Final Report Summary - C-IPM (Coordinated Integrated Pest Management in Europe)

Executive Summary:
Europe faces the challenge of responding to the mandatory implementation of the principles of Integrated Pest Management (IPM) as called for by Directive 2009/128/EC on the sustainable use of pesticides. IPM is facing both external and internal challenges. External challenges include (i) increasing needs to manage pests (pathogens, animal pests and weeds) due to climate change and evolution of pesticide resistance and (ii) complexity of effective pest management strategies in a context of reduction of pesticide availability. Internal challenges include decreasing budget allocated to IPM research, increasing scarcity of human expertise, lack of knowledge transfer into practice, communication gap within and between countries, and lack of multi-, inter- and transdisciplinary IPM research.

The major objective of C-IPM was to contribute to research defragmentation by coordinating national IPM research and extension efforts as well by pooling existing resources. Through a consortium of 34 partners from 21 countries, C-IPM has been able to position IPM in the European innovation landscape by interacting with a large number of stakeholders and researchers. C-IPM has created a forum among its partners for exchange and identification of IPM research needs and gaps, strength and weakness and future direction to overcome the existing IPM challenges. Mapping activities together with thematic workshops on long term challenges as well as a series of knowledge sharing workshops made it possible to build up a Strategic Research Agenda for IPM in Europe (http://c-ipm.org/strategic-research-agenda/) that covers four main themes: (i) favour preventive measures for sustainable pest management, (ii) increase the availability of alternatives to conventional pesticides, (iii) foster IPM solutions to overcome minor uses issues, and (iv) facilitate IPM implementation through an understanding of drivers and impact of IPM.

C-IPM identified a list of Minor Uses needs without or insufficient solutions and identified the topics where IPM research is needed and where available IPM tools could be implemented. This complements existing activities undertaken by the EU Technical group and the Commodity Expert Groups on, minor uses. C-IPM has also been acting as a facilitator to help finding solutions for minor uses by directly granting research projects that aim to find workable solutions.

Finally, C-IPM collected and analysed research infrastructures and capacities that can contribute to a better coordination of national IPM-related research. Special emphasis was put on the networking of long term filed experiments and of demonstration farms as well as on the coordination of pest monitoring systems.

C-IPM started implementing its strategic research agenda through two transnational calls. Seven research projects have been granted within the call 2015 (5,985,000 Euros total funding) and nine within the call 2016 (6,487,061 Euros total funding). Overall, C-IPM started aligning National IPM-related research by creating knowledge hubs and implementing transnational calls. A continuation of these activities is foreseen through other instruments.

Project Context and Objectives:
Today’s agriculture faces multiple challenges including the need to ensure food security and food safety, on the one hand, and
to address increasing concern related to the negative effects of pesticides in agriculture, on the other. Consequently, there is a need to put in place sustainable and durable crop protection strategies. Integrated pest management (IPM) has potentials of preventing crop losses and ensuring high quality production to address issues related to food security and food safety and at the same time reduce reliance on conventional pesticides. Member States have been requested to implement the principles of Integrated Pest Management (IPM) as called by Directive 2009/128/EC on the sustainable use of pesticides. However, IPM is facing various external and internal challenges. External challenges include (i) increasing needs to manage pests (pathogens, animal pests and weeds) due to climate change and evolution of pesticide resistance and (ii) complexity of effective pest management strategies in a context of reduction of pesticide availability. Internal challenges include:

- A low level of collaboration and communication between funders of IPM research both at country level and between the Member States;
- Limited transfer of research knowledge into practice;
- Dominant short term and project-based funding;
- Decreasing trend in budget allocated to IPM research;
- Increasing scarcity of human expertise;
- Monodisciplinary research focus and lack of interdisciplinary IPM research;
- Scarcity of system experiments to feed holistic research approaches;
- Lack of design on the bottom-up organisation of applied research through fundamental research.

Recently, many European countries have intensified their national efforts on IPM research and development (R&D). However, IPM R&D efforts are often carried out across Europe within national initiatives and in a fragmented fashion. Therefore, their operational outputs would benefit from closer collaboration between IPM research funders and managers at European level, and by pooling IPM R&D efforts on common priorities. This need was reflected via a transnational collaborative initiative, represented by C-IPM.

The overall goal of C-IPM was to ensure a higher level of implementation of IPM among European farmers by creating synergies from national investments in research and extension. Preliminary work carried out in the Standing Committee on Agricultural Research Collaborative Working Group (SCAR CWG) on IPM had highlighted the feasibility of generating added value via joint activities that range from information sharing and the creation of knowledge hubs to the development of joint transnational actions.

The specific goals of C-IPM were to:
1. Identify synergies and gaps in existing national and transnational programmes and define an IPM-specific strategic research agenda and implementation plan;
2. Define a specific strategic research agenda for IPM in Europe;
3. Organise and fund joint transnational calls;
4. Ensure better translation of national and European IPM-related programmes into applicable innovations.

C-IPM supported the formulation and implementation of national research programmes dedicated to the development of IPM strategies and contributed to the implementation of National Action Plans (NAPs), by facilitating the sharing of national experiences on pesticide-related policies.

Project Results:
C-IPM has yielded a number of results which are described below on a work package basis.

WP1: Development and publication of a Strategic Research Agenda on IPM in Europe

C-IPM has prepared and published a strategic research agenda (SRA) for IPM in Europe with the aim of promoting coordinated efforts in the area (http://c-ipm.org/strategic-research-agenda/). In addition, an executive summary of the SRA was prepared.
with key messages including major IPM challenges in Europe (both research and organisational) and key strategies to overcome major challenges.

The SRA is designed to address the key concerns of improved coordination of national research efforts to enhance IPM implementation. It provides recommendations on future European and national IPM research in terms of challenges for agriculture and crop production. The content of this document takes into account the previous initiative of the SCAR Collaborative Working Group on IPM (2011-2013) and the outcomes of mapping national research priorities and needs as well as workshops on national research programmes and infrastructures put in place by C-IPM.

The overall objective of the C-IPM SRA was to delineate both short to medium as well as long-term priorities for IPM research to identify gaps and enable enhanced IPM implementation in Europe. The short-term agenda aims to create a forum for exchange and identification of IPM research and development priorities, connect existing initiatives and coordinate joint transnational research calls.

