The overall objective of PURE project is to provide practical IPM solutions to reduce dependence on pesticides in selected major farming systems in Europe, thereby contributing to a reduction of the risks to human health and the environment and facilitating the implementation of the EU pesticides package while ensuring continued food production of sufficient quality.

During the first two years, work was conducted in each selected farming system, to test IPM solutions, specific models and practical tools, and to assess the efficacy, the practicability, the relevance and the robustness of IPM solutions under different environmental conditions by means of on-station and on-farm experiments. The cost-benefit balance will complete the comparative assessment. This multi-criteria evaluation, the adaptation of solutions to the constraints of farming systems during on-farm experiments and the continuous involvement of relevant stakeholders in the design process ensure that the IPM solutions offering the best trade-offs as viable solutions for effective implementation are identified.

A design-assessment-adjustment cycle was adopted to ensure continuous validation and improvement of the IPM solutions.

PURE participants were very active during this second year of the project.

Hereafter, you can have access to:

- PURE first booklet 2013, short description of the main results obtained during the second year of the project;
- Information on Future IPM in Europe: PURE first stakeholders congress;
- A number of deliverables of the different activities.

Coordinator: francoise.lescourret@avignon.inra.fr
Dissemination Contact: philippe.delval@acta.asso.fr

The Pure Booklet 2013

Every year, PURE project will produce a series of booklets to give information about the results get during the year. This year, the booklet covers all the cropping systems activities as well as Co-innovation and IPM design and assessment methodology. With this short document, you are informed about the first results obtained in the project.

The complete PURE 2013 booklet is available at: http://www.pure-ipm.eu/node/297

Each individual booklet is also available on the publication section of the activities.
Definitely, the congress “Future IPM in Europe” was a big and successful event that closed the second year of the project PURE. The event gathered more than 600 participants from 37 countries in the world.

About 100 presentations, 4 workshops on new products and strategies, and 160 posters allowed the participants to have an overview on what is IPM in Europe now and in the forthcoming years. The book of abstracts can give you some information and details about presentations done on research or policy domains. First of all, “Biocontrol methods” was the topic gathering the highest number of presentations and posters (more than 60). Some of the highlights of these contributions (about this topic) are presented hereafter.

A number of publications describes tests of new biological compounds on several pests, mainly Drosophila suzukii, Tuta absoluta, Delia radicum, powdery and downy mildews, pests and diseases on apples.

In the PURE project, the Plant – pest – enemy activity (see page 14) is testing some of biocontrol solutions. The efficacy of a parasitoid wasp, Trichogramma achaeae, and of a predator, Necremnus artynes against Tuta absoluta is being studied.

A lot of biopesticides is under development or test:
- Biofungicides: Ampelomyces quisqualis (fungus) against powdery mildews; Aureobasidium pullulans, Bacillus subtilis, B. amyloliquefaciens against Botrytis and fire blight bacteria; Aureobasidium pullulans against pome fruit post-harvest diseases; Bacillus sp. against Alternaria sp.
- Trichoderma sp. on numerous fungi (Botrytis, powdery mildew, downy mildew, trunk diseases of grapevine, Armillaria and other root rots and canker diseases)
- Bioinsecticides: different fungi against Delia sp. - biomolluscicides: nematods Phasmarhabditis hermaphrodit
- Bionematicides: Aphanocladium album Semi-chemicals are also important for mating disruption or mass trapping. New original methods of mating disruption were developed against Planococcus ficus (grapevine mealybug) and codling moth with puffers or aerosol techniques.

Mass trapping was used against the medfly (Ceratitis capitata) or the sugar beet weevil (Bothynoderales punctivenris).

Volatiles resulting from plant herbivore interactions play an important role in the behavioral decisions of phytophagous, predatory and parasitoid insects and could be used for managing pest insects. Particularly, results confirmed the role of dimethyl disulfide in reducing D. radicum egg numbers and revealed other compounds that both influence plant infestation by the fly and regulation by its main natural enemies in France and Scotland. This compound seems to have good effectiveness against root-knot nematodes in protected crops (tomato, pepper, cucurbit). A publication describes some compounds emitted by barley roots against two main disease species Fusarium culmorum and Cochliobolus sativus. Some essential oils were tested against foliar and soil-borne diseases and as seed treatments.

The use of induced resistance as an alternative method to control pests and diseases in crops requires further study, since previous attempts to exploit this concept resulted in variable levels of effectiveness or undesirable side effects on plant growth, and did not address durability of the induced protection. Several compounds were tested against many foliar diseases (Botrytis, powdery mildew, Fusarium diseases).

