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IPM seen from the perspective of Sustainable Use Directive Objectives

OPERA guidelines for implementation

UNIVERSITÀ CATTOLICA del Sacro Cuore

Bridging science and policy

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OPERA is a young, growing think tank and a research centre of the Università Cattolica del Sacro Cuore, a major European private university.

It is an independent, non-profit scientific organization, committed in supporting the successful implementation of the agri-environmental measures within the European legislation.

The fundamental contribution of OPERA is to use the potential of existing scientific researches as well as the existing expertise and knowledge to support the stakeholders in their political and technical decisions concerning agriculture, and particularly the management of agricultural risks relating to pesticides and the environment. One objective is to provide a series of pragmatic recommendations to policy makers to bridge the interest and objectives of agriculture and environment as well as to ensure efficient implementation of the agriculture related policies in the EU.

FOREWORD

Last century has witnessed the biggest changes agriculture has ever seen: the productivity increased enormously and high quality, nutritionally rich and safe agricultural products have been provided by farmers.

Plant protection plays one of the major roles in the development of this success. At the same time, the evolution of chemical, toxicological and environmental sciences acknowledged the incidence of possible undesired environmental effects, contamination of foodstuffs and risks for human health.

The most developed countries together with the international organizations moved therefore gradually their attention from the efficacy of the single tools to the sustainability of the practices. This is also one of the key principles at the basis of the new Directive on the Sustainable Use of Pesticides (SUD), but also of IPM (Integrated Pest Management), which is incorporated and recommended by the SUD.

Starting from one of the official definitions of IPM ("Integrated control represents procedures which utilizes all economically, ecologically, and toxicologically acceptable methods for keeping the pests under the threshold of harmfulness with preferential and meaningful utilization of natural restricting factors") the authors of this publication stress the importance of considering IPM as a broad ecological approach utilizing a variety of pest control techniques, targeting the entire pest complex of a crop ecosystem: an approach therefore, not a specific measure.

As a consequence, the SUD includes a list of principles to be followed for an IPM approach: from prevention to monitoring and intervention with all the possible solutions (including anti-resistance strategies and biological control), targeting specifically the plant protection product to be used and its application. The authors mirror these basic principles against actions to be taken and tools to be provided, while assessing opportunities, constraints, required support and possible funding for the respective implementation at farm level.

Since the major need of not leaving farmers alone in the adoption of IPM procedures, training and demonstration of pilot cases together with the establishment of a common network between farmers, advisors, researchers and plant protection products producers in each country are seen as the only sustainable solution, coupled with implementing farmers funding policies.

To establish common priorities for IPM implementation, research needs to be encouraged, both at Member State and at European level in a framework of activities dealing with sustainable development of the farm business.

Communication to the public of higher safety and quality of food and environment deriving from the application of this framework should be in the future a major concern as to boost consumer confidence in European food products.

Ettore Capri
Director of the OPERA Research Centre

The EU Sustainable Use of Pesticides Directive requires Member States (MS) to develop a legislative framework and National Action Plans (NAP) that includes the aim of reducing the potential risk associated with pesticide use.

Over the past year, the OPERA Research Centre has been actively involved in identifying guidelines and strategies to meet the objectives of the Sustainable Use Directive (SUD).

One of the most important requirements for implementation is the promotion of IPM and of alternative approaches to reduce the risks of pesticide use to human health and the environment.

OPERA experts have been mapping the elements of the IPM concept and defining existing practical solutions to set up a comprehensive package of guidelines to assist stakeholders in choosing the right approach that would better answer to the legislation requirements and promote IPM as a sustainable farming practice.

TABLE OF CONTENTS

THE "GREEN REVOLUTION"

Last century has witnessed the biggest changes agriculture has ever seen. Agriculture was for centuries a subsistence activity, being able to produce only a limited excess of food and fibres for a not so numerous non-involved population. The twentieth century industrial revolution changed the situation radically. Theories like that of Malthus anticipated a difficult future for humanity, since he was pointing out that exponential increases in the population will be followed by periods of famine, plaques and wars to reduce the number of people to match the quantity of food produced, which can increase only arithmetically. But luckily, industrial development has changed agriculture as well as industry. The "green revolution" moved agriculture to a new paradigm.

With the introduction of fertilizers, machinery, better quality seeds, irrigation, plant protection products and good farming practices productivity was significantly boosted. The reduction of manpower requirements and labour intensity with the increase in technology have both driven agriculture far from its original status to a highly professional activity. High quality, nutritionally rich and safe agricultural products are at the heart of farmers' activities, with technology playing a major role. However, an idealistic perception of agriculture still survives among the general public and in the media, with a conspicuous distance between reality and its representation.

Plant protection plays one of the major roles in the development of agricultural practices. A few remedies against fungal diseases, like inorganic substances such as copper and sulphur, existed at the debut of the last century. Today, several hundred inorganic and organic chemical and biological products are available to farmers.

When the first insecticides came into common use, scientists and technicians quickly realized that their great efficacy against noxious insects was accompanied by a parallel effect on some beneficial non target organisms, altering the population equilibrium and dynamics in an unfavourable direction regarding crop defence. From this first assessment and by realizing that natural enemies were able to support the fight against crop pests, the concept of Integrated Pest Management (IPM) started to be developed, leading to the premise that to protect the harvest multiple tools should be applied in conjunction with the use of chemicals.

At the same time, the evolution of chemical, toxicological and environmental sciences acknowledged the incidence of undesired environmental effects, contamination of foodstuffs and risks for human health. The most developed countries together with international organizations started to build up a complex regulatory system, submitting the production and distribution of plant protection products to strict rules, with the main target of avoiding hazardous effects. The attention gradually moved from the efficacy of the single tools to the sustainability of the practices.

EUROPEAN AGRICULTURE AND PLANT PROTECTION

Europe has always played a leading role in the "Green Revolution" and in the progress of plant protection practices. Within the economical evolution agriculture remained a strategic sector not only because it provides food supplies but more and more because it provides raw materials for other industries. However global competition on the market, particularly regarding commodities, made the situation for European farmers increasingly difficult.

European policy constantly adapted to answer to farmers' needs and market requirements at the same time, putting in place measures to protect human health and the environment. Twenty years have already passed since the first common European regulatory framework was put in place regarding the authorization of plant protection products. In this period both the procedures to allow the products on the market and the presence of their possible residues in the foodstuffs have been subjected to great attention and strict consideration. Within this period, many products which were not considered safe enough by the progressively severe regulations have been taken off the market.

