EUROPEAN COMMISSION
DIRECTORATE-GENERAL
ENVIRONMENT
Directorate B - Protecting the Natural Environment
ENV.B.3 - Biotechnology, Pesticides and Health

Implementation of IPM principles

Guidance to Member States

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PURPOSE OF THIS DOCUMENT

This document aims to give practical guidance to Member States with regard to requirements concerning Integrated Pest Management (IPM) under the new Framework Directive on the sustainable use of pesticides.

It contains examples of actions allowing successful implementation of IPM principles by professional users of pesticides and proposes them as possible models. More details can be found in the BiPRO study on IPM.

Economic aspects regarding the implementation of IPM (e.g. cost/benefit analysis) can be found in the Impact Assessment of the Thematic Strategy on the sustainable use of pesticides.

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1. INTRODUCTION

The Framework Directive on the sustainable use of pesticides aims to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and on the environment and by promoting the use of IPM and of alternative approaches or techniques such as non-chemical alternatives.

In Article 14 of the Directive, Member States are requested to:

- promote the use of IPM by professional users of pesticides (amongst other low pesticide-input pest management approaches);
- establish or support the establishment of necessary conditions for the implementation of IPM (in particular information and tools for pest monitoring and decision making, advisory services);
- ensure that the general principles of IPM, laid down in Annex III, are implemented by all professional users by 1 January 2014;
- encourage professional users to implement crop- or sector-specific guidelines for IPM on a voluntary basis.

This guidance document aims to help Member States (MS) implement these provisions and identify the boundaries between general and crop specific IPM elements. It also contains information on actions MS will have to take before IPM principles can be made mandatory, it shows possible ways to take these actions and to monitor compliance. The connections and the differences between IPM and Good Plant Protection Practise (GPPP) are also highlighted and concrete examples are given.

2. WHAT IS INTEGRATED PEST MANAGEMENT?

In the Framework Directive, IPM is defined as *'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'*. This definition derives from a FAO definition.

IPM can be described as a holistic and dynamic ecosystem approach for crop protection that combines different management strategies to obtain robust cropping systems and minimise pesticide use. It improves continuously and is based on four key steps:

- Application of continuous, manifold general precautionary and supportive measures such as appropriate crop rotation, cultivation techniques, hygiene measures and enhancement of important beneficial organism by the utilisation of ecological infrastructures inside and outside the production sites.
- Use of a well established continuous monitoring methodology/system, including a pest warning and forecast system, in order to follow the development of pests and diseases.
- Use of an appropriate decision making system. Based on the monitoring results, this shall enable the professional user to decide whether and when to apply plant protection measures.
- In case plant protection measures are necessary, several rules must be followed:
    - Non-chemical methods should be preferred whenever they provide satisfactory control
    - In cases where chemical methods have to be used, they shall be as specific as possible and shall have the least side effects
    - The intervention shall be minimised
    - Anti-resistance strategies should be applied where needed
    - Success of intervention shall be checked based on records and monitoring

Figure 1 shows how these different elements work closely together.

In other words, IPM relies on complementary methods drawn from a diverse array of approaches including biocontrol agents, plant genetics, cultural and mechanical methods, information technologies, and also plant protection products to face critical situations. This diversity of methods is needed for sustainability purposes: the continuous use of one single method to control a given pest, be it the most favourable solution initially, will rapidly induce pest populations to evolve and overcome this method (chemical or non-chemical).

The way the general principles are implemented in practise depends on local conditions (soil, climate, weather conditions, pest pressure, etc.) and changes over time.

