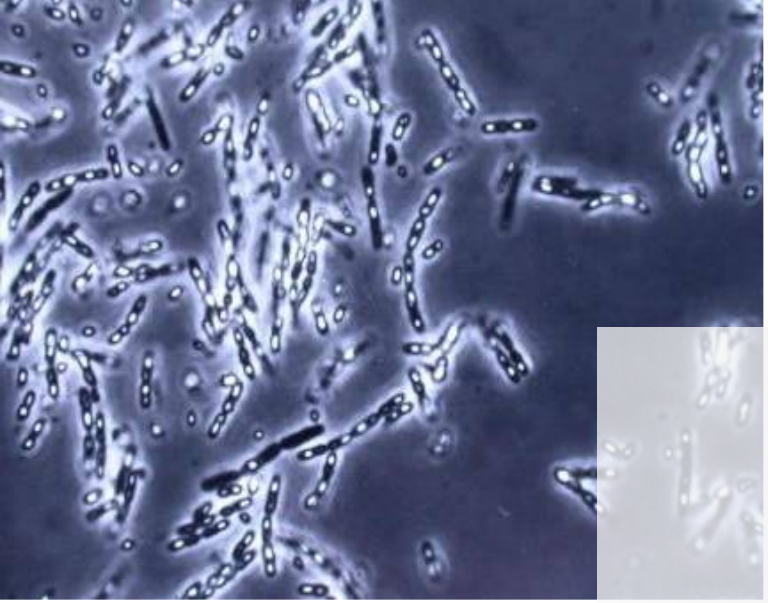


Prospects for biocontrol methods and agents in integrated pest management

Marek Tomalak
Department of Biological Control

Institute of Plant Protection
National Research Institute
Poznań

New legal regulations of the European Parliament and of the Council

- **Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC**

  Preamble (35) „To ensure a high level of protection of human and animal health and the environment, plant protection products should be used properly, in accordance with their authorization, having regard to the principles of integrated pest management and giving priority to **non-chemical and natural alternatives** whenever possible.”

- **Directive 2009/128/EC of the European Parliament and the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides**

  Preamble (19) „(…) Member States should describe in their National Action Plan how they ensure the implementation of the principles of integrated pest management, with priority given wherever possible to **non-chemical methods of plant protection** and pest and crop management.”

Non-chemical methods of plant protection

- **Cultural methods**

  - proper selection of planting locality, plant species and varieties, proper soil cultivation methods, methods and timing of sawing and planting, crop rotation, fertilization, timing of harvesting, etc.

- **Physical / mechanical methods**

  - traps, barriers and protecting covers, mechanical removal of pests, weeds and infested parts, etc.