The SRA is supposed to lay the groundwork for the implementation of future joint transnational research. In this context, the SRA has:

- Supported network IPM-related research and created synergies based on a status quo survey of existing research activities on IPM within the EU;
- Identified overlaps and gaps to avoid duplications as well as opportunities and complementarities for improved transnational coordination and joint initiatives on research;
- Enhanced pre-existing and established new linkages between research programmes and initiatives towards coordination of IPM research and development (R&D) in Europe;
- Identified future challenges for European crop protection which require IPM solutions;
- Identified opportunities and mechanisms for knowledge transfer/sharing; training & dissemination of information of IPM research.

The SRA describes research priorities that cover four main themes:

- favour preventive measures for sustainable pest management,
- increase the availability of alternatives to conventional pesticides,
- foster IPM solutions to overcome minor uses issues,
- and facilitate IPM implementation through an understanding of drivers and impact of IPM.

Four additional knowledge sharing workshops were organised, which were not planned initially in the workplan but deemed necessary based on the interests expressed by C-IPM partners. The topics were decided based on the most important common priorities of partners. The main objective of the thematic workshops was to promote exchange among partners on a given topic and provide recommendations in terms of research needs.

- « The needs for research on biological and integrated protection in cropping systems » (Paris from 27th to 28th January 2016, in cooperation with EcoPhyto and IOBC-WPRS)
- « Benefits and potential of demonstration farms for IPM uptake » (23-24th May in Bonn, Germany)
- « Breeding for IPM » (4-6th July in Radzikow, Poland)
- « Research approaches and control of Drosophila suzukii (6th September 2016 in Thessaloniki, Greece in the context with the 9th International Conference on Integrated Fruit Production)

All presentations and a summary report are available on the C-IPM website [http://c-ipm.org/].

During the third and last year of C-IPM activities and funded period, ways on how to approach a possible future for the ERA-Net were considered by the consortium. The continuation of C-IPM activities was discussed at meetings of the Executive Committee (Ex-Com) and of the Governing Board (GB), at the second annual meeting in Rome as well as during the final
conference held in Brussels in December 2016. It was concluded that it would be necessary to continue C-IPM activities and the following 8 possible scenarios for the continuation were identified:

2. Fund a “secretariat” for a self-sustaining network (Euphresco model)
3. Establishment of a core group of 3-4 C-IPM partners to maintain networking activities;
5. Combination of Option 1 + Option 4
6. Combination of Option 1 + Option 3
7. Combination of Option 3 + Option 4

Option 1, option 4 and option 5 were considered the most relevant ones and have been further explored before the end of C-IPM.

WP2: Mapping and analysis of existing research based on future needs

The ERA-Net C-IPM identified current priority research areas and areas which require future research as well as gaps in national research programmes (Figure 1 in Annex). Main research needs are the development of alternative and biocontrol measures in IPM, pest monitoring and decision support systems (PMS/DSS), resistance breeding (for IPM) and the development of IPM solutions for Minor Uses (MU). Moreover, the need of knowledge sharing and dissemination work was identified as an important factor to foster the implementation of IPM in Europe. This issue was addressed via the development of tailor-made solutions on, and together with demonstration farms and joint cross-border initiatives, the use of pest monitoring and decision support systems.

The identified research needs led to two research calls in 2015 and 2016 and numerous projects financially supported by national funders. However, there is still a need for fundamental research, especially as regards to weed control, resistance breeding, climate change, and new invasive species.

Thematic workshops were dedicated to address future challenges arising from the political and societal sphere as well as novel innovations building the future base of IPM by bringing together scientists, governmental officials, policy makers, industrial companies, and agricultural advisors, in order to support the implementation of IPM in Europe.

In the initial phase of the project, national research programmes and funding opportunities were identified and analysed in a general survey about the current national research context and situation of IPM in Europe. This mapping of the current policy situation, major components of policy programmes related to IPM, and qualitative as well as quantitative goals, confirmed that crop protection and IPM are pertinent on the national policy agenda. Specific national and/or regional research programmes exist, supporting directly the national crop protection policy. Some countries have research programmes related to IPM, tightly integrated into their overarching policy framework of risk reduction.

The current national research context and situation in Europe was analysed, focusing on the identification of research priorities and needs in European countries. The analysis concerning research programmes focused on identifying research priorities, long term needs, possibilities for collaboration and existing research gaps.

Current national research priorities indicate that major national investment in terms of human resources and national funding are committed to i) variety breeding and the identification of resistant varieties, ii) decision support (DSS) and pest monitoring systems (PMS), as well as iii) biological control and non-chemical methods for direct control of pest populations. Other
priorities are the management of resistance development and the mapping of resistant pathotypes. Research on preventive measures in IPM such as crop rotation, cropping systems and weed management are more complex and seem to be addressed only partially in a number of programmes.

C-IPM partners indicated the need for more research especially in the following areas: weed research, alternative control methods, breeding for resistance, IPM in minor use crops, and further adaptation of DSS and PMS to current varieties and pathotypes with the underlying fundamental research on pest biology.

The survey analyses also pointed out weaknesses, gaps, or lacks in existing programmes (see below). Weaknesses include the insufficient transfer and adoption of research results in practice, which is partly due to missing interfaces between the needs and resources of farmers and research activities, as well as organisational deficiencies in national research coordination. The adaptation of prognosis models and DSS to different climatic conditions, the further advancement of biological protection and adoption in practice as well as breeding for IPM are areas of research which deserve more attention.

Gaps also concern missing links and joint initiatives to promote the awareness of the consumer on the quality of food produced under IPM. Socio-economic research is crucial for the viability and the translation of research results into practice.

Gaps and associated challenges for European research on biocontrol
1. Missing integration of biocontrol into IPM strategies
   • The holistic approach for pest management strategies is needed.
   • Implementation of biocontrol methods into existing tested and verified systems requiring adaptation.
2. Absence of large suite of biocontrol solutions and new effective application techniques are missing for open field crops.
   • R&D to develop new effective application techniques especially for open field crops.
   • Ensure that biological control methods will be successfully developed, tested and applied in open field crops.
3. Development and use of pheromone traps, entomopathogenic fungi, nematodes, and plant extracts did not yet reach sufficient practice level.
   • Screening of biocontrol solutions and testing in field trials long-term experiments to proof their in-field efficacy.
4. Lack of continuous funding for the development of biological plant protection and methods and tools.
   • Development of new PPPs based on biological ingredients need to be funded and covered in future research calls.
5. Limited readiness for uptake of biocontrol solutions by farmers
   • Information sharing about field trials and research results is a strong component for improving knowledge transfer and enhance uptake.
   • Further research on the formulation and efficacy of biological control agents as well their optimal integration in IPM systems under variable climatic conditions
   • Development of a harmonised registration process for new BCA’s; Improvement of lengthy and cost-intensive development and registration process for bio pesticides.

