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Introduction

ENDURE sees **Integrated Pest Management (IPM)** as a **continuously improving process** in which **innovative solutions** are **integrated** and **locally adapted** as they emerge and contribute to reducing reliance on pesticides in agricultural systems. IPM is a key component of **Integrated Farming (IF)** which, according to IOBC, is a farming system that produces high quality food and other products by using natural resources and regulating mechanisms to replace polluting inputs and to secure sustainable farming. Emphasis is placed on a **holistic systems approach** involving the entire farm as the basic unit, on the central role of agro-ecosystems, on balanced nutrient cycles, and on the welfare of all species in animal husbandry. The preservation and improvement of soil fertility and of a diversified environment are essential components. Biological, technical and chemical methods (used only as a last resource when no other economic alternative methods are available) are balanced carefully taking into account the protection of the environment, profitability and social requirements. During Integrated farming external costs and undesirable impacts on environment, profitability and social surrounding should be minimized.

IPM largely relies on **indirect measures**, thus on **prevention**, such as:
- optimal use of natural resources, such as natural enemies and landscape elements;
- farming practices without negative impact on the agro-ecosystem, such as cover crops;
- protection and augmentations of antagonists.

In the case of **direct**, thus **control measures**, IPM is stuck to
- decision making based on the results of monitoring and forecasting systems
- use of control measures (physical, cultural, biological and/or chemical) acting exclusively upon target organisms;
- application of measures from less selective to most selective ones

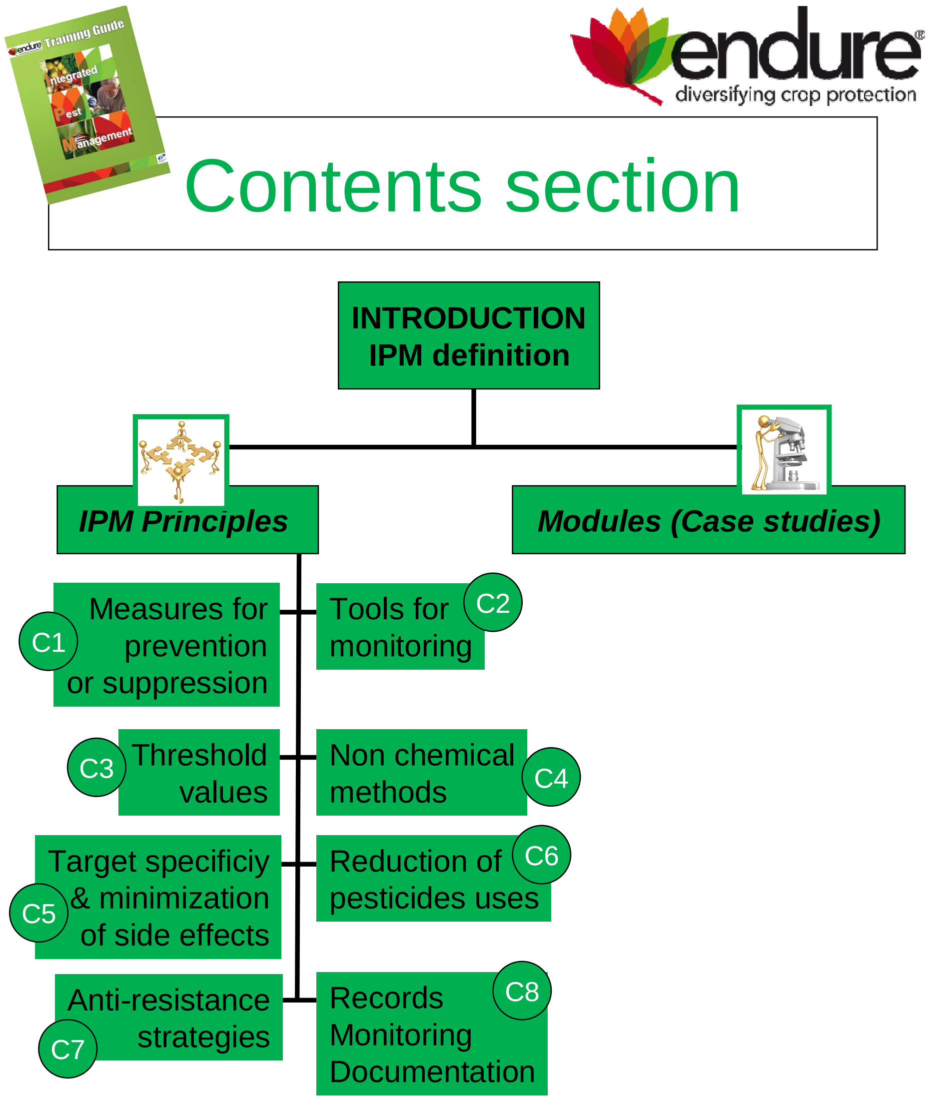
In promotion and adoption of IF and IPM advisors play key role, since they are in intense connection with farmers, they support farmers with information on different issues on environment and profitability. To be able to fulfil this task, advisors have to be trained continuously keeping in focus the new, innovative results of IPM. Continuous training of farmers is also a key aspect of IPM and IF.

The practice of IPM for a single crop may have some difficulties, as pest management must be considered in time and space. The entire agro-ecosystem must be considered when planning IPM for one crop. As the application of IPM

depends not only on the biological characteristics of the agro-ecosystem, but also on regional economical and social aspects, the IPM program must be adapted to each region.