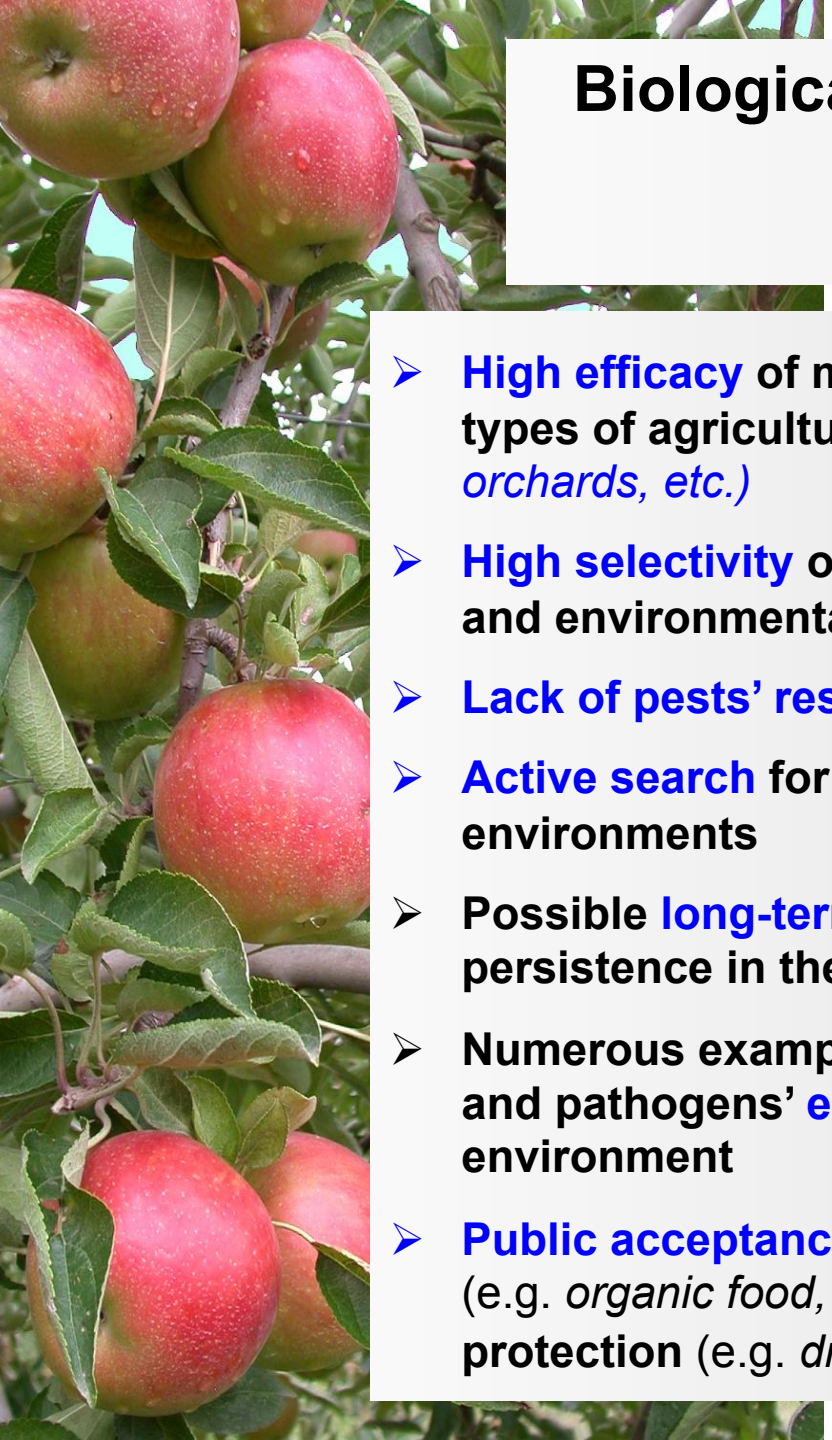
- **Biotechnological methods**

  - genetic engineering of crop plants for pest or pathogen resistance, etc.

- **Biological methods**

  - the use of beneficial viruses, microorganism and macroorganisms which kill or control populations of harmful organisms

  Frequently, also the use of semiochemicals and other compounds of plant or animal origin which modify pest activity, attract, repel, reduce development or kill them



Biological control as a non-chemical and natural alternative
ADVANTAGES

- **High efficacy** of many biocontrol agents and products <u>in some</u> types of agricultural crops (*greenhouses, mushroom houses, orchards, etc.)*
- **High selectivity** of biocontrol agents – high level of consumer and environmental safety
- **Lack of pests' resistance** to biocontrol agents (!?)
- **Active search** for the pest organism (prey / host) in agricultural environments
- Possible **long-term beneficial activity** – reproduction, persistence in the environment
- Numerous examples of **great potential** of **native** plant pests' and pathogens' **enemies, naturally present** in agricultural environment
- **Public acceptance** for fulfilling special demands of consumers (e.g. *organic food, food for children*) and environmental protection (e.g. *drinking water supply, protection of urban parks*)

Global market for biological control products

(*The new biopesticide market*, *RC-204R Report, Business Communications Company, Inc., 2009*)

Global market for synthetic pesticides

- **2005 - $26.7 billion**
- **2010 - $25.3 billion – average annual decline 1.1%**

Global market for biological control products

- **2005 - $672 million**
- **2010 - $1075 million – average annual growth 9.9%**

Share of biological control products in global market

- **2005 – 2.5%**
- **2010 – 4.2%**

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Trends in global market for biological control products

Europe – fastest developing region !!! (5 years !!!)

- **2005 - $135 million**
- **2010 - $270 million – average annual growth 15.0%**

South America – slowest developing region

- **2005 - $70 million**
- **2010 - $88 million – average annual growth 5.0%**

(*The new biopesticide market, 2009*)

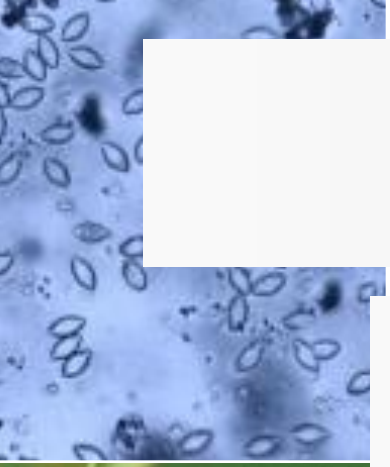
PROSPECTS: Dynamic growth of the use of biocontrol agents