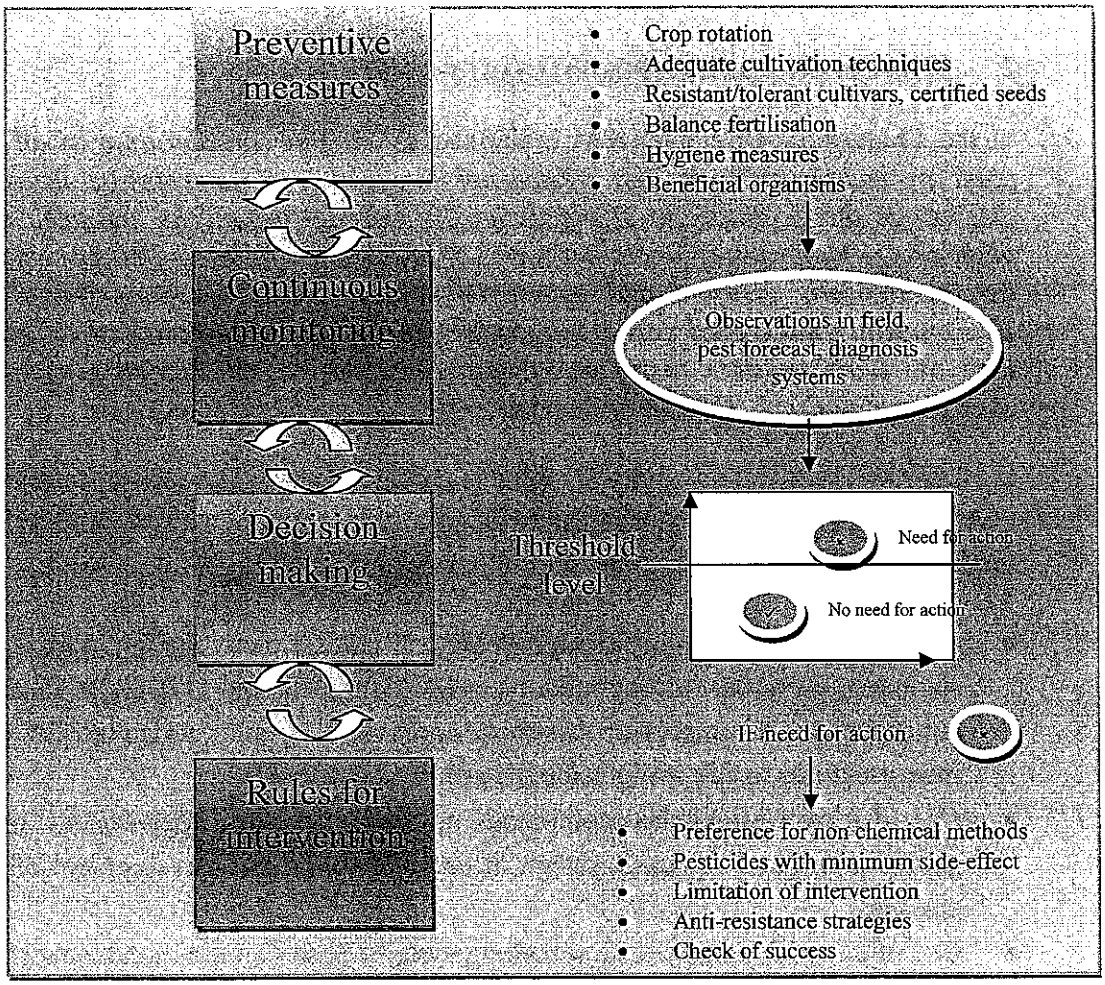

Figure 1 Main steps for integrated pest management

2.1. General principles

IPM relies on eight general principles listed in Annex III to the Framework Directive. These principles complement each other and it is their combination that ensures success. However, some principles are more crucial than others in the IPM process. For instance, prevention of pests (principle 1) is of paramount importance.

Principle 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 (e.g. 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 spread of harmful organisms by hygiene measures (e.g. 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.

What does this principle mean?

In order to achieve an effective Integrated Pest Management system it is essential to combine various preventive measures to create or favour conditions that will reduce the frequency and intensity of pest outbreaks and lead to robust cropping systems. A thorough implementation of Principle 1 is essential for the success of IPM.

In this regard, each category of this list should be fulfilled as far as possible: for instance prophylactic or hygiene measures adapted to cropping systems should always be applied, certification of disease-free seeds, seed potatoes, bulbs, cutting and new sorting technologies are very helpful to avoid problems, and conservation of the natural biodiversity for an optimal exploitation of natural pest control services is of paramount importance. Continuous cropping in non-perennial crops should be definitely avoided, and wherever feasible, alternating winter and spring-summer crops in arable rotations should be encouraged to break the life cycle of many pests more efficiently than a rotation of the same duration with winter crops only. Similarly, rotations between leaf and root crops should be promoted for vegetable cropping systems, and crops of the same botanical family should occur as least as possible. As far as conservation tillage is concerned, its use needs to be assessed on a case-by-case basis since in some conditions it could lead to greater herbicide dependency or favour certain fungal outbreaks.

It should be kept in mind that this list is not closed nor exhaustive. The formulation used is "among other options," which means that the six points mentioned are the most evident in this regard but addition of further necessary elements depending on local situations has to be considered in any case.

Which tools need to be set up by MS before a professional user can apply the principle?

In order to enable professional users to implement and apply this principle MS should ensure that clear guidance is provided regarding appropriate practise for all elements mentioned in this principle. For example, it is necessary to provide information related to appropriate crop rotation schemes that should be used.

The information should be easily accessible for all professional users (e.g. through a web-based system, newsletters, information offices, specific meetings, etc.) and should be adapted to their local situation. Independent certified advisers should definitely be involved in decisions made at this key step.

Applied research to determine a range of appropriate preventive measures is also important for allowing application of this principle.

Principle 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.

What does this principle mean?

Pest/disease monitoring is one of the key elements of an IPM system. The purpose of monitoring is to collect information 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/system has therefore a significant impact on the success of IPM.

Such monitoring shall at least include regular and thorough observation in the field as well as advice from professionally qualified advisors, completed where feasible by scientifically sound warning, forecasting and early diagnosis systems. Sound systems of certified advisors, but also adequate tools for pest monitoring and forecasting are therefore essential to be developed.

Which tools need to be set up by MS before a professional user can apply the principle?

One significant aspect is applied research related to optimisation and further development of tools for pest monitoring and forecast. Such research should be supported to a large extent at national level and should be carried out by appropriate national experts in the relevant authorities or related institutes, taking multi-year effects in consideration.

Specific early warning instruments should support the monitoring carried out at farm level and professional organisations or advisory services should be involved to provide such information. Member States should precisely specify which monitoring activities will have to be carried out by competent authorities, professional organisations, advisory services or professional users.

The production of logical guidelines including crop-specific elements could provide professional users with all information necessary to apply efficient monitoring in the sense of IPM, in particular:

- Who should carry out the monitoring to ensure effectiveness? Qualification levels and independency should be considered.
- How shall the monitoring been carried out? It should be considered that different crops might require different monitoring methodology/systems. The need to identify pests and diseases correctly is one of the most crucial issues.

Principle 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.

What does this principle mean?

Considering the outcome of the monitoring activity (e.g. a specific pest has been identified at a given density) and based on sound decision rules (e.g. above which pest density is intervention necessary in this specific situation?) the professional user has to decide whether an intervention is needed and, in such case, which one would be the most suitable. Sound intervention thresholds can be very useful, however thresholds may not always be available, apply or be appropriate. Only if professional users are aware of the full set of up-to-date information will they be in a position to decide whether intervention is needed and to ensure that pest management will be done in an integrated way.

