C-IPM Workshop on projects funded under calls 1 & 2
22-23 November 2018
CIS Paris Kellermann, 17 Boulevard Kellermann - 75013 PARIS

Draft Agenda 1.6
15 October 2018

Thursday 22 November	
13:00	Welcome coffee
13:30	Introduction/objectives, overview of the C-IPM Strategic Research Agenda and outcomes of C-IPM calls
13:45	Session 1 – IPM and minor Uses (4 projects) Introduction by the chair and rapporteur: challenges 15' each + 30' discussion (how the research carried out help solve minor uses issues)
15:15	Session 2 - Pest and disease monitoring for IPM (first part - 2 projects) Introduction by the chair and rapporteur: challenges 15' each
15:45	Coffee break
16:15	Session 2 - Pest and disease monitoring for IPM (second part – 4 projects) 15' each + 45' discussion (contribution to IPM implementation)
18:00	End of the day
19:00	Dinner (sponsored by Ecophyto)

Friday 23 November	
08:30	Session 3 – Sustainability (1 project) and integrated biocontrol (2 projects) Introduction by the chair and rapporteur: challenges 15' each + 30' discussion
9:45	Coffee break
10:15	Session 4 – Integrated weed management (3 projects) Introduction by the chair and rapporteur: challenges 15' each + 20' discussion Reducing dependence on glyphosate: research challenges – *Xavier Reboud, Inra, France* 20' + 20' discussion General discussion on Integrated Weed Management (30')
12:30	Lunch
13:45	Presentation of Ecophyto II+ - *Marion Bardy, French Ministry of agriculture* Status of National Action Plans and link to transnational research – *Tsvetana Georgieva, DG Sante* Follow-up of C-IPM: projects selected under SusCrop - *Philippe Nicot, Inra, France* Conclusion

	15’-20’ each + 30’ discussion
15:30	Meeting close

Acronym	Coordinator	Topic
Minor uses		
FlyIPM	Dr Rosemary Collier (Univ. of Warwick, UK)	C2
AAPM	Dr Johannes Fahrentrapp (ZHAW, CH)	C4
C-RootControl	Hans Rediers (PME&BIM KU Leuven, BE)	C3
UNIFORCE	Dr Bruno Gobin (PCS, BE)	C2
Pest and disease monitoring for IPM		
PeMaTo-EuroPep	Dr Rob Moerkens (Proefcentrum Hoogstraten, BE)	A3
SpotIT	Dr Berit Nordskog (NIBIO, NO)	A3
SmartIPM	Dr Christine Poncet (INRA, FR)	A3
IPMBlight 2.0	Dr Didier Andrivon (INRA, FR)	A3
ElatPro	Mrs Katharina Wechselberger (AGES, AT)	A3
IPM4Meligethes	Prof Heikki Hokkanen (Uni. Helsinki, FI)	A3
Sustainability		
API-Tree	Dr Aude Alaphilippe (INRA, FR)	A2
Integrated Biocontrol		
EURO-RES	Dr Stephen Kildea (Teagasc, IE)	B2
Defdef	Dr Merijn Kant (UvA, NL)	B1
Integrated weed management		
DSS-IWM	Arnd Verschwele (JKI, DE)	A
BioAWARE	Dr David Bohan (INRA, FR)	A2
RELIUM	Dr Maurizio Sattin (CNR, IT)	B2

Caption:

Call 1

Call 2

Session and projects description

Session 1 - Minor uses – Four projects

- FlyIPM: Integrated control of root-feeding fly larvae infesting vegetable crops
- AAPM: Automated Airborne Pest Monitoring of *Drosophila suzukii* in Crops and Natural Habitats
- C-RootControl: A holistic approach for the management of crazy (hairy) root disease, caused by rhizogenic Agrobacteria in tomato, cucumber, and eggplant cultivation
- UNIFORCE: Unification of IPM Forces to Control Mites in Berries, Soft Fruits and Woody Ornamentals

• FlyIPM

The aim of the proposed project is to improve the management of root-feeding fly larvae infesting outdoor vegetable crops using an integrated approach (IPM). The key pest insects are *Delia radicum*, *D. floralis*, *D. antiqua*, *D. platura* and *Psila rosae* and all considerably reduce crop yield and quality if not managed effectively. We will improve the management of these pests by 1) assimilating and synthesizing information on pest life-cycles and on monitoring and forecasting approaches to improve integration of control methods; 2) developing methods to reduce the likelihood of adult insects finding and/or infesting susceptible crop plants; 3) developing and refining methods for biological control of larval and adult insects with entomopathogenic fungi (EPF) and nematodes; 4) integrating existing and newly-developed methods of control into IPM strategies and 5) disseminating information to a community of stakeholders to improve pest management at field and farm level. This will reduce the need for, and improve the performance of, insecticidal methods of control, increase the quality of produce, minimize waste both pre- and post-farmgate and reduce insecticide use and the resulting adverse effects on the environment and human health.