As the policy has been paying a greater and greater attention to health, environmental safety and sustainability, a new and stricter Plant Protection Products Package has come into force. The new Directive on Sustainable Use of Pesticides together with the Regulation for placing PPP on the market explicitly mention **IPM as key practice.** MS are called upon to promote the use of Integrated Pest Management and of alternative approaches or techniques such as non-chemical alternatives to pesticides.

Agrochemicals, as chemical products, are subject to the general regulations of chemical substances, mainly concerning hazard classification, labelling and packaging. Moreover they require a specific authorization process, driven by the new Regulation (EC) n. 1107/2009 of 21 October 2009 *concerning the placing of plant protection products on the market.*

Specific provisions are in place to regulate the technical characteristics of the pesticide application machinery used in agriculture. These rules ensure that new equipment has all the necessary characteristics to reduce the impact on human and animal health as well as on the environment. Meanwhile, Article 8 of the SUD establishes rules for regular inspection of application machinery in use.

From another perspective, related to the good agricultural practices (and not identifying necessarily a human risk level) a separate, constantly updated regulation sets the limits for pesticides residues remaining in foodstuff after field treatments (MRLs).

It is worth mentioning that, for pesticides, even the collection of statistical data on their use is specifically regulated. The result is a highly complex system, where interplay among rules forces all operators, from "farm to fork", to devote much effort in ensuring safe use for the agrochemicals, from the perspective of the environment, human and animal health protection.

Plant protection products have to undergo a complex procedure before entering the market. Each product is subject to strict scrutiny of the scientific data following standard protocols. Toxicology, impact on non-target organisms and efficacy of field applications are accurately assessed. The procedure includes the approval of the product label which must provide relevant information for the users regarding product composition, warnings, characteristics, application dosage and use directions. Users are required by legislation to follow these recommendations (Art 55 of Regulation 1107/2009) as well as the relevant provisions of the SUD.

DEFINING IPM

The diligent application of plant protection products is important to assure efficacy and avoid problems: it is commonly defined as Good Plant Protection Practice (GPPP). In IPM practice, when chemical means are involved, GPPP is extremely important, but GPPP is only a component of the overall strategy.

The possibility to deploy natural enemies to control crop pest was described and applied almost a century ago. Insects, predators, parasites or parasitoids, were used in order to control adverse populations. The practice was considered as Integrated Control Concept (ICC).). Use of natural enemies in plant protection plays an important role as part of IPM, but biological control should not be identified with IPM.

So, what is IPM? The attempt to define it originated from the consideration that all crop care practices have a direct or indirect impact on pests, their development and their power to compromise agricultural production. Fertilization, soil management, irrigation and crop variety choices all contribute to the crop health and to its ability to resist diseases and competition from other organisms.

Definitions of Integrated Pest Management (IPM) given by international organizations attempted to define the concept. In the first instance the Food and Agriculture Organization (FAO) states: "*Integrated control represents the system of pest regulation which takes into account respective environment and population dynamics of harmful species and utilizes all suitable techniques and methods in the most effective combination to maintain pest population under the threshold of harmfulness*".

Very similarly, the International Organisation for Biological and Integrated Control of Noxious Animals and Plants (IOBC-OILB), stated: *"Integrated control represents procedure (method) which utilizes all economically, ecologically, and toxicologically acceptable methods for keeping the pests under the threshold of harmfulness with preferential and meaningful utilization of natural restricting factors."*. It should be noted again that Integrated Control is only a part of IPM.

According to the above mentioned approaches, the emphasis is given firstly on the anticipation and prevention of pest problems whenever possible. IPM uses all appropriate pest management techniques such as enhancing natural enemies, semiochemicals (chemical substances which attract or confuse insects, but are not toxic to them), planting pest-resistant crops, adopting cultural management, and applying pesticides judiciously.

The aim of IPM is to limit the occurrence of pests, using a mix of methods like low –cost available biological or natural control methods, agricultural practices, farm management decisions and chemical pesticides as a targeted method of action. The non-chemical methods should be preferred if they provide satisfactory control, while in cases where the chemical methods should be used; their use should have the least side effects. The chemical methods have to be as specific as possible and the doses to be applied should be kept to the minimum possible level.

In this wider definition, IPM is a broad ecological approach to pest management utilizing a variety of pest control techniques, targeting the entire pest complex of a crop ecosystem. Appropriately, this approach to IPM targets to ensure high quality agricultural production in a sustainable, environmentally safe and economically sound manner.

EU LEGISLATION AND IPM

The wide scope of the definitions has brought a large spectrum of interpretations and guidelines to be taken into consideration as best practices and adopted in the field.

The Directive for Sustainable Use of Pesticides that was adopted as part of the Pesticide Package shall become applicable as from 14th December, 2011 and will be a turning point regarding the implementation of IPM as Member States shall have to take *all necessary* measures to promote low pesticide-input pest management, giving *wherever possible* priority to non-chemical methods, so that professional users of pesticides switch to practices and products with the lowest risk to human health and the environment among those available for the same pest problem.

To understand the relevance of these provisions for the concept and definition of IPM we need to follow what is literarily stated by the new provisions. IPM as stated by the Directive is: "Article 3 - **Definitions [….]** 6. *'integrated pest management' means careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimise risks to human health and the environment. 'Integrated pest management' emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms".*

Following this definition, it is clear that the implementation of the principles of IPM can take many different forms and solutions. Such solutions must be tailored to the specificities of a certain cropping system, climatic conditions and pest pressure, availability of efficient solutions or timing during a cropping cycle.

A totally "no" use scenario can be considered as an easy way out, but the major impediment is that such an approach cannot deliver on economic and social security. Agricultural production cannot deliver the multifunctional benefits of food and social security without proper plant protection strategies.

Also, this interpretation may create confusion between IPM and organic farming practices. We should make a clear distinction between IPM and specific production systems, like organic farming, that by definition ban the use of chemicals (or in reality, ban only the use of some chemicals) in the protection of crops. It should be made clear that IPM is not a production standard or a farming practice, but a tool to be used in all farming systems. **Hence, any tendency to replicate restrictions to farming does not constitute IPM.** The implementation should concentrate on providing solutions to manage pests in an integrated and economically efficient way.