It is essential to consider all possible interactions and consequences of any intervention. Economic, health and environmental impacts will have to be taken in consideration for decision-making.

Which tools need to be set up by MS before a professional user can apply the principle?

It is important to provide every professional user with access to necessary information. Such information needs to be regularly updated and specific for each crop and for each pest. In particular, sufficient information related to pests will be needed by professional users. Regular and specific training on IPM as well as availability of certified independent advisory services to provide information are crucial tools to ensure proper decision-making.

The agronomical status of pests observed has to be taken into account in the decision making. Pests can be allocated to three categories:

(i) key or major pests persistent and occurring perennially which dominate management practise. In the absence of control, they cause severe economic damage;

(ii) occasional pests whose status fluctuates and are under control in adequate biological and environmental conditions;

(iii) minor pests that cause no significant damage under prevalent conditions but whose population might be directly stimulated by control procedures at controlling key or occasional pests.

This classification can change from year to year and combination effects have to be taken into account (minor pests can become key pests in combination with other pests while key pests may also become occasional ones).

In addition, the legal status of pests observed (i.e. according to Directive 2000/29/EC) has to be taken into account for the decision making: decision will of course depend upon whether a pest is a quarantine organism and whether full eradication has to be endeavoured.

Many already elaborated decision making systems are available for purchase that are produced by private or international organisations. Such available systems which might already be in use by professional users provide a good basis on which to further build up a national decision making system or which might be suitable as an alternative.

Where feasible and applicable, thresholds levels can help professional users make decision. There are four distinct types of thresholds commonly used for one single pest and one single crop:

- The visual threshold is the minimum density of a pest at which it can be observed.
- The damage boundary indicates the level at which damage can be observed.
- The economic injury level (EIL) is the level at which a pest population is capable of producing an amount of damage that, if prevented, could offset the costs of treatment. In other words, this is the level at which treatment costs are balanced with the benefit resulting thereof. It needs regular updating.
- The action threshold (AT) is the level just below the EIL at which one should apply a plant protection measure to keep an increasing pest population from reaching the EIL.

The relation between the above-mentioned levels is shown schematically in Figure 2.

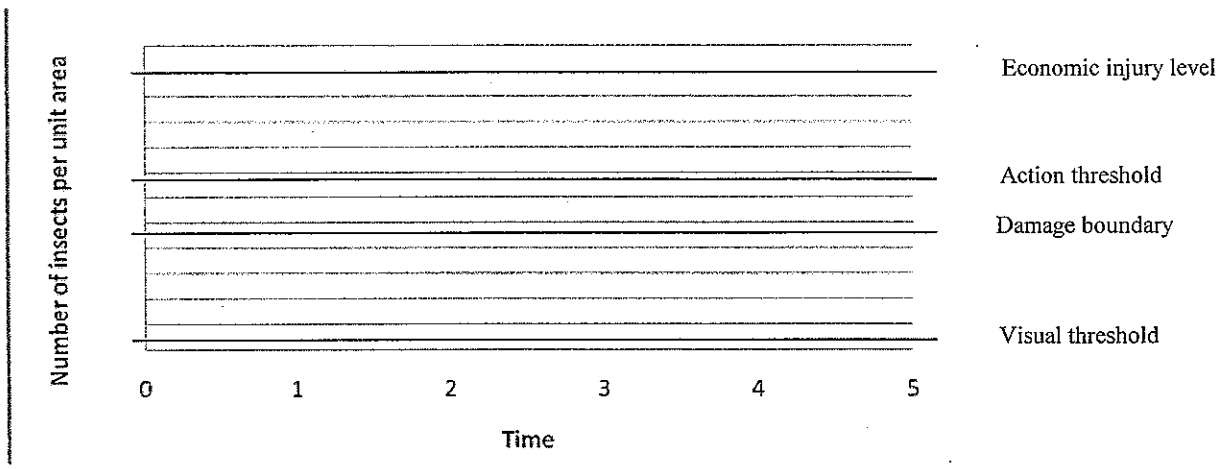

Figure 2 **Correlation of different intervention levels**

Establishing an action threshold is not a simple task but can be useful. In order to provide efficient information to all professional users, research on this topic should be encouraged by Member States.

Principle 4 Sustainable biological, physical and other non-chemical methods must be preferred to chemical methods if they provide satisfactory pest control.

What does this principle mean?

This principle and the following ones provide clear guidance as to what kind of intervention should be considered in case plant protection measures are necessary. Principle 4 means in particular that chemical methods should be used as a last resort, in case other methods (biological, mechanical, etc.) would not lead to the pest management needed in this specific situation.

Releases of bio-control agents or the use of other non chemical methods have usually lower and/or slower pest control power. They should therefore be combined as much as possible in order to achieve satisfactory management or regulation of pest populations, keeping in mind that total pest eradication is often not needed.

Alternative methods may be more time-consuming or may be more expensive than chemical methods. However, one should be aware that the costs of pesticides do not incorporate externalities, i.e. they do not reflect the real costs for the whole society deriving from negative impacts to human health and the environment.

It is therefore crucial to change practices and shift from simple solutions at relatively low apparent costs towards more complex combination of pest management practices which are much more sustainable and lead to benefits for the whole society.

Which tools need to be set up by MS before a professional user can apply the principle?