Gaps and associated challenges for European research on Pest Monitoring & Decision Support Systems (PMS/DSS)
1. PMS/DSS partly lack updated pest development models
   • Update of diverse models on same pests/diseases by meta-models, which are ring-tested and validated.
2. Threshold values are missing for many crop-pest-combinations and existing models require adjustments to current varieties and pest pressure
   • Research to re-evaluate and re-define threshold models with underlying fundamental research.
3. Development models for the biology of pest and diseases have great variances across the regions, due to the different climatic conditions.
   • Enhance networking to enable a cross-border use of PMS/DSS. Adopt forecasting and monitoring systems at field and landscape levels, in order to harmonise the systems in Europe.
4. Resistance mapping is a key factor for IPM and ensuring effective resistance management
• A cross-border surveillance network is of great interest in Europe
Gaps and associated challenges for research on breeding for IPM
1. Breeding traits only partially respond to the needs in IPM systems.
   • R&D programmes should address breeding targets and IPM strategies simultaneously and as a holistic system
   • Adapt plant breeding to crop rotation, crop diversification.
2. Lack of breeding methods to improve durability and stability of resistance
   • Research new breeding technologies could support IPM
3. The correct identification of resistance genes is missing
   • Work sharing in the evaluation of cultivars, performed across different locations according to standardised protocols
4. Lacking resistance traits in various crops and especially minor use crops
   • Development of varieties for specific pedo-climatic conditions and focus on minor crops are important to promote breeding for IPM.
5. Pesticide use is not always adapted to resistant or tolerant varieties
   • Development of reliable information and decision support for growers
Gaps and associated challenges for European research on Demonstration farms
1. Lack of knowledge exchange and information transfer between the different actors in agriculture, especially between researchers and practice
   • Demonstration farms play a key role for knowledge sharing about IPM methods and the development of tailor-made solutions for growers and require long-term funding.
2. Slow uptake of IPM tools and methods in practice
   • Development of tailor-made solutions for growers
3. Indicators are missing, in order to measure the success of the implementation of IPM
   • Develop indicators for the implementation of IPM.
4. Combination of human and social sciences requires more attention; there is no holistic approach as regards the impact of socio-economic aspects to IPM
   • Fostering interdisciplinary research, including human and social sciences, in order to work at the level of the complete food chain.
5. Field trials and/or long-term experiments in IPM and actively support the implementation of new technologies in practice
   • Long-term funding would support the development of system strategies

WP3: Mapping and analysis of minor uses problems and possible IPM solutions

A comprehensive data base entitled “Table of needs on minor uses problems without sustainable solution” was compiled based on a survey among the ERANET C-IPM partners and the National Minor Use coordinators within the EU and associated countries, in order to identify the priority minor use problems for which IPM solutions are needed. Based on the analysis of the compiled Table of Needs a ranking was elaborated on mutual crop/target (=pests) combinations between countries for which IPM solutions are needed. During the annual meeting in Lisbon on November 26-28, 2014, the highest ranking crop target combinations were presented. The participants selected 10 priorities. These 10 priorities were input for the longlist of topics for the first and the second call of the ERANET C-IPM.

Subsequently, IPM research and implementation priorities for minor uses were identified including a state of the art on existing research and identification of research priorities including the diversification of control methods and existing tools in the context of specific minor use problems”. A database search was performed in order to i) identify the availability of IPM tools and alternative solutions to pesticides for the management of the listed target pest species, and ii) define the research areas, where the availability of IPM tools is limited.

Based on the survey, the availability of IPM solutions for minor crops and the need for further research was interpreted taking into account the following four dimensions:
• Potential availability of individual IPM tools that sum up to an IPM strategy. The aim of the research in this dimension is to
diversify the offer of alternative single tools (in our study it concerns 18 single tools) to increase the total number of tools available.

- Applicability of single tools in local conditions. The aim of the research in this case is to adapt the individual solutions to local needs and improve their reliability in order to ensure that those tools are usable and could be adapted to local conditions.
- Integration of single tools into IPM strategies. Research aims to combine and synchronize tools into an integrated crop management strategy.
- Adoption of single tools or IPM strategies by growers. Technical and socio-economic bottlenecks to adoption of individual or integrated solutions need to be assessed in order to find out the reason of their non-adoption and contribute to future adoption.

The literature review was limited to evaluate the availability of single IPM tools at the first dimension. Even though the searched databases offer ready-to-use solutions for farmers, these tools still needed to be further evaluated at the other dimensions of availability. Therefore, C-IPM partners and other experts were consulted in order to evaluate the listed tools along the four dimensions of the study. In addition, as a pilot activity of this evaluation, an expert consultation was held on Drosophila suzukii, on the 6th September 2016 in Thessaloniki, Greece. The workshop was organized back-to-back with the 9th International IOBC conference on Integrated Fruit Production.

Finally, results of the study were presented at the Commodity Expert Groups and the Horizontal Expert Group meeting, held from the 27-29th September 2016 in Munich, Germany for further feedback. Experts of the Minor Use Commodity Group were asked to evaluate the availability of IPM tools to control the following pests and diseases: i) Aphids in leafy vegetables, ii) Drosophila suzukii in fruit crops, iii): Whiteflies/thrips in (protected) ornamentals/vegetables, iv): Leaf spots and downy mildew in leafy vegetables, and v) Invertebrate pests/diseases in legume crops (peas and beans).