It also has to be seen that extensive production systems do not automatically deliver in terms of food safety and human health. The recent problems with high concentrations of copper and sulfur residues in food as well as the level of mycotoxins or the infestation with various bacteria (e.g. E-coli case in Germany) stand as living proof.

One of the principles behind the authorization of PPP state that *"to ensure a high level of protection of human health and the environment, plant protection products should be used properly, in accordance with their authorisation, having regard to the principles of integrated pest management and giving priority to non-chemical and natural alternatives wherever possible."*

This supports the basis that IPM includes the use of PPP according to the European legislative framework. **As a clear and unique definition of IPM is difficult to develop, given the variability of cropping and climatic conditions, the legislator has decide to include in the Directive 2009/128/EC (on the Sustainable Use of Pesticides, SUD) a list of principles to be followed for an IPM approach.** Annex III of SUD identifies these principles which define the concept of IPM for the European farmers (see annex I). The MS are required to provide the necessary framework and supporting systems for their implementation.

The provisions subject to implementation cover measures to be put in place for training for users, sales requirements, pesticide application equipment, aerial spraying, information to the public, measures to protect water and the aquatic environment, reduction of pesticide uses in specific areas, handling, storage and IPM.

As the SUD is included in the statutory management requirements for direct support schemes under the common agricultural policy, it becomes a compulsory requirement for obtaining subsidies, and hence becomes part of the cross-compliance system. IPM therefore becomes not a differentiated standard of production, but a tool available for all farming activities.

IPM CONCEPT AND ITS APPLICATION

Focus points

In Europe IPM implementation started from some activities and measures correspondant to a number of the principles of IPM. The European countries focused their interest on different principles depending on the priorities they have set for themselves and the existing implemented legislation schemes or action plans:

- **Measures on preventing and/ or suppressing harmful organisms** are the main and basic element of IPM. The choice of the appropriate resistant or tolerant varieties, the optimal crop protection, the adequate cultivation techniques, the balanced fertilization and the utilization of ecological infrastructures are some of the indirect plant protection methods, for the prevention of key pests, diseases and weeds. Furthermore, the tools of **monitoring of pests, diseases and weeds** constitute an adequate method to determine whether and when the direct control methods should be applied.
- Another principle that is commonly followed by a large number of member states is **target-specificity** and minimization of side effects. The main priority regarding the direct application of plant protection methods is to have minimum impact on human health, non-target organisms and the environment. The products used should be appropriate for the targets and their impact on the environment shall be minimized by applying the right dose.
- **Record keeping, monitoring, documentation and checking** of success are required regarding the mode of application since based on these records on the use of pesticides and on the monitoring of the harmful organisms, the professional users can check the success of the applied plant protection measures.
- Furthermore, Member States' authorities address aspects such as **correct spray-free buffer zones to water** and the general prevention of contamination of areas outside the field by wind drift. Adequate buffer zones between treated crop areas and sensitive off-crop areas should be observed.
- Finally, attention must be focused on the **training of the farmers** and the provision of mandatory certificates for the persons in charge of crop protection decisions regarding relevant training on the identification of pests, weeds and diseases. The training system should be supported by a database containing general knowledge on best available techniques, practices, cultivar and varieties. The training system should include continuous learning, willingness to improve the implemented systems and the skills of the operators, the distributors and the consultants.

The requirements of implementing IPM point out the need to include all the possible available measures to obtain a proper defense for the crop, also considering health, social, economic and environmental aspects.

Integrated pest management should be seen from the scientific perspective as a strategy to anticipate and eliminate expected yield losses through a proper plant protection strategy while reducing environmental impact and considering economical threshold levels for the harmful species affecting each crop.

The recognition of the role played by natural regulating factors especially from the point of view of biodiversity is essential, consequently the complete eradication of harmful organisms is not the purpose of the forecasted action, but regulation of their populations based on environmental and economically acceptable levels.

The principles of IPM consist of the combination of all the available controlling methods, such as agronomic practices, choice of crop varieties, rotation of cultivations etc, while the use of control methods that act exclusively upon the target organisms such as pests, weeds and diseases are used as alternatives in order to counteract crop noxious entities. The promotion of natural mechanisms of control in the frame of the ecological requirements is the priority of the system. Furthermore, the use of pesticides should be targeted. Their dosage is applied at the necessary minimum level, while utilizing the full potential of preventative and non-chemical measures. In general, IPM is a complex approach in harmony with the objectives of integrated plant production, with a particular emphasis on the sustainability of plant production.

SUMMARIZING THE OBJECTIVES OF AN IPM SYSTEM

- regulate harmful organism populations;
- identify the harmful organisms and set the economical thresholds;
- keep them under the economical threshold;
- maintain a balance in the agro ecosystem;
- exploit as far as possible the role of antagonists (parasitoids, predators and pathogens) in pest control;
- provide proper growth conditions for the crop to avoid stress situations;
- apply defense means, preventive and curative, including chemicals, in the most accurate way;
- integrate knowledge and technical practices in interdisciplinary and systemic approaches;
- manage a dynamic and effective flow of information about the factors influencing the success of applied measures and the records of effectiveness after the application.

Elements for a proper approach

Any practical IPM approach cannot be applied before having a **proper understanding of the biological, environmental, toxicological and economical processes** both for the crop and for the entire agricultural system of a specific area. In any case, the agricultural production in terms of quantity and quality should be at the heart of all endeavors of the defense strategies.

The role of **preventative measures** is to protect the crop by taking into consideration plant behaviors and environmental conditions favorable to pest development. All agronomic practices concur towards achieving preventative results. Thus, farmers have to care about:

- choice of crop;
- crop rotation and coexistence with other crops;
- correct fertilization (time, quantity, products);
- soil management;
- seed choice (quality, variety, resistance);
- improved plants through modern molecular biotechnology;
- seeding practices (date, density, soil conditions, seed treatments);
- plant treatment in field and harvest procedures.

When the combination of the above mentioned measures is not sufficient to grant the health of the crop below the economic threshold level it is then necessary to move to the **repressive or curative phase.**

Commonly applied measures are:

- application of plant protection products, biological or "natural" occurring chemicals;
- application of plant protection products, synthetic chemicals;
- physical methods, including trapping;
- use of semiochemicals preventing insect mating or attracting them in traps;
- establishment of natural enemies, parasites, predators, competitors on feeding substrate.