Here again, provision of information is a crucial prerequisite to enable professional users to apply this principle correctly. There are two main elements of information, which appear necessary for principle 4. On the one hand, it is necessary to give guidance related to possible biological, physical and other non-chemical methods. Such information must be specific for cropping systems as well as for pests and diseases. One should ensure that all professional users have access to information easily and that information is updated continuously. On the other hand, the principle states that non-chemical methods are preferred where they provide satisfactory pest control. It should be made clear to professional users what is meant by "satisfactory pest control". In particular, this is correlated with a reduction but not necessarily with a complete eradication of the pests. To define "satisfactory" one should consider decreasing rates and periods as well as sustainability of a measure. It has proven to be a good concept to carry out demonstration experiments or to use demonstration farms in order to show how non-chemical methods

can be applied efficiently. It is essential to support research and practical testing at national level.

Subsidies to farmers making the effort to already shift towards IPM strategies before 2014 should be included in their rural development programmes.

Principle 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.

What does this principle mean?

Like principle 4, principle 5 provides a rule in case plant protection measures have to be applied. In such a case, it addresses chemical plant protection methods, including plant and tree extracts and mineral pesticides. Where pesticides have to be applied, priority shall be given to measures which have the minimum impact on human health, non-target organisms and the environment. The product applied must be appropriate for the target as indicated on the product label, or for officially approved off-label uses.

For this principle, it should be considered that the aim is not the complete elimination of a pest, but the reduction to a level below the economic threshold.

Which tools need to be set up by MS before a professional user can apply the principle?

Similarly to other principles, the provision of continuously updated information is also for principle 5 a prerequisite in order to enable professional users to apply the principle. It is important to provide specific information for each combination of pest/crop, indicating which pesticide can be used taking into account the target specificity as well as hazardous properties (including toxicology and ecotoxicology) and classifications of the product. The involvement of advisory services to assist professional users when carrying out comparative assessments of possible treatments is crucial.

Principle 6

The professional user should keep the use of pesticides and other forms of intervention to levels that are necessary, e.g. 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.

What does this principle mean?

In accordance with the demand for "as much as necessary but as little as possible" it is a stated aim of IPM to limit interventions 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 or frequency reductions or partial applications have to be applied where appropriate. Advisory services should be involved in this regard.

The registered label dose is a maximum dose that has been established based on many trials as part of the authorisation procedure. Often, appropriate and lower doses can be recommended specifically if information on pest level, weed size and canopy is included in the decision making.

The increased risks of resistance when applying lower doses are true mainly in intensive systems (e.g. continuous cropping) and not 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.

Which tools need to be set up by MS before a professional user can apply the principle?

Access to sufficient information and guidance, in particular regarding "what is the necessary level" is very important. In addition to economic aspects, training, experience, attitude to risk and the quality of advice are important parameters. In this respect the role of independent certified advisers is very important.

The establishment of a network of reference farms (random sample of typical farms) and some demonstration farms (to demonstrate how interventions can be minimised) would also contribute to provide guidance to farmers. This would also allow the collection of necessary minimum data in main crops, which may vary from region to region and year to year. With this approach it is ensured that all influences (seasonal, local, etc.) are taken into consideration on an up-to-date basis.

Principle 7

Where the risk of resistance against a plant protection 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.

What does this principle mean?

According to the IRAC (Insecticide Resistance Action Committee), resistance may be defined as 'a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species'.

Resistance problems generally occur when pesticides with a similar mode of action are used at high doses and/or with high frequencies. Studies on fungicide resistance have

shown that using less products on smaller areas usually slows down the emergence of resistance.

Diversifying the methods of plant protection (e.g. physical, biological, chemical) and alternating among classes of pesticides with different modes of action can help to lessen the possibility of pest resistance. As mentioned in principle 6, the conditions for IPM implementation *per se* help to keep risks for resistance problems low.

Which tools need to be set up by MS before a professional user can apply the principle?

The tool to be established before professional users can apply principle 7 is once again information, preferably provided via a network of independent and qualified advisers. Such information should cover several aspects in particular:

- Information on known risk of resistance development for specific products and pests
- Recommendations for anti-resistance strategies, notably the use of alternatives with different modes of action (notably non-chemical solutions) and reduction of doses, frequencies or application areas

Principle 8
Based on the records of the use of pesticides and on the monitoring of harmful organisms, the professional user should check the success of the applied plant protection measures.

What does this principle mean?

In order to check the success of applied plant protection measures, 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.).

It is required from the professional users to reflect on the efficiency of their strategies This approach is important for learning from experiences and is helpful for all following interventions or decisions of non-intervention. It is important to note that this principle addresses all types of intervention, not only chemical ones.

Which tools need to be set up by MS before a professional user can apply the principle?

Proper documentation provides an excellent basis for reviewing if the established tools are helpful and lead to a real implementation of integrated pest management. Clear guidance must be provided to professional users as to how success should be checked and which data should be used for this. In this regard, continuous monitoring before and after intervention, decision-making processes and applied plant protection measures as well as

levels of plant development, threshold limits used etc. are of interest. Only with the full set of available information is it possible to evaluate understanding and real implementation of IPM principles.

It should be made very clear that success of a plant protection measure does not mean the complete elimination of a pest, but that the decrease below specific levels of pest pressure. 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 some more time.

2.2. Difference with Good Plant Protection Practice

Good Plant Protection Practice (GPPP) is defined in the Regulation on the placing of plant protection products on the market as a *'Practice whereby the treatments with plant protection products applied to a given crop, in conformity with the conditions of their authorised uses, are selected, dosed and timed to ensure optimum efficacy with the minimum quantity necessary, taking due account of local conditions and of the possibilities for cultural and biological control.'* This definition was drafted by EPPO (European and Mediterranean plant protection organisation).

GPPP gives general rules on the use of plant protection products:

- it has to be in line with legal requirements,
- the choice of the treatments, the dosage of products and time of interventions have to ensure optimum efficacy with the minimum quantity of products,
- possibilities for cultural and biological control have to be taken into account in the decision making.