The results of the database research on available IPM tools for Minor Use problems and the expert evaluation was presented at the workshop of C-IPM in consultation with the Minor Use Co-ordination Facility in Brussels 5th of December 2016. The results were presented according to the main obstacles that prevent implementation of these tools: i) lack of IPM tools in the database against target pest species or ii) available tools but not adopted due to agronomic or economic reasons or due to the existing knowledge gap. Outcomes of the discussion allowed to further fine-tune research and implementation priorities for Minor Uses. Below the summary of recommendations are given based on the bottlenecks preventing implementation of IPM tools:

**IPM research inputs needed:**

1. IPM tools to control Aphis nasturtii in watercress;
2. Biological control, Conservation Biological Control, innovative pesticide application technologies, monitoring for Drosophila suzukii (the latter is addressed in the AAPM project selected for funding under the 2nd project call);
3. IPM tools to control Ramularia beticola on beet leaves, Peronospora valerianellae in corn salad, Cladosporium sp. and Peronospora farinosa f. sp. spinaciae in spinach
4. Biological control, biopesticides for Delia platura

**Research on how to overcome agrotechnical bottlenecks:**

1. Biological control of aphids in leafy vegetables
2. Physical tool, post-harvest clean up sprays for Drosophila suzukii
3. Biological control, application of reduced doses for leafspots and mildew in leafy vegetables
4. DSS, biological control, innovative pesticide application techniques for B. lactucae
5. Biological control and biopesticides for pests and diseases in legumes, seed treatment for Delia platura

**Contribution to the development of research concepts and implementation by private companies to overcome economical bottlenecks (e.g. increased production quantity of certain tools, such as insect nets, traps, etc. may result in lower and**
competitive prices):
1. Physical crop protection for Drosophila suzukii
2. Biological control or whiteflies in protected crops

Knowledge sharing to overcome the lack of awareness
1. Conservation Biological Control (CBC), innovative pesticide application technologies for aphids
2. Biological control, CBC, physical control tools for whiteflies in greenhouses
3. Biological control, innovative pesticide application techniques for Bremia lactucae in leafy vegetables
4. Resistant varieties for whiteflies in greenhouses
5. DSS for aphids and for Bremia lactucae in leafy vegetables

WP4: Analysis of IPM-related infrastructures and capacities

A survey was initiated between the C-IPM partners to map out existing relevant policies, on-going research and existing infrastructures for IPM research, extension programmes and initiatives designed to support IPM implementation. A questionnaire was designed ad hoc and circulated to 37 national recipients from 22 European countries. The overall aim was to put in place strategies, including knowledge sharing and coordination of activities, based on priority areas for joint efforts among countries, in order to fully benefit from the existing national resources.

Research within IPM often requires long term experiments and monitoring activities to capture the effects of both preventive and curative actions. To accommodate long term activities funding opportunities must prevail for more long term investments in the basic infrastructures required to support research in IPM. Currently, research funding typically covers projects with a limited time span (2-3 years), which means that in order to continue long term activities the researchers continuously have to incorporate the basic activities in new projects with new objectives. The consequence is that long term activities can have a changing focus over the years. Planning and conducting such actions across borders will increase the outcome by adding geographical variation and incorporating knowledge from a broader research and farming community. Furthermore, extensive exchange of knowledge decrease the risk of reproducing/duplicating activities conducted in other countries. There are different levels of IPM implementation among European countries and the development of IPM proceeds at different speed and to different levels of integration and with different priorities. The experiences made in countries with a strong focus on IPM can benefit countries, which have focussed less on IPM in the past or only on parts of IPM. It is important to focus cross-border collaboration on the areas where cooperation have an added value compared to national actions.

Three focus areas on infrastructures (demonstration farms, forecasting and decision support systems, and long-term field experiments) have been identified by C-IPM, through workshops with a broad range of stakeholders and surveys among partner countries, as the supportive activities for IPM implementation with the highest priority for cross-border co-operation. Proceeding with increased co-operation among the European countries within these areas will target some of the weaknesses identified in the Strategic Research agenda; lack of collaboration and communication among funders and researchers, respectively, limited transfer of research into practice and a short termed focus for research funding.

• Demonstration farms

In the survey, 12 countries stated that they have, or previously have had, demonstration farms. The nature of these demonstration farms differs and the variety of crops covered is very broad, but a common feature is that the demonstration farms are privately owned farms. Research stations are not included in this category. The experiences among partner countries can serve as examples for other countries planning to set up such facilities or an inspiration for how to improve existing concepts. Even though there is large variation among the existing setups of demonstration farms, ranging from more than a network of 2000 farms in France to 7 farms for a limited period of time in Denmark or individual initiatives for several farms in other countries, some common guidelines can be deducted and serve as a reference.
All countries highlighted the importance of dedicated demonstration hosts, availability of well-educated, updated and independent advisory services and support to network establishment among local farmers with similar interest/cropping systems. Networks connected to demonstration farms decreases the learning curve for farmers new to IPM, makes the farming community able to respond more rapidly to new incentives, reduces the amount of redundant work, prevent “re-invention of the wheel” and increases innovation and bottom-up changes. The concept is known as Communication of Practice (CoP) within many areas.

Demonstration farms are a highly valuable tool to bridge the gap from research to practical implementation. The potential in cross-border co-operation with demonstration farms lies in the experience exchange on how to select the hosts, how to make the framework around the demonstration farm network function, how to motivate other farmers to follow the model farmers, how to support the model farmers with advice, how to convey information from demonstration farms to a broader audience, and when necessary with economic subsidies. A pronounced benefit of cross border cooperation on demonstration farms lies in the establishment phase for countries starting such activities. The conditions are highly diverse among countries in Europe and all countries have to find the best practice. It is, however, highly beneficial to have experiences to build on in the establishment period. In later phases, when established and running, there might be other opportunities for collaboration; visits between countries, inspiration if new crops are introduced in a country etc.

All of these benefits depend on the ability to communicate in a common language, and the partners in a cross border network should be willing to produce documentation and information in English to a common database/platform.

Demonstration farms are very important for the transfer of research into practice, but the funding of long term running demonstration projects is a challenge and not all research funding possibilities are relevant. Dissemination activities are highly relevant for research projects, a fact which is increasingly recognised by funders, yet not easily funded as a basic forth running activity.

• Forecasting and decision support systems (DSS)

Sharing of warning systems, forecasting models and decision support systems is another opportunity, which has a large potential for transnational co-operation. In the survey, many partner countries highlighted forecasting and DSS as important for increasing the impact of IPM advice on practical management. Experiences with monitoring in one country can be of high value for another country initiating monitoring of specific pests. Co-operation on development and adaption of forecasting systems and DSS will reduce the resources needed for building such structures in other countries and create synergies in knowledge gathering. The existing systems should be examined for opportunities for use in other countries. For most models this will require adaptation to local conditions. As well as sharing decision support systems, transnational sharing and development of databases will decrease the amount of redundant work and will instead speed up the building of databases, result in more complete knowledge databases, and the databases will end up covering larger geographical areas.

