ENDURE

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General and regional recommendations for innovative IPM development in MBCS

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CO Confidential, only for members of the consortium (including the Commission Services)	

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Summary

Maize based cropping systems (MBCSs), with different shares of maize in the crop sequence, are common in European arable systems. The pesticide load differs across EU regions according to the type of active ingredients and target organisms involved. MBCSs may involve various crops and are infested by various arthropod pests, weeds and diseases. The introduction of innovative practices in IPM strategies can better address the EU strategic commitment for a sustainable use of pesticides and consequently more environmentally sustainable MBCSs. However, an evaluation of these innovations before implementation in IPM strategies is essential for the development of sustainable cropping systems.

The RA2.6b group (Table 1) proposed a list of innovative IPM tools (those that could be developed and implemented in the next 5-10 years) and conducted an expert based survey for their evaluation. Results from this evaluation and recommendations for innovative IPM tools aiming at pesticide use reduction, for future implementation in MBCSs of four European regions, are presented in this deliverable. Regional recommendations covered MBCSs of the northern region consisting of Denmark, the Netherlands and Poland, the central-eastern region with Tolna and Békés counties in Hungary, the south-western region with Ebro valley, Spain and the southern region with Po valley, Italy (Table 2).

Table 1. Teams involved

SZIE - Szent István University, Hungary
CNR - National Research Council, Italy
SSSUP - Scuola Superiore Saint' Anna, Italy
UdL - University of Lleida, Spain
AU - Aarhus University, Denmark
PPO - Wageningen University and Res. Center, Appl. Plant Production, The Netherlands
IHAR - Plant Breeding and Acclimatisation Institute, Poland

Table 2. Main MBCSs identified in four European regions

North	silage maize continuous and rotated, not irrigated
Central-eastern	grain maize continuous (Tolna county) or in rotation (Békés county), not irrigated
South-western	grain and silage maize rotated and continuous grain maize, irrigated
Southern	grain and silage maize rotated and continuous grain maize, irrigated

1. Introduction

Maize (*Zea mays* L.) is one of the most important European crops and is cultivated for different production purposes, such as grain for food, feed and processing, seed and green maize (silage and biogas). Grain maize production dominates in central-southern Europe, while silage maize in central-northern Europe, usually as continuous maize or in rotation with other crops depending on the country/region. Crop protection in maize is mainly based on pesticide applications with different levels of IPM implementation within Europe. A broad insight on pest, weed and disease problems of maize, pesticide use and IPM in Europe was reported by the maize case study group of the ENDURE project. However, in order to properly address crop protection in European maize production and achieve a more sustainable production with less pesticide use or dependence, a maize-based cropping system (MBCS) approach is essential, providing information about the type of sequence present (continuous or rotated maize), crops in the sequence and crop protection practices against all important pests, weeds and diseases of the system. The introduction of innovative practices like Bt maize resistant to European corn borer (*Ostrinia nubilalis* Hübner), Mediterranean corn borer (*Sesamia nonagrioides* Lefebvre), western corn rootworm (*Diabrotica virgifera virgifera* LeConte), or herbicide tolerant hybrids, precision spraying, user friendly and reliable Decision Support Systems (DSSs) and pest forecasting methods in IPM strategies can better address the EU strategic commitment for a sustainable use of pesticides and consequently more environmentally sustainable MBCSs. However, in order to introduce such innovations for the development of sustainable cropping systems, evaluation of the agronomic, environmental, economic, and social aspects of each IPM tool should be considered.

MBCSs of the four European regions were identified and the current status and advanced practices (already available but not implemented) of crop protection against major pest, weed and disease problems in these systems were determined and reported in DR2.17. Building up from the work done, the RA2.6b group conducted an expert based survey, where experts from the four regions were asked to evaluate the potential agronomical, environmental, economical and social impact of innovative Integrated Pest Management (IPM) tools on MBCSs of their region, aiming in sustainable pesticide use.