Differences and similarities between, IPM and GPPP can be summarised in Table 3

Table 3 Similarities and differences between GPPP and IPM

	Good Plant Protection Practice	Integrated Pest Management
Compliance with legal regulations	Strict compliance with legal regulations with additional recommendations in terms of optimising treatment efficacy with minimised side-effects	Strict compliance with legal regulations with additional requirements in terms of a more sustainable farming with minimised intervention and side effects
Prevention and Suppression of harmful organisms		
- **Crop rotation**	Recommendations	Requirements, e.g. 3-field rotation in arable cropping
- **Cultivation techniques**	Common practise	Appropriate practise has to be used

- **Resistant varieties** - **Fertilisation, irrigation** - **Hygiene measures** - **Enhancement, beneficial organisms**	Use of site-related appropriate varieties Common practice Common practice Consideration of natural pest control	Use of resistant varieties when feasible Best practice has to be used Best practice has to be used Consideration and use of natural control. Beneficial organisms are included in action thresholds, use of selective pesticides, enhancement of natural pest control by field margins and other structural elements
Monitoring	Observation of fields for infestation	Pest monitoring according to information of advisory services or monitoring plan. use of available forecasting tools
Threshold values	Threshold values can be used for decision-making after simple evaluation of infestation, including experience and. if possible, advisory service information	Decision-making after field monitoring using action thresholds where available and all available forecasting and decision making systems
Non-chemical methods	Not appropriate	Preference is given to non-chemical methods
Target specificity and side-effects	Use of authorised and appropriate pesticides with least side-effects	Use of most appropriate intervention with least side-effects
Minimum necessary	Users have to use the minimum quantity of products ensuring maximum efficacy	Users have to keep pesticide use to levels that are necessary (as much as needed and as low as possible) by reduced doses. reduced application frequency and partial applications
Documentation	Documentation of field-related pesticide use	Documentation of field-related infestation situations and pesticide use

GPPP is fully in line with IPM principles and is applied when plant protection products are used as part as control methods available for IPM.

In other words, IPM is a holistic approach which incorporates GPPP when plant protection products are used but goes beyond GPPP.

2.3. Crop-specific IPM guidelines

MS will have to ensure that guidelines are developed for different cropping systems or sectors. The implementation of such guidelines by professional users of pesticides will be voluntary.

These guidelines will be based on the eight general IPM principles, however they will go beyond the general principles through addition of further "higher level" requirements: these additional requirements could either be independent from the existing principles and address other aspects or be more prescriptive and provide a higher level of details in the way to apply the IPM principles.

In other words, crop-specific IPM principles should contain, in addition to requirements deriving from the general IPM principles, two types of further requirements:

- Additional independent principles, which are not addressed within the general principles but are beneficial for specific crops or cropping systems.

Example: for a potato crop, in addition to entry level (mandatory) requirements proposed in Chapter 5 (concrete example) for Principle 1, a higher level (voluntary) requirement could be to also include implementation of a specified minimum distance between potato fields in the same farm.

- Specific concretisation of the general principles for each cropping system: the degrees of freedom left to professional users when applying the IPM principles for a given cropping systems are decreased.

Example: for a potato crop, a mandatory requirement regarding crop rotation could be to adopt a 3-year rotation without any other Solanaceae crop whilst a voluntary requirement could be to also impose alternating winter and spring-summer crops as well as leaf and root crops.

The proportion and content of both types of further requirements can of course vary depending on the cropping system, the local situation (soil, climate, pest pressure, etc.) and over time. In any case, a minimum concretisation of the general principles will be necessary for each cropping system in order to ensure effectiveness, as well as addition of independent requirements as far as possible.

This could be illustrated in Figure 4.

An obvious way for a professional user to implement general principles of IPM for a given crop is of course to implement the corresponding crop-specific IPM guideline.