Another issue related to decision support systems are economic thresholds. Among the responses in the survey there is a high demand for new/updated economic threshold values for pest control. Cross-border co-operation to determine robust thresholds is regionally feasible, and for some areas make more sense than division by political borders, but local conditions must be considered before adopting thresholds from other geographical regions.

A broad variety of DSS exist across Europe. Some systems are regularly updated whereas others are out of use or not maintained regularly. This highlight the difficulties of decision supports systems, which are high in demand of maintenance and require a steady funding to function in the long term. Similar to the challenges for funding of demonstration farms, it can be difficult to fund decision support systems through research funding, but there is a possibility of charging a user’s fees (e.g. Crop Protection Online in Denmark). The broad variety of systems also poses a constraint if they are not presented to the
advisors and farmers in an orderly way. It is highly valuable with national platforms, e.g. the German ISIP (Informationssystem Integrierte Pflanzenproduktion/The information system for Integrated Crop production). When national platforms exist it is also easier to cooperate among countries.

Sharing experiences of the most efficient information flow route from research to farmers will also be of high value for countries establishing new monitoring, forecasting and decision support systems.

• Long-term field experiments

Research driven long term field experiments hosted by non-profit organisations offer opportunities to study cropping systems, which are not applicable in an experiments located by a farmer. The field experiments funded for research purposes can apply high risk strategies that provide research results later applicable in a practical management strategy. Sharing of results/experiences from long term field experiments will multiply the knowledge gained from these experiments and add to the development of optimised long-term IPM strategies. IPM long-term field experiments are complex, require many levels of treatments and successive years of running before results are acquired. Comparing and collecting data from concurrent field experiments focusing on different strategies will increase the IPM knowledge base. There will be large benefits in connecting the long term field experiments in a network, which could increase both the scientific and the practical value of such experiments. In the long run, co-operation might results in common protocols for long term field trails being established, this will add a spatial factor to the outcome. Even though no common protocol is adopted, sharing experiences and results will be of value.

Knowledge sharing among long term experiments can support planning of new experiments, exchange experiences with data sampling and analyses and results from different experiments can support conclusions. In 2013, the network IPM-Ease was established, which gathers 27 cropping system experiments (Lechenet et al.).

The short termed funding, the usual premise for project funding, makes is difficult to establish and run long term field experiments. The constant need to refund through new projects causes shifts in objectives and will inevitable cause a change in the treatments applied to the experimental plots thus blurring the results of the field experiments on IPM. This continuing hunt for new project funding also makes any cross border co-operation extremely cumbersome as the funding has to be international unless the participating countries can agree to support projects with the same objective multilaterally. ERA-nets could be a source for such multilateral funding, but the calls have to be targeted for the purpose. Again this can only be the funding basis for a limited time span.

WP5: Develop and fund joint transnational calls

Two transnational calls were launched by C-IPM, the first in 2015 (funding 2016) and the second in 2016 (funding 2017). Virtual common pot was the funding mechanism adopted and the evaluation was done at two stages (pre-proposal and full proposal).

Based on mapping activities, the Strategic Research Agenda identified four main areas for research:
• Cluster A: Preventive measures for sustainable pest management,
• Cluster B: Availability of alternatives to conventional pesticides,
• Cluster C: IPM solutions to overcome minor uses issues,
• Cluster D: Drivers and impact of IPM.

Based on needs and priorities expressed by partners, C-IPM translated the SRA into possible topics for calls. Cluster D was not selected as a potential topic during the course of C-IPM. C-IPM identified possible topics for calls and produced a short topic description that fit with funders’ priorities.
For the first call, subtopics A3, B2, C1, C5, C8 were selected by funders. For the second call, A2, A3, B1, B2, C2, C4, C5, C7, C11 were selected.

The first call had a total distributed budget of 5.63 million of Euros. After an evaluation by independent expert peer review the following 7 three-year projects were funded by this call. A kick-off meeting of these projects was held on December 5th, 2016 in Brussels. The main objectives of the kick-off meeting were to i) give an overview about the importance and aims of the funded projects and the potential results expected, and ii) promote exchanges between the coordinators of the different projects as well as among the coordinators and the ERA-Net partners.

List of projects selected for funding in the first C-IPM call:
• C - RootControl - A holistic approach for the management of crazy (hairy) root disease, caused by rhizogenic Agrobacteria in tomato, cucumber, and eggplant cultivation (Topic C) - BE, FR, CH
• DSS - IWM - Design and customization of an innovative Decision Support System (DSS) for Integrated Weed Management (IWM) (Topic A) - DE, DK, ES
• UNIFORCE - Unification of IPM Forces to Control Mites in Berries, Soft Fruits and Woody Ornamentals (Topic C) - BE, CH, NL, ES
• IPMBlight 2.0 - IPM2.0 for sustainable control of potato late blight - exploiting pathogen population data for optimized Decision Support Systems (Topic A3) - FR, DK, NO, EE, UK
• SmartIPM - Smart DSS for IPM in Protected Horticulture (Topic A3) - FR, ES, DE
• ElatPro - Spotting the needle in a haystack: Predicting wireworm activity in top soil for integrated pest management in arable crops (Topic A3) - AT, BE, FR, DE, IT, CH
• IPM4Meligethes - Novel biosafe IPM strategies to manage pesticide resistance in pollen beetles (Topic B1) - FI, BE, DK, EE

Likewise, the second call had a budget of more than 7 million of Euros and after an evaluation by independent expert peer review the following 9 three-year projects were funded by this call (6.48 M€ distributed):
• API-Tree - Developing Apple Pest control strategies through an Integrated agro-ecosystem approach (Topic A2) - FR, DK, FR, BE, SE, BE, ES, ES
Several improvements were made in the second call, based on lesson learnt from the first call, in terms of flexibility in timeline and evaluation procedure. However, there remains a need to improve the matching between available funding and ranking of projects the lack of which is appeared during the second call. Indeed, in the second call, 7.25 millions of Euro were available but only 6.48 millions of Euro (89%) were used for the call. The reason is that, because the projects are funded with virtual common pot mechanism, when a country puts a consistent amount of funding but researchers from that country do not apply or apply only for a few project proposals, or that their proposals are considered of lower quality, the available fund is not used.

WP6: Communication

The objective of WP6 was to provide information about C-IPM and its activities as well as to provide platforms for communication between the involved partners.