European Community 1985-2004

- ***Bacillus thuringiensis* 1985 (95%) – 2004 (25%)**
- **Macroorganisms 2004 (55%)** **Reasons for this situation !??**

(*Biocontrol Network, Montreal, Kanada, 2008*)

PROSPECTS: Gradual changes in the share of particular groups of biocontrol agents



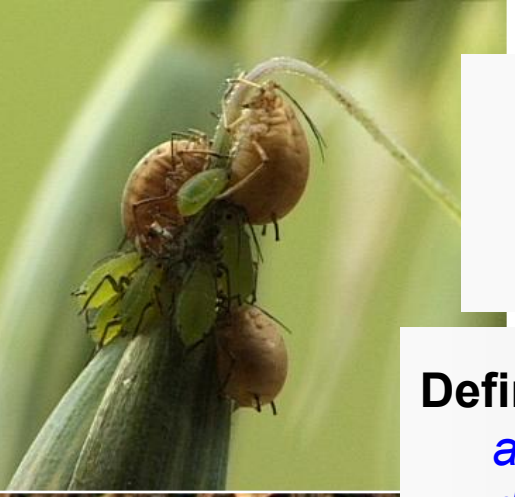
What biological methods can offer to integrated pest management?

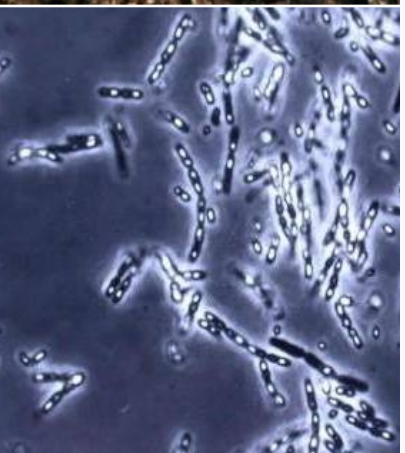
- **Species and specific strains** of antagonistic (i.e. pathogenic, parasitic and predaceous) organisms which can effectively and safely limit populations of some economically important pests and pathogens, and **can be integrated** with other control measures
- Technologies for their **mass production and formulation**
- **Formulated biocontrol products** based on these organisms
- Technologies of their **application** in specific conditions of some agricultural crops …

... as well as continuously growing knowledge on:

- **Mechanisms of regulation of agricultural pests and pathogens** by native antagonistic organisms, **naturally present** in the agricultural environment
- **Mechanisms of regulation of the antagonistic organisms** by environmental factors

... and much, much more.





Biological control as non-chemical and natural alternative STRATEGIES

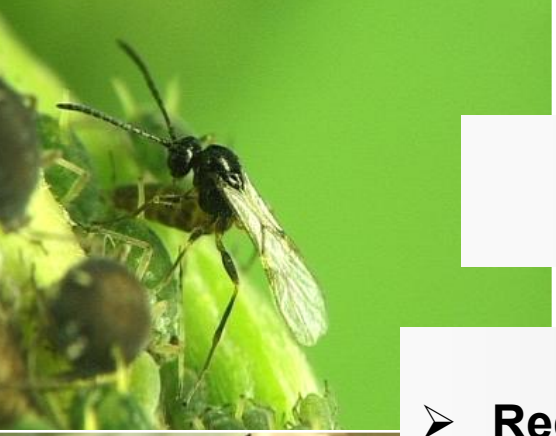
Definition (DeBach, 1964) *„the action of parasites, predators, and pathogens in maintaining another organism's population density at a lower average than would occur in their absence"*

BIOLOGICAL CONTROL

Natural biological control: spontaneous activity of many native antagonistic organisms

Applied biological control

- **Inoculative (=classical)** – import and release of exotic natural enemies against exotic or local pests – long-term activity
- **Augmentative** - mass rearing and release of natural enemies which are already present in particular environment or are easily available – short-term activity, limited persistence
- **Conservative (=conservation)** – conservation of existing populations of native natural enemies by modification of their environment