Finally, some plant extracts seem to have interesting effects: chesnut tannins against carrot cyst nematode, Glycyrrhiza glabra extract against downy mildews, Quassia amara against apple and pear pests.

Push-pull strategies were tried to tackle pollen beetles. Other methods like physical ones were studied; so, new original methods were developed:
- mating disruption against Scaphoideus titanus (leafhopper) with vibrational techniques,
- radio frequency treatment with fruit immersed in water to control post-harvest brown rot in peaches,
- use of electrolyzed water to improve fruit quality of some citrus.

Some experimental results highlighted that ozone treatment can be useful to extend apple fruit shelf life and for decay control with a view to applying environment friendly storage strategies (test on Penicillium expansum and patulin production). Some posters presented new models or monitoring systems. For example, a webcam-based system was proposed to monitor three moth species (Anarsia lineatella, Cydia pomonella and Lobesia botrana) in Hungary.
Few preventive methods were presented. Breeding has been the subject of research on tomatoes, cereals, vines, stone fruits for Sharka, pears, cabbages. Some results of holistic approaches from PURE project were shown on winter wheat system in France and on maize based system in three European regions (Italy, France, Hungary) as well as other studies from research centres across Europe.

Contact: ilaria.pertot@fmach.it

For more information about organizers and sponsors:
http://futureipm.eu/Organizers
http://futureipm.eu/Sponsor-Exhibition/Sponsor

Available on PURE website are thematic extracts from this book of abstracts:
- Application techniques
- Biocontrol
- Dissemination
- IPM
- Models & DSS
- Monitoring
- Physical methods
- Policy
- Preventive measures

Project activities

Results from the different PURE activities are provided through deliverables or events.

IPM DESIGN AND ASSESSMENT METHODOLOGY

Universal Simulator is a generic modelling tool designed for model developers in life sciences, foremost in the area of applied ecology. A first version of Universal Simulator was developed in the ENDURE project, targeted at integrated weed management, and it is the overall objective in PURE to develop Universal Simulator further as a tool, making it a useful one for ecological modelling in general and crop protection in particular. Thus, Universal Simulator would be available as a common modelling tool, across PURE activities and also outside PURE, as Universal Simulator is developed as an open-source tool using standard programming procedures.

Universal Simulator was established as a collaborative modelling platform and it was accomplished with three objectives:

To establish Universal Simulator as a general-purpose modelling tool that can be used as a common modelling platform in PURE.

To develop Universal Simulator-based models in collaboration with other PURE activities.

To use Universal Simulator as teaching tool in a yearly, web-based PhD course on ecological modelling.

PURE Modelling workshop: The main objective of this workshop, held in Paris on June 8th 2012, was to present methodological advances with regards to the modelling for ex-ante and ex-post assessment of IPM solutions, ecological modelling, multiple pest modelling, and optimization techniques. The presented case studies include major crops (cropping systems based on wheat or maize), field vegetables, orchards, vineyard and Controlled Environment Agriculture systems.

The PURE thesaurus aims at clarifying terms used among PURE partners. For the moment, only terms specific to PURE have been defined. However, this thesaurus should be seen as interactive as possible and partners are invited to submit new entries.

Contact: jean-noel.aubertot@toulouse.inra.fr

For more information:
http://www.pure-ipm.eu/publication/4

A collaborative modelling platform: Universal Simulator
PURE Modelling workshop
PURE Thesaurus

Universal Simulator is available at the project website www.ecolmod.org
Virtual field visits

Now available on the website, we can virtually visit PURE experiments all around Europe. The description is in local language and in English.
You can find the first virtual visits at:
http://www.pure-ipm.eu/virtualvisit/2
or in each Cropping system section.

Maize-based cropping system

The crop protection strategies tested in maize 2011 on-station experiments showed that the conventional strategy had the best weed control and maize yield (although not significant) in both Italy and Hungary under the specific local conditions. However, the IPM-based strategies tested can:

partly compensate for the lower costs due to the reduced herbicide use and the exclusion of soil insecticides.

have a 60% reduction of herbicides applied per ha (band application) and conserve beneficial organisms on the field through the use of selective insecticide or bioinsecticide, thus being more environmentally sustainable. Especially, “Innovative cropping system” in both experiments was the strategy with the less pesticide input (only post-emergence in band application) and therefore with the minimal environmental impact.