To this aim, WP6 engaged C-IPM in external communication by implementing interactions with relevant players and related initiatives and disseminating project outcomes to stakeholders and the public at-large. More specifically, dissemination of the project outcomes was made to a mailing list which was built on the one currently used by ENDURE (more than 2,200 entries), as well as 267 resource groups identified by C-IPM.

A communication kit was also produced which aimed at presenting the project. The kit included a 4-page flyer designed to introduce C-IPM, a poster providing a view on the project on a permanent basis, easily used by all partners to communicate on C-IPM.

Newsletters were prepared annually to inform stakeholders about C-IPM activities (workshops, position papers, coordinated actions, calls). In total, 12 newsletters with a total of 50 news articles were sent electronically via a mailing list to the C-IPM partners, to stakeholders and resource groups identified by C-IPM. The mailing list consists of about 400 contacts. In addition, all reports of the thematic workshops (2 in total), the SRA workshop (one), and knowledge sharing workshops (4 in total) were made available on the website. More specifically, dissemination of the project outcomes was made to a mailing list which was built on the one currently used by ENDURE (more than 2,200 entries), as well as 267 resource groups identified by C-IPM.

The following newsletters were sent electronically via the above-mentioned mailing list.

• 2014: 2 newsletters (September, November) – 9 articles;
• 2015: 5 newsletters (January, February, June, September, December) – 18 articles;
• 2016: 4 newsletters (March, May, June, September) – 22 articles;
The final conference took place on the 6th of December, 2016 at University Foundation, Brussels. Approximately 100 policymakers, researchers and stakeholders from over 20 European Member States/Associated countries were present at the conference. The aim of the meeting was to present the results of C-IPM, including a Strategic Research Agenda for IPM in Europe, and to explore the potential of future networking on IPM in Europe (details are provided in D6.5).

The conference began with an introduction to the C-IPM followed by a short presentation on i) outcomes of mapping of IPM-related research in Europe and joint priorities, ii) outcomes of C-IPM calls, iii) knowledge sharing activities, iv) presentation of the C-IPM strategic research agenda, and v) future options of European IPM networking activities after C-IPM. A Panel discussion was organised during the workshop which aimed at providing feedback on the outcomes of C-IPM, to express views as for possible scenarios for the future of IPM research and development (R&D) in Europe and to indicate what could be the specific role of stakeholders to support transnational collaboration on IPM. Relevant organizations/institutions to crop protection, such as ECPA, IBMA, IOBC-WPRS, COPA-COGECA as well as representatives of the European Commission (DG Agri, DG Research and DG Santé) were invited to openly express their views about what should/could be done to promote IPM and to align IPM-related R&D in Europe (see D6.5 for details). All participant recognised that C-IPM played an important role to promote IPM R&D in Europe and that a further continuation of this project will be highly beneficial to promote the sustainable use Directive in Europe.

Project website: http://c-ipm.org/

The project was made widely known to stakeholders and the general public through a dedicated external website. The website was established to foster communication by implementing interactions with relevant players, disseminating project outcomes to stakeholders and the public-at-large. This website presents information on the objectives and activities of the consortium as well as its achievements, provides possibilities for stakeholders to participate in workshops and stakeholder consultations on the strategic research agenda for IPM in Europe. Presentations, proceedings and/or reports from the workshops are also made available on the website as shown by an example below.

All information related to the call are announced on the website, which also provides links to the submission tool. In addition, detailed partner contact information and profiles of countries (with National Actions Plans) participating in C-IPM are also on the website.

For each funded project a newsletter was produced introducing the project. The newsletter can be seen on the webpage (http://c-ipm.org/research/c-rootcontrol/) as below.

The C-IPM public webpage has also been used to inform about European IPM research projects and networking initiatives, both from the past and present, including ENDURE, PURE etc.

The intranet part of C-IPM was used by the ERA-Net partners during all duration of the project to upload documents of common interest from different work packages. All these documents were the basis for internal communication, project management and administration.

WP7: Management

The overall objectives of the project were to be achieved through the 7 Work packages (WP’s). A WP-leader assisted by a WP Deputy leader managed each WP. The WP-leaders were responsible for the delivery of milestones and deliverables from the WPs, as well as for the communication with the parties participating in the WPs. The WP Deputy leaders assisted the WP leaders in timely delivery of milestones and deliverables.
The overall management of the project was done at two levels by means of a Governing Board and a Management team. Led by the Coordinator, C-IPM was steered by a Governing Board whose strategy and decision was implemented by an Executive Committee and a management team.

Work package leaders and task leaders:

- WP1 leader: INRA
  Task leaders: INRA, AGES, DAFA;
- WP2 leader: JKI
  Task leaders: MFAL-GDAR, JKI, DAFA, CRA-W
- WP3 leader: NVWA
  Task leaders: MAAF, SZIE,
- WP4 leader: DAFA
  Task leaders: DAFA, MIPAAF
- WP5 leader: INIA
  Task leaders: INIA, AGES, BLE, FOAG
- WP6 leader: DAFA
  Task leaders: DAFA, INRA
- WP7 leader: INRA
  Task leaders: INRA

The Governing Board (GB)

The Governing Board included the coordinator and a leading person representing the funding body. Chaired by MAAF, the Governing Board was the highest decision making body which surveyed the development of IPM, analyzed its results and ensured the relevance of the whole process to the objectives for which it was built.

In total, 4 meetings of the GB were held. The following are details about the date, venue and topics discussed during these meetings.

1. 28th November 2014, Lisbon:
   - Activities foreseen in 2015
   - Accession to new parties (SPW & ILVO)
2. 15th June 2015, Paris:
   - New C-IPM membership,
   - Overview of deliverables submitted for the first period,
   - Update on the C-IPM action plan,
   - Overview of the first periodic report procedure.
3. 13th November 2015, Rome:
   - Decision on involvement of HARO (Hellenic Agricultural Research Organization, Greece) into the second C-IPM call,
   - Update and debriefing on the first periodic report, monitoring of activities, possible re-allocation of budget,
   - Validation of the action plan 2016,
   - Organisation of additional events/workshops not initially scheduled:
   - Discussion on C-IPM after C-IPM: willingness to maintain the consortium, possible scenarios, action plan,
   - Final C-IPM conference: date, possible venue and organisation.
4. 23rd June 2016, Bonn:
   - Presentation and discussion on different scenarios for the future of C-IPM,
   - Update on the final conference,
   - Update on organization of thematic workshops on breeding for IPM and Drosophila suzukii,
   - Monitoring of milestones and deliverables,
   - Final reporting
   - Validation of procedures for monitoring funded projects after 2016

The Executive Committee (Ex-Com)
Chaired by the Coordinator, the Ex-Com was in charge of the general management of C-IPM. It was composed of the Coordinator, the WP leaders as well as Task leaders. The Ex-Com worked under the Governing Board supervision to ensure smooth and timely implementation of the Annual Work plans approved by the Governing Board. In particular, the Ex-Com:

• Assisted the Coordinator in the implementation of the decisions of the Governing Board in addressing technical and organizational tasks;
• ensured a tight coordination among the different activities;
• Provided mutual assistance and coordination between the WP leaders and the Deputy leaders for achieving their objectives;
• Facilitated the communication between the different partners and tasks.