The main outcomes of the project will be 1) improved understanding of pest and natural enemy phenology, together with refinement of existing monitoring and forecasting approaches; 2) scientific progress from research on methods of manipulating pest insect behavior which may lead to novel methods of control; 3) scientific progress in pest control with entomopathogens and on plant-EPF-insect interactions which may lead to new and more efficacious approaches to their application and 4) integration of control methods under field conditions leading to improved control; 5) information and techniques will become more freely available within Europe. The main target group will be vegetable producers in Europe and their advisors but the project will also involve the wider supply chain, which includes companies that supply products and information for pest monitoring, forecasting and control, seed companies, processors and retailers. The scientific community will also benefit from the newly generated knowledge and information about the project will be of interest to consumers and home gardeners. The consortium consists of 9 partner organizations from 8 countries and represents a significant proportion of European expertise on these pest insects.

• AAPM

Drosophila suzukii has become a serious pest in Europe since its spread in 2008 to Spain and Italy, attacking many soft-skinned crops such as several berry species, cherry and grapevines. Pest monitoring is the basis of its control. Therefore, an efficient and accurate monitoring system is essential in order to identify the presence of *D. suzukii* in the crops and the surrounding area, and to prevent damage to economically valuable fruit crops. Existing methods for monitoring *D. suzukii* are costly, time and labor intensive and consequently conducted at low spatial resolution and prone to errors. We therefore propose to develop a novel system to overcome current monitoring limitations consisting of traps which are monitored by means of an Unmanned Aerial Vehicle (UAV) and an automatic image processing pipeline for the identification and count of number of *D. suzukii* per trap location. The automated monitoring has an advantage over current methods in terms of (1) labor intensity, (2) sampling interval, (3) automatic integration into DSS, (4) monitoring of diverse and even hardly accessible habitats, and (5) population monitoring in vast areas in relation to climatic and other geo-processed parameters. A multi-variable sticky trap evaluation will allow selecting the most suitable one to attract the target insect. A small multi-rotor UAV platform will be flown at multiple intervals to capture high resolution color aerial photographs of the insect traps. The photographs will be subjected to image processing algorithms to identify the presence or absence of *D. suzukii* and their counts. The data collected will be transferred to a decision support system (DSS) to provide valuable information for growers in a format that is both meaningful and accessible, thereby demonstrating the added value and social importance of applied science and technology to the wider community and food security.

• C-RootControl

"Hairy or crazy root disease" (HRD) is characterized by extensive root proliferation and occurs on several dicotyledonous plants, among which many economically important crops. Since the early 1990s, hydroponically grown cucumber plants, and later tomato crops and eggplants, have been affected by the disease, causing substantial economic losses. HRD is a rapidly spreading disease, with an increased prevalence in several European countries. In addition, HRD is a highly persistent disease because rhizogenic *Agrobacteria* can form biofilms around plant roots and in the irrigation system. Biofilms are difficult to remove because they provide a niche where microbes are protected against disinfectants. Therefore, high concentrations of chemicals are required to remove biofilm. Moreover, several chemicals are converted to toxic by-products, which has led to the awareness that the use of chemical biocides should be replaced or reduced. Therefore, there is clearly a need for integrated pest management (IPM) strategies to control HRD, especially because of (i) the rapid spread and high persistence of this disease; (ii) the current lack of sustainable and effective plant protection products; and (iii) the economic losses associated. IPM takes advantage of all appropriate pest management options, with minimum use of chemical pesticides.

The main objective of this project is to develop long-term sustainable IPM solutions allowing to reduce the problems attributed to HRD. To achieve this, we propose a holistic approach, in which plant cultivation, irrigation system (biofilm), and the plant microflora are included. Specific scientific objectives and expected outcomes include the development of a reliable monitoring tool for rapid detection of HRD, screening for new biocontrol organisms, evaluation of novel anti-biofilm compounds, and new cultivation techniques to reduce disease symptoms. In addition, we want to establish a close interaction with stakeholders at a transnational level, establish increased awareness in the target group, and advise growers/advisors regarding an IPM strategy and demonstrate its efficacy in greenhouse experiments.

Currently, there are several national research initiatives studying the problem of HRD, each with their own focus. However, a European initiative that joins research groups with complementary expertise is required for the holistic approach proposed here in order to make a leap in developing IPM strategies to reduce HRD.