IPM tools tested on-farm

The following IPM solutions against weeds and European Corn Borer (ECB) were tested in 2011 and in 2012 in the different countries and evaluated for their sustainability as listed below (only 2011 results):

1. In Italy (five trials), where pre-emergence herbicide was not applied in IPM-weed plots, in four out of the five trials scouting and the use of predictive models indicated no early post-emergence herbicide application, thus only hoeing was practiced. Compared to the conventional strategy, this IPM tool resulted in overall good weed control, minimum environmental impact (only one trial treated), lower total costs (70-190 €/ha), increased gross margin (€140-320/ha) in three out of five trials.

2. In Slovenia (two trials), the false seedbed plus harrowing at 2-3 maize leaves and low dose of post-emergence herbicide applied in IPM-weed plots resulted in similar control as in the conventional strategy, lower environmental impact, lower total costs (10-50 €/ha), increased gross margin (€50/ha) in one out of two trials.

3. In Germany (two trials), the hoeing combined with band-spraying of post-emergence herbicide in IPM plots resulted in: partial control in one trial and no control in the other where was highly infested with Chenopodium polyspermum, lower environmental impact, increased costs and decreased the gross margin.

4. In Hungary (four trials), early post-emergence herbicide in band application plus hoeing (when urea is applied) in IPM-weed plots resulted in good control, lower environmental impact, lower total costs (≈ €55/ha), increased gross margin (€40-210/ha) in all trials.

5. Overall (all locations), no significant difference was determined in ECB damage between conventional insecticide treatment and Trichogramma releases against ECB indicating that Trichogramma can provide acceptable control against ECB. This biological control improved the environmental sustainability of maize systems but also increased the total costs (€30-60/ha more in almost all trials) and reduced the gross margin (€10-110/ha less in almost all trials) compared to the conventional plots.

The report provides a first list of IPM solutions by also presenting results of the ex-ante assessment of the sustainability of advanced and innovative systems that are being tested in long term on-station experiments during the four years of the project.

Example of diagram results of the three tested cropping systems:

Results are detailed on the three pillars of sustainability in three countries, France, Italy and Hungary with diagrams like in figure 2.

Contact: maurizio.sattin@ibaf.cnr.it
For more information:
http://www.pure-ipm.eu/publication/28

First list of tested IPM solutions which improve the sustainability of maize based systems.
Field vegetables cropping system

The objective of the year was the analysis of different IPM methods and an assessment with DEXiPM. Due to the complexity and diversity of vegetable production and the special circumstances on the experimental stations only single-methods were tested on distinct sites. Therefore, all experiments conducted in the different countries, refer to the test of single pest control techniques applied independently on one crop. These techniques are adapted to the particular conditions of each country and expertise of partners.

In the first deliverable produced, an ex-ante assessment of IPM solutions for selected areas in different countries is demonstrated and experiments run in 2012 are described. The results obtained with the DEXiPM analysis during this first stage of experiments are:

Economic sustainability: it is higher in the current and intermediate systems than in the advanced system. This is due mainly to a reduction of the gross margin with a combination of a very low production value and an increased production cost (entomopathogenic nematodes).

Social sustainability: it is high in all systems.

Environmental sustainability: it increases logically in advanced system (reduced pesticides use and lower air emissions).

In 2013, on-station experiments will be conducted with a selection of the best or most promising systems. In this case, the re-design is based on experiences achieved in 2012. Furthermore the most promising methods will be chosen to be tested additionally on on-farm experiments in Denmark, Germany, Slovenia and The Netherlands.

Grapevine cropping system

First, the document produced describes the adaptation of the assessment tool on the following different aspects:

- Economy: selling price, production cost, labour cost
- Social: access at output market
- Environmental: % of area covered, period covered, pesticide ecotoxicity, resource used, environmental quality, biodiversity.

The different IPM solutions was adapted and tested in six European regions: France – Mediterranean area and Atlantic area, Germany, Italy – North eastern, Po valley and Tuscany.

The main results are:

- The global assessment of the three French Mediterranean systems shows no variation of the overall sustainability between the two innovative IPM solutions (InnoBio: “Organic”, with biocontrol solutions and IPM-50%: IPM, 50% average TFI in the region, no herbicide) compared to the current system.

- In the Atlantic area, Standard IPM (IPM System) is compared with an organic farming system (Organic) and an innovative prototype using resistant to diseases varieties (Resistant Varieties). Despite a high overall sustainability assessment for IPM, “Organic” and “Resistant Varieties” are better evaluated. Social and environment sustainability are increasing and the economic part is stable. But we have to be careful because the analysis assumed that the production is marketable and this is currently not true.