The Ex-Com was composed of the following partners: INRA, DAFA, JKI, CRA-W, NVWA, MAAF, INIA, BLE, MIPAAF. Other task leaders were also invited: AGES, SZIE, FOAG, MFAL.

In total, 10 meetings of the Ex-Com were held, including 6 physical and 4 tele-meetings. The following are details about the date, venue and topics discussed during these meetings.

1. 9th January 2014, Paris:
   - Practical implementation of the DoW,
   - Contribution to the European Research Area,
   - C-IPM administrative issues.

2. 25th April 2014, Paris:
   - Terms of reference for the participation of resource group,
   - organization of the first thematic workshop, organizing committee and invited speakers,
   - Organization of National IPM research programmes (January 2015): structure, organizing committee, venue and dates,
   - Follow-up of the questionnaire on WP2+WP3,
   - launching of the web site, communication kit, newsletters, collaborative workspace,
   - clarification of the call procedure and the timetable,
   - Discussion about a limited call in 2014 for those Member states who are ready to fund transnational calls in 2015, and application of the implementation tool.

3. 23rd June 2014, Paris:
   - organization of the first thematic workshop, organizing committee and invited speakers,
   - analysis of the questionnaires on WP2,
   - Workshop on R & D programmes, analysis of the questionnaire and validation of Terms of Reference,
   - implementation of WP5,
   - follow-up on the annual and WP meetings,
   - follow-up of the questionnaire on minor use needs,
   - follow-up on the Personnel exchange,
   - follow-up on the newsletter, flyer and communication tools,
   - Follow-up on the update of deliverables,
   - Follow-up on the update of monitoring tools, and follow-up on the consortium agreement.

4. 17th September 2014, Berlin:
   - Discussion on WP2 report & implication in the SRA,
   - update on the table of needs on minor use,
   - Final programme for the thematic workshop,
   - Pilot call topics, mechanisms and task force for scientific contents,
   - Final programme for the annual meeting,
   - Proposal for Workshop on R & D programmes,
   - Follow-up on the ppt draft template and newsletter,
   - The SRA workshop (M15): possible date and venue,
   - Second thematic workshop (M18): possible date and venue.
5. 23rd January 2015, Paris
- Validation of the draft SRA to be sent for “public” consultation,
- The SRA workshop organization,
- clarification on the concept of knowledge sharing (KS) & criteria,
- Organization of the first call, call implementation,
- Second thematic workshop,
- Suggestions for project communication and dissemination, and monitoring of funded projects and impact analysis of the call.

6. 22nd April 2015 (tele-meeting):
- Update on the launching of the call,
- discussion on knowledge sharing issues, personnel exchange,
- update on the organization of the second thematic workshop,
- update on the C-IPM periodic report,
- new C-IPM Membership.

7. 23rd September 2015, Berlin:
- Update and debriefing on the first scientific report, feedback from WP leaders,
- discussion of topics that would deserve in-depth analysis and possibly benefit from knowledge sharing and workshops,
- finalization of the SRA and revision of the second version,
- follow-up of WPs, need for corrective actions,
- WP5 Follow-up of the first call, update on the second call including topic selection and next steps,
- preparation of the Rome annual meeting.

8. 8th February 2016 (tele-meeting):
- Feedback on the first call and its implication on the organization of the 2nd call,
- organization of the 2016 workshops,
- preparation of a document on the future of C-IPM,
- organization of the final conference of C-IPM,
- update on the C-IPM activities (monitoring tools and deliverables) and budget,
- creation of the webpage for each funded project within the 2015 call at: c-ipm.org
- executive summary of the C-IPM SRA, and Proposal of FACCE JPI.

9. 5th April 2016 (tele-meeting):
- Monitoring of the work packages and remaining tasks,
- Possible need for additional C-IPM meetings on the above items, a tele-meeting with different WP,
- planning of a Governing Board physical meeting in June (date and venue),
- Draft agenda of the final conference.

10. 24th October 2016 (tele-meeting):
- Logistics for the WP3 workshop,
- kick-off meeting of the projects funded by the first call,
- final conference,
- call group meeting,
- preparation of final reports.

The Management Team:

Daily management work and handling of the project logistics were done by the Project Management Team working under the control of the project coordinator. The responsibilities of the management team encompassed feasibility studies, creating public and private partnerships, managing projects using process-based approaches, disseminating and promoting results. In particular, the team was responsible for:
- Project administration (including planning, preparation and follow-up of the various Governing Board and ExCom meetings);
- Consolidation of the periodic project reports;
- Financial administration (monitoring of expenses against budget allocations, consolidation of financial summary sheets, etc.)
- Consolidation and control of the cost claims according to the contractual requirements,
- their conformance with the work done and the audit certificate to be produced by the partners;
- Assistance to individual project partners on specific administrative issues;
- Communication facilities and coordination (web-based collaborative tool).

Potential Impact:
C-IPM responded to the widely perceived need to coordinate research to support development and implementation of IPM and alternatives techniques as MS face the challenge of responding to the mandatory implementation of the general principles on IPM within the requirements of the Framework Directive on the Sustainable Use of Pesticides. More specifically, C-IPM created synergies from existing national research and extension efforts. C-IPM emphasized the fact that in crop protection, the innovation process can only occur if farm advisory services are closely associated to innovative and applied research efforts. Consequently, the project promoted activities involving networking of existing initiatives as well as joint calls leave the door open to demonstration farms.

C-IPM mapped IPM research across Europe and, based on the outcomes, defined common European agenda thereby creating financial efficiency. C-PM, by reaching a size large enough to achieve European-level impact, established networks of research activities and joint transnational calls.