- **UNIFORCE**

Blackberry, currant, raspberry, strawberry and azalea are attacked by mites of the families *Eriophyidae* (as the blackberry mite, *Acalitus essigi*, and the black currant gall mite *Cecidophyopsis ribis*), *Tarsonemidae* and *Tetranychidae*. These mites have similar life styles, they are tiny, often hidden and difficult to monitor until damage is conspicuous. An efficient, sustainable and integrated way to control these mites in-field is missing. As the target crops are minor crops in most countries, cooperation between multiple European research organizations will boost each country's limited and separate capacities.

UNIFORCE will tackle problems by combining the individual experience of each partner. The goal is to develop in-field solutions within the 2 year project term. UNIFORCE research structure will focus on the tritrophic interactions between plant, pest and beneficials.

We will characterize harmful and predatory mites *via* experience, field surveys and literature. Sampling techniques will be optimized to allow fast early detection and monitoring. Besides predatory mites, other natural enemies found in association with pest mites will be identified as potential biological control agents. Direct and indirect plant defense in specific cultivars for each crop will be studied. Jasmonic acid (JA) and salicylic acid (SA) pathways, as well as mite responses to plant volatiles related to these defense pathways will be characterized. Possibilities of integrating these natural defense mechanisms into biological-control based IPM programs will be explored.

IPM programs including the use of predatory mites will be developed. Commercial and newly found predators will be evaluated. Efficiency and conservation of predators will be optimized based on knowledge of the pest life cycle, dose and timing of releases of predatory mites and methods to support them (e.g. pollen, mulch layers). Control methods with predatory mites will also be tested with selective pesticides (e.g. sulphur) or biopesticides that can potentially work synergistically. Furthermore, potential applications of plant volatiles will be studied. Part of this research will be elaborated in close collaboration with growers in different European countries to translate UNIFORCE research into directly applicable IPM strategies. Finally, project results will be summarized into a tool with practical advice for growers on how to identify, monitor and control the most important mites in the target crops.

- **Session 2 - Pest and disease monitoring for IPM – Six projects**
  - PeMaTo-EuroPep: Pest Management tool for tomato and pepper in Europe
  - SpotIT: IT-solutions for user friendly IPM-tools in management of leaf spot diseases in cereals
  - SmartIPM: Smart DSS for IPM in Protected Horticulture
  - IPMBLIGHT 2.0: IPM2.0 for sustainable control of potato late blight - exploiting pathogen population data for optimized Decisions Support Systems
  - ElatPro: Spotting the needle in a haystack: Predicting wireworm activity in top soil for integrated pest management in arable crops
  - IPM4Meligethes: Novel biosafe IPM strategies to manage pesticide resistance in pollen beetles

PeMaTo-EuroPep

Pest monitoring is the basis of good biological control. The interest for monitoring among European greenhouse vegetable growers increases year by year. An efficient, standardized monitoring system, that covers all present pests is lacking. Moreover, the focus should shift from classical pest monitoring systems (PMS) towards ecological monitoring systems (EMS), whereby the ratio of pest and beneficial is determined. This ratio is indispensable to determine the required control strategy. Although biological control is the basis, greenhouse tomato and pepper crops in Belgium, The Netherlands and Spain are sprayed between 2 and 10 times a year with chemical plant protection products (PPP) respectively. These numbers indicate the necessity of innovative monitoring and decision tools, to induce a shift towards biological control.

One on one predator-prey relations like *Macrolophus pygmaeus* and *Trialeurodes vaporariorum* in tomato crops are relatively easy to control. In practice, these species co-occur with other pests and beneficials which results in a complex food web. The required pest/beneficial ratios for biocontrol can vary in absence or presence of other organisms. Additionally, the heterogeneous distribution of pests throughout the greenhouse complicate the choice of correct control strategies. Due to the limited information, useless or inappropriately timed chemical PPP's are often applied, with increased chance of pest resistance. Decision support systems (DSS) based on monitoring data of the grower should bridge the gap between the actual (often *ad-hoc*) and ecological pest management of the growers.

In this research project an efficient and innovative EMS and DSS is developed for tomato and pepper greenhouse crops. This EMS is based on efficient (automated and accurate) use of sticky traps and plant observations. This will be achieved by usage of innovative techniques like light multispectral camera's to detect and quantify spider mite (Tetranychus urticae) damage and (semi-) automatic identification of pests and beneficials on yellow sticky traps. The DSS is based on population models (Lotka-Volterra derivatives), which are often used in ecology and epidemiology. These models will allow for spatio-temporal forecasting of the population dynamics of pest and beneficial species in greenhouses. The developed differential equations will be linked to the EMS, resulting in a DSS which will be useful in any European greenhouse.