2. Expert based survey on innovative IPM tools

In February 2010, the MBCS group developed a template for expert interviews (Annex 1) where innovative IPM tools were listed. The most promising IPM tools for the future were chosen based on the group's expertise and on the hypothesis that in the next 5-10 years they will be developed and available on the market, ready for implementation in IPM strategies for MBCSs. An Expert Based Survey (EBS) was conducted by interviewing ten experts from each region and asking their opinion on the potential agronomic, environmental, economic and social impact (negative, neutral or positive) that each tool could have on the MBCSs. SPSS was the statistical package used to analyse the qualitative data and determine the most sustainable tools for innovative IPM recommendations in MBCSs of each region. For each tool, the ten answers of the experts were sorted and the first and last were eliminated to avoid bias of extreme cases. The symbols used in the templates for interviews were transformed in numerical values: --, 1; -, 2; 0, 3; +, 4; ++, 5. For each aspect of the tool, the median and range were estimated, which are the appropriate statistics for ordinal scale. If the median was < or ≥ 3 then the tool had negative (--, -) or no (0) and positive impact (+, ++) on MBCSs, respectively. If the range was ≥ 3, it means that there were various types of answers (negative, neutral and positive) and its positive and negative effects are being debated. An innovative IPM tool for each region was finally recommended only when all four aspects (agronomic, environmental, economic, social) of the tool had positive impact on MBCSs.

3. Recommendations of innovative IPM tools for MBCS of four European regions

The tolerant/resistant maize cultivars, early detection methods, pest and disease forecasting models, precision/patch spraying using GPS spray maps and the community based decisions through information sharing were recommended for IPM implementation in MBCSs of all regions. Experts evaluated that these tools can 1) be efficient to control pests, weeds or diseases (agronomic impact), 2) reduce the use or dependence of pesticides (environmental impact), 3) result in a net profit of the systems within a time frame of 3-4 years (economic impact) and 4) be accepted by the society in terms of their environmental and health impact, as well as safety of end product (social impact). Only in the case of the southern region, although an overall positive economical impact of early detection methods and precision/patch spraying was indicated, there was a high range of answers with 12.5% of the answers giving a negative impact on MBCSs.

The predictive models for natural enemies population dynamics were accepted as a promising IPM tool from the experts in some regions, as they evaluate that such ecological models can enable the evaluation of the pest suppression effect in a pest–predator system and can potentially reduce pest control costs and crop yield loss in MBCSs. In the other two regions, experts had some doubts about the usefulness of such models as although these models will predict natural enemies dynamics, probably, there will be the need of an insecticide application due to the diversity (natural enemies feeding on some pests) or the abundance of the pests in the system, thus resulting to a neutral evaluation of this tool.

The predictive models of weed emergence were recommended for implementation in IPM strategies of MBCSs of the central-eastern and southern regions with experts indicating positive impacts of all aspects on MBCSs. In both regions, the expert survey indicated that, by using these models, weed control can be optimised as the efficient timing of weed management procedures will be determined, resulting in a possible reduction of redundant herbicide applications or mechanical weeding and therefore a positive impact on the environment, on the net profit of the systems and on the society's acceptance was foreseen. In contrast, a neutral economic and social evaluation was obtained from experts of the northern region as they considered that such predictive models will just indicate the timing for weed management and not reduce the work, pesticide and cost load. Similarly, in the south-western region, the social acceptance of these models was thought that will be neutral.

The Decision Support Systems (DSSs) were widely accepted as an important IPM tool for most regions, indicating an overall positive impact on MBCSs. They evaluated that by using DSSs, a decision making process that will determine "if", "how" and "when" pest control is needed can be implemented, thus reducing redundant pesticide applications or mechanical interventions. Only in the central-eastern region there was an appraisal that DSSs will have a neutral impact on the society, whereas for the economic impact, although a general positive impact was foreseen, there was a wide range of answers with 25% evaluating a probable negative impact of DSSs.

Innovative mechanical weed control was another recommendation from the experts of most regions, as if mechanical weed control options will be developed that can provide more efficient weed control, then a positive environmental and economical impact can be obtained by reducing or not practicing at all herbicide applications, thus achieving lower production costs. However, in the central-eastern region a negative economic impact was evaluated, as experts were concerned about the prices of such mechanical innovations which will probably not be sustainable for farmers of this region.

Innovative pest control (i.e. mating disruption, push-pull strategies, feeding arrestants) was positively evaluated and recommended for the MBCSs of central-eastern, south-western and southern regions. The implementation of this tool/method in IPM of these MBCSs, if developed and widely on the market in the future, will provide efficient pest control without insecticide applications or the use of seed dressing thus reducing the costs and the pesticide load in these systems. In the northern region, a neutral economic and social impact was determined because the price of such products may be equivalent to the current pest control options practiced and the fact that in this region there is already a low number of insecticide applications will make no difference to the society's concerns.