SOURCES

ENDURE DEFINITION OF IPM
http://www.endure-network.eu/about_crop_protection/endure_s_definition_of_ipm
IOBC (International Organization for the Biological and Integrated Control of Noxious Animals and Plants)
http://www.iobc-wprs.org/ip_ipm/index.html
E.F. Boller, J. Avilla, E. Jörg, C. Malavolta, F. Wijnands & P. 2004. Esbjerg, Integrated Production: Principles and Technical Guidelines, 3rd edition. 50 pp. IOBC WPRS Bull. Vol. 27 (2).



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IPM PRINCIPLE 1	Measures for prevention and/or suppression of harmful organisms

Date (28/10/2010)

WHAT IS…	Measures for prevention and/or suppression of harmful organisms are those cultural, mechanical, biological etc. measures, conducted over time and space, which will reduce the frequency and intensity of pest outbreaks and will lead to robust cropping systems.
WHY	IPM requires a holistic approach. In IPM there is not only one best control method but farmers should benefit from all available and possible control tools and implement the pest management strategy in a multi-year and multi-field context.
HOW	Among the options available, the prevention and/or suppression of harmful organisms should be achieved or supported especially by: ► Crop rotation ► Use of adequate cultivation techniques (for example, stale seedbeds, appropriate sowing dates and plant densities, under-sowing, conservation tillage, pruning and direct sowing) ► Use, where appropriate, of resistant/tolerant cultivars and standard/certified seed and planting material ► Use of balanced fertilisation, liming and irrigation/drainage practices ► Preventing the spread of harmful organisms through hygiene measures (for example, by regular cleansing of machinery and equipment) ► Protection and enhancement of important beneficial organisms (for example, through adequate plant protection measures or the utilisation of ecological infrastructures inside and outside production sites).
EXAMPLE	Crop rotation is the primary non-chemical control option and pest prevention tool. The case of western corn rootworm (WCR, an invasive pest of maize) is a good example for how rotation supports the management of the population of this pest. WCR females lay their eggs in the soil of maize fields, eggs overwinter and hatch the following spring/early summer. If maize is followed by maize, larvae will feed and damage the maize root system. If maize is rotated to other crops, WCR larvae will not find suitable food sources and will die. Depending on the share of non-rotated maize and on the population size of WCR, not each maize field should be rotated in each year. By considering the local conditions and other additional population suppression tools, the WCR population

	can be managed efficiently.
SOURCES	► Draft Guidance Document for establishing IPM principles ► ENDURE GUIDE-Western Corn Rootworm in Europe: Integrated Pest Management is the only sustainable solution
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IPM PRINCIPLE 2

Tools for pest monitoring

Date (28/10/2010)

WHAT IS…	Pest monitoring is an element of Integrated Pest Management that allows the pest population density in fields to be estimated. For monitoring pest populations, different tools and systems have been developed.
WHY	The purpose of monitoring is to collect information on pest presence and density allowing professional users to make appropriate and timely decisions for managing pests. Monitoring helps to determine whether intervention is needed and if so what, where, when and how. The monitoring methodology or system therefore has a significant impact on the success of IPM.
HOW	Monitoring methods and tools: ► Regular and thorough visual observations in the fields ► Various traps (colour cards, pheromone and other bait-based traps etc.) ► The results of monitoring should be interpreted in context, with the results of field observation ► Using or benefiting from scientifically sound early warning, forecasting and early diagnosis systems ► Advice from professionally qualified advisers. Relevant information (meteorological pest density, disease incidence etc.) that can help farmers in their decision-making may originate from various sources, such as: ► Competent authorities ► Professional organisations ► Advisory services ► Professional users.
EXAMPLE	The case of western corn rootworm (WCR) offers a good example for monitoring. Adults can be detected with sensitive and highly attractive pheromone and floral bait-based traps established in the maize field. Visual plant checks during the period of adult activity gives additional information on the population density. Colour sticky cards can also be used for this purpose. Adult feeding (symptoms on maize leaves and silks) also add information to the above. Monitoring WCR population in several fields over a larger area gives a broad

	picture of WCR population levels in the region which should be accompanied by data from local fields. This offers mutual benefits for all farmers in the area.
SOURCES	► Draft Guidance Document for establishing IPM principles ► ENDURE GUIDE-Western Corn Rootworm in Europe: Integrated Pest Management is the only sustainable solution. ► ENDURE INFORMATION CENTRE: Keywords: Measures > Decision support /control
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IPM PRINCIPLES 3

Decision making

Date (28/10/2010)

WHAT IS…	Decision making is the process that allows the grower to take the decision on applying pest control methods. It is based on the results of monitoring pest populations and should be taken in the context of observed abiotic (soil, weather, etc.) conditions and biotic (pests, natural enemies, etc.) elements in the field.
WHY	Proper, scientifically sound decisions can be taken via the decision making process. This considers the environmental, health and economic impacts which are part of an Integrated Pest Management strategy.
HOW	Decision making should be conducted considering the outcome of the monitoring activity and based on sound decision rules. Economic, health and environmental impact have to be taken into account during decision making. End users may consider threshold levels, where they are feasible and applicable. There are four types of threshold levels: ► Visual threshold (minimum density of the pest, at which it can be observed) ► Damage boundary (the level at which damage can be observed) ► Action threshold (below the economic injury level: at this point end users should apply a plant protection measure to keep an increasing pest population from reaching the economic injury level) ► Economic injury level (a pest population which is capable of causing damage in which treatment costs are balanced with the resulting benefit of treatment). Robust and scientifically sound threshold values are essential components for decision making. However these threshold values should be interpreted in the context of local farming and cultivation conditions. Decision Support Systems (DSS) support this process. DSS are – almost exclusively – computer-based data processing mechanisms where the end user has to ‘feed’ the system with appropriate input data.
EXAMPLE	IN the ENDURE project, a group of ENDURE experts collected and reviewed several DSS used in various crops and orchards: ► Diseases in horticultural crops (18 DSS) ► Diseases in arable crops (37 DSS)