- **SpotIT**

SpotIT is a Nordic-Baltic initiative to provide cereal farmers with better models for predicting leaf spot diseases in wheat and barley, aiming for user-friendly dissemination of model outputs through locally adapted IPM-tools. Leaf diseases are a major threat in cereal crops in the Nordic-Baltic area and fungicides are widely used for reducing yield losses. Improved management strategies can reduce numbers of unnecessary fungicide sprays and optimize timing of the needed fungicide treatments. It will contribute to increased food production, better economy for the growers and minimize negative impact on the environment.

SpotIT aims to provide locally adopted disease forecasting models via a trans-national platform allowing cost efficient development of locally adapted DSS in native language, to facilitate the use of IPM. The main objectives will be to: 1) Characterize end-user groups and their preferences for leaf spot models and DSS, 2) Understand the motives behind farmer decision-making in relation to IPM-tools to optimize the precision and quality of pest management strategies. 3) Improve and validate risk prediction models for wheat and barley diseases based on field observations and historical data, 4) Develop IPM-tools that accommodate local user needs, based on available infrastructure, locally available input data and technology resources.

Despite development of national DSSs in many countries, users do not always utilize the available tools. End-user needs and preferences will be investigated to understand how local DSS can be disseminated better as a tool for support of IPM. Several models for leaf spot diseases in cereals have been developed, but national DSSs usually implement locally developed or individually selected models. Many models are thus only offered to limited user groups. In the Nordic-Baltic region, a common approach for DSS implementation and disease modelling is a natural consequence of the comparable conditions for cereal growth and disease development. The Norwegian Open Source technology platform VIPS will provide a trans-national facility for model testing and validation, allowing for testing with input data from all participating countries in SpotIT. Relevant IPM-tools will be developed to utilize both existing national DSS and facilitate joint use of a trans-national system. Although this project will focus on leaf spot pathogens, the resulting DSS platform can easily be used for other host, pest or pathogen systems.

- **SmartIPM**

Greenhouse crops, as well as the other horticultural crops are subject to strong market requirements regarding the visual quality of products and very high levels of pest risks. This has led to intensive use of pesticides worldwide with very high indexes of treatment frequency but this "all chemical" plant protection strategy exhibits nowadays serious limits due to the reduction in available active ingredients (Ecophyto plan in France, REACH internationally) and to the increase in pest resistance phenomena.

Despite strong expectations about their socio-economics and environmental issues, integrated pest management strategies are slow to take a sufficiently robust concrete form to be widely adopted. The reason for this delay lies mainly in the fact that the fundamental understanding of agro-ecosystem functioning at the local farm level appeared much more challenging than had been expected even in greenhouses. Indeed, multiple unexpected interactions between pests, beneficials and plants are observed at the farm level when "truly integrated" pest management is implemented making the targeted ecosystem services inoperative. We assume that the only way to build a robust IPM strategy is to design accurate tools to monitor and manage the spatiotemporal dynamics of all the key biotic components. This implies development of tools for risk assessment and assistance in decision-making, specifically dedicated to farmers or advisers.

Within this framework, this project aims at developing, optimizing and validating DSS tools in a real context of greenhouse cropping system, namely:
- To develop tools to assess the health status of crops *via* the sampling and information analysis of main biotic factors from the monitoring of European network of experimental stations and farms;
- To promote the acquisition and implementation of expertise (knowledge) necessary for decision-making adapted to local specificities and constraints;
- To build or optimize predictive models to anticipate pest and natural enemies dynamics in real cropping situation thanks to systemic trials carried out in Europe;
- To develop decision support systems and tools relying on the re-definition of local, regional, and European decision rules (DR) taking into account socio-economic aspects of farms.

This intelligent system will be based on the IS S@M developed so far on ornamentals in France and Italy.
(http://sam.sophia.inra.fr/sam/NOUVEAU_SITE/pages/Accueil/accueil.php?langue=fr)

- **IPMBlight 2.0**

Late blight, caused by *Phytophthora infestans*, remains the major threat to potato crops in Europe, and a main reason for pesticide use. Despite the release of resistant cultivars and the implementation of modern DSS operated from web platforms or mobile apps, integrated management of late blight still relies heavily on many fungicide applications (up to 25 per season in some regions). The need is thus obvious to develop strategies that take full advantage of alternative options for more sustainable crop protection and better fungicide stewardship. To be sustainable and adopted, such strategies must be tailored to the variability of *P. infestans* populations and their rapid evolution - the IPM 2.0 concept. This in turn supposes that pathogen populations be monitored for both genotypes and phenotypes, including virulence, aggressiveness and fungicide sensitivity.