These approaches, although accurate from a theoretical point of view, in practice are dealt with in a very short time frame. It should be considered that the correct approach for IPM would imply the combined use of all these measures to reduce the risk posed by the pest. It should be highlighted that failure of risk reduction (including with chemical control) can increase even more than usual the quantity of pesticides used, if applied too late.

An important factor lies within the time frame available for the tools chosen to take effect. If all preventative agronomic measures are taken, and if during different vegetative stages of the plant pest occurrence is detected which would have a definite negative impact on the crop growth and yield, the chemical treatments are bound to be applied so as to not prejudice the potential outcome of their crop.

Also, costs of the preventative alternatives and their effectiveness compared to the chemical solution are an important aspect farmers shall take into consideration. The endpoint of the strategy lies in the level of crop protection the farmer uses. This is related to the economic threshold. When the pest's presence is below the threshold, no intervention is justified. Otherwise the farmer has to carefully choose a mix of control measures to assure sufficient level of crop protection to avoid economic losses.

All plant protection products should be applied following appropriate calibration of machinery and according to the producer's prescribed instructions. Application guidelines for plant protection products are described in the label and strictly regulated by the new Regulation. As the label specifies the quantity necessary for the ideal vegetative stage of the plant/ha this has to be carefully observed. Therefore precise application technology of products is one of the most important preventative measures. Instructions on the label need to be interpreted to ensure a correct and precise application of PPP's due to the different vegetative stages of the crop, climate conditions and application period time frames.

The pragmatic definition of IPM practices- cultivation specific, is dependent on a sophisticated understanding of the ecology, structure and dynamics of the "agro-ecosystem" involved. It is possible to point out some general principles, however, a clearly defined package of IPM pest control measures does not exist. The solution lies in a "problem-solving" and "decision-support" system for managing pest problems.

Useful tools for implementation

It has been noticed that in both developing and developed countries, IPM research programs can only be successful with involvement of farmers and other stakeholders. Defining the appropriate nature of that engagement, however, is not a simple task because research, training and extension interactions require financial and human resources and because both farmers and scientists have comparative advantages in particular aspects of the knowledge generation process.

The usefulness of establishing general guidelines for specific rules has been demonstrated several times. These can indicatively provide for defining:

- Selection criteria for seeds and propagation materials (certification, disease tolerance, protection applied)
- General criteria for the correct choice of plant protection products (preference for certain categories, definition of selectivity)
- Indication about the level of application (single farm, aggregated farms, wider areas)
- Criteria for defining threshold, monitoring and assessment of pest (networks, scouting, trapping, data sharing)
- Criteria for implementing training and support services
- Assessment of general measures for application, statistics, controls.

In some cases, **more specific regional guidelines** need to be made available. They set more crop specific detailed rules based on:

- the designated areas
- pest tolerance and climatic compatibility of variety choices
- specific pest thresholds
- pest identification, defining dangerous life stages, assessment criteria, trapping
- seeding or planting criteria (density, spacing, timing, soil conditions)
- fertilization and possible influence on pest development
- agronomic practices (pruning, tillage, harvest, vegetation debris clearing)
- possible alternatives to chemical treatments (biological control, antagonists, physical devices)
- plant protection product selection and their application rate and timing (selectivity, resistance prevention, dose tuning).

The implementation of IPM in Europe should be supported in the field by raising the awareness of farmers and advisers in order to ensure wide implementation in practice. Furthermore, relevant research, developed in consultation with farmers and advisers, proves to be useful.

HOW TO ACHIEVE IPM IMPLEMENTATION AS REQUIRED BY SUD?

Article 14 of the Directive requires MS's to take all necessary measures to promote IPM implementation essential for the success of reducing pesticide risks. The legislation is not proposing an innovative approach to IPM, but actually recording and promoting a set of widely recognized principles, within Annex III of the Directive.

The eight points of the Annex recall the adoption of: agronomic measures, monitoring, threshold levels, specificity of application, preference for non-chemicals if providing satisfactory pest control, resistance management and check of results in relation with the applied measures. These have all been mentioned in the discussion about the definition of IPM. The existing experiences on the general aspect of IPM implementation, on organization requirements, on information sharing and on detailed application in specific crops and environments, should be taken into account in transposing the legislative provisions into national legislation.

The concept of IPM requires some precautionary or supportive measures to be considered in order that the natural benefits are taken into consideration. Such measures could be regarded as indirect plant protection, covering a choice of appropriate resistant/tolerant cultivars, optimal crop rotation, adequate cultivation techniques, balanced fertilization and irrigation practices, protection and enhancement of important natural enemies by adequate plant protection measures and utilization of ecological infrastructures inside and outside production sites to enhance a supportive biological control. It should be mentioned that the above points are the most important but there is always the possibility of the need for further elements to be added depending on the requirements of each situation.

To reply to the **first principle** stated in Annex III of Directive 128/2009 we recommend the development of clear guidance documents throughout the MS relating to appropriate practices for the elements mentioned.

Specifically, this should tackle the necessary information related to:

- Viable crop rotation schemes, according to the climatic and agronomic specificities. To take account of heterogeneous conditions these can be developed at regional level.
- Inventory of the adequate cultivation techniques with clear and pragmatic recommendations for farmers,
- Criteria for the selection of resistant/tolerant cultivars and standard/certified seed and planting material,
- Guidelines for the use of balanced fertilisation, liming and irrigation/drainage practices,
- Minimum recommendations for hygiene measures to prevent the spreading of the most common pests,
- Protection and enhancement of important beneficial organisms for the main crops.

It is essential to provide guidance for all these elements specifically, for the most important crops in each MS in order to give to the professional users the information needed for its appropriate use in practice.

In the tables below the general principles set in the Annex III of the Directive 128/2009 are mirrored against actions to be taken and tools to be provided while assessing the opportunities, constraints, the required support and possible funding for the respective implementation at farm level.