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	► Pests (18 DSS) ► Weeds (9 DSS)
SOURCES	► For concrete examples of DSS, see the draft Guidance Document for establishing IPM principles ► http://www.endure-network.eu/about_endure/all_the_news/dss_helping_farmers_make_smart_decisions
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IPM PRINCIPLE 4	Sustainable non-chemical control methods

Date (28/10/2010)

WHAT IS…	Sustainable non-chemical methods are those cultural, biological, ethological, physical etc. methods, which provide satisfactory pest control without devastating costs for the farmer.
WHY	In IPM, sustainable biological, physical and other non-chemical control methods must be preferred to chemical methods if they provide satisfactory pest control. These methods are less harmful to human beings and to the environment than the conventional use of pesticides, resulting in less environmental load. They are an important contribution to the sustainable use of pesticides over the long term.
HOW	Possible methods: ► Use of ecological infrastructures to enhance functional biodiversity ► Creation of an appropriate rotation system ► Physical/mechanical control ► Plant resistance/tolerance ► Biological and microbial control ► Pheromone and other attractant-based controls (ethological control methods) Alternative methods: ► May be more time consuming ► May have lower and/or slower pest control power ► May be more expensive ► May have less negative impact on environment ► May be more sustainable ► Are more beneficial for society as a whole Considering the characteristics of alternative methods, in order to achieve satisfactory management or regulation of pest populations, these methods should be combined as much as possible. **Training**: Farmers should be aware that total eradication of the pest is often not needed. In line with this principle, end users should be trained to be able to differentiate the different threshold levels (see Decision making). Training of end users could be conducted on demonstration fields and/or demonstration

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	farms, where they can see how non-chemical methods function in practice. Moreover, with participatory training end users can observe continuously the application, effect and result as well as the economic, health and environmental impact of non-chemical methods.
EXAMPLE	Application of parasitoids (for example, *Trichogramma* species, which are microscopic wasps and parasitise the eggs of European corn borer, ECB) is widely used in many areas in Europe. Development of entomopathogenic nematodes against pests is also an example for this. Use of biological control tools (predators and parasitoids) in greenhouses is also common in Europe
SOURCES	► Draft Guidance Document for establishing IPM principles ► ENDURE GUIDE- Non-chemical Control of Corn Borers Using Trichogramma or Bt Maize ► ENDURE GUIDE-The participatory approach ENDURE NETWORK - Easing the way for biological controls
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IPM PRINCIPLE 5

Prioritize the use of selective pesticides

Date (08/11/2010)

WHAT IS…	Selective pesticides are those non toxic to non-target organisms, such as beneficial organisms, including vertebrates and human beings. Specific pesticides are those toxic only to a limited number of pests. The specificity may be limited to a unique species, such as some entomopathogenic virus, or to a group of them. This principle provides a rule to select the pesticides, including plant extracts and mineral pesticides, to be used in case of need: priority shall be given to those pesticides which have the minimum impact on human health, non-target organisms and the environment.
WHY	The selectivity of the pesticides minimizes the impact of chemical control on human health and on the environment. More specifically, it minimizes their undesirable effects on natural enemies that maintain insect pests below the economic thresholds, preventing the possible outbreaks of secondary pests. Nevertheless, it is also necessary to keep in mind that when a broad spectrum pesticide (toxic to several pests) is substituted by a selective one, the populations of some secondary pests may temporarily increase, until a new equilibrium with their natural enemies is reached.
HOW	Educate farmers and advisers to always choose the right pesticide for the right job. As usually a given pesticide is not selective to every natural enemy, it is essential to identify the key natural enemies in each specific crop for each region. The protection of these key natural enemies should be the priority. One important source of information on the toxicity of pesticides to natural enemies and humans is the work of the IOBCwprs Working Group "Pesticides and Beneficials.
EXAMPLE	The use of entomopathogenic virus and other selective pesticides for codling moth control facilitates the control of the European Red Mite on apples by its phytoseiid predators. Different species of phytoseiids that occur naturally in apple orchards are able to maintain the populations of ERM below the economic threshold. The continuous use of pesticides for codling moth control that are toxic to them is responsible of ERM population outbreaks that seriously damage apple trees.

	The use of pesticides selective for the precise species of phytoseiid present in the region allows successful ERM biological control.
SOURCES	http://www.iobc.ch/toolbox.html
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IPM PRINCIPLE 6

Use the correct amount of pesticide

Date (08/11/2010)

WHAT IS…	Once the decision to use a pesticide is taken, having considered the IPM principles, the grower must decide on how to apply the pesticide, the amount of active ingredient per ha (dose), quantity of spraying liquid per ha, frequency of application, complete or partial spraying of the field etc. According to this principle, an IPM-farmer uses as little pesticide as possible, but as much as needed.
WHY	It is an aim of IPM to limit pest control measures to the necessary minimum in order to favour robust cropping systems with a high biodiversity and to use natural processes rather than external inputs for plant protection. Depending on the outcome of the monitoring and decision making systems, the use of pesticides is sometimes unavoidable. In such cases, dose and/or frequency reductions or partial applications have to be considered.
HOW	To apply this principle, the grower must have access to sufficient information and guidance on what is the necessary amount of a specific pesticide. The role of independent professional advisors and of official advisory services is very important. The establishment of a network of reference and demonstration farms is another tool.
EXAMPLE	The correct way to comply with this principle is to know when to apply the lower or the higher registered doses. There is some discussion on the use of lower doses, as they are sometimes recommended depending, for example, on weed and canopy size. The increased risks of resistance development when applying lower doses are true mainly in intensive systems (e.g. continuous cropping) but they are reduced if professional users make full use of preventive measures. Thus if the conditions for the implementation of "true" IPM are met, diversification of pest management approaches will itself strongly reduce the risk of occurrence of pest resistance.
SOURCES	European Commission. Directorate General Environment. Implementation of IPM principles Guidance to Member States.
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IPM PRINCIPLE 7	Apply anti-resistance strategies