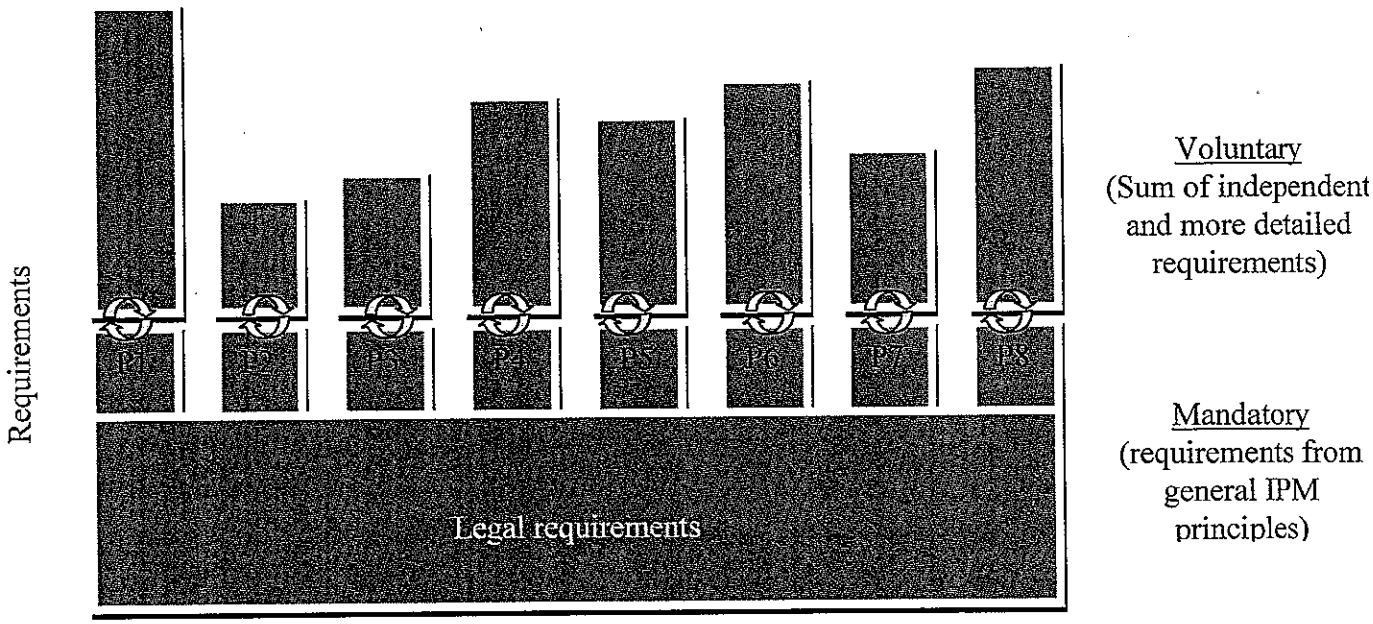

Figure 4 Relation between general and crop specific IPM principles (P= principle)

3. PREREQUISITES FOR SUCCESSFUL IPM

The success of IPM strategies depends upon a number of key parameters that Member States will need to develop or further support as soon as possible, in order to prepare the transition until 2014. Minimum pre-requisites are the following.

3.1. Availability of a range of effective and affordable IPM solutions

Crop-specific guidelines have been developed for a number of crops in Member States. However, for many cropping systems, applied research is still needed to develop successful crop-specific strategies for IPM. Public and private research on sustainable and innovative crop protection technologies as well as multidisciplinary research on whole cropping systems should therefore be supported at national level.

At the same time, synergies should be created at European level, in particular via ENDURE and, after ENDURE, via a new project on IPM to be launched in 2011.

3.2. Access to knowledge on IPM strategies for professional users

Communication on IPM to professional users definitely needs massive investment and development. In this regard, training systems developed in Member States under the Framework Directive will be an important instrument, as well as efficient surveillance networks.

It will also be crucial that Member States support the development of certified IPM advisory services organised by cropping systems to bridge the gap between research and end-users and help farmers for the adaptation of IPM principles to local situation. Such advisors could train groups of professional users on IPM in the framework of workshops, winter schools, demonstration sessions in demo-farms or specific field meetings. They could also assist them along the growing season for the practical and local adaptation of the IPM principles, and could therefore play a key role for compliance monitoring.

In particular, information provided to professional users should highlight the importance of:

- the use of various preventive measures,
- the continuous need for monitoring (in crops and using surveillance or forecast networks) and how to do this monitoring,
- a sound decision-making system. Professional users should be told where they can obtain relevant information and how this information should be used. The involvement of plant protection services is strongly recommended in this process. In particular, a list of official laboratories for pest detection should be available for professional users.

Convenient tools for communication may be web-based systems, newsletters, information offices. Professional users should be encouraged to adopt modern media and communication systems.

3.3. Promotion of IPM before 2014

Much before IPM principles become mandatory in 2014, it will be very important that Member States give positive signals to professional users, in order to encourage them to implement IPM strategies as soon as possible. To this end, Rural Development Programmes prepared by Member States should incorporate financial incentives for farmers to already start implementing IPM principles before 2014.

This should be accompanied by information campaigns on IPM for consumers and the supply chain, notably retailers and supermarkets, in order to increase IPM acceptance in the whole food chain. Such campaigns would aim to increase consumer demand for IPM products and reward IPM practices, thus delivering positive market signals for farmers.

When starting IPM and moving to less familiar practices, farmers may face higher risks of reduced yields. Without any financial support coming from rural development and without any positive signals coming from supply chains and consumers, farmers would not be encouraged to shift towards IPM strategies before 2014. When IPM general principles become mandatory as from 2014, professional users will have any way to implement those principles, but then no financial support will be available any longer to facilitate this transition and compensate possible yield reductions.

However, as crop- or sector-specific IPM guidelines will be implemented on a voluntary basis, it will still be possible for farmers to receive subsidies for implementing those guidelines, provided this is foreseen in MS rural development programmes.

4. COMPLIANCE MONITORING

In addition to encouraging compliance, starting from the transition period before 2014, MS competent authorities will of course have to check compliance with legislation.

A possible way to monitor compliance could be evidence provided by the professional user showing:

- the appointment of an appropriate advisory service (including implementation of e.g. warning service subscription) as well as regular contacts with this service;
- approval for each crop before the growing season of an IPM plan by a certified IPM advisory service;
- evidence for regular pest monitoring activity.

It may be most appropriate to place more responsibility for compliance on advisory services rather than on farmers. Advisers would be the most appropriate people to assess whether decisions made on the ground are in line with IPM strategies and thus whether professional users really implement IPM principles. This highlights the importance of having a well-developed and efficient network of advisory services certified on IPM.

Elements which could be controlled for the various principles are listed in Table 5.