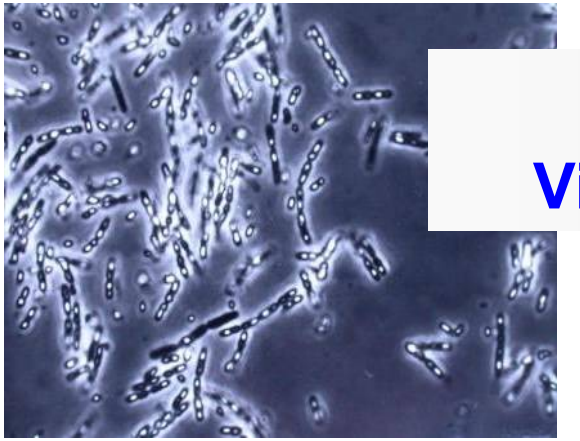
I. Natural biological control

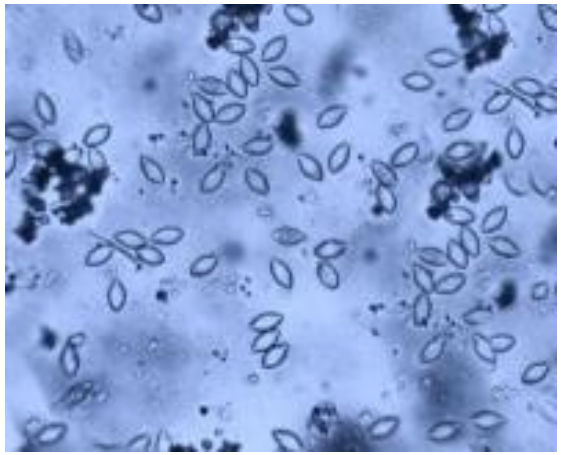
- Reduction of pest organisms by their **natural enemies** widely present in their habitats
- **Spontaneous activity** of hundreds species of viruses, microorganisms and macroorganisms **without human intervention**
- **Most common**, but usually **underestimated** way of controlling pests' and pathogens' populations in agricultural ecosystems
- **Highly dependent** on environmental conditions
- Usually, **not considered** and, thus, **heavily suffering** during routine chemical control in conventional plant protection

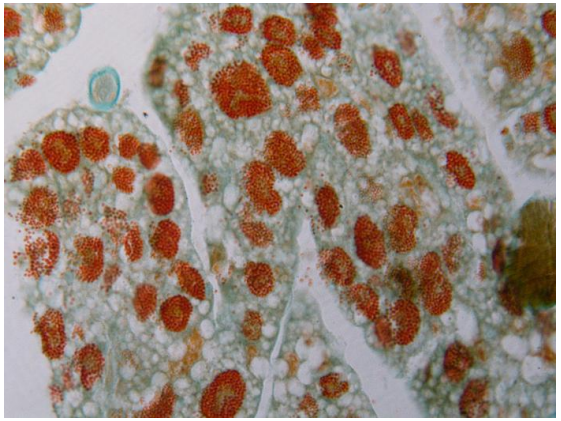
PROSPECTS: With greater attention paid to quality of the environment, greater effectiveness of native natural enemies of pests and pathogens can be expected

Biocontrol agents

Viruses and pathogenic microorganisms







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Biocontrol agents

Parasitic organisms (parasitoids)

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Biocontrol agents

Predaceous organisms

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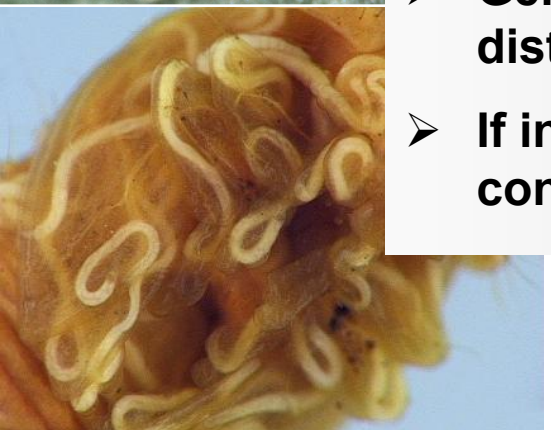
II. Inoculative (=classical) biological control

- **History: some 2,000 – 4,000 introductions worldwide; 20 - 55% established; 5 - 15% successful control of addressed pests**
- **First introductions over 100 years ago** (*Rodolia cardinalis* against cottony-cushion scale, *Icerya purchasi*)
- **In Poland, only a few successfully established species**

  Good example: *Aphelinus mali* – against wooly apple aphid (*Eriosoma lanigerum*) (Kawecki, 1936)

  Unsuccessful establishment: *Perillus bioculatus* (Wegorek & Schmidt, 1962) *Podisus maculiventris* (Pruszyński & Wegorek, 1980), etc.
- **Occassional environmental risk -** *Harmonia axyridis* – presently widely distributed in Europe