Refer. To Annex III	Actions	Tools	Opportunity	Constraints	Support needed for	Financial support
1 Prevention and/or suppression of harmful organisms	Crop rotation	Guidelines on viable crop rotation schemes	Improve fertility, easier pest and weed prevention	Not always applicable	Market access for alternative crops	Promote through CAP measures, subsidies
	Cultivation techniques	Inventory of the adequate cultivation techniques	Improve fertility, reduce energy input, soil stability	Not always applicable, depends on farm organization, machinery	Training, demo trials, external technical assistance	Possibly cost saving, promote through CAP measures
	Resistant, tolerant seeds- varieties	Criteria for the selection of cultivars and certified seed and planting material	Reduced incidence of pests and lower impact of treatments	New varieties to be tested in advance, market acceptance, typical varieties substitution, cost increase	Training, demo trials, external technical assistance	Additional value on the market
	Balance fertilization, irrigation	Guidelines	Plant fitness improvement, precision farming, cost reduction	Organization to be adapted, insufficient information available	Training, demo trails, on site assistance	Facilitate access to credit, saved costs
	Hygiene measures	Minimum recommendations for crop and pest specific hygiene	Easy to implement	Time consuming	Training and advisory services	Promote through CAP
	Beneficial organism introduction	Guidelines	No need to apply products	Limited availability against some pests, none for weeds. Difficult to maintain in place	Training, Facilitate organism availability, On site assistance	Facilitate access to credit, tax deduction on investments, saved costs

The **second principle** focuses on the monitoring of harmful organisms. This has to be addressed at two levels:

A Simple instruments to be used at farm level (e.g. checklists, observation sheet, simple software) provided for the main crops and most common pests

B A public monitoring system designed at national or regional level collecting information on the evolution of the main pests and providing forecasts. The system can provide for an interface for the processing of data collected at farm level and their validation with the forecasts at national level.

In the implementation of IPM, monitoring and decision-making work together. Considering the outcome of monitoring, and taking into consideration the scientifically based threshold values, the professional user decides whether or not the plant protection methods should be applied. The integrated approach on plant protection will be applied when the professional user is aware of the full set of up-to-date contextual information.

The aim of applying the **third principle** is to develop a system that maximizes the chance of economic management of pests with the lowest risk for the environment, the professional user, and the bystanders. This aim can be reached if threshold values are established and simple management decision support tools are provided to farmers (e.g. leaflets with decision schemes, recommendation from plant health authorities, simple software, etc.)

Refer. To Annex III	Actions	Tools	Opportunity	Constraints	Support needed for	Financial support
2 Monitoring harmful organisms	Regular observations in the field (scouting)	Checklists, observation sheet, software	Avoid useless treatments (wrong products, wrong timing), improve farmer competence	Requires expertise to be built in time, high level advisory services	Training, on site assistance	Potential cost saving
	Warning, forecasting and early diagnosis	Public monitoring system at regional or national level	Avoid useless treatments, Improve efficacy	Requires expertise to be built over time, high level of advisory, investment in detection devices (meteo, traps, etc.), time c onsuming	Training, on site assistance, model development at proper scale, information platform available	Public funds
3 Application of plant protection measures	Threshold as application criteria	Management decision support tools (e.g. leaflets with decision schemes, recommendation from plant health authorities, simple software, etc.)	Avoid non beneficial treatments	Requires expertise to be built over time, high level of advisory services, Risk of damages from pest population	Training, on site assistance, threshold definition at proper scale, information platform available	Potential cost saving

The **fourth principle** emphasizes the preventative plant protection measures for suppressing the occurrence of harmful organisms. In the case where the biological, biotechnical, mechanical and physical methods provide satisfactory control, they should be used in preference. It should be taken into account that the bio-control agents would preferably be applied in combination with other measures. We should be aware of the fact that the use of non-chemical methods might lead to higher economic costs for the users in the end.

The necessary guidance should be given to the professional users relating to the possible biological, physical and non-chemical methods that are available for each specific crop. It is important to ensure that satisfactory pest control is met by the chosen method, by decreasing rates and application timings as well as achieving sustainability of a measure.

The **fifth principle**, that pesticides applied shall be as specific as possible for the target, aims to reduce pest levels to under the economic thresholds or to eliminate them completely with minimal impact on non-target organisms. Where pesticides have to be applied, attention should be paid to minimizing the impact on the environment and non-target organisms and to protection of the user's health.

The tools we recommend for the application of this principle comprise a set of guidelines for choosing the right plant protection product category for the main pests combined with constantly updated information on the best application technologies as well as the most appropriate mitigation measures to reduce the impact on health and environment. Authorities should give greater importance in providing information on the handling of pesticides and use of personal protective equipment.

Keeping pesticide application at the necessary level is an essential detail for the implementation of IPM and it is included in the **sixth principle** from Annex III of SUD. The dosage of pesticides that is stated on labels is established after years of experimental studies to ensure efficiency. If adequate decision support is employed, the presence of harmful organisms and optimal dates for control can be determined and hence the dosage of the pesticides can be reduced. It should be carefully determined if the dosage reductions are lower than the minimum recommended on the label as this may not be appropriate or useful. In such cases, careful and scientifically accepted handling and use are suggested.

Refer. To Annex III	Actions	Tools	Opportunity	Constraints	Support needed for	Financial support
4 Sustainable biological, physical and other non-chemical methods	Alternative to chemical control	Guidance on the alternative control means and their efficiency	Avoid treatments when valid alternative available	Application not providing satisfactory pest control, No alternative method available	Training, on site assistance	Promote through CAP measures
5 The pesticides applied shall be as specific as possible for the target	Select plant protection products efficacious to the pests present	Guidelines on PPP category to be used and on mitigation measures to reduce risk	Increase efficacy on pest control by precise applications	Limited spectrum of action for the selected products	Training, on site assistance	No support needed
6 Use of pesticides at necessary levels	Enforce doses and applications frequency included on the label	Information campaign on the need to respect the label	Cost reduction, development of good agricultural practice	Possible resistance development due to under dosing	Training, on site assistance	Public funds

The issue of pests' resistance to pesticides is discussed on the **seventh principle** as one of the aspects that is affected by various factors and depends on the interaction of the pests with the pesticides that are used. Once developed, it can remain a problem even after pesticides are not applied any more. Resistance problems tend to develop over time when pesticides with the same mode of action are over-used.

Variation of the plant protection methods and alternating between the chemical classes of pesticides with different modes of action reduces the potential development of pest resistance. As development of pest resistance has many implications on the effectiveness of the products used, authorities should develop strategies to counteract this tendency, based on international guidelines (IRAC, FRAC). Such strategies should be accompanied by simple recommendations for farmers as well as recommendations for the advisory services.