Table 5 Possible elements for compliance monitoring

No.	Principle	Elements that can be used as performance indicators
(1)	Measures for prevention and/or suppression of harmful organisms	Is the professional user aware of possibilities related to preventive and supportive measures and has he applied them appropriately? In particular:
	1.1 Crop rotation	Has the professional user checked the latest information related to crop rotation? Has a crop rotation scheme been applied, which was recommended by certified advisors for the region?
	1.2 Cultivation techniques	Has the professional user checked the latest information relating to current practicable cultivation techniques? Has a cultivation technique been applied, which is recommended by certified advisers for the region?
	1.3 Resistant varieties	Has the professional user checked the latest information relating to varieties known to be resistant or tolerant to specific pests? Has a resistant or tolerant variety been used? Were certified seeds or planting materials used?
	1.4 Fertilisation/irrigation	Has the professional user checked the latest information on fertilisation and irrigation measures and techniques appropriate for the regional conditions? Has an appropriate fertilisation /irrigation been applied, which is recommended by certified advisers for the region?
	1.5 Hygiene measures	Has the professional user checked the latest information related to hygiene measures? Have hygiene measures been applied?
	1.6 Enhancement of beneficial organisms	Has the professional user checked the latest information relating to enhancement of beneficial organisms? Have measures relating to protection and enhancement of beneficial organisms been applied, which are recommended by certified advisers for the region?
(2)	Tools for pest monitoring	Is the professional user aware of any early warning or forecasting system used at MS or regional level? Has any information been considered relating thereto? Has the professional user implemented a monitoring system appropriate for the region? Has he carried out monitoring activities at regular intervals? This can be checked in the documentation.
(3)	Decision-making	Has the professional user applied any decision-making system recommended by certified advisers in the region? In particular, where thresholds were available, were they applied?
(4)	Non-chemical methods to be preferred	Where plant protection measures are necessary – has the professional user checked the availability of non chemical

		methods? Have non-chemical methods been applied? If not, were the treatments approved by certified advisers or justified by particular reasons?
(5)	Target-specificity and minimisation of side effects	Where various pesticides are authorised for a specific purpose – has the professional user selected the one with the highest target specificity and the least side effects? In cases of any deviation from this rule – was the decision approved by certified advisers or justified by particular reasons (e.g. anti resistance strategies)?
(6)	Reduction of use to necessary levels	Where plant protection measures are necessary – has the professional user checked the possibility of keeping the intervention to a necessary level? Have any reduction measures been applied which are recommended by certified advisers for the region?
(7)	Application of anti-resistance strategies	Where plant protection measures are necessary – has the professional user checked the information on risks for resistance development and available anti-resistance strategies? Where necessary, has the professional user applied a strategy which is recommended by certified advisers for the region?
(8)	Records, monitoring, documentation and checking of success	Has the professional user carried out a proper documentation of the preventive measures, monitoring and applied plant protection measures? Was success checked immediately after a plant protection measure?

5. CONCRETE EXAMPLE: CONTROL OF COLORADO POTATO BEETLE (CPB, *LEPTINOTARSA DECEMLINEATA*) IN POTATO

It is presumed that the farmer is informed about the pest's life cycle, the conditions under which the damage is caused, action thresholds and available control measures. Larvae and adult beetles feed on the foliage of the host plants, but it is the larvae that can cause extensive damage if populations are high. If left uncontrolled, it can completely defoliate a potato crop and consequently will have a pronounced effect on yield. Feeding of adult beetles occurs from April and of larvae from May.

Table 6 Possible concrete elements for implementation of general IPM principles

General principle	Action
(1) Measures for prevention and/or suppression of harmful organisms	
1.1 Crop rotation	It is presumed that the farmers have knowledge of the benefits arising from crop rotation and already puts it into practice. However, current practicable measures and new scientific findings regarding CPB suppressing crop rotation shall be provided to

	them. Thus farmers should know that planting potatoes in the same field year after year is unfavourable. The infestation level caused by CPB considerably increases when the distances between rotated fields and locations where potatoes were planted the previous season are near. In other words, the farther this season's potato field is from last season's potato field, the fewer the pest problems. The farmer should know that crop rotation can delay CPB population build up, but will not prevent an infestation unless fields are fairly well isolated. Non-host crop rotation is to be preferred. In general, avoid solanaceous crops as rotation choices. Although longer non-host crop rotations are ideal, they are often not economically feasible. A rotation of less duration is still beneficial, but to a lesser degree. Based upon the information given and after taking economic considerations into account, a crop rotation suppressing CPB infestation, organized on three fields and appropriate to control nematodes as well, could be: potato, winter wheat, winter rye.
1.2 Cultivation techniques	It is a prerequisite for the farmer to be provided with information about the current practicable cultivation techniques that help to optimise the crop growing resulting in plants having a high tolerance to CPB feeding.
1.3 Resistant varieties	Since no varieties are known to be resistant to CPB in Europe, the farmer should be provided with information on tolerant varieties by MS authorities. Furthermore, MS authorities should provide information about the different levels of susceptibility of approved potato varieties and their suitability for different regional conditions. Since many pests can be transmitted in infected seed tubers, including bacterial ring rot, blackleg, common scab, late blight, potato viruses, powdery scab, Rhizoctonia, root knot nematodes, silver scurf, and wilt diseases, certified seed tubers should be used. Despite the fact that certified seed tubers are not guaranteed to be disease free, they show low percentages of pest and disorder symptoms. Specialised advisors on varieties should be consulted in this matter in order to enable the farmer to choose a variety that is appropriate for the regional growing conditions, possibly one being more tolerant to CPB and warrants sales.
1.4 Fertilisation, irrigation	The farmer is to be provided with special information on fertilisation and irrigation measures and techniques appropriate for the regional conditions by MS authorities. Fertilisation and irrigation on tribute to healthy crops, consequently becoming more tolerant to CPB infestation.
1.5 Hygiene measures	Hygiene measures are of less importance in CPB control, but measures of equipment disinfection have to be considered when soil is infested by yellow and white potato cyst nematodes (***Globodera rostochiensis*** **and** *Globodera pallida)* or virus diseases.
1.6 Enhancement of beneficial organisms	The farmer is to be provided with special information on the potential of beneficial organisms in reducing the infestation level. Thus, the farmer should know that generalist predators such as ladybird beetles, lacewings, predatory bugs, spiders, etc. provide some control. There are also a number of CPB parasites. *Doryphorophaga doryphorae* and *D. coberrans* are two species of fly that parasitize CPB larvae: a

	wasp, *Edovum puttleri*, parasitizes eggs. In the first half of the season, soil predators, mostly ground beetles, climb potato plants to feed on second- and third-instar larvae of the CPB. In the second half of the season, ladybird beetles and green lacewings are the predominant predators, feeding on eggs and on first and second instars. Mulched plots support greater numbers of predators compared to non-mulched plots, resulting in significantly less defoliation by CPB. Tuber yields increase by a third. MS authorities should support the maintenance and building of field margins by providing information and raising attention to regional environmental programmes including financial promotions if available.

