligena*
Potassium bicarbonate	Fungicide
Lecithin	Fungicide

Source: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:250:0001:0084:EN:PDF

Protection: Products for organic agriculture

Insecticides (mainly substances of crop or animal origin (plant extracts and oils)	
Azadirachtin extracted from Azadirachta indica (Neem tree) – (commercial product in Bilgaria - NeemAzal)	Insecticide (especially sucking insects – aphids, thrips)
Gelatine	Insecticide
Plant oils (e.g. mint oil, pine oil, caraway oil). Rapeseed oil	Insecticide, acaricide, fungicide and sprout inhibitor.
Natyral pyrethrum (Pyrethrins extracted from Chrysanthemum cinerariaefolium)	Insecticide (its effectiveness is not selective – it also damages populations of useful organisms)
Quassia extracted from Quassia amara	Insecticide, repellent
Rotenone extracted from Derris spp. and Lonchocarpus spp. and Terphrosia spp.	Insecticide

Protection: Products for organic agriculture

Insecticides – substances produced by microorganisms

Substances produced by microorganisms	
Spinosad (commercial product on this base in Bulgaria: Syneis, Laser)	Insecticide (based on a compound found in the bacterial species Saccharopolyspora spinosa (S. spinosa)) Only where measures are taken to minimize the risk to key parasitoids and to minimize the risk of development of Resistance
Microbial preparations (Biocontrol)	
Bacillus thuringiensis (commercial products in Bulgaria: Dipel, Foray etc.)	Bacteria attacking caterpillars of butterflies.
Virus products (commercial products in Bulgaria: Madex granulovirus (CpGV) as the active ingredient)	Codling and Fruit Moths

Protection: Products for organic agriculture

Other substances	
Fatty acid potassium salt (soft soap)	Insecticide
Lime sulphur (calcium polysulphide)	Fungicide, insecticide, acaricide
Paraffin oil Insecticide, acaricide Mineral oils Insecticide, fungicide; only in fruit trees, vines, olive trees and tropical crops (e.g. bananas);	Insecticide, acaricide
Mineral oils	Insecticide, fungicide; only in fruit trees, vines, olive trees and tropical crops (e.g. bananas);
Ferric phosphate (iron (III) orthophosphate)	Molluscicide

Substances to be used in traps and/or dispensers	
Diammonium phosphate	Attractant, only in traps
Pheromones	Attractant; sexual behaviour disrupter; only in traps and dispensers
Pyrethroids (only deltamethrin or lambdacyhalothrin)	Insecticide; only in traps with specific attractants; only against *Bactrocera oleae* and *Ceratitis capitata*

Relevance of Biocontrol

- Application of Spinosad against codling moth kills parasitoids of woolly aphid
- Mass reproduction of woolly aphid cannot be distroyed by biopesticides (avoid secundary problems)
- Application of selective granulovirus against codling moth more reasonable

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