PROSPECTS: Could be effective against exotic pests (e.g. *Diabrotica virgifera*)**, but needs a strong research and financial support from state institutions**



III. Augmentative biological control

- The strategy most frequently used in practice
- Uses beneficial organisms from various taxonomic groups, which are mass reproduced and frequently available commercially
- Usually, easy application
- Results observed within a few days – good for intervention
- Single or multiple introductions – establishment in the environment is not expected
- Generally, good advising system provided by producers or distributors
- If integrated – selectivity of chemical pesticides must be considered

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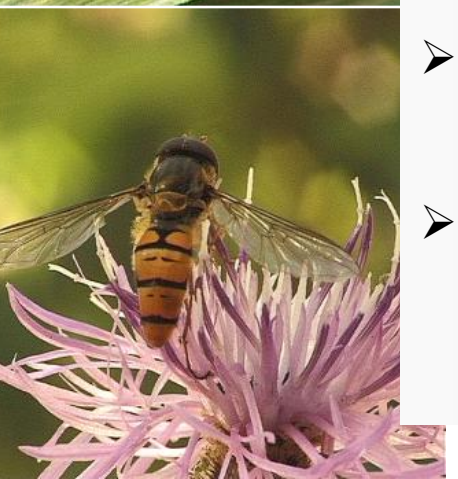


III. Augmentative biological control

- **Practical use in integrated systems:**

  - glasshouse crops (predatory and parasitic arthropods, bacteria, fungi, entomopathogenic nematodes) – **greatest success in Poland**

  - edible mushrooms (entomopathogenic nematodes)

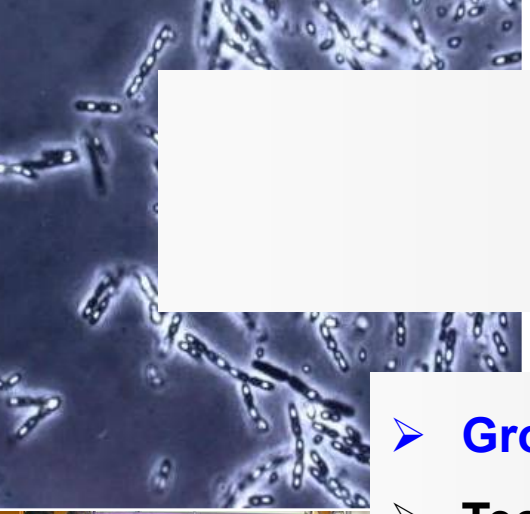
  - orchards (viruses, bacteria, predatory and parasitic arthropods, nematodes)

  - tree nurseries (bacteria, entomopathogenic nematodes)

  - open field crops (bacteria, fungi, parasitic insects)

- **Many products available for glasshouse crops, but only a few products for field crops**

- **Many products available for insect and spider mite control, but only a few for weeds and plant pathogenic bacteria and fungi**



Main areas of continuous development of augmentative biological control

- **Groups, species and strains** of biocontrol agents
- Technologies for economic **mass production** and stabilization of **product quality**
- **Formulation** methods for biocontrol agents
- **Range** of biocontrol products **available** on the market
- **Areas** of practical use (new crops, open field cultures, etc.)
- **Methods of application**
- **Producer, consumer and environment-friendly requirements for registration of biocontrol agents and product !!!**
- **Promotion**, **distribution**, and **advising**

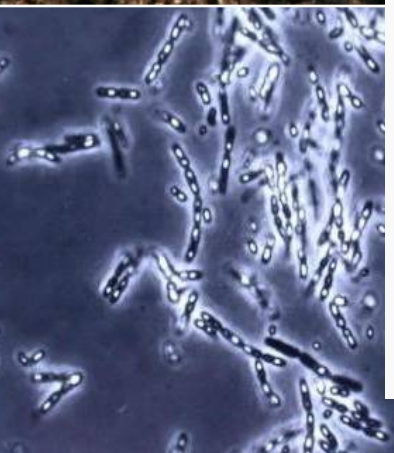
PROSPECTS: Major improvements in all of these areas

IV. Conservative (=conservation) biological control

- **The strategy of greatest potential for integrated pest management in open field crops**
- **Relies on native beneficial organisms naturally present in the environment**
- **Imposes a number of limitations** (if necessary, application of selective pesticides only, avoiding of 'radical' cultural practices, etc.)
- **Selected cultural practices can help** (intercropping, strip mowing, etc.)
- **Creation of additional ecological infrastructures** (refuges: planting hedges, wood patches, grass strips, corridors, etc.)
- **Requires new education** (holistic approach to agroecosystems)