(2) Tools for monitoring

The farmer shall implement all monitoring measures appropriate to the given conditions. Therefore information is to be provided on recent appropriate tools for monitoring CPB by MS authorities, e.g. estimation of foliage loss in % and checks of 5 plants at 5 sampling points in a visualized line. To assist in the detection of insects, a small, white drop cloth can be positioned at the base of the plant; then gently tap the plant to dislodge any insects that may be present. Note: a batch of CPB eggs can easily be mistaken for ladybirds eggs. Furthermore, in Germany, the implementation of computer based forecasting systems e.g. SIMLEP 1-3 (Simulation Leptinotarsa= Colorado potato beetle) can be used in order to obtain the precise date for chemical control measure by the plant protection advisory service and farmers. Authorities of all MS should promote the adoption or development of such computer based forecasting models.

(3) Threshold values as basis for decision-making

Threshold values are to be defined by MS authorities and made available to the farmers. It is crucial to the farmer to know the action threshold values for CPB prior to a pesticide application. Action threshold values for CPB control are reached e.g. at 20% foliage loss or 20% of examined plants showing a high infestation which is 1 adult or 1 batch of eggs or 10 larvae.

(4) Non-chemical methods to be preferred

The farmer shall implement non-chemical methods for pest control whenever feasible. MS authorities shall especially support the implementation of this particular principle by providing information on recent research findings, field demonstrations, training programmes and seminars. Existing non-chemical methods to control the CPB are:

- NOVODOR FC (*B. thuringiensis* ssp. *tenebrionis)*, a form of Bt that is not genetically engineered and can be used
- NEEMAZAL-T/S (Neem seed-extracts)
- SPRUZIT NEU (pyrethrum/rape oil)
- Combined application of NEEMAZAL-T/S and, 2 days later, NOVODOR FC treatment is the best strategy for controlling defoliation through CPB
- Parasitic nematodes; commercial formulations of *Heterorhabditis* species are available and have been shown to be more pathogenic, to the CPB than *Steinernema* species of nematodes, which are also commercially available
- Bt is effective only if ingested by the pest, and then only in the larval stage. Furthermore, Bt sprays are generally effective only against newly hatched CPB larvae. Applications should be made within one to two days.

Essential for a successful control of CPB by using the listed bio-pesticides is the ideal timing of the treatment at the maximum occurrence of larvae (L3/L4).

(5) Target-specificity and minimization of side effects

To enable the farmer to comply with the requirements, MS authorities shall provide extensive information on recent research findings regarding side effects on non-target organisms as well as on new developments in drift minimizing spraying equipment.

Notice, the authorisation of pesticides to control CPB varies between MS.

To allow the farmer to select a pesticide or pesticide combination as target-specific as possible, a balanced decision-making, pest control effect, side effects on non-target organisms and resistance avoidance is to be aspired to. In other words, the selection of a pesticide shall be as protective for the environment as possible and meet economic requirements of the farmer as well. Drift of pesticide into other adjacent fields, public or private grounds or survey water while applied, is to be minimised as well. The farmer should know and respect buffer zones close to his acres and leave border strips to field margins untreated. He should use certified and most precise spraying equipment.

(6) Reduction of use to necessary levels

The farmer is to be provided with information by MS authorities to enable him to avoid unnecessary treatments in CPB control. When implementing this particular principle it is crucial to consider that all general principles significantly contribute to a reduced use of chemical pesticides to a necessary level.

If the population distribution of CPB permits, the farmer should consider the option of partial or border strip-applications to reduce insect numbers. Furthermore, he should know about timely intervention at larval state, L1-L2, will enhance insecticide effectiveness and provide better pest suppression. Late season pesticide applications to reduce overwintering adults are not cost effective and contribute greatly to increasing insecticide resistance.

(7) Application of anti-resistance strategies

The farmer is to be provided with all useful information on threatening pesticide resistance of CPB in his region and strategies to prevent further resistance development by MS authorities. Additionally, MS authorities shall acquire further information on this subject from the pesticide producing industry and evaluate the obtained results.

The CPB has been steadily gaining resistance to the insecticides commonly employed to control this insect. To prevent further resistance development, alternation between different classes of insecticides for the first and second larvae generation is strongly recommended. A proper control strategy is based upon the different modes of action of the active substances included. The reduction of application rate should not be permitted. The major classes of available active substances are: Pyrethroids, Neonicotinoids and Spymericines.

(8) Records, monitoring, documentation and checks of success

The farmer shall document all surveyed data on infestation level, occurrence of beneficial organisms, conduced treatments as well as results of pest control measures.

Therefore, the farmer is to be provided by the responsible MS authority with a template (digital or print version) to enable him to easily write down all collected data. To check the success of pesticide application, the farmer should monitor the infestation level promptly after the treatment. This is particularly necessary in the case of threatening CPB resistance towards certain active substances or when biological control measures are applied, which often allow only a moderate control.