IPMBlight 2.0 aims at validating the IPM 2.0 concept, with potato late blight as a case study. To this end, it will analyze genotypic (WP1) and phenotypic (WP2) variation in reference collections of the pathogen sampled from sexual and clonal populations collected in partner countries, and develop new DSS models while adjusting existing ones to offer risk assessment based on both epidemiological, weather-driven infection likelihood and pathogen phenotypes (WP3). The new DSS modules will therefore be able to best inform tactical choices ('should I spray now?') and strategic decisions ('can I trust this resistant cultivar? how can I adjust my spraying schedule accordingly?) for improved late blight control.

The project builds on the monitoring activities carried out within EuroBlight, and complements them by providing critical, but currently unavailable phenotypic data. EuroBlight is a large collaborative network of scientists, breeders, agrochemical industries, DSS developers and extension specialists dedicated to improved blight control, which has been active for over 20 years. IPMBlight 2.0 will use the IT platforms and population typing protocols, developed and validated within EuroBlight, to generate and disseminate original data and analyses on pathogen evolution, improved open-source DSS models and to establish a reference network of laboratories able to track new emergences within European *P. infestans* populations. Through its international links, IPMBlight 2.0 will also provide updated information regarding the connections between European and global populations of the late blight pathogen.

- **ElatPro**

Wireworms, the larvae of click beetles (Coleoptera: Elateridae), are abundant soil-dwelling insects which attack the below-ground parts of a wide range of crops, thereby inflicting severe economic damage. Typically, wireworms damage crops when they forage in the upper soil layers. They migrate to deeper layers when soil conditions become unfavorable, or for moulting and hibernation. Predicting these vertical movements and identifying when wireworms actually dwell in upper versus deeper soil layers is crucial for the decision and timing of control measures for these pests.

Recently, the prognosis model SIMAGRIO-W has been developed as a decision support system to forecast the activity of Agriotes wireworms in upper soil layers, based on soil moisture, temperature and soil type. Albeit successfully applied in field tests in western Germany, the model performed poorly when it was evaluated in eastern Austria. This discrepancy in the model's performance may be due to differences in temperature tolerance between the different Agriotes species occurring in eastern Austria and in Germany. Moreover, the model does not take into account other parameters which might be important drivers of wireworms' vertical movements such as species-specific movement behaviors, larval age, root availability, and plant volatiles

The current project directly addresses these gaps of knowledge and aims to significantly improve the current model to develop a wireworm decision support system which is applicable across European arable land. Laboratory experiments, which will reveal how specific parameters affect larval vertical movement behavior of abundant Agriotes species, will be combined with field surveys in potato, maize and chicory fields across several European regions. These data will be used to extend and improve the model, which will thereafter be evaluated using an independent set of field data. Additionally, through the coordinated field surveys in many countries, the main pestiferous species of wireworms occurring in different regions will be identified, which is an important prerequisite for a widely applicable IPM strategy against wireworms. As such this project provides a unique opportunity for creating a novel strategic decision making tool for pestiferous wireworms which would not be possible to obtain through research in any one country alone.

- **IPM4Meligethes**

The IPM4Meligethes-project targets the pollen beetle *Meligethes aeneus*, which is a key European pest on oilseed rape (OSR). OSR is an important food crop (vegetable oil), feed crop (domestic protein), and an energy crop (biodiesel). Current cropping systems require several insecticide sprays annually, mainly to control the pollen beetle. The beetle has evolved resistance throughout Europe to the only insecticide class widely available, pyrethroids. In line with the call objectives, we propose to go beyond the traditional resistance management programs, which rely on the continuous discovery and registration of new insecticides and new modes of action. We propose to develop novel, safe, sustainable, and economically feasible strategies, where only seldom is a need to resort to insecticide spraying. This will ease the selection pressure on the pest, and prolong the efficacy of the available insecticides.

The project will provide a set of cascading alternatives for pollen beetle control. The basic new tool is simple (change in tillage regimes) and ready to be taken up, after appropriate applied research. Together with revised and dynamic thresholds and improved forecasting and monitoring tools, growers will be able to radically reduce insecticide use, with all associated economic and environmental benefits. Novel safe and precise control tools will help growers to manage occasional pest population peaks, even without insecticides.

The key components of the proposed work include: (i) Cropping system buffering against pest outbreaks via innovative biological control, (ii) Development of forecasting and monitoring methods, and revised dynamic treatment thresholds; (iii) Targeted precision biocontrol for delivery of novel biocontrol products; and (iv) Development of RNA interference methods for *Meligethes aeneus* control. These are new, effective, non-toxic, and selective/biosafe approaches, to control the pest, and to avoid problems with pesticide resistance.