Since in the EU the number of active substances is rather limited due to the high approval criteria used, such resistance situations are very much likely to occur. Failure to address this problem through an appropriate strategy will not only have negative consequences on the crops but will exaggerate the impact on environment and human health.

The **eighth principle** of IPM in the Directive 128/2009 is based on the record keeping on the use of pesticides and on the monitoring of harmful organisms. The success of applied plant protection measures should be checked so as to evaluate their efficiency and decide on necessary adjustments in the future.

Refer. To Annex III	Actions	Tools	Opportunity	Constraints	Support needed for	Financial support
7 Anti-resistance strategies should be applied to maintain the effectiveness of the products	Use of multiple pesticides with different modes of action	Regional or national anti/resistance strategy with simple recommendations for farmers, based on international guidelines (IRAC, FRAC)	Maintain product efficacy and hence optimal pest control	Reduced product availability due to authorization restrictions	Training, on site assistance, product availability	-
8 Check the success of the applied plant protection measures	Maintain records on pesticide use and on the monitoring of harmful organisms	Recommendation	Progressively implement sustainable use, capitalize experience	Higher workload	Direct and indirect checking and recording, to reward system in place	-

RESOURCES AND ACTIONS TO ACHIEVE A SUCCESSFUL IMPLEMENTATION OF IPM PRINCIPLES

IPM requires certain resources for implementation related to knowledge transfer and to production methods.

Knowledge transfer means training, information and research

Training is explicitly required by the SUD for the whole complex of measures, but it appears particularly relevant for IPM. Pest identification, presence estimation, threshold definition, timely application, technical application notions, product choice are examples of skills to be developed.

Pest identification focuses on the correct taxonomic identification of early stages of pest development, (i.e. juvenile form vs. adult). Identification is the preliminary stage to *presence estimation,* which is probably the most critical stage of pest assessment. It requires knowledge of sampling schemes or scouting that cannot be done without proper training and in field practical exercise under the supervision of expert advisors.

Correct presence estimation is the bases for the *threshold definition*. This requires the expertise of trained advisors to plan interventions at the right time (considering several other factors, like wheatear information, or changes in the development stage of the pest). The *technical application* of plant protection solutions is of extreme importance. There are many specific aspects farmers need to know for a precise application of chemical remedies, like equipment calibration, nozzle selection, specific volumes in precise percentages to be applied to different stages of vegetation. The assessment of the efficacy and the evaluation of the level of crop protection achieved needs to be considered in training, as key elements for farmer's choices.

Many farmers, mostly in the case of specialized crops, are already familiar with IPM practices as they had been taken up in the past. Anyway, a challenging effort is to create a common ground of understanding of the concept and its application. Farmers should not be the only ones subject to training- retailers, advisors and decision makers should also share the same understanding about the principles of IPM.

Training should not be episodic, but gradual, moving, from a basic understanding towards higher and more permanent sessions, keeping all the involved operators up to date with the technical progress.

It can be organized either by the national or regional authorities, or by the private sector under the guidance of the public authorities.

Furthermore, the implementation of IPM as an obligatory agricultural tool should be communicated to the wider public to boost public confidence in the agricultural production methods and to stimulate the necessary market and public support and funding for its implementation.

Information is a compulsory requirement of IPM

Today available technologies provide an ideal platform to circulate the necessary information to help the implementation of IPM practices. Meteorological data, pest detection and population dynamics, alerts, application timing, resistance monitoring and more general advice should be available on an easy to access web platform, integrated with a proper local support service for farmers who have no familiarity with information technologies.

General meteorological data needs to be timely and precise, integrating microclimatic data, collected at local level. Climatic and microclimatic conditions are extremely important for planning applications, and are also relevant to specific pest development, particularly fungal diseases. *Pest identification* and presence level *detection* are key elements to forecasting population or disease development dynamics. Notifications of pest occurrence, application timing suggestions and resistance risk monitoring are largely dependent on the quick and proper circulation of information within the farming community. Data should be made available on an easy to access web platform, integrated with a proper local support service for farmers less used to information technologies. Web based models for IPM management with user friendly interfaces could be a further development and include self assessment and result checking tools.

The flow of information should by bidirectional, to verify the correct implementation of IPM and the actual result of the recommendations. The application of monitoring and surveying would provide not only comparable results of the uptake of the measures and the level of implemented IPM practices but also the effects in time of the efficacy of IPM on reducing risks.

Again subsidiarity is indicated as the way to manage the information devices at different scale. The availability of broadband internet connections in rural areas is a pre-requisite to manage information and may represent a relevant infrastructural investment.

Research, development of research outputs, technology transfer are elements which should constantly feed the IPM implementation. New requirements are likely to emerge by the application of IPM and research needs to provide answers that can be translated into practical tools. Research must provide both solutions and feedback data after application. A successful uptake of research results passes through public – private partnership, which should be supported and stimulated. A way to integrate the process, from research to the actual ability to implement innovation by the end users, may be represented by "concept farms", centres of excellence where plot trials, demo trials and information activities take place.

EVOLUTION OF IPM PRACTICES AT FARM LEVEL

IPM is a farm-based tool that is implemented by the farmer based on the specific situation of each field and cultivation. There is not any single recipe for IPM, while the site, the time of season, the weather conditions and many other factors affect its implementation and require flexible management decisions to adapt to the local agronomic, pest and on-farm circumstances. IPM has to be economically sustainable by the farmers and needs to consider the economics of pest management versus the economic viability of the crop, since it had to remain profitable.

Historically the concept of IPM appeared even before its official definition, at the beginning of the 1950's in the US due to a dramatic situation of insect resistance and other pest resurgence as a consequence of a non appropriate use of pesticides in cotton. A successful strategy was implemented, combining control practices with agronomic technical changes and variety choices. Timely applications of pesticides, definition of economic thresholds and reintroduction of natural enemies were the winning elements of the control approach. Then, in 1970 FAO started a global program of IPM diffusion where these elements stood out as the major themes within the projects, combining chemical means and other resources.

Today in the US both the public service and the private sector are promoting IPM, delivering knowledge through the internet and centralized IPM websites. The aim is to maintain a tight connection between agricultural production, research, extension programs and stakeholders. Similar and efficient services are also delivered in Europe such as in Italy; in this country for example the Region Emilia Romagna since the beginning of the 1990 is sending daily information on pest ecology and their control to each farmer web registered throughout mobile and webservice.