Date (08/11/2010)

WHAT IS…	Resistance to a pesticide is the capacity of a population of one pest species to survive the exposure to doses of a pesticide lethal to 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. At one moment, this percentage is high enough to provoke field control failures. This principle states that anti-resistance strategies should be applied.
WHY	Resistance to a pesticide may lead to an increased use of pesticides (dose and frequency), if no anti-resistance strategy is applied. This increase may also have detrimental effects on the environment, human health, the commercial life of an otherwise effective pesticide and even the ability to cultivate a specific crop in an area.
HOW	Grower access to information and guidance not provided by manufactures or distributors of pesticides is essential. The information could e.g. be provided via a network of independent and qualified advisers. Such information should cover known risk of resistance development for specific products and pests and recommendations for anti-resistance strategies.
EXAMPLE	Strategy for preventing Codling Moth (*Cydia pomonella*) Resistance to Insecticides in apple and pear orchards: 1. Apply adequate cultural methods and mating disruption. 2. Monitor the population. 3. Choose specifically acting (selective) products as far as practicable. 4. Direct the application to the most susceptible stage of development. 5. Respect manufacturer's recommendations. 6. Use products from any one group for only one generation per year. 7. Ensure that the application technique is appropriate to obtain complete coverage of the target area of the tree. 8. Do not re-use products from the same Mode Of Action group until resistance has been proven to be absent.

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SOURCES	EPPO, 2002. Standard for the efficacy evaluation of plant protection products. Resistance Risk Analysis. (http://www.eppo.org/Standards/Gl213.html) European Commission. Directorate General Environment. Implementation of IPM principles Guidance to Member States. Insecticide Resistance Action Committee (IRAC) (http://www.irac-online.org/)
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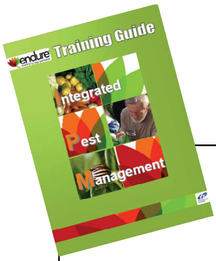
IPM PRINCIPLE 8	Evaluate the success of the applied plant protection measures

Date (08/11/2010)

WHAT IS…	The application of a plant protection measure has been effective when the pest population has been maintained below the economic injury level, not when the pest population has been (almost) completely eliminated. This concept has to be explained to growers very clearly. It is also important to note that this principle addresses all types of intervention, not only chemical ones.
WHY	IPM is a continuous process always including the latest improvements in plant protection. The knowledge of the success of the plant protection measures applied is a key element to achieve this improvement. The maintenance of farm records in e.g. field books allows a detailed study of the reasons of possible failures that might have occurred in the fields, and the proposal of corrective actions.
HOW	Monitoring pest populations after application of a pest control method is essential. Clear guidance must be provided to growers as to how success should be checked and which data should be used for this. In order to explain the success or failure of an applied plant protection measure, documented evidence is required on the preventive measures established by the professional user, on the monitoring activity carried out before and after intervention, on the characteristics of intervention (what, when, how, etc.).
EXAMPLE	Proper documentation provides an excellent basis for reviewing if the established tools are helpful and lead to a real implementation of integrated pest management. The "field books", established, for example, in the frame of Integrated Production Guidelines, provide a detailed guide to comply growers' activity during the growing season. In order to be able to compare measures in a very rough way it seems appropriate to categorise results of success checks into (e.g.) 'measure failed', 'measure provided adequate results' or '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 more time.
SOURCES	European Commission. Directorate General Environment. Implementation of IPM principles Guidance to Member States.
CONTACT PERSONS	Jesus.Avilla@irta.cat ; Jozsef.Kiss@mkk.szie.hu