C-IPM completed the work begun in the SCAR CWG by resuming the mapping exercise begun in the CWG. C-IPM even extended the mapping analysis to a broader range of countries and, by focusing on specific research and development areas, led to a definition of a common strategic R&D agenda on IPM. C-IPM listed a number of topics of common priority across Europe which will benefit from knowledge sharing activities via cross-border collaboration.

C-IPM, by coordinating IPM research at European level, avoided funding overlap between national initiatives and EU funding. This was done by identifying areas for joint activities and distinguishing between those activities that are best left at the national level and those that can gain from joint national actions.

C-IPM consortium reached a critical mass with the potential for a snowball effect in Europe in terms of coordinating future IPM research. With 21 countries involved in coordinating activities and in linking their research programmes, significant multi-country actions were taken. Such a transnational coordination was particularly important, in terms of funding resources, given the modest current national research budgets allocated to IPM, which would not have allowed to reach the entire and diverse agricultural production systems. In such a context, C-IPM brought together numerous existing research programmes and created synergies from national investments by organizing two transnational calls funding 16 research projects.

Key strategies proposed by C-IPM to overcome the challenges that IPM is facing:

1. Focus on multidisciplinary research
   • Foster research based on a multidisciplinary approach to understand the drivers of IPM adoption. Since IPM covers a large set of principles and is, by far, not solely limited to reducing pesticide use.

2. Changes in paradigm
   • Combine research on individual crop-pest relationships and integrate them into system guidelines instead of a narrow focus on specific crop-pest relationships. IPM implementation will benefit from a broad system approach in research;
   • Promote research on “lock-in” and transition phase to examine to what extent agricultural actors are locked in by “past socio-technical choices” and identify possible mechanisms of transition to IPM that consider multi-actor perspectives;
   • Support long-term research projects based on cropping system approaches and ensure funding to maintain/strengthen infrastructure for long-term IPM research.

3. Strengthen infrastructure and knowledge exchange
• Establish the necessary scientific infrastructure and scientific advisory capabilities to support modernisation of the monitoring and decision support systems for pests;
• Encourage knowledge sharing and adaptation of IPM approaches to minor crops/ uses by involving stakeholders;
• Integrate active and participatory dissemination into IPM research projects to ensure proper knowledge exchange and promote IPM implementation;
• Increase communication on the environmental benefits of IPM and formulate transparent and meaningful messages to the general public by focusing on IPM benefits.

4. Develop alternatives to pesticides:
• Better integrate biological control into IPM systems and identify the bottlenecks concerning the application of biological control in arable crops and other field crops where no or only limited alternatives to pesticides are available for protection;
• Build strategies to promote durable resistance management and monitor the occurrence of resistance development in order to slow down or prevent the resistance development and to guide decision-making in terms of sustainable pest resistance management strategies.

Workshop/conferences

The exchange of information and techniques is one of the key points for research collaboration and the success of IPM implementation. Therefore, C-IPM engaged in a number of knowledge sharing activities addressing the exchange between researchers and funders at European level. Existing knowledge sharing networks often have a scientific background meaning that, often, only researchers are involved in such activities. C-IPM took this into account and aimed to bridge the missing link between fundamental and applied research. This was done by involving a broad range of stakeholders in knowledge sharing activities, including research funders and managers.

The following workshops (thematic and knowledge sharing) were organized by C-IPM on specific topics in different European countries with the aim to facilitate the knowledge exchange between national funders/managers and researchers. Such workshops were dedicated to address future challenges arising from the political and societal sphere as well as novel innovations building the future base of IPM by bringing together scientists, governmental officials, policy makers, industrial companies, and agricultural advisors, in order to support the implementation of IPM in Europe. This helped identify key priorities in specific research areas as well.

- Future challenges for IPM in a changing agriculture“, 8 October 2104, Berlin, Germany
- “Existing R&D IPM-related programmes“, 13 January 2015, Poznan, Poland
- “Strategic Research Agenda for IPM“, 15 March 2015, Paris, France
- “Role of existing and new technologies addressing the challenges of IPM“, 15 June 2015, Paris, France
- “Joint International workshop on Biocontrol“, 27-28 January 2016, Paris, France
- “Demonstration Farms on Integrated Pest Management“, 24-25 May 2016, Bonn, Germany
- “Breeding for IPM in sustainable and low-input agricultural systems“, 4-6 July 2016, Radzikow, Poland
- “Joint C-IPM and IOBC workshop on European agenda setting for research to cope with Drosophila suzukii“, 4-8 September 2016, Thessaloniki, Greece

Acknowledging the fact, that IPM research is based on a cropping system approach, all C-IPM partners emphasized that it will be difficult to develop and accomplish the collaboration activities with short term project funding. Building on the current achievements there is a need to maintain knowledge sharing activities on a permanent basis to speed-up IPM implementation and to optimise economic resources and time needed to address these issues via transnational collaborations.

C-IPM has no direct socio-economic impacts as such but addresses an issue, “Reduce the reliance of agriculture on pesticides”, that is supported by the civil society. By helping align IPM-related research programmes in a range of member states, C-IPM should foster the implementation of IPM, which, in turn, has implications for the environment.

List of Websites:
Project website: http://c-imp.org/
The project was made widely known to stakeholders and the general public through a dedicated external website. The website was established to foster communication by implementing interactions with relevant players, disseminating project outcomes to stakeholders and the public-at-large. This website presents information on the objectives and activities of the consortium as well as its achievements, provides possibilities for stakeholders to participate in workshops and stakeholder consultations on the strategic research agenda for IPM in Europe. Presentations, proceedings and/or reports from the workshops are also made available on the website as shown by an example below.

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For each funded project a newsletter was produced introducing the project. The newsletter can be seen on the webpage (http://c-ipm.org/research/c-rootcontrol/) as below.

The C-IPM public webpage has also been used to inform about European IPM research projects and networking initiatives, both from the past and present, including ENDURE, PURE etc.

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Federal Office for Agriculture (FOAG)

Turkey:
Ministry of Food, Agriculture and Livestock (MFAL-GDAR)

United Kingdom:
The Department for Environment, Food and Rural Affairs (DEFRA)
ASSOCIATE PARTNERS:

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Fonds Wetenschappelijk Onderzoek Fonds Wetenschappelijk Onderzoek (FWO)

Greece:
National Agricultural Research Foundation (NAGREF)

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