- German winegrowing regions are characterized by a generally high Botrytis risk in the late season. Varieties with compact clusters are common. DEXIPM suggests that our growing system is not profitable (low economic sustainability). There is a need for a higher plant protection input in Germany compared to other European winegrowing systems.
regions. BCAs against Botrytis are not an alternative under German conditions as they only produce costs, efficacy being questionable. The main bottleneck for the implementation of this innovation is the marketing of wine from unknown varieties.

- In northern Italy, Decision Support System (DSS) is the strategy with the highest economical sustainability, followed by the others two that are at the same level. Differences in environmental sustainability were observed only between the two DSS strategies and the Baseline.
- In northern Italy, the first differences are present in resources use and in aerial and above soil biodiversity.
- In the Po valley, interestingly, the analysis of the three production systems (Baseline, DSS, and DSS+BCA) by DEXiPM Grapevine reveals some significant differences in the social and the economical sustainability while an increased environmental sustainability was found only for the DSS+BCA tool.
- In central Italy, in the whole the protocols proposed appear profitable from the economic, environmental and social sustainability point of view.

Contact: ilaria.pertot@fmach.it
For more information: http://www.pure-ipm.eu/node/319

Ex-post assessment of IPM solutions tested in experimental stations and farms and updates of database of alternatives to pesticides and IPM solutions

Protected cropping system

The objective of the first document we produced was to highlight the diversity of modelling tools useful and/or necessary in order to implement robust IPM strategies under greenhouse cultivation.

Control of relative humidity in greenhouse (photo IVIA)

This document describes:
- distributed climate models
- pest airborn transfers
- pest forecasting models
- population dynamics models
- and learning and sustainability models to help decision making.

Protected cropping system

The objective of the second document was to investigate the current situation and developments in greenhouse tomato sector, and the marketing of tomatoes in Europe, in relation to crop protection. The research focused on the southern regions (Spain, Italy and southern France) but also in the Netherlands and Belgium. The export to Germany is also taken into account.

There are some fundamental differences between northern and southern Europe (the borderline between both is the south-east of France):

<table>
<thead>
<tr>
<th>Harvest of crops</th>
<th>Northern</th>
<th>Southern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>During the summer period</td>
<td>During the winter period</td>
</tr>
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<table>
<thead>
<tr>
<th>Cultivation</th>
<th>Northern</th>
<th>Southern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate and soil-less</td>
<td>Soil</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Greenhouses</th>
<th>Northern</th>
<th>Southern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covered with glass</td>
<td>Covered with plastic</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Climate control</th>
<th>Northern</th>
<th>Southern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilation, heating, screen control, CO₂</td>
<td>Ventilation</td>
<td></td>
</tr>
</tbody>
</table>

All these differences result in decreasing levels of physical production from north to south, except in the most southern part of Spain (Almeria) and partly in Italy (Sicily) because of the longer growing period in these two regions. The share of production that is exported is higher in the north than in the south as well the use of IPM.

Contact: Christine.Poncet@sophia.inra.fr
For more information:
http://www.pure-ipm.eu/publication/32

Performance and side effects of IPM solutions using model-based tools tested by greenhouse trials

Recent developments and market opportunities for IPM in greenhouse tomatoes in Southern Europe
INNOVATIVE RESEARCH ACTIVITIES

PURE has the objective to enrich the knowledge base required by the IPM design process with new solid scientific knowledge and practical tools with the participation of innovative industries on:

- Pest evolution and enhancement of the durability of IPM solutions;
- Exploitation of plant-pest-enemies mechanisms to derive bioproducts in a broad sense;
- Population and community ecology of IPM at the field and landscape scale to enhance pest regulation by cultural strategies and habitat manipulation;
- Combination of whole-field monitoring methods (pest risk level monitoring) with micro-diagnostic nanotechnology (fine pest species and genotype identification), decision engines and other emerging technologies.

In addition, PURE will incorporate some research results into the cropping system studies. This provides the opportunity to re-design IPM solutions – new combinations of tactics and strategies incorporating innovations – thus matching the principle of repetitive design-assessment-adjustment cycles in cropping systems studies.

First results of these innovative research activities are presented hereafter.

**Pest evolution and enhancement of the durability of IPM solutions**

One of our tasks deals with the risk analysis of resistance development to biological control. The general objective of the work is to estimate the risk of losing efficacy of biological control against crop pests and diseases.

The work was divided in two parts:

- A review of the scientific literature that assess the potential for plant pathogens and plant pests to become resistant to biocontrol agents.