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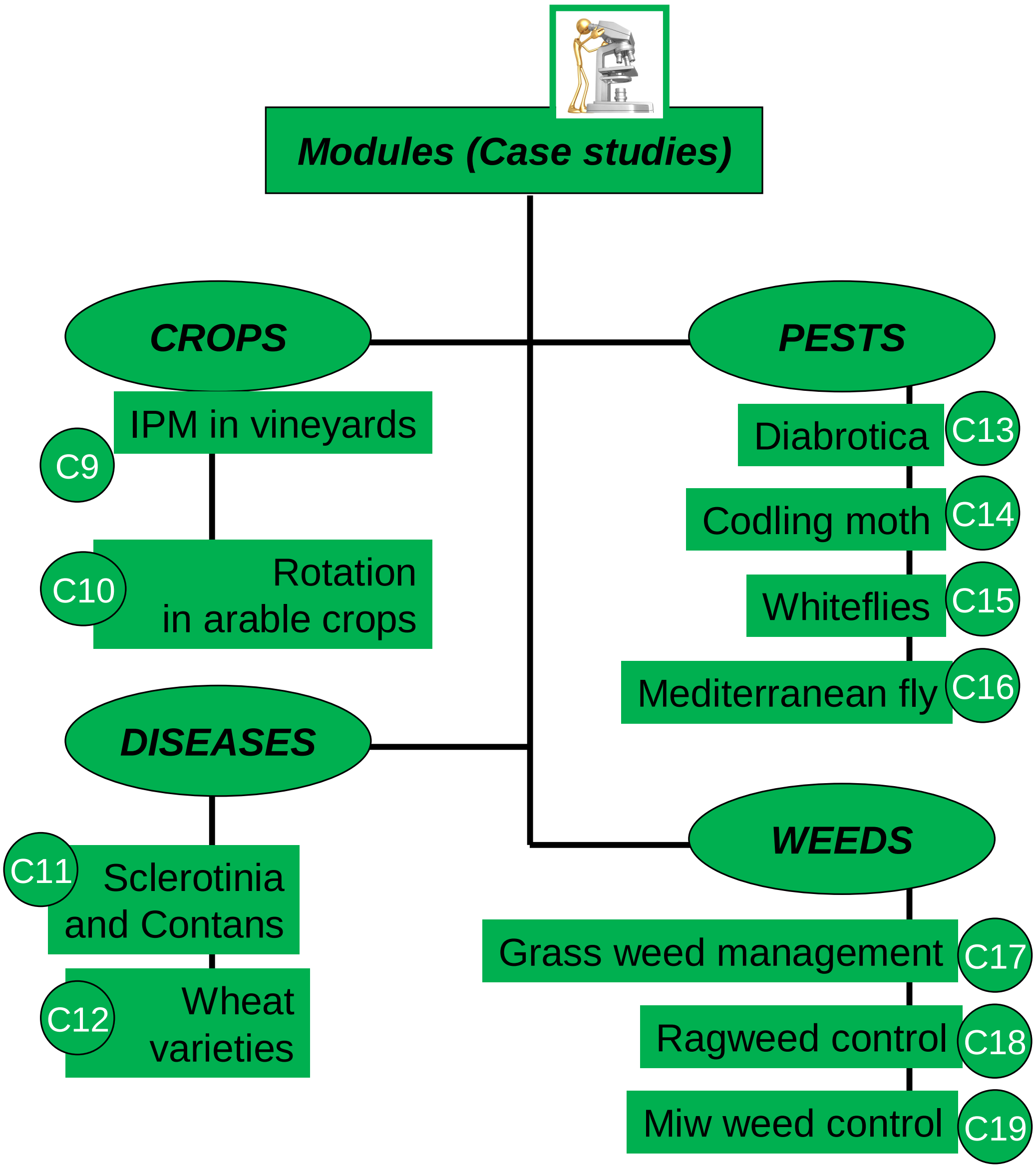

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MODULE 9

IPM IN SUSTAINABLE CROPS:
The example of IPM in French vineyards

Date (16/08/2010)

WHAT IS…	Sometimes a more global approach is needed to introduce a specific concept or to inform trainees (for example, students) in a short time about an overview on a crop. A 10 to 15-slides presentation is usually enough to present the objectives, stakes and technical aspects of a specific crop.
WHY	On average, viticulture is the agricultural activity with the most intensive use of pesticides in terms of the mass of active substances per unit area. In 2003 (and in the 25 member countries at that time), it used more herbicides than fruit production and arable crops, but less insecticides than fruit production. Fungicides represented more than 90% of the total mass of pesticides, due to an intensive use of inorganic sulphur (76% of fungicides). Yet viticulture still used 80% more synthetic fungicides than fruit production, and 13 times more than arable crops. The development of a module about one crop allows a synthesis of all ins and outs about IPM on this crop. This is not a very detailed approach but a broader one that can reveal all the aspects.
HOW	The different slides approach the different aspects of IPM in a sustainable crop: ► Objectives ► Stakes ► Key issues ► Main IPM techniques for different pests ► Good field practices with pesticides ► Use of general principles of IPM
EXAMPLE	The example on grapevine and the module is produced by IFV (Institut Français de la Vigne et du Vin/French Institute for Vine and Wine).
SOURCES	**ENDURE website:** ► Tackling pesticide use in grapes ► Deliverables: DR1.23 Pestice use in viticulture **Partner websites:** ► http://www.vignevin.com ► http://www.vignevin-sudouest.com
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MODULE 10

IPM in arable rotations

Date (08/11/2010)

WHAT IS…	IPM in arable rotations focuses on all the IPM principles, from preventive measures over careful consideration of applied pest control strategies through to the evaluation of the success of the control selected. In this presentation, the focus is on IPM in arable rotations as analysed in the ENDURE case studies.
WHY	In order to maintain sustainable production of food and feedstuff in Europe it is important to use IPM measures in arable cropping. By doing so, **damage to the environment** and risk to **human health** is kept at a minimum, while a **high yield and good quality** is preserved. If pest management is based solely on chemical control the risk of build-up of pesticide resistance is increased, along with higher risks of pesticide residues in crops and the environment.
HOW	Teach the participants about the **effective** use of chemical as well as non-chemical crop protection. Lead the participants through **the eight IPM principles** and use the examples of grass weed management and maize-based systems to underline the statements.
EXAMPLE	The title almost says it. One of the most important IPM measures in arable rotations is the use of an **appropriate cropping sequence**. In ENDURE, several case studies have focused on this particular measure. Among other things, this has, for example, resulted in suggestions for **optimised winter crops based cropping systems**, with **reduced reliance** on chemical pest control, and o**ptimised maize based cropping systems**. Several publications have been produced in relation to these case studies (see SOURCES).
SOURCES	On the ENDURE website, are a number of relevant leaflets: ► IPM in winter crops based cropping systems ► Maize based cropping systems in four European regions: SWOT analysis and IPM considerations ► General Recommendations for IPM Development in European Maize Based Cropping Systems: Innovative Methods and Tools ► Innovative IPM Tools for Maize Based Cropping Systems in Northern Europe ► Métodos Innovadores en IPM Para Sistemas de Cultivo Basados en el Maíz en el Valle del Ebro, España ► Strumenti Innovativi di IPM Raccomandati per Sistemi Colturali Basati sul Mais in Pianura Padana, Italia ► ENDURE Information Centre: http://www.endureinformationcentre.eu