Although a positive agronomic, environmental and social impact of biological control was considered by the experts of all regions, only in the south-western region there was an overall acceptance and recommendation of this tool. Experts from the first regions were concerned that the cost of such control will either compensate the cost of pesticide applications (northern and central-eastern regions) or its implementation will not be economically sustainable for the system (southern region).

In the northern and southern region, conservation biological control (CBC) was recommended for IPM in these systems. The experts' opinion on this method is that by conserving and enhancing the natural enemies in these systems (i.e. provision of resources or refugia in the field, habitat manipulation, limiting pesticide use), pest populations and high infestation levels can be balanced and eventually reduced in the long term, resulting in the reduction of chemical pest control. On the other hand, a neutral agronomic (central-eastern region), social (south-western region) and economic (both regions) impact was evaluated, indicating that it will not be so efficient for pest control, the society will not conceive any relation of this method to environmental and health impact, and safety of end product, or not result in any significant economical impact on the MBCSs, respectively.

The use of cover or green manure crops in MBCSs was proposed in the northern and central-eastern region with the latter having a high range of answers about the agronomic (12.5% negative answers) and economic (25% negative answers) impact of this method. This evaluation was based on the ability of these crops to reduce pest pressures (i.e. weed suppression), attract beneficial insects, spiders or mites, improve the soil structure and soil fertility, and so providing economical benefits to the system. In the other two regions, the use of cover or green manure crops was determined not to significantly affect the agronomical, economical, and social aspects of the MBCSs (south-western region), or not providing any significant profit to the system (southern region). If the cover crop is not carefully selected (i.e. considering the soil type, water availability, cropping sequence, and cultural practices) then some disadvantages may arise from their use, like the increase of specific weed problems, attraction of arthropod pests, depletion of soil moisture, decrease availability of plant nutrients or the increase of the associated costs.

Finally, the composition and sequence of the crop rotation was positively evaluated for all aspects only in the northern region. However, the positive agronomic and environmental impact that derives from this tool was noted from experts of all regions. Cropping sequences that provide varying patterns of resource competition, allelopathic interference, soil disturbance, inhospitable soil environment (i.e. alfalfa) and mechanical damage result in a more diverse environment that disrupts the growth and dominance of a particular weed or the life cycle of pests and diseases that were best adapted to a monoculture. In central-eastern and southern regions a neutral economical impact was determined as the inclusion of some crops important for agronomical (i.e. pest, weed or disease control) or environmental (i.e. enhance or attract natural enemies, improve soil fertility) reasons may not influence the net profit of the system.

4. Innovative IPM tools not accepted for implementation by the expert based survey

Insect resistant GM maize (already existed but also new varieties against different pests), herbicide tolerant GM crops, automatic weed monitoring tools and longer term system monitoring were not accepted for IPM implementation in MBCSs of all regions, respectively. In most cases, experts evaluate that GM crops can have a positive agronomic, environmental and economic impact on MBCSs of their regions; however, there was a common concern about the social impact


From Science to Field
Maize Based Cropping Systems (MBCS) Case Study - Guide Number 5

Strumenti innovativi di IPM raccomandati per sistemi colturali basati sul mais in Pianura Padana, Italia

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of these tools and their acceptance by the society, with answers ranging from negative (northern and central-eastern regions) to neutral (south-western and southern regions). Moreover, in the northern region, experts considered that the insect resistant GM maize might have a neutral economic impact as the higher costs of the GM maize due to technology fees maybe will compensate any probable costs that will derive from insecticide application. In the southern region, there was also a neutral response about the agronomic impact of herbicide tolerant GM crops (glyphosate or other herbicides in the following 5-10 years), as although the inclusion of such crops in MBCSs will simplify the weed management and reduce the risk of failed weed control, they may induce evolution of herbicide resistance in the longer term (i.e. glyphosate-resistant weeds).