The main beneficiaries of the results to be obtained are the oilseed rape growers in Europe. Indirectly many other groups are targeted, including the OSR-based industries, crop protection industries, as well as crop protection authorities, regulators, policy makers and the general public. As the problem to be solved is pan-European, only a European project involving the best expertise available, can successfully address the question.

- **Session 3 - – Sustainability (one project) and integrated biocontrol (two projects)**
  - API-Tree: Developing Apple Pest control strategies through an Integrated agro-ecosystem approach
  - EURO-RES: Eurowheat - Fungicide Resistance Network
  - Defdef: Defenseless defenses: does biological control work better on unprotected plants?

- **API-Tree**

Apple accounts for 35% of European orchards and the sustainability of apple production is questioned since it relies on a heavy use of pesticides. The objective of the API-tree project is to design and assess the efficiency and sustainability of combinations of practices, which are alternative to chemicals to control apple pests. The whole apple pest complex will be considered, with a focus on aphids, for which chemical control solutions are missing due to regulatory pesticide withdrawal.

The novelty of this project is the integrated approach that takes into account agroecosystem management, orchard design and practices, as well as economic constraints. A range of geographic and climatic conditions is covered by API-tree thanks to the consortium, which comprises countries from Northern to Mediterranean Europe. This also permits to share various experiences and knowledge to propose innovative context-adapted solutions. API-tree will permit to design and assess new orchard systems in collaboration with end-users (mainly growers), who will participate in co-design activities and test some proposed strategies in their commercial orchards. Targeted practices will aim at building consistent and resilient systems that reduce both pest attacks and damage to attacked plants. All the partners have skills in ecology and agronomy and expertise in methods and practices that foster the defense of the apple tree against pest attacks and the control of apple pests by their natural enemies. Those practices are related to the enhancement of plant diversity (additional cultivars, cover crops, introduction of companion plants…), to soil and tree management (cultural practices) and to the design of agroecological infrastructures (e.g. habitat management to provide pest natural enemies with food resources and shelters, push-pull plant assemblages, etc.).

The sustainability of the designed strategies will be evaluated using the multicriteria assessment tool DEXiFruits to account for economic, environmental and social performances of the experimented orchards. The outcomes of the project are i) Integrated Pest Management strategies which can be implemented in different contexts, with information on their efficacy, mode of action, feasibility and costs; ii) methods to design and evaluate innovative orchards and iii) knowledge sharing and dissemination, including European and local interactions to discuss and implement approaches and orchard systems with advisors and growers.

• EURO-RES

Currently wheat production in northern Europe is reliant on the application of plant protection products throughout the growing season. Fungicides account for approximately 25% of these applications, with *septoria tritici* blotch (STB) the primary target. Unfortunately the evolutionary potential of Z. tritici coupled with the highly specific nature of current fungicide chemistries place the pathogen at a high risk of fungicide resistance development. Over the last decade the consequences of this have been observed at field level, with varying levels of resistance to the main fungicides now reported in Northern Europe. In addition to fungicide resistance, changes in the registration of plant protection products within the EU will impact upon the availability of current and future chemistries. It is therefore imperative that both the potential development of resistance and subsequent spread is minimized. To achieve this it is essential to continually monitor Z. tritici populations for risk of resistance development and to develop strategies that reduce this risk and the spread of resistant strains whilst maintaining disease control. The proposed EURO-RES project aims to 1) Determine the level of resistance in Z. tritici populations in Europe and analyse the dynamics of fungicide resistance based on molecular methods 2) Develop and test robust and sustainable IPM control strategies for the control of Z. tritici that minimize the risk of fungicide resistance development 3) Make publically available the research findings in a manner that can be readily utilized by extension services and growers through the EuroWheat knowledge hub (http://eurowheat.au.dk) 4) Establish a network of scientists, partners from relevant chemical companies, extension and authorities that can carry on continuously monitoring and the dissemination of information after the project has ended.

• Defdef

The increasing concerns about environment and human health (EU Directive 2009/128/CE) have put constraints on the availability of pesticides. Thus crop protection in the EU relies increasingly on the use of biological control and plant resistance breeding while synthetic pesticides are replaced by alternatives of natural origin. The general consensus is that integrating these approaches is the most logical way forward. We argue that this may not be true in many cases. Predator-prey models predict that resistance breeding and pesticides – either synthetic or natural - may hamper biological control to an extent that the level of overall crop protection will often decrease rather than increase. These models point out that prey quality and predator mortality are the two key determinants of pest equilibrium densities. These two parameters are directly and indirectly affected by pesticides and plant resistance traits such that pests may often reach higher densities - not lower.