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MODULE 11	USE OF BIOLOGICAL CONTROL
	

Date (07/10/2010)

WHAT IS…	Where biological control is possible it is an alternative method that allows us: ► To avoid the use of pesticides ► To reduce the impact of crop protection on the environment. There has been little development in biological controls against fungi as very often it is not competitive with conventional practices, in terms of both effects and costs. At the moment, we have examples in vineyards, oilseed rape, sunflower, field and glasshouses vegetables in Europe.
WHY	The use of biocontrol agents is included in one of the important general IPM principles. This is because a lot of biological control agents are considered to have a lower impact on human health and the environment when compared to pesticides. *Coniothyrium minitans* is not classified as a toxicological and ecotoxicological active ingredient.
HOW	The different slides reveal the different aspects of IPM use of a biological agent: ► Damages and life cycle of the pathogen ► Disease management and IPM solutions ► Pesticide resistance of the pathogen ► Biology of the agent and recommendations for use ► The use of IPM's general principles
EXAMPLE	*Sclerotinia* stem rot (*Sclerotinia sclerotiorum*) is a major disease in winter oilseed rape which causes severe yield losses twice a decade. Chemical control is usually applied at the beginning of the flowering stage every year. Because a reduced use of chemicals is expected, a biological control agent such as *Coniothyrium minitans* could be useful for controlling the disease.
SOURCES	**ENDURE website:** ► In depth: Biological controls ► Easing the way for biological controls ► **ENDURE INFORMATION CENTRE** Keywords: Measure > non-chemical control > biological control Keywords: measure > training material > identification of beneficials
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MODULE 12

Resistant cultivars of winter wheat in IPM

Date (31/10/2010)

WHAT IS…	The use of cultivars with effective resistance genes is an important measure to reduce the risk of disease development and yield losses in winter wheat. Cultivar resistance against major diseases offers one of the greatest potentials for reducing dependence on fungicides in integrated control strategies.
WHY	Wheat is the most important cereal crop grown in Europe. Yield losses from specific wheat diseases are significant worldwide. Resistant plants (cultivars) are able to overcome the effect of a specific pathogen without yield loss, while susceptible ones react with severe symptoms and yield loss to pathogenic infection. Cultivars tolerant to a specific pathogen can endure infection without severe yield loss.
HOW	Training on resistant wheat varieties: ► Collection of information from EuroWheat website ► Collection of information from national sources (for example, national databases) ► Sharing personal experiences among the participants of the training ► Demonstration field visits ► Establishing small experimental plots to have local information on different wheat varieties ► Presentation and discussion with local breeders on resistant wheat varieties
EXAMPLE	There are a wide range of wheat cultivars in Hungary (GK and MV varieties) which possess good resistance to the major wheat diseases, such as stem rust, brown rust and powdery mildew. Growing new varieties has the advantage of including resistance/tolerance against leaf spot diseases and *Fusarium*. It is essential to consider local conditions (climate, soil type) as well as growing conditions (tillage, crop rotation etc.) when selecting wheat cultivars.
SOURCES	► Eurowheat website: http://www.eurowheat.org/EuroWheat.asp ► **On the ENDURE website:** http://www.endure-network.eu/about_endure
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MODULE 13

IPM for Western Corn Rootworm (WCR) in Central and Eastern Europe

Date (25/10/2010)

WHAT IS…	Western Corn Rootworm (WCR) (*Diabrotica virgifera virgifera* LeConte) is an invasive pest of maize in Europe. WCR larvae cause damage of economic significance by feeding on the root system of maize. Adults consume maize (and other) pollen and silks that could lead to reduced seed setting.
WHY	WCR was first detected in Europe in 1992, in one small field used for continuous maize production close to Belgrade (Serbia, formerly Yugoslavia) international airport. The pest has spread rapidly through Europe. The greatest spread of the WCR population has occurred in the Carpathian basin towards northern and eastern areas. WCR had been detected in 20 European countries by 2009, but had been successfully eradicated in three countries. The larger the size of the infested area, the greater the possibility of the jumping-spread movement beyond the actual spread line (i.e. from central Europe to the Venice region in Italy. However multiple transatlantic introduction of the pest has also been proved. WCR was first detected in Hungary in 1995, with the first damage of economic significance observed in 2001. Heavy yield losses were experienced in infested areas comprising continuous maize fields. Farmers were shocked and did not know how to manage this pest. Information on the biology of the pest in European areas was not available. Control tools, options and IPM strategies were not available or widespread in Europe.
HOW	The presentation analyses: ► The morphology, life cycle and damage of WCR ► Cultural practices and biological control methods ► Chemical control options ► How to develop IPM for WCR
EXAMPLE	WCR females lay their eggs in the soil of maize fields. After overwintering, larvae hatch and feed on maize root systems if maize is planted again in the same field. Therefore, rotation of maize to other crops is the most important non-chemical control strategy. However, rotation of maize should be conducted as part of a system approach over time and space. Not every field should be rotated every year, but a carefully planned rotation system on the farm or over a larger area should be planned in which some maize fields might not be rotated.

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SOURCES	► **On the ENDURE website:** ENDURE NETWORK - Guide to tackling WCR now available / All the news / About ENDURE ENDURE NETWORK - Learning IPM lessons from WCR in Hungary / All the news / About ENDURE ENDURE NETWORK - New training leaflet: the participatory approach / All the news / About ENDURE ► **On the ENDURE INFORMATION CENTRE:** http://www.endureinformationcentre.eu Keywords: Pests > western corn rootworm
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MODULE 14

CODLING MOTH
Biology and control

Date (02/11/2010)

WHAT IS…	Codling moth is the common name in English of the insect *Cydia pomonella*, one of the key arthropod pests of pome and stone fruits. Other common names are carpocapse des pommes et des poires (French), Apfelwickler (German), Gusano de las manzanas y las peras (Spanish) and Baco delle mele (Italian). The larvae develop inside the fruits, boring a tunnel to the seeds. In the absence of control measures and depending on the areas and the years, it may cause the destruction of almost all the production.
WHY	As it is a direct pest of high value crops, its economic injury level is very low (1-2 % of injured fruits at harvest). Chemical control has been, and still is in many areas, the most commonly used control method. In extreme cases, up to 15 sprays are needed. Consequently, the knowledge of codling moth biology and codling moth control are key elements of any IPM programme for apples and pears.
HOW	The biology of codling moth and the registered control methods vary according to the country, despite the ongoing process of standardisation of pesticide registration in the EU. To adapt the module to your own case you should: ► Specify the biology of codling moth to your area ► Specify its importance as a pest ► Check the monitoring tools available in your country ► Check the control methods available in your country
SOURCES	http://www.inra.fr/hyppz/RAVAGEUR/6cydpom.htm http://www.ipm.ucdavis.edu/PMG/r4300111.html
CONTACT	Jesus.avilla@irta.es

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MODULE 15

WHITEFLIES

Biology and control

Date (05/11/2010)

WHAT IS…	Whiteflies are important worldwide pests of vegetable, cotton and ornamental crops, although they can also develop on a wide range of cultivated and wild plants. Two whitefly species are the main pests of tomato in Europe: *Bemisia tabaci* and *Trialeurodes vaporariorum*. *Trialeurodes vaporariorum* is widespread in all areas where greenhouse production is present, and *B. tabaci* has invaded, since the early 1990s, all subtropical and tropical areas. Biotypes B and Q of *B. tabaci* are widespread and especially problematic. *Bemisia tabaci* currently co-exists in many horticultural and ornamental crops with the greenhouse whitefly *T. vaporariorum.* Differentiating the two species is important, firstly because *Bemisia* is very good at transmitting some important viruses. Secondly, whether using natural enemies or insecticides for control, knowledge of the species present in the crop will help us to choose the best options.
WHY	Whiteflies and whitefly-transmitted viruses are some of the major constraints for European greenhouse production. For tomato crops the ranked importance of *B. tabaci* correlates with the levels of insecticide use, showing *B. tabaci* as one of the principal drivers behind chemical control. Confirmed cases of resistance to almost all insecticides have been reported. Integrated Pest Management based on biological control (IPM-BC) is applied in all European countries and has been identified as the strategy using fewer insecticides. Other IPM components include greenhouse netting and TYLCD-tolerant tomato cultivars. For population monitoring and control, whitefly densities and whitefly species are always identified.
HOW	The IPM-BC approach is mainly based on inoculative releases of the parasitoids *Eretmocerus mundus* and *Encarsia formosa* and/or the polyphagous predators *Macrolophus caliginosus* and *Nesidiocoris tenuis*. However, some limitations for wider implementation have been identified: lack of biological solutions for some pests, costs of beneficials, low farmer confidence, costs of technical advice, and low pest injury thresholds.

	The biology of whiteflies and the registered control methods vary according to the country, despite the ongoing process of standardisation of pesticide registration in the EU. To adapt the module to your own case you should: ► Specify the biology and species composition of whiteflies in your area ► Specify its importance as a pest ► Check the monitoring tools available in your country ► Check the control methods available in your country
SOURCES	France: www.ambroisie.org
CONTACT	Rosa.gabarra@irta.es ; judit.arno@irta.es

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MODULE 16

MEDITERRANEAN FLY

Biology and control

Date (02/11/2010)

WHAT IS…	Mediterranean Fruit Fly (medfly) is the common name in English of the insect *Ceratitis capitata*, a very polyphagous species which is one of the key arthropod pests of stone and citrus fruits. Other common names are mouche méditerranéenne des fruits (French), mosca mediterránea de las frutas (Spanish) and mosca delle pesche (Italian). Usually, several larvae develop inside the fruit, facilitating the decomposition of plant tissue by invading secondary microorganisms.
WHY	The high importance of medfly is due to several characteristics: it is a direct pest of high value crops, it attacks fruits near to maturity, it is very polyphagous and the adults can fly long distances, and it is a quarantine species in important countries such as the USA. Chemical control has been, and still is in many areas, the most commonly used control method. Spraying must be applied near to harvest, which strongly limits the insecticides that can be used. Consequently, knowledge of its biology and control are key elements of any IPM programme for pome, stone and citrus fruits.
HOW	The biology of medfly and the registered control methods available vary according to country, despite the ongoing process of standardisation of pesticide registration in the EU. To adapt the module to your own case you should: ► Specify the biology of medfly in your area ► Specify its importance as a pest ► Check the monitoring tools available in your country ► Check the control methods available in your country
SOURCES	http://www.inra.fr/hyppz/RAVAGEUR/6cercap.htm http://www.horticom.com/pd/imagenes/73/718/73718.pdf
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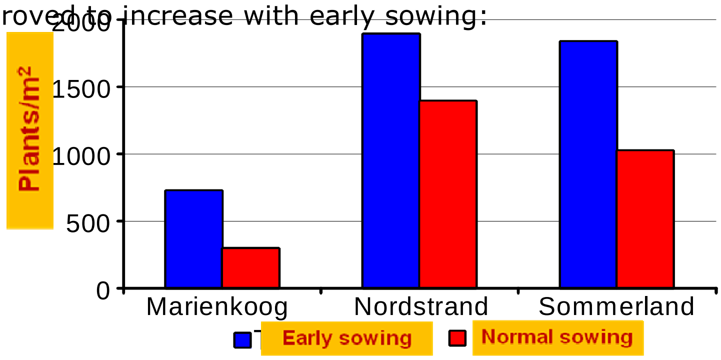
MODULE 17

Grass weed management with IPM

Date (20/10/2010)

WHAT IS…	In crop rotations dominated by winter crops and, especially cereals, problems with grass weeds are very likely to increase, as the life cycle of many grass weed species matches that of the winter crops.
WHY	In many cases, grass weeds are effectively controlled with herbicides. However, increasing incidences of herbicide-resistant grass weeds are being reported, which is why alternatives are needed. These alternatives include both preventive and curative measures.
HOW	The major tool to prevent the proliferation of grass weeds is **crop rotation**. Increasing the amount of spring sown crops will depress the development of winter annual grass weed species. However, changing the crop rotation is often very costly to the farmer, due to decreases in productivity. Other measures include: ▶ **Delayed sowing** ▶ **Optimal plant density** ▶ **Focused soil cultivation** ▶ **Glyphosate before sowing the main crop** ▶ **Optimised use of herbicides** (through monitoring, adjusted dosages etc). It is, however, always important to focus on the total farm economy before implementing these measures.
EXAMPLE	The amount of *Alopecurus myosuroides* has, in German experiments, been proved to increase with early sowing: 
SOURCES	**On the ENDURE website:** ▶ Leaflet on IPM in winter crops based cropping systems ▶ On the ENDURE Information Centre

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MODULE 18

INVASIVE WEEDS

Date (16/06/2010)

WHAT IS…	Invasive weeds can cause serious problems because they occupy the land, breed profusely, cause yield losses and greatly reduce biodiversity. They may also cause other damage: ▶ Degradation of facilities by root systems ▶ Hazard (fire, damages, visibility on roads etc) ▶ Allergenic
WHY	The fight against invasive plants is crucial and must be mastered, in particular, because of the capacity of these species to reproduce, spread and colonise. Reproduction takes place either: ▶ By producing large number of seeds ▶ By transporting organs of conservation
HOW	The following points should be described and adapted to the context: ▶ Context and problem: why this weed is a problem in your country or area. ▶ Dissemination and development: what are the main characteristics that can influence control methods. ▶ Identification and possible confusion: specify the criteria for identification and differentiation with other weeds that look like it. ▶ Biology and life cycle: description of the main points of biology and adaptation of the cycle in the regional context. ▶ Control: what methods are possible and how to focus on Integrated Pest Management (prophylaxis, non-chemical) in the different environments where the plant grows. ▶ IPM principles: take stock of the principles used in the fight against invasive weeds.
EXAMPLE	Ragweed (*Ambrosia artemisifolia*) in France (Rhône-Alpes and Burgundy)
SOURCES	▶ France: www.ambroisie.info (in French) ▶ Germany: www.ambrosia.de (in German) ▶ Switzerland: www.ambrosia.ch (in French, German and Italian) ▶ In English: www.internationalragweedsociety.org
CONTACTS	▶ bruno.chauvel@dijon.inra.fr ▶ chollet@cetiom.fr ▶ alain.rodriguez@acta.asso.fr ▶ philippe.delval@acta.asso.fr ▶ m.mangin@arvalisinstitutduvegetal.fr

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MODULE 19

ALTERNATIVE WEED CONTROL IN ARABLE CROPS

Date (02/06/2010)

WHAT IS…	Integrated Weed Management (IWM) is a broad term covering many non-chemical methods that can be combined and applied in various ways to the crop to constitute an IWM strategy.
WHY	Substantial reductions in herbicide input can be achieved in arable crops through using IWM. This crop management option uses less herbicide and gives the following advantages: ► Environmental: less pollution ► Agricultural: less risk of resistance, positive effects on soil ► Economic: equivalent margins
HOW	This includes various ready-to-use techniques such as stale seedbed preparation, pre-emergence cultivation, inter-row cultivation, band-spraying or broad-spraying at reduced doses where appropriate that can be used, in an adapted way, in arable crops. Some experimental techniques are being tested to establish their agricultural and economic feasibility for the future.
EXAMPLES	Different examples of crop management are taken from 'Desherb'sol', a French network involving technical institutes, agricultural chambers and machinery co-operatives.
SOURCES	► Cetiom website ► Bourgogne Chamber of Agriculture website ► On the ENDURE website: **Integrated Weed Management Case Study – Guide Number 1** ► On the ENDURE Information Centre: Keywords : measure > non-chemical control > mechanical measures
CONTACTS	Désherb'Sol ► lucas@cetiom.fr ► marie-sophie.petit@bourgogne-chambagri.fr ► itb10@itbfr.org ► matthieu.killmayer@arvalisinstitutduvegetal.fr ► munierj@dijon.inra.fr ► elise.begue@Cuma.fr

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