IV. Conservation biological control

Modification of the environment in order to improve living conditions of native beneficial organisms



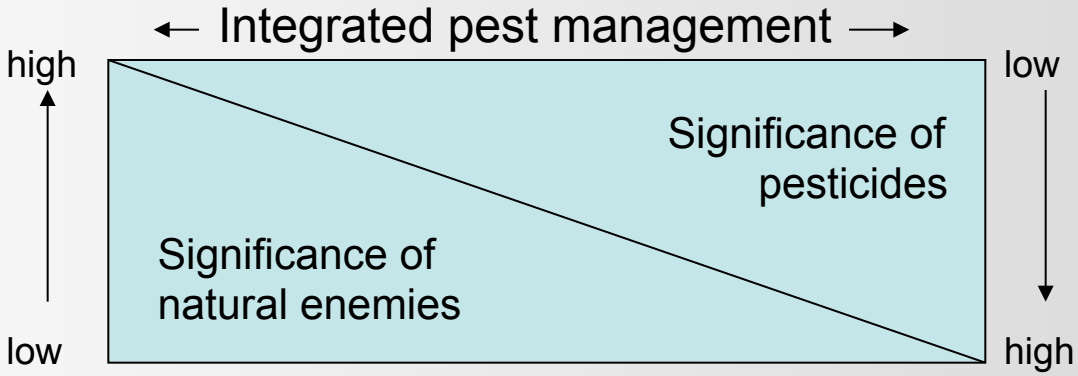
A. Modification of chemical control programs – integration of natural enemies and pesticides

B. Improvement of environmental diversity through creation of proper ecological infrastructures (landscape complexity – mosaic: crop – non-crop habitats, isle elements, ecological corridors, edge effect, etc.) **– minimum 5% of the farm area.**

- **Providing alternative sources of food for beneficials**
- **Providing shelters and proper microclimate**
- **Ensuring presence of alternative species of prey and hosts**

IV. Conservation biological control

Pesticides *vs.* natural enemies



Ruberson *et al.*, 1998

Potential susceptibility of:

- **antagonistic and entomopathogenic fungi – to fungicides**
- **entomopathogenic nematodes – to nematocydes**
- **predaceous mites and insects – to acaricides / insecticides**
- **parasitic insects – to insecticides**

PROSPECTS: With more rational use of chemical pesticides in IPM - potential growth of significance of native natural enemies

IV. Conservation biological control

A. Integration of natural enemies and pesticides

Forms of integration

- **Use of selective pesticides**

  - application of pesticides with a wide spectrum of activity may reduce natural enemies, including those of presently 'unimportant' pests → fast growth of so far 'unimportant' pests' populations

Not toxic: 0-50% / 0-30% Moderately toxic: 50-75 / 30-79 Toxic: > 75% />80%

http://www.iobcwprs.org/ip_ipm/03022_IOBC_PesticideDatabase_2005.pdf

- **Temporal separation of pesticides and natural enemies**

  - pesticides - when natural enemies in tolerant phase of development

- **Spatial separation of pesticides and natural enemies**

  - local application of pesticides into pest colonies ('hot spots')
  - application of pesticides to alternate rows or patches
  - application of pesticides, when most natural enemies pupate in the soil

PROSPECTS: Better understanding and continuous update on pesticide selectivity to natural enemies

Environmental diversity

B.1. Providing alternative sources of food

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IV. Conservation biological control

B.1. Providing alternative sources of food

- **Nectar, pollen, honeydew – different nutritive value for adults of various parasitoid and predator species** (wasps, flies, lacewings)
- **Various nutritive value of particular plant species / flower types, etc.** (form and size of mouthparts)
- **Significance of flowers of cultivated crops** (e.g. rapeseed) **grown in the vicinity of other crops**

PROSPECTS: Better understanding of specific effects of food quality on populations of natural enemies

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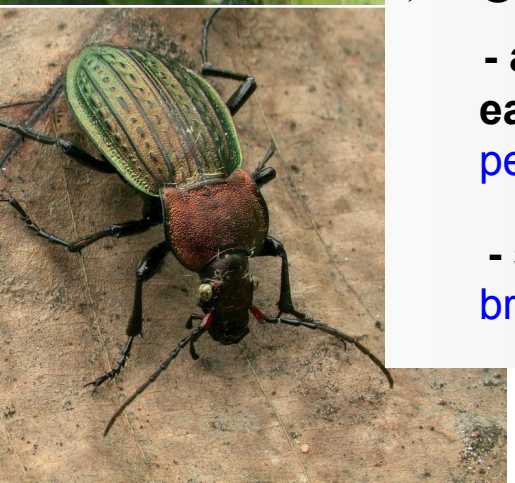