European farmers, like farmers in the other developed agricultural countries, gradually became familiar with the concept of IPM, for several reasons; in some cases IPM practices were voluntarily adopted as a mean to rationalize crop protection costs, through a more appropriate application of the plant protection products; in many other cases it was due to a driven "voluntary" process, adopted to comply with the qualification of specific geographic areas, specific productions systems or to comply with the standards required by the food industry or retailer chains.

In Europe two driving forces led this evolution - legislation and requirements imposed by the food industry and retailers. In this last case, quality incentives were offered, justified by the increased costs and the will to offer an image of responsibility to the consumer, presenting on the shelves products clearly identified with a guarantee mark and with the adoption of residue limits below the official MRLs.

Several programs were implemented since the 1980s by national authorities like Denmark, Sweden, Belgium, Italy, Germany, Spain and Austria. These plans often were not truly IPM programs, as they mainly targeted the quantitative reduction of agrochemicals or the substitutions of some of them. During those years and later on, a progressive implementation of good plant protection practices (GPPP, through specific crop protocols) and additional measures lead to the development of IPM programs, mainly for vegetables and orchards and to a lesser extent other crops. The guidelines developed by IOBC (International Organization for Biological and Integrated Control of Noxious Animals and Plants) constituted a relevant reference for the public sector.

The European food industry and retailers took an active role in the dissemination of IPM through GLOBALGAP which serves as a practical manual for Good Agricultural Practice (not necessarily for IPM) developed by a private body that sets voluntary standards for the certification of production processes of agriculture. It is designed to reassure consumers about how food is produced on the farm. The organization left it to the producers to define the details of IPM implementation, providing only a guideline - a basic standard toolkit, where several actions are suggested for each of the three pillars of IPM: a) **prevention,** b) **monitoring and evaluation**, c) **intervention**. They also provided training, certification and benchmarking systems to ensure the integrity of all associated processes.

The Member States apply different activities and measures in order to reduce the risk of plant protection products. In Austria for example, these measures are applied in national and regional level as well. Austria applies a measure-mix, i.e.: numerous measures and provisions from various legal fields, supported by additional measures with financial compensation. In Finland there is no legal status of IPM but IPM principles are used in greenhouse vegetable production by over 90% of the growers. In Poland the implementation of the general principles of IPM is obligatory since 2004; however, the implementation of crop specific standards is voluntary. Furthermore, in Estonia, there is no clear distinction between IPM and the good protection practice.

Just as an example the Greek agricultural authorities have released a comprehensive guideline on "System of Integrated Management in Agricultural Production" which includes consistent information on the implementation of Integrated Pest Management. The aim of the guidelines is to obtain a united and uniform implementation of the requirements of the standards AGRO 2-1 and AGRO 2-2. AGRO 2 that refer to the management of the agricultural environment and Integrated Pest Management (IPM). The document describes the general principles as well as setting detailed requirements for the implementation in crop production. These requirements refer to all the stakeholders involved in the production process.

Furthermore, they have released three more crop specific protocols (under the heading of AGRO 2), that are focused on the cultivation of cotton, peaches and olives under the guidelines of IPM.

As general principles, the standard provides guidelines on all the aspects that refer to agricultural practice such as:

- Plant propagation
- General cultivation techniques
- Soil management
- Fertilization
- Irrigation systems
- Plant protection
- Pest management
- Harvest and post-harvest management
- Equipment management and energy management
- Waste management
- Environment and biodiversity
- Operators' health and workers' training

It was difficult to evaluate the penetration of IPM practices in Europe and only partial data are available about the level of adoption in specific production areas. In some cases IPM was considered as the actual technical standard, while in others even GPPP was still a goal to be achieved. Anyway a strong base of practical experiences is already in place providing a starting point for the further adoption of IPM. To be more effective this heritage needs a stronger integration and emphasis throughout the different public and private organizations, where information exchange, sharing of experiences and evidence of pragmatic and effective solutions could circulate and hence become common practice.

LIMITATIONS IN IMPLEMENTING IPM

The major challenge for the decision makers will be to find economic resources to sustain the knowledge transfer, by directly providing or indirectly incentivizing the activities of training, information and research. Gradual, realistic targets are to be defined according to local conditions.

At the initial stage of IPM implementation some measures can be introduced more promptly. Threshold levels may be introduced quickly as farmers are already familiar with the most widespread pests that commonly occur. Traps and other monitoring devices should also be a priority. Soil management techniques require more time, but are anyway consistent with other short – medium term objectives. The choice of crop varieties more resistant to pests, if available, can be implemented in a short time for herbaceous crops, but are a matter of long term planning for vines and orchards. Alternative practices to chemical treatments need a case by case approach and, if available and competitive with chemicals, may require specific training and a certain time lapse before being fully implemented.

More specific actions may be demanded by producers' associations, unions or other intermediate bodies, but the real question is how the farmer can bear the extra costs. Providing good quality services through policy is a positive measure, however considering that the cost of inefficiency may not be immediately detectable, the final burden weighs on farmers.

Taking into consideration the supporting activities outlined, the next step is to understand how the farmer will manage the actual extra cost of implementing IPM.

The extra costs are represented through: the additional workload required, training, the IPM activities (field scouting, more precise application, information exchange, controls), investments in machinery and other equipment.

The easiest answer, currently practiced by more robust economic activities, is to move the costs down to the final consumer. Consumers will be more open to accept extra costs if they are convinced of the corresponding benefits, food safety and sustainability. This needs to be better transmitted to the general public, in the sense of providing a greater confidence in modern agriculture.

It will be difficult to sell the concept of IPM as a mark of a more efficient and reliable food production process if it is described only as a sum of rules. Food industry and retailers have to play a fundamental role in this perspective. Strong partnerships based on sustainable projects between farmers and the food industry could have several advantages from an economic, social and environmental perspective. Through stabilizing business partnerships farmers could gain long term contracts ensuring their income; consumers could be provided with specific knowledge of production techniques and food safety and quality information; environmental concerns could be tackled by continuous agriculture production on available land, sustainable use of the natural resources, enhancing biodiversity and preservation of the countryside.