The automatic weed monitoring and the longer term system monitoring are also not recommended due to the common, in most cases, neutral economic or social impact evaluation of these tools in all regions. For the automatic weed monitoring tools experts from the northern, central-eastern and southern regions suggest that this IPM tool will have a neutral economic impact on MBCSs, although answers varied from negative to positive with the highest range of answers in the central-eastern and southern regions. The reason for this result is that although the price of these tools may be high, there will be a probable long term compensation by the reduction in herbicide use, thus a neutral impact on MBCSs. Similarly, for the longer term system monitoring, a neutral economical impact was indicated in the northern, central-eastern and south-western regions considering that the implementation of this IPM tool/method may not result in any significant net profit of the system in 3-4 years, but there might be a compensation by the more efficient pesticide applications (yield loss reduction) through monitoring of the major pests, weeds or diseases of the MBCSs. For both tools, a neutral social impact in MBCSs was also determined in southern region, and in south-western region for automatic weed monitoring, as experts evaluate that probably the importance of these tools, in terms of their environmental and health impact or the safety of end product, will not be conceived or of interest for the society.

5. Conclusions

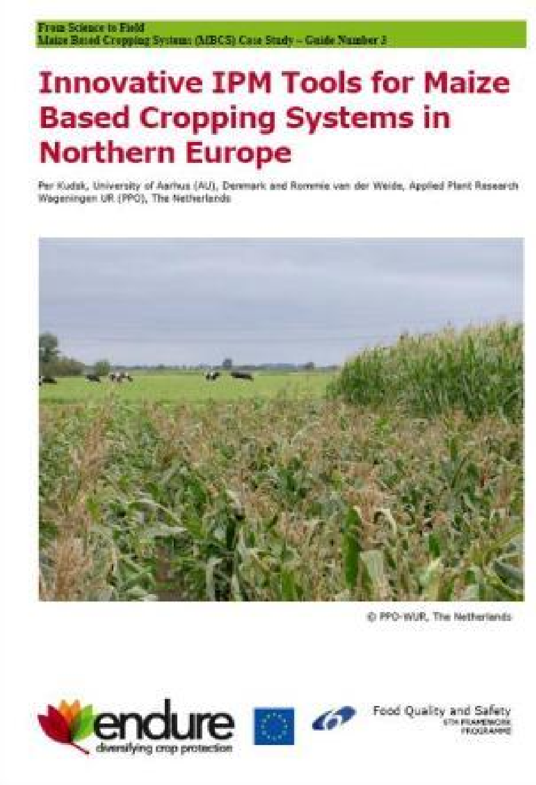
The determination of five common (i.e. for all considered regions) recommendations of innovative IPM tools for implementation in MBCSs is the most significant outcome of this study, showing that some IPM tools have a general value and could be the basis of a large scale future IPM implementation in Europe. Differences in the recommendations of innovative IPM tools between regions exist, mainly due to the neutral or negative evaluation of the economic (i.e. automatic weed monitoring tools) and social impact (i.e. GM crops) that some tools will have on MBCSs of their region.

Regional policies that promote applied multi-disciplinary research and farmer incentives to encourage the adoption of innovative IPM strategies in MBCS will be essential. This research should evaluate systems that have longer term benefits and be economically competitive with the current ones. The new Framework Directive on the sustainable use of pesticides can provide a solid basis for this purpose.

6. Annex: Leaflets from the MBCS (Available at www.endure-network.eu)

Number 1: SWOT analysis

Number 2 :General recommendations



From Science to Field
Maize Based Cropping Systems (MBCS) Case Study – Guide Number 3

Innovative IPM Tools for Maize Based Cropping Systems in Northern Europe

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Number 3: Northern Europe

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Maize Based Cropping Systems (MBCS) Case Study – Guide Number 4

Recomendaciones sobre métodos innovadores en el manejo integrado de plagas, enfermedades y malas hierbas para los sistemas de cultivo basados en el maíz en el Valle del Ebro, España

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Innovatív integrált növényvédelmi módszerek és eszközök a kukoricára alapozott növénytermesztési rendszerekben

Bán Rita, Dorner Zita, Kiss József, Lévay Nóra, Papp Komáromi Judit, Pálinkás Zoltán, Posta Katalin, Szalai Márk, Terpó István és Veres Andrea (Szent István Egyetem, Növényvédelmi Intézet, Gödöllő)

Kukorica vetésváltás Tolna megyében
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Number 6 : Hungary