We urge for this counter-intuitive concept to be tested because, if so, it would profoundly alter the rationale behind the design of IPM strategies. Our aim is to assess to which extent prey densities in a predator-prey system – i.e. a biocontrol agent and its target pest - are influenced by chemical plant resistance traits and natural pesticides.

To reach this aim, we will make use of a wide range of tomato defense mutants - i.e. hormone and secondary metabolite mutants - and different (green) pesticides with a varying degree of toxicity to biocontrol agents. We will work with predatory mites and spider mites, primarily in field and greenhouse experiments using tomatoes. We will use life history and population data to parametrize predator-prey models to fine-tune the current predictions. We will also monitor the detoxification responses in prey and predators exposed to plant defenses or pesticides directly, or indirectly *via* their food, to gain a better understanding of resistance and susceptibility and allowing for the development of molecular markers that might predict the outcome of predator-prey interactions. Finally, our working hypothesis suggests that plants lacking resistances might be more protectable *via* biological control than resistant plants. However, removing resistances *via* breeding may be feasible but may also open up niches for new pests. This we will test *via* both greenhouse and field trials.

➢ Session 4 - Integrated weed management – Three projects

- DSS-IWM: Design and customization of an innovative Decision Support System for Integrated Weed Management
- BioAWARE: Could Biodiversity Assure Weed regulAtion for Resilient Ecosystem service provision?
- RELIUM: Herbicide resistant *Lolium spp*. in climatically and agronomically diverse European countries

• DSS-IWM

Partners from Denmark, Spain and Germany are involved in the project DSS-IWM which will run from 2016 to 2018. The project will provide a decision support system for weed control in maize and winter wheat. Farmers and advisors as the main target groups can use the system *via* web portals which already exist for integrated pest management (e.g. ISIP in Germany). The project will also define the business conditions for ISIP and IPMC in order to make sure that DSS-IWM will be available and supported in the long run.

Farmers will benefit from economical savings in input of herbicides by maintaining a high efficacy and market profit. These economic effects are accompanied by positive environmental effects due to reduced herbicide dosages.

DSS-IWM will design and customize an innovative, online DSS IT platform which will be long-term supported. The main results of the new scheduled project will be:
a) DSS-IWM is ready to online use for weed control in maize and winter wheat
b) DSS-IWM provides reliable decisions including national conditions
c) DSS-IWM considers thresholds for weed densities
d) DSS-IWM includes economic calculation on treatment costs
e) DSS-IWM offers mechanical options wherever possible
f) DSS-IWM facilitates herbicide resistance management

Based on recent research work on many different regional prototypes of decision support systems for herbicides a number of gaps and research needs could be identified. For example dose-response functions have to be validated under field conditions in maize and winter wheat. Furthermore specific tools like economic calculations or resistance management have to be added to DSS-IWM. Finally, we aim to select and improve the best test version or strategy for practical applications.

For feasible purposes and dissemination we will demonstrate the DSS-IWM for farmers and advisors on field days and exhibitions. First experiences and results will be published in relevant national journals for farmers and for similar interesting groups. We also expect feed-back by farmers and advisors organized by meetings or web-based queries. There is an additional opportunity to publish the findings of the project in a more scientific manner in international journals, as well as presentations on national and international conferences.

- **BioAWARE**

The goal of C-IPM is to ensure a higher level of implementation of Integrated Pest Management among European farmers. By re-analyzing existing data and conducting targeted experiments, BioAWARE will test whether a high richness and abundance of species or functional groups (biodiversity) of weed seed predators assures natural weed control, in the long term, by increasing regulation rates and rendering them resilient to the variation in environmental conditions in EU agriculture. We will then examine both how the weed seed predator diversity can be managed using a combination of in-field and landscape managements, to assure weed seed control, and that can be used to replace or reduce the applications of herbicides as part of weed IPM. To meet the pressing need for farmer-acceptable weed IPM, which they could adopt, we will evaluate the attitudes of farmers (ecological, social and economic) towards natural weed regulation, assured by weed seed predator diversity, relative to herbicide-based weed control. Through co-development by farmers, agronomists and scientists, practical weed IPM solutions will then be developed, demonstrated and evaluated. The ecological, social and economic knowledge we gain for how farmer perceptions change with the resilience of natural regulation, will detail the training, know-how and economic support required to deliver farmer-acceptable IPM that balances natural (biodiversity-derived) and chemical weed control sustainably across the EU.