- Laboratory studies that provide factual data on the sensitivity of plant pathogens and of plant pests to specific biocontrol agents. These laboratory studies were done on the plant pathogen *Botrytis cinerea*, the causal agent of grey mold on various crops, and the pest *Cydia pomonella*, the codling moth on apple.

Throughout the review of the scientific literature, we have shown that resistance could also appear against biocontrol agents. However, this resistance phenomenon is still rarely observed in nature (except for some pests). Some of the possible reasons for this are:

- Biocontrol agents are not used very often and mostly on small surfaces. Thus, pathogens and pests are exposed to these agents on small and fragmented areas, which reduces the selective pressure and the spread of resistant individuals.

- The mechanisms of action of biocontrol agents are very diverse. Resistance is therefore less likely to happen.

However, a significant number of specific and non-specific resistance mechanisms have been identified. This highlights the necessity for proper management of these new products in order to avoid repeating the mistakes made with chemical pesticides. The use of biocontrol agents requires a good knowledge of their mode of action to be able to alternate targets and thus associate them with other treatments. The acquired knowledge would allow to use them optimally, and to include them in an integrated pest management scheme.

The laboratory studies reveal the importance of considering several strains/populations of a bioaggressor when screening for a biocontrol agent, to obtain a good representation of the population and thus take into account the potential durability of biocontrol.

Significant research efforts are still needed to anticipate the potential failure of biological control and integrate durability concerns both in the screening procedure of new biocontrol agents and in the careful management of their use once they become commercially available.

Contact: wopke.vanderwerf@wur.nl

For more information: http://www.pure-ipm.eu/publication/5
Plant-pest-enemies interactions

The use of the chemical plant defence activators as an alternative method to control pests and diseases in crops requires further study, since previous attempts to exploit this concept resulted in undesirable side effects on plant growth, and did not address durability of the induced protection. The overarching objective of our work is to optimise the cost-benefit balance of the response to different defence activators in tomato. Costs are evaluated in terms of plant growth, fruit production and potentially effects on plant-beneficial microbes, whereas the benefits are measured in terms of consistency of induced resistance, range of effectiveness, durability of the protection, and compatibility between different defence activators and/or genotype-dependent basal resistance. So far, we have achieved the following goals:

1) optimisation of two different defence activator application methods with the example of seed treatment and seedling treatment in tomato. We conclude that seedling treatments with BABA or JA can provide an efficient means to protect hydroponically cultivated tomato under greenhouse conditions, provided that an optimal balance is found between the costs (growth reduction) and benefits (disease protection) of this form of induced resistance.

2) demonstration of effectiveness of defence activator treatments against fungi, insects and nematodes. This one was realized on grey mold, white fly and various nematodes species. Although single defence activator treatments rarely provided full disease protection, our results suggest that these applications exert enough effectiveness to reduce frequency and/or intensity of fungicide/pesticide usage.

3) evidence for interactions between effectiveness of (combinations of defence activators and tomato genotype. Together, our results demonstrate statistically significant interactions between effectiveness of defence activators and tomato genotype, indicating genetic loci that influence the strength and/or durability of the resistance response to defence activators. This outcome creates opportunities for tomato breeding programmes to select for genetic traits that increase responsiveness to chemical defence activators.

4) identification of two tomato gene candidates encoding a putative receptor protein of the chemical plant defence activator β-amino butyric acid (BABA) by extrapolation of research results from Arabidopsis to tomato. Together, these results indicate that BABA-induced defence priming can be enhanced and uncoupled from the associated costs by increasing IBI1 expression and reducing GCN2 expression.

The insect Tuta absoluta is a serious pest in all the countries where tomato is grown. In protected crops, where the damage can be extremely serious, there are the optimal conditions for combining sustainable tools of control, such as false trail and biological control. This task concentrated on the characterization of insect parasitoids available commercially in order to certify them from a taxonomical and biological point of view. Besides, the insect parasitoids of mealybug pests of grapewine were characterized following the same integrative approach, combining morphological and molecular data.

Set up of protocols for integrative characterization of natural enemies of Tuta absoluta commercially available all over Europe and of parasitoids of mealybug on grapewine collected all over Europe. The protocol includes: morphological, molecular and biological characterization.

Contact: toby.bruce@bbsrc.ac.uk
For more information: http://www.pure-ipm.eu/publication/6

Effective plant activator treatment combinations
More efficient strains of parasitoids and protocols for certification for use against insect pests
Ecological engineering for IPM: from