The possibility of a direct compensation for IPM passes through the integration of this practice and the other requirements of the Directive into the Common Agriculture Policy due to the inclusion of SUD in cross-compliance. Taking into account more general EU rules, other possibilities may be represented by facilitating access to credit for investments (machinery, storage and pollution prevention facilities), tax deductions for investments, social security facilitates and other indirect measures consistent with local rules.

REGULATORY INITIATIVES RECOMMENDED TO BE TAKEN INTO CONSIDERATION FOR A SUCCESSFUL IMPLEMENTATION OF IPM

- Provide a robust extension service network, integrate it with stakeholder advisory initiatives
- Make available a training network open to the contribution of all the involved categories (farmers, advisors, PPP producers, researchers), working on a permanent basis and learning from experience
- Consider financial support to the farmers as a priority in implementing funding policies (CAP support, credit facilities, insurance funds) and rewarding diligence
- Define a realistic roadmap to a gradual implementation of general and specific measures
- Establish a network of demonstrative excellence centres, where IPM can be shown in practice and pivotal training provided
- Coordinate research efforts at national level on the basis of priority problems, then consider technology transfer a primary tool
- Maintain a clear distinction between organic farming and IPM farming; the scope of the directive is not to move one model to the other.
- Avoid the application of IPM rules as a way to re-authorize plant protection products. A wider variety of solutions is a relevant aid to implementing IPM. Authorized products are safe by definition when properly applied, and mitigation measures are the natural complement to IPM
- Implement application surveys and controls avoiding an extra bureaucracy charge to farmers, privilege indirect assessments and recordings which can help farmers in self evaluating the efficacy and the cost of IPM practices
- Delegate as far as possible to local aggregations, as subsidiarity costs will be less than for centralization and they are more flexible in responding to specific exigencies and market solicitations
- Promote initiatives to increase public awareness that IPM agriculture provides unrivalled food quality and safety; and is where tradition and technology successfully meet.
- Implement innovation technologies such as the use of mathematical models for predicting the intervention time and the application technologies

ANNEX I

General principles of integrated pest management (Annex III to the Directive)

1. The prevention and/or suppression of harmful organisms should be achieved or supported among other options especially by:
   - crop rotation,
   - use of adequate cultivation techniques (i.e. stale seedbed technique, sowing dates and 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 spreading of harmful organisms by hygiene measures (i.e. by regular cleansing of machinery and equipment),
   - protection and enhancement of important beneficial organisms, e.g. by adequate plant protection measures or the utilisation of ecological infrastructures inside and outside production sites.
2. Harmful organisms must be monitored by adequate methods and tools, where available. Such adequate tools should include observations in the field as well as scientifically sound warning, forecasting and early diagnosis systems, where feasible, as well as the use of advice from professionally qualified advisors.

3. Based on the results of the monitoring, the professional user has to decide whether and when to apply plant protection measures. Robust and scientifically sound threshold values are essential components for decision making. For harmful organisms threshold levels defined for the region, specific areas, crops and particular climatic conditions must be taken into account before treatments, where feasible.
4. Sustainable biological, physical and other non-chemical methods must be preferred to chemical methods if they provide satisfactory pest control.
5. 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.
6. The professional user should keep the use of pesticides and other forms of intervention to levels that are necessary, i.e. by reduced doses, reduced application frequency or partial applications, considering that the level of risk in vegetation is acceptable and they do not increase the risk for development of resistance in populations of harmful organisms.
7. Where the risk of resistance against a plant protection measure is known and where the level of harmful organisms requires repeated application of pesticides to the crops, available anti-resistance strategies should be applied to maintain the effectiveness of the products. This may include the use of multiple pesticides with different modes of action.
8. Based on the records on the use of pesticides and on the monitoring of harmful organisms the professional user should check the success of the applied plant protection measures.

REFERENCES

1. Development of guidance for establishing Integrated Pest Management (IPM) principles, 07.0307/2008/504015/ETU/B3, Final Report 24 April 2009. Subcontractor: BiPRO Beratungsgesellschaft für integrierte Problemlösungen, Subcontractor: Julius Kühn Institute
2. ENDURE - IPM TRAINING GUIDE,
3. Integrated Pest Management, The perspective of partners in the food value chain. The document is prepared in common with by the following associations: CELCAA, European Crop Protection Association, COCERAL, freshfel Europe, PIP, COPA-COGECA, AREFLH, EISA
4. ENDURE (2010) - Integrated Pest Management in Europe, The ENDURE Network of excellence shares the fruits of four years' research with the crop protection community. Project achievements 2007-2010, INRA, 132 pp
5. ENDURE Policy Brief Nr 1,2,3November 2010
6. United States Department of Agriculture - Natural Resources Conservation Service, Conservation Practice Standard - Integrated Pest Management (Ipm), January 2010.
7. Rechcigl J. E., Rechcigl N. A. (eds.). Insect pest management: techniques for environmental protection. Lewis Publishers, Boca Raton, New York, 2000.
8. Pimentel D. (ed.). Encyclopedia of Pest Management. CRC Press, Boca Raton, London, New York, 2007.
9. Ciancio A., Mukerji K. G. (eds.). General Concepts in Integrated Pest and Disease Management. Spinger, Dordrecht, 2007.
10. Ciancio A., Mukerji K. G. (eds.). Integrated Management of Arthropod Pests and Insect Borne Diseases Spinger, Dordrecht, 2010.
11. Flint M.L., Daar S., Molinar R.. Establishing Integrated Pest Management Policies and Programs: A Guide for Public Agencies. University of California – Division of Agriculture and Natural Resources, Davis, 2003.
12. Hommel B., Dachbrodt-Saaydeh S. (eds.). EU Expert Meeting on National plans and programmes for the reduction of risks associated with the use of plant protection products. Berlin, March 13 – 14, 2007. Kleinmachnow, 2007.
13. Jervis M. A. (ed.). Insects as Natural Enemies. A Practical Perspective. Spinger, Dordrecht, 2005.
14. Peshin R., Dhawan A. K. (eds.). Integrated Pest Management: Innovation-Development Process. Spinger, Dordrecht, 2009.
15. Radcliffe E. B., Hutchison W. D., Cancelado R. E. (eds.). Integrated Pest Management - Concepts, Tactics, Strategies and Case Studies. Cambridge University Press, New York, 2009.

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