IV. Conservation biological control

B.2. Providing shelters and proper microclimate

- **Annual crops – *vs*. – multi-year / perennial crops –** different levels of periodic disturbances in the environment – availability of shelters

- **Perennial crops – harvesting systems – periodic disturbances or 'disasters' in populations of local beneficials** – (strip mowing or leaving refuges provides food, shelter and favorable microclimate)

- **Overwintering of beneficials**

  - annual cultures – limited availability of shelters – field refuges: easy colonization of fields in the spring (e.g. 'insects' banks' – with perennial grasses, shrubs, and trees)

  - setting other overwintering shelters (e.g. boxes for lacewings; branch debris at the base of trunk of fruit trees, etc.)

IV. Conservation biological control

B.2. Providing shelters and proper microclimate

- **Periodic application of pesticides and inadvertent reduction of beneficials – shelters / refuges facilitate re-colonization** (wood and grass strips, field borders, tree corridors, etc.)
- **Introduction of additional plant species to provide shading and improve microclimate**

  - *e.g.* ryegrass in corn – improves survival of *Trichogramma* (Orr et al., 1997)

  - *e.g.* clover and bean grown together with cabbage – increase of numbers of parasitoids (Wiech, 1991,1993; Theunissen et al., 1995)

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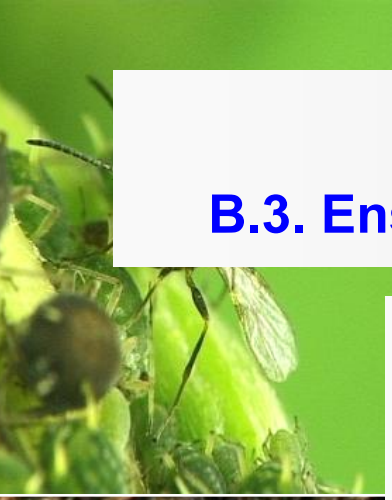
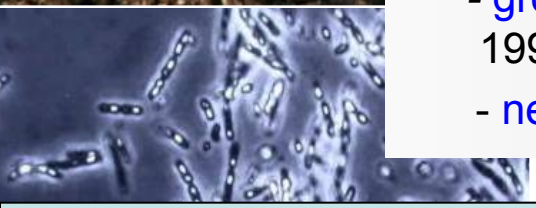
IV. Conservation biological control

B.3. Ensuring presence of alternative species of prey and hosts





- **Corelation of presence and abundance of beneficials with availability of alternative hosts / prey on neighboring plants/crops** (important for generalist species)

  - Many generations annually – new hosts / prey species needed outside the period of mass presence of major pests

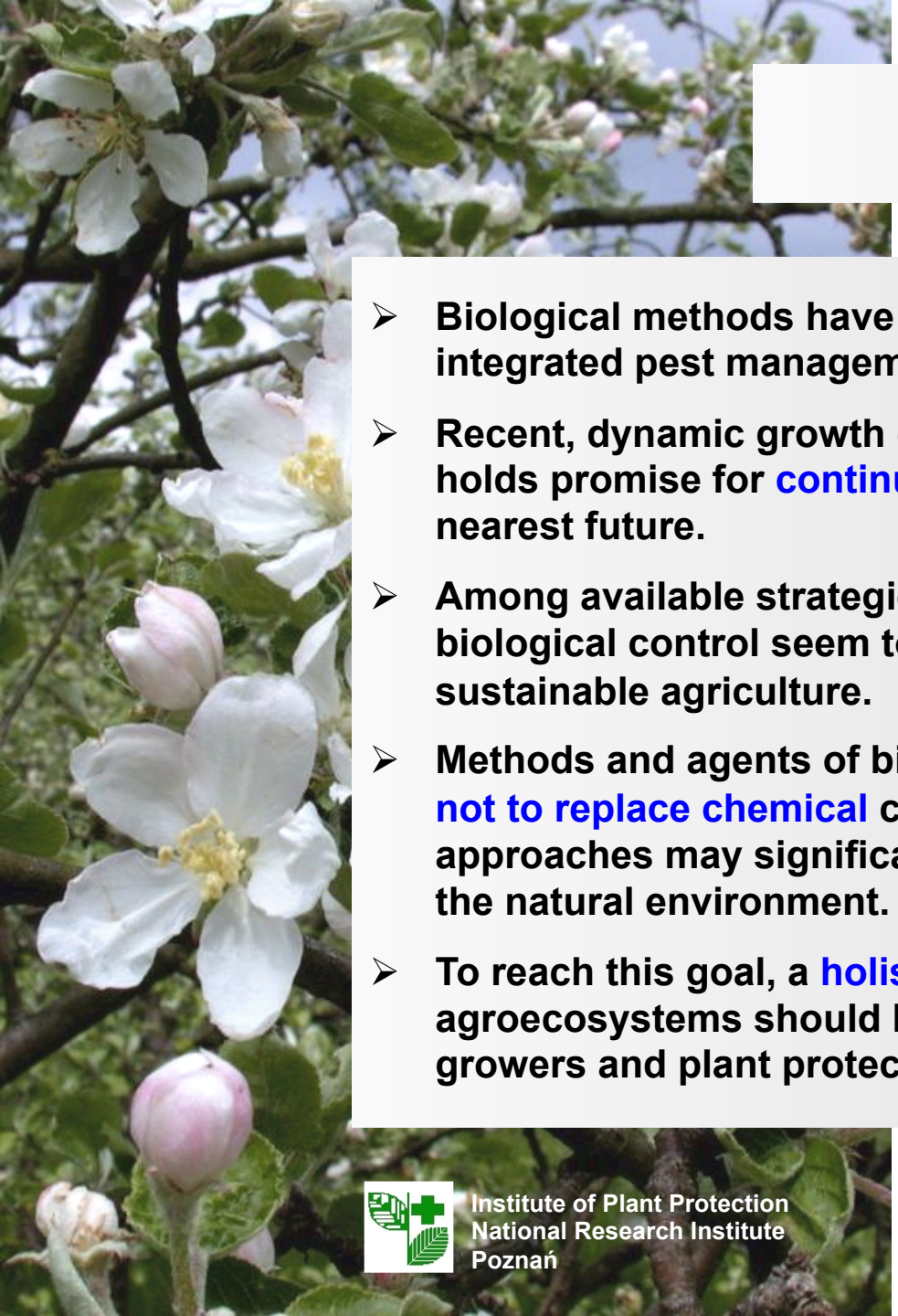
  - *e.g.* Hoverflies feeding on tree aphids in spring – move to aphids on agricultural crops in summer (Wnuk, 2005)

- **Indirect effects of organic matter in the soil on abundance of beneficial organisms**

  - ground beetles preying on eggs of *Delia brasicae* - (Humphreys et al., 1994);

  - nematophagous fungi (Sosnowska & Banaszak, 2000)

PROSPECTS: Further improvements in design and construction of ecological infrastructures to facilitate better availability of food and shelter for beneficial organisms – key BCAs - more species-specific approach



Conclusions

- Biological methods have already proved their **high efficacy** in integrated pest management in <u>some</u> agricultural crops.
- Recent, dynamic growth of the share in global pesticide market holds promise for **continuous growth** of use of biocontrol in the nearest future.
- Among available strategies **augmentative** and **conservation** biological control seem to be of greatest value for future sustainable agriculture.
- Methods and agents of biological pest and pathogen control **are not to replace chemical** control, but **rational integration** of these approaches may significantly ease the agricultural pressure on the natural environment.
- To reach this goal, a **holistic** approach towards the agroecosystems should be widely popularized among plant growers and plant protection advisors.

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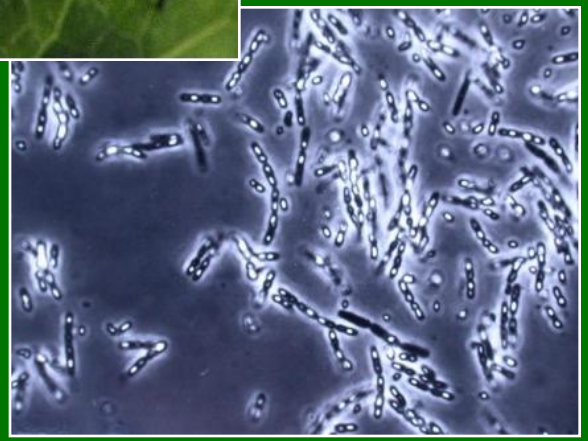
Thank you for your attention !!!



http://www.dropdata.org/download/Bluesky2Green_Fields_6.pdf

Let's try to integrate !