- **RELIUM**

Lolium spp. populations resistant to ACCase and/or ALS inhibitors have been reported in the three countries involved in the project: *L. multiflorum* and *L. perenne* are present in Denmark and Italy, while *L. rigidum* is found in perennial cropping systems in Italy and Greece. *Lolium spp*. is a serious weed problem all over Europe and therefore represents a unique opportunity for gaining a better understanding of the evolutionary process leading to herbicide resistance and develop transnational management strategies that can be adapted to national conditions.

The project aims at monitoring, mapping, developing innovative detection tools and characterizing (patterns, levels and resistance mechanisms) selected resistant populations as well as devising resistance management strategies for *Lolium* in various agronomic situations. This is a truly European project where each participating country will focus on specific tasks and complement each other to devise novel weed management strategies. Partners will continuously exchange information and plant material.

Monitoring, collection of information on fields in which resistance evolved and mapping the diffusion of resistant biotypes will be done in all countries. Target site resistance mechanism will be studied in Italy where they will also devise a robust tool for quick diagnosis of this type of resistance as well as to characterize the first glyphosate resistant *Lolium* population in Europe collected in fields managed through conservation agriculture. The Danish partner will focus on metabolic herbicide resistance and develop a reliable method based on next generation sequencing to diagnose this type of resistance. They will compare biotypes of *Lolium spp*. sampled from diverse cropping systems in the three countries. The partners in Greece will focus on the biochemical and molecular diagnostic tools for glyphosate resistant *Lolium spp*. Maps of diffusion of all resistant biotypes as well as resistance management guidelines will be made all available online. Relevant stakeholders, farmers' organizations, farmers' advisors, and national herbicide resistance action groups will be involved throughout the project in devising resistance management strategies, discussing and disseminating the outcomes of the project. Dissemination will mainly be done through the web. An open-day meeting will be organized in each country at the end of the project to present the results.

List of projects selected

Call 1

Acronym	Coordinator	Topic[1]	Project related to
C-RootControl	Hans Rediers (PME&BIM KU Leuven, BE)	C	C3
DSS-IWM	Arnd Verschwele (JKI, DE)	A	A
ELATPRO	Mrs Katharina Wechselberger (AGES, AT)	A	A
IPM4Meligethes	Prof Heikki Hokkanen (Uni. Helsinki, FI)	B	A
IPMBlight 2.0	Dr Didier Andrivon (INRA, FR)	A	A
SmartIPM	Dr Christine Poncet (INRA, FR)	A	A
UNIFORCE	Dr Bruno Gobin (PCS, BE)	C	C2

Call 2

Acronym	Coordinator	Topic[2]	Other related Topics
AAPM	Dr Johannes Fahrentrapp (ZHAW, CH)	C4	A3
API-Tree	Dr Aude Alaphilippe (INRA, FR)	A2	B1
BioAWARE	Dr David Bohan (INRA, FR)	A2	A2/B1
Defdef	Dr Merijn Kant (UvA, NL)	B1	B2
EURO-RES	Dr Steven Kildea (Teagasc, IE)	B2	A2/A3/B2
FlyIPM	Dr Rosemary Collier (Univ. of Warwick, UK)	C2	A2/B1
PeMaTo-EuroPep	Dr Rob Moerkens (Proefcentrum Hoogstraten, BE)	A3	C5/C7
RELIUM	Dr Maurizio Sattin (CNR, IT)	B2	B2
SpotIT	Dr Berit Nordskog (NIBIO, NO)	A3	A3

[1] A : Innovative and new pest monitoring tools and Decision Support Systems (DSS)
B: Pest resistance management (the term pests includes: viruses, bacteria, phytoplasms, insects, artropods, fungi and weeds) (PRM)
C: Minor Uses (MU)
C2: Mites (spider, rusts and bud) in berries and small fruits
C3: Soil borne pests and diseases (often polyphagous).

[2] A2: Integrated, sustainable and resilient Cropping systems (RESCROPS)
A3: Innovative and new pest monitoring tools and Decision Support Systems (INNO-DSS)
B1: Innovative direct biological control methods in holistic IPM approach (INDIBICOM-IPM)
B2: Pests resistance management (PRM) (the term pests includes: arthropods, bacteria, fungi, insects, phytoplasma, viruses)
C2: IPM for Delia/Psila flies (cabbage root fly and carrot fly)
C4: Fruitflies in stone fruits, pome fruits, berries and small fruits; Drosophila suzukii and others fruitflies
C5: Mites (spider, rusts and bud) in berries and small fruits
C7: Control of thrips and whiteflies on protected crops