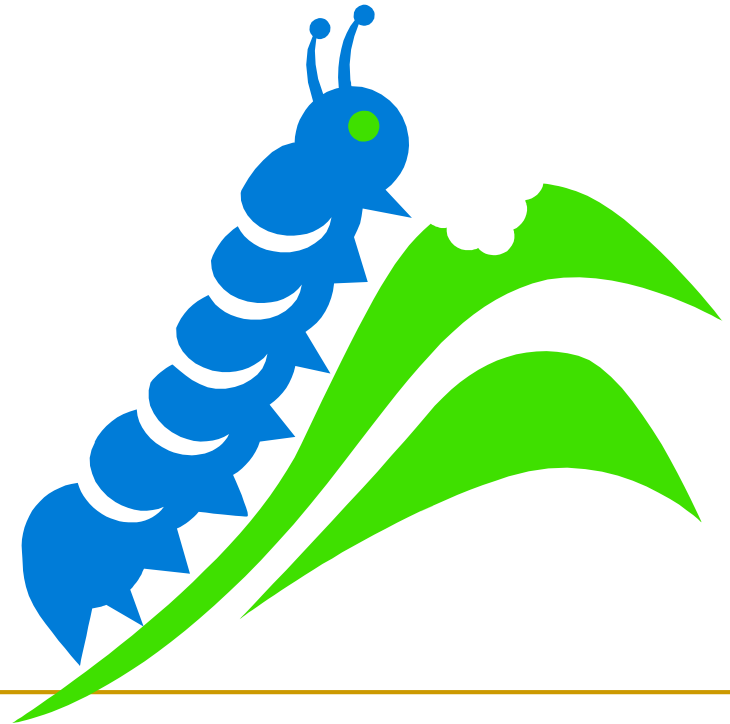
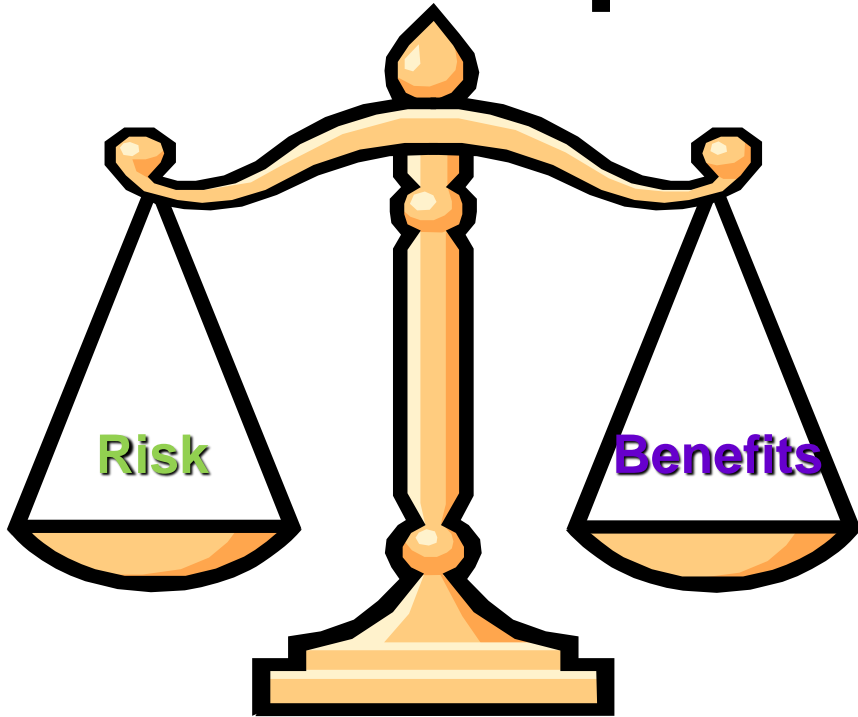


Integrated Pest Management (IPM)

Concept and Principles



Index

- Pest definitions and concepts
 - **IPM concept and definition**
 - **IPM Strategies**
 - **IPM Principles**
 - Topics for final discussion
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Pest definitions and concepts

An injurious and noxious or troublesome living organism [that] does not include a virus, bacteria, fungus or internal parasite that exists on humans or animals (British Columbia Pesticide Control Act, 1997)

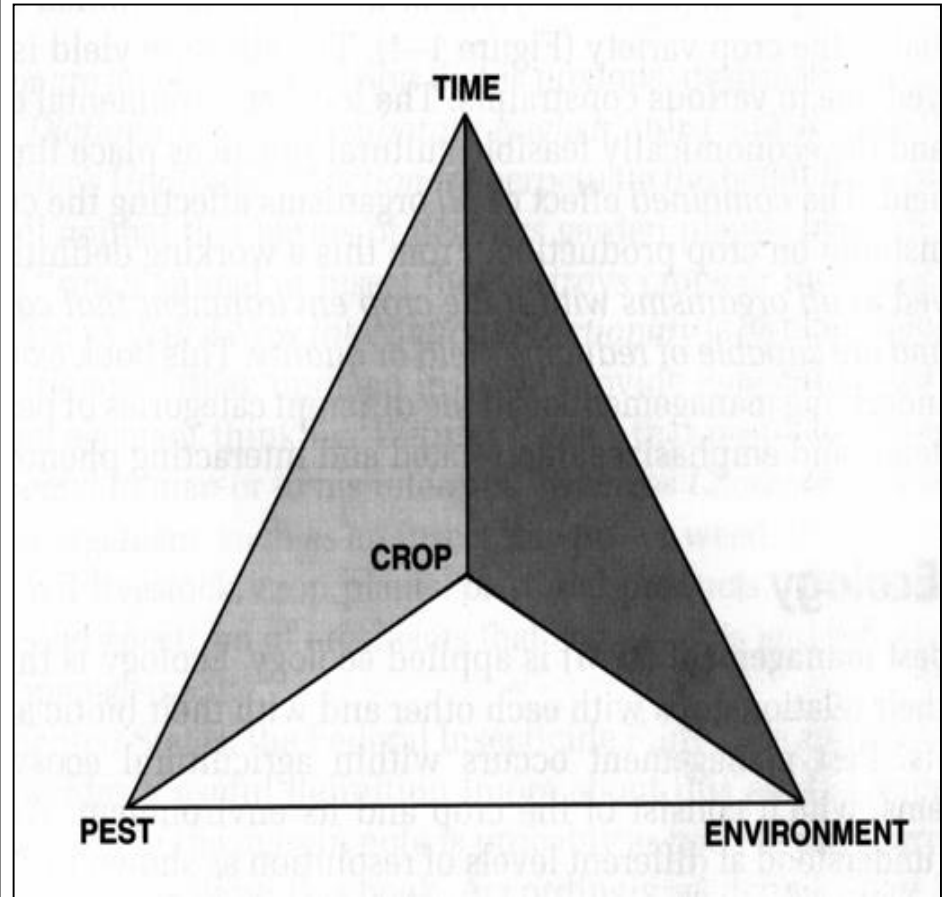
Includes insects, weeds, plant pathogens, birds, non-human mammals and other organisms which pose non-medical problems to humans and non-veterinary problems to animals

How do pests become pests?

1. New crop introductions
2. New organism introductions
3. Production system practices
4. Removal of limiting factors
5. Low tolerance

Four things required to “make” a pest

- 1. Pest species must be present at the right stage**
- 2. Environmental criteria must be met.**
- 3. Crop must be a susceptible variety and growth stage.**
- 4. All of the above must occur at the same time.**



The Pest Complex

- The specific collection of pest species attacking a specific commodity or cropping system at any given time and location.
- A given complex is divisible into different “groups”:
 - Invertebrates (arthropods, Arachnids)
 - Vertebrates (mammals, birds)
 - Weeds (perennials, summer/winter annuals)
 - Plant Pathogens (fungi, bacteria, viruses, nematodes)

Each pest species has a given status within a complex

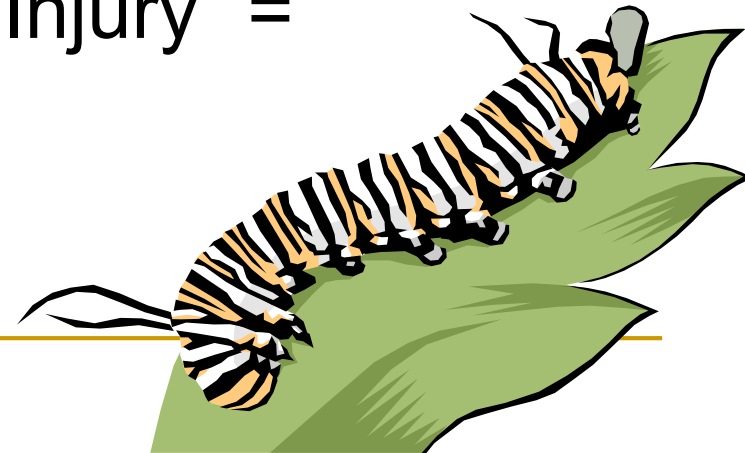
- Key pests
 - Minor pests
 - Secondary pests
 - Occasional pests
 - Potential pests
 - Migrants
 - Accessory Species
 - Vectors (Pest status often linked with pathogen)
 - Alternate Hosts
-

Pest Injury versus Damage

Injury – The effect that the pest has on the crop or commodity.

Damage – The effect that injury has on man's valuation of that crop or commodity.

For crops, “Injury” is biological and “Damage” is economic. For non-crops, “Injury” = “Damage”.



General Impact of Pests -- Injury

- Consumption of plant parts
- Chemical toxins, elicitors, and signals
- Physical damage
- Loss of harvest quality
- Cosmetic damage
- Vectoring of pathogens
- Direct contamination



General Impact of Pests – Non-injury

- Costs incurred to implement controls
- Environmental and social costs
- Regulatory costs (embargoes, quarantines, shipment costs, etc.)

“To Keep Pests Below the Economic Injury Level (EIL)”

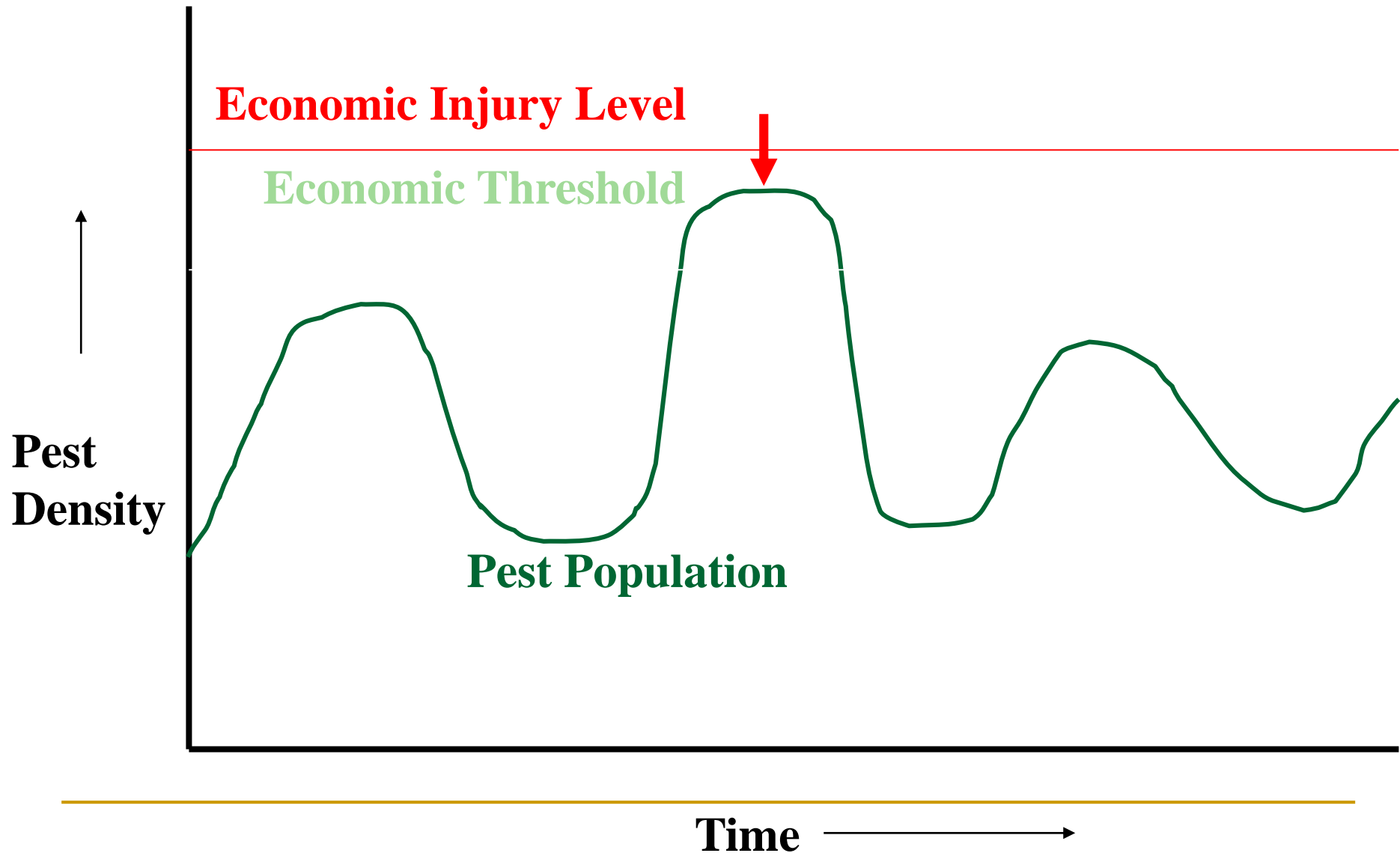
■ Economic Injury Level:

- Cost of control = \$ amount of damage caused by the pest**
 - Includes amount of pest damage**
 - Cost of each control practice**
 - Are determined through extensive research**
 - Economic Injury Level is the information that is necessary to develop an Economic Threshold, which is used by crop advisors**
-

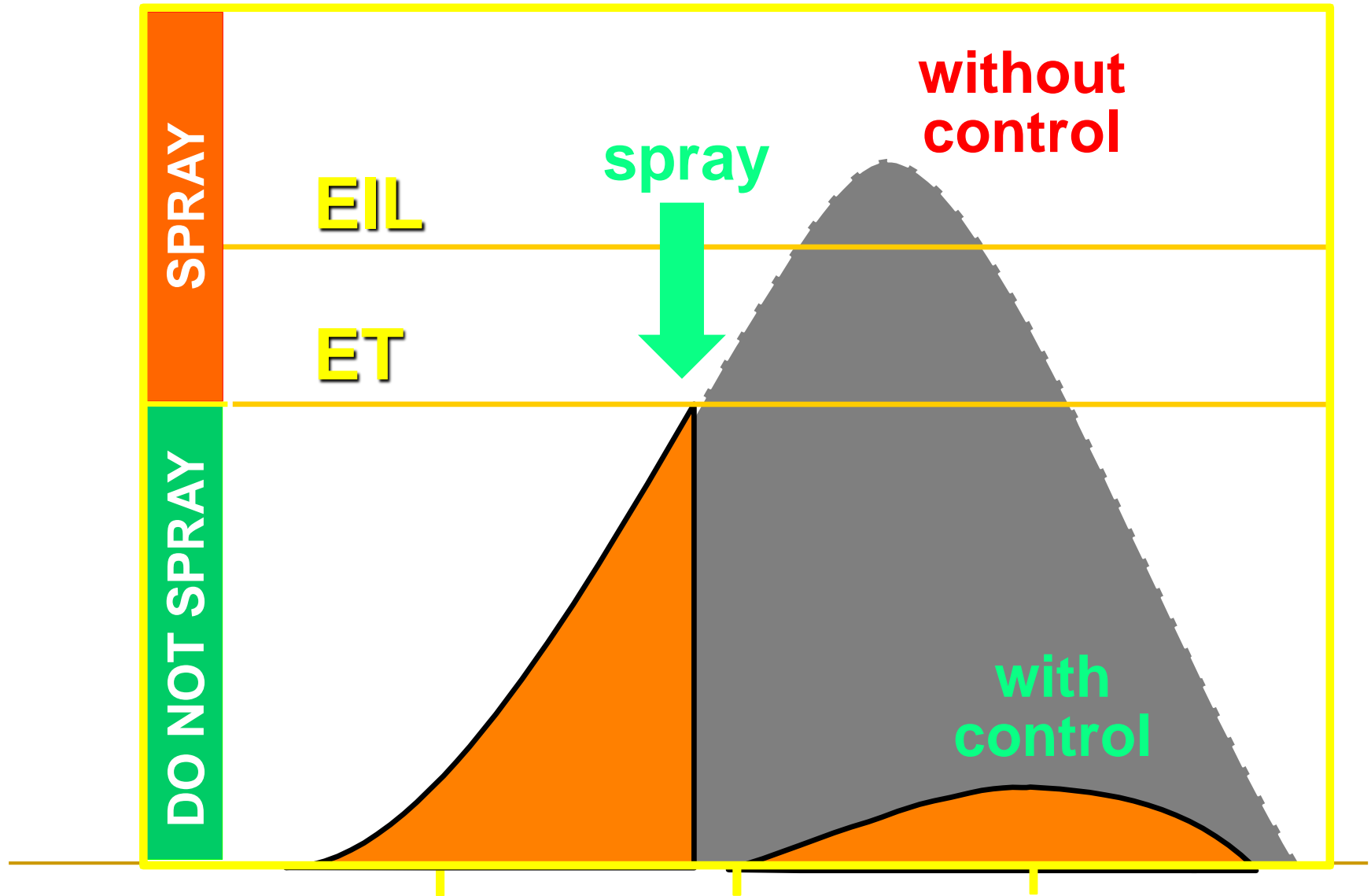
Economic Threshold Level (ETL)

- Pest Population at which a grower must take action to prevent a pest populations from reaching the economic injury level
 - Economic threshold is slightly below the economic injury level
 - Pest populations must be increasing

Introducing “Pest Management”



Introducing “Pest Management”



Introducing “Pest Management”

- “Management” -- a process by which information is collected and used to make good management decisions to reduce pest population impacts in a planned, coordinated way.
 - Requires:
 - ❑ Tolerance
 - ❑ Information
 - ❑ Strategy
-

IPM concept and definitions

There are several definitions of Integrated Pest Management. Most of them include the aspects highlighted by IOBC in the following one:

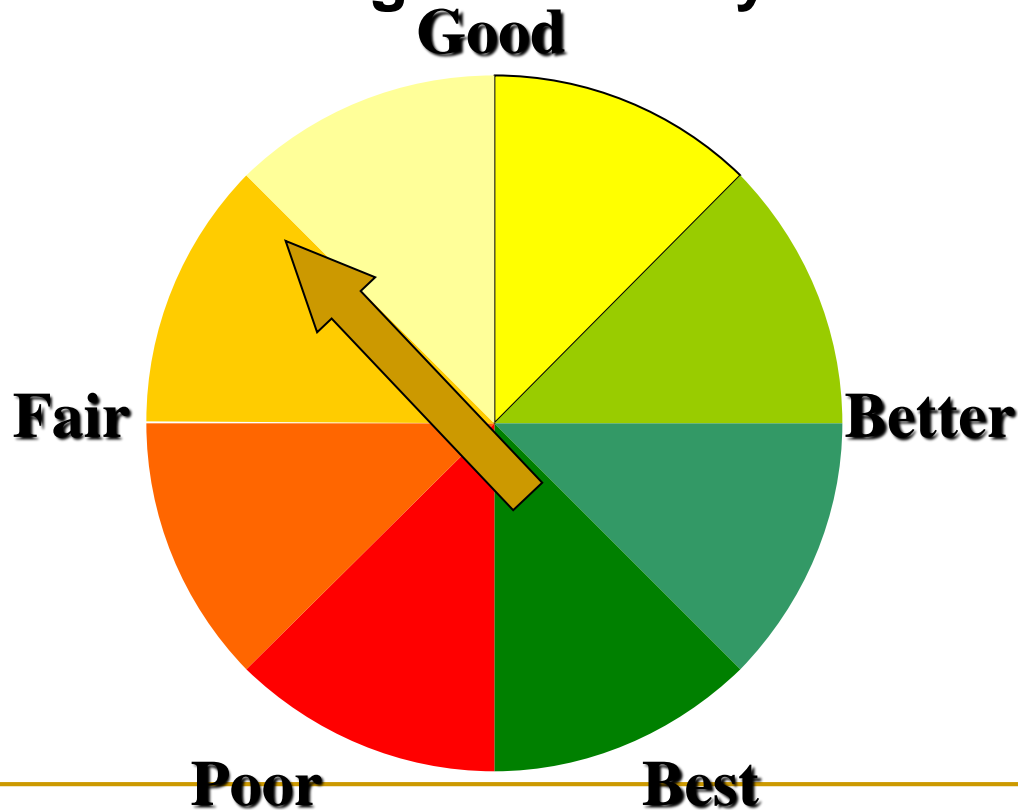
“The use of all economically, ecologically and toxicologically defensible methods to keep damaging organisms below economic threshold levels with conscious exploitation of natural control factors is emphasized”

So:

“IPM is a sustainable approach to manage pests by combining biological, cultural and chemical tools in a way that minimises economic, environmental and health risks”

IPM concept and definitions

IPM is then a continuously improving process in which innovative solutions are integrated and locally adapted as they emerge and contribute in reducing reliance on pesticides in agricultural systems.



Why we need IPM?

- ❑ Pest resistance to pesticides (insects, weeds, plant diseases)
 - ❑ Emergence of secondary pests when pesticides disrupt beneficial organisms “secondary pest outbreaks”
 - ❑ Impact of pesticides on beneficial organisms and non-target species, pest resurgence
 - ❑ Environmental concerns from pesticides misuses
 - ❑ Economic incentives (improve yields, lower pest control costs)
-

Philosophy of IPM

Multidisciplinary science, practiced in context with other crop production techniques, like soil fertility and irrigation management

A holistic (systems) approach to pest management

Preventive strategies over prescriptive tactics

Long term management over short term control

Target key pests with non-disruptive solutions and thus avoid secondary pest outbreaks

Monitoring, decision making, control tactics, and evaluation are also components to IPM

What IPM Is and Isn't

- **Stresses a multi disciplinary approach to pest management based on knowledge of**
 - ❑ **Entomology**
 - ❑ **Plant Pathology**
 - ❑ **Nematology**
 - ❑ **Weed Science**
 - ❑ **Crop Sciences (Horticulture/Agronomy)**
 - ❑ **Soil Science**
 - ❑ **Ecology**
-

IPM is not static

- **New Pests**
 - Aphids
 - **New Races/strains of pests**
 - Western corn rootworm
 - **Weed Species shifts**
 - Roundup ready technology
 - Tillage system
 - **Pesticide Resistance**
 - Colorado Potato Beetle
-

IPM strategy

Indirect Plant Protection Methods

Monitoring and Forecasting Systems

Direct Control Methods

But, still, how the different methods are prioritized ?



IPM strategy

0. **Legal control methods**
(quarantine)
1. **Optimal use of natural resources prior to planting**
(agronomic techniques, plant resistance)
2. **Farming practices without negative impact on the agroecosystem**
(agronomic techniques, mechanical methods)
3. **Protection and conservation of natural enemies**
(biological control, ecological infrastructures)



IPM strategy

4. Use of selective pest control methods

(sterile insect technique, biological and microbial control, ethological (pheromone-based) control)

5. Use of other pest control methods

(chemical control, but also with a preference for the most specific and selective pesticides)

In Short, It utilizes all suitable pest management tactics.....”

Cultural
Mechanical
Sanitary
Natural

Biological
Host Plant Resistance
Pesticides

Should Pesticides be used in an IPM Program?

- **Pesticides can to be used in an IPM program, however only as a last resort and of course in a manner that is legal.**
 - **Pesticides are to be used when there is no risk of environmental damage or when benefits outweigh the risks. Use pesticides only when other control practices aren't available, economical or practical.**
 - **Must monitor pest populations in the field.**
 - ❑ **Identify the pest**
 - ❑ **Compare pest population and the economic threshold**
 - ❑ **Life stage susceptible to pesticide?**
 - ❑ **Crop stage and preventable loss.**
-

Components to approach IPM

- **Prevention**
 - *Prevent introduction to the farm, pest reservoirs, spread between fields*
 - **Avoidance**
 - *Avoid pest susceptible crops or practices that increase pest losses*
 - **Monitoring**
 - *Monitor and identify pests, manage sites of high pest risk and use decision support tools*
 - **Suppression**
 - *Cultural, physical, biological and chemical methods of suppressing pests*
-

IPM Principles

Principle 1: prevention

- use of resistant/tolerant cultivars and standard/certified seed and planting material,
 - appropriate and high quality cultivars in local conditions
 - resistant/tolerant to key diseases, pests
 - crop rotation
 - balanced use of inputs
- protection and enhancement of key beneficial organisms,
 - selection of pesticides with less harmful side effect
 - application techniques (reduce spray drift)
 - timing of application
 - judicious utilization of ecological infrastructures inside and outside production sites.
 - special attention to avoid harm to pollinators
 - maintain overall biotic diversity

IPM Principles

Principle 1: examples

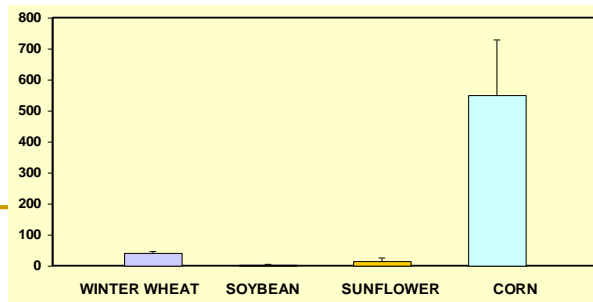
Crop rotation trial for Western Corn Rootworm:

Field margin maintaining biodiversity

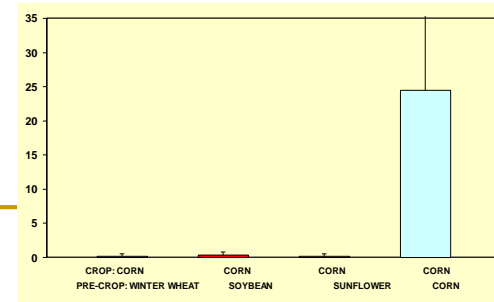
Maize rotated to maize,
soybean, sunflower,
winter wheat



WCR adults captured in
soybean, winter wheat,
sunflower, maize



WCR larvae in subsequent
year's maize after the pre-
crops listed before



IPM Principles

Principle 2: monitoring

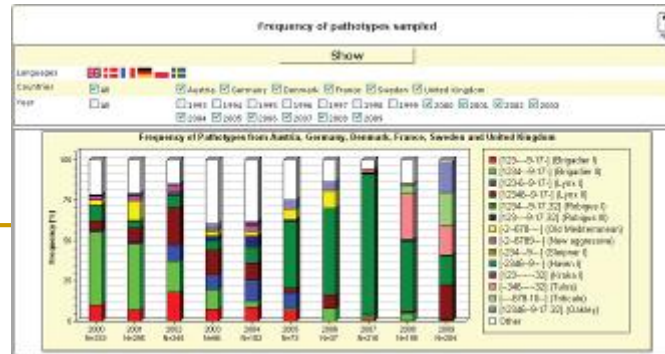
Harmful organisms must be monitored by adequate methods and tools, where available.

Monitoring methods and tools:

- regular and thorough visual observations in the fields;



- scientifically sound warning, forecasting and early diagnosis system;

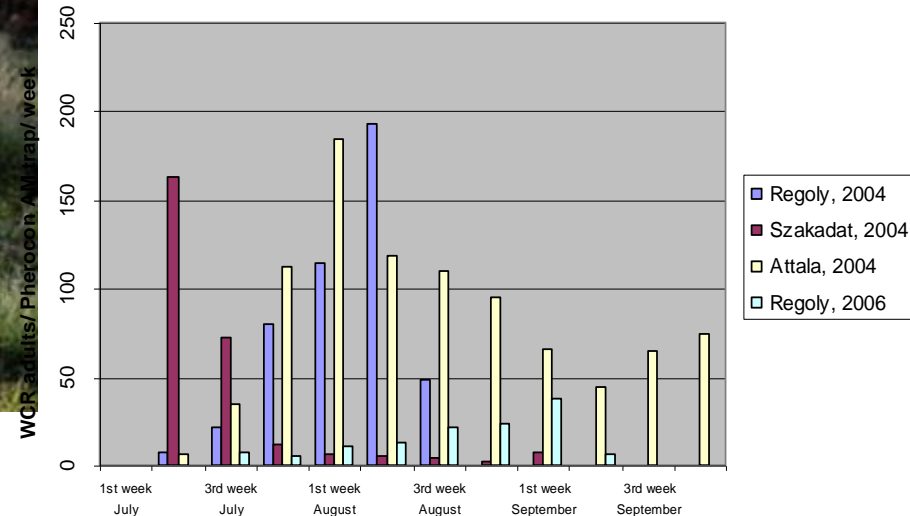


Early warning
system for wheat
yellow rust
(Eurowheat)

IPM Principles

Principle 2: examples

- various traps (color cards, pheromone and other bait based traps, etc.)



- use of advice from professionally qualified advisors



Population built up of WCR, monitored by Pheromone traps, at different locations and in different years in Hungary

IPM Principles

Principle 3: decision-making

Based on the results of the monitoring, the professional user has to decide whether and when to apply what for plant protection measures.

This decision should be taken in consideration of:

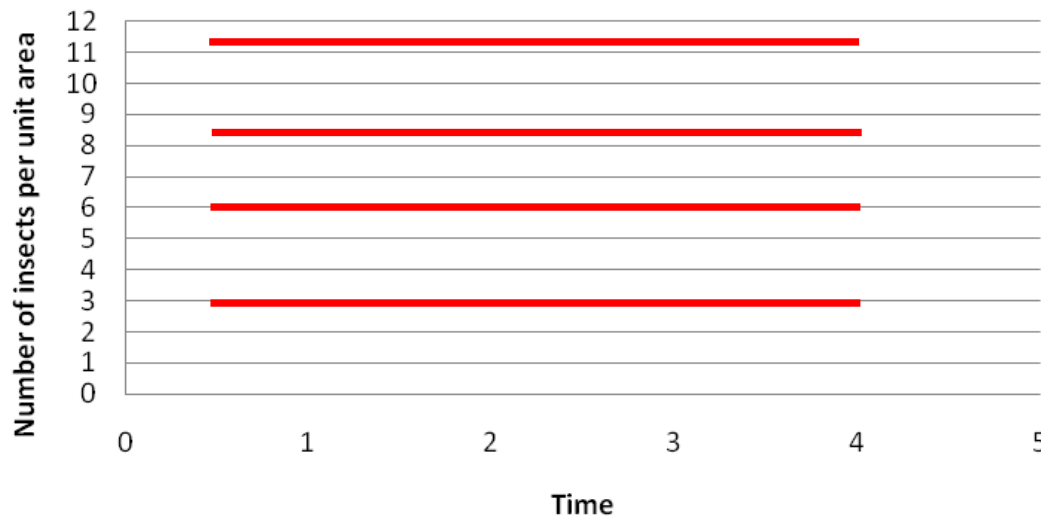
- **observed abiotic (soil, weather, etc.) and biotic (pests, natural enemies, etc.) elements on the field**
 - **environmental, health and economic aspects**
 - **robust and scientifically sound threshold values**
 - **Economic Threshold levels (ETLs) defined for a region, specific areas, crops and particular climatic conditions.**
-

IPM Principles

Principle 3: decision-making

There are four type of threshold levels, such as:

- visual threshold (pest population is already observable)
- damage boundary (damage can be observed);
- action threshold (end-user should apply a plant protection measure;)
- economic injury level (a pest population is capable to cause a damage, which treatment costs are balanced with the benefit resulting thereof).



- economic injury threshold
- action threshold
- damage boundary
- visual threshold

IPM Principles

Principle 3: examples



Result of collaboration between scientists, advisers and meteorologists



Weed management strategy in consultation with agronomist

IPM Principles

Principle 4: non-chemical methods

Sustainable biological, physical and other non-chemical methods must be preferred to chemical methods if they provide satisfactory pest control.

Methods:

- **Use of ecological infrastructures to enhance functional biodiversity**
 - **Creation of an appropriate rotation system, etc.**
 - **Physical/mechanical control**
 - **Plant resistance / tolerance**
 - **Biological and microbial control**
 - **Pheromone and other attractants-based control (ethological control methods)**
-

IPM Principles

Principle 4: non-chemical methods

Alternative methods might:

- be more time consuming;
- have lower and/or slower pest control power;
- be more expensive;
- have less negative impact on environment;
- be more sustainable;
- are more beneficial for whole society.

Training of end-users:

- the AIM is pest management, and NOT eradication;
 - differentiate threshold levels
 - on demonstration fields and/or farms
 - according to participatory training principles.
-

IPM Principles

Principle 4: examples



Grape moth larva attacked by a chalcidoid ectoparasite



Mechanical weed control



***Trichogramma cards in maize-
against European corn borer***



***Encarsia formosa-against
whitefly in glasshouse***

IPM Principles

Principle 5: pesticide selection

The pesticides applied shall be as specific as possible for the target and shall have the least side effects on human health, non-target organisms and the environment

- **Specific pesticides are those toxic to a limited number of pests**
 - * **One or few species: Codling moth granulosis virus**
 - * **Higer taxonomic category: Aphicides**
- **Selective pesticides are those non toxic to non-target organisms**
 - * **Beneficial organisms: parasitoids and predators**
 - * **Human beings**
 - * **General fauna and flora: terrestrial and aquatic fauna**

IPM Principles

Principle 5: pesticide selection

- The specificity and selectivity of the pesticides
 - * Minimizes their undesirable effects: i.e. environmental pollution
 - * Prevents the outbreaks of secondary pests due to the elimination of their natural enemies: i.e. phytoseiids that control mite populations
 - * But the substitution of a broad-spectrum pesticide by a selective one may temporarily increase the population of secondary pests
 - The key natural enemies in each situation must be identified, as they are the ones to be protected
-

IPM Principles

Principle 5: pesticide selection

- **Sources of information: the IOBCwprs database**
 - <http://www.iobc.ch/toolbox.html>
 - **Toxicity to natural enemies is evaluated in laboratory, semi-field and field experiments, following a sequential plan and using standardized methods:**
 - **1 harmless**
 - **2 slightly harmful**
 - **3 moderately toxic**
 - **4 toxic**
-

IPM Principles

Principle 6: reduced pesticide use

The use of pesticides should be kept to the minimum levels that are necessary

- **The decision of the use of a given pesticide has been taken! now, the grower needs to decide on:**
 - * **amount of active ingredient per ha (dose)**
 - * **quantity of spraying liquid per ha**
 - * **frequency of application**
 - * **complete or partial spraying of the plot**
- **This principle states the priority of the use of the minimum amount of active ingredient per unit of surface necessary for an efficient use of the pesticide**

IPM Principles

Principle 6: reduced pesticide use

- **How to comply with this principle**
 - **Use of the minimum registered dose**
 - **Reduced application frequency**
 - **Partial sprayings of the surface**
 - **What about the sometimes recommended use of reduced doses? Discussion**
 - **They may be ok if they are related to weed or canopy size**
 - **But there may be an increased risk of resistance, mostly in intensive systems**
 - **The role of independent professional advisors and official advisory services is essential**
-

IPM Principles

Principle 7: anti-resistance strategies

Available anti-resistance strategies should be applied to maintain the effectiveness of the products.

- Resistance of a pest to a pesticide is the capacity of a population of this pest species to survive to the exposition to doses of the pesticide which are lethal to the normal populations of the species
- It develops because some individuals have mechanisms of resistance (they are able, for example, to metabolize the pesticide)
- These individuals are selected by a repeated use of the pesticide, and their percentage in the population increases until it provokes control failures in the field

IPM Principles

Principle 7: anti-resistance strategies

- **Consequences of pesticide resistance**
 - **Increase of the dose and the number of sprayings of a pesticide applied by the growers**
 - **Decrease of the commercial life of a pesticide**
 - **Increase of the risks for human health and the environment**
 - **Loss of the possibility of cultivating a crop in a entire area**
 - **How the grower can avoid its development**
 - **Having appropriate information and guidance on known risk of resistance development for specific products and pests and recommendations for anti-resistance strategies**
-

IPM Principles

Principle 7: examples

Strategy for preventing Codling Moth (*Cydia pomonella*)
Resistance to Insecticides (IRAC)

- Apply adequate cultural methods and mating disruption
 - Monitor the population
 - Choose specifically acting (selective) products as far as
 - Direct the application to the most susceptible stage
 - Respect manufacturer's recommendations
 - Use products from any one group for only one generation per year
 - Ensure that the application technique is appropriate to obtain complete coverage of the target area
 - Do not re-use a products from the same MOA group until resistance has been proven to be absent
-

IPM Principles

Principle 8: evaluation

Based on the records of control methods and the monitoring of harmful organisms the professional user should check the success of the applied plant protection measures

- The application of a plant protection measure has been successful when the pest population has been maintained below the economic injury level, not when the pest population has been completely eliminated
- This concept has to be explained to growers very clearly
- It is also important to notice that this principle addresses all types of intervention, not only chemical ones

IPM Principles

Principle 8: evaluation

- **Checking the success is important because**
 - **IPM is a continuous process that always needs improvements**
 - **The knowledge of the success of the plant protection measures applied is a key element to achieve this improvement**
 - **The maintenance of farm record in field books allows a detailed study of the reasons of failures that might have occurred, and the proposal of corrective actions**
-

IPM Principles

Principle 8: evaluation

- **Success may be rated in categories**
 - **‘measure failed’**
 - **‘measure provided adequate results’**
 - **‘measure provided excellent results’**
- **For each category, a definition is necessary, taking into account the monitored pest decrease and the necessary period for the plant protecting measure.**
- **It is important that such definitions are established for each plant protection measure group separately, since a non-chemical method might lead to the same success, but might take some more time.**

Implementation of IPM Philosophy

These IPM components and principles together change the way we view pest control; from short term *control* with pesticides to long term *management* strategies involving multiple approaches that introduce more permanent solutions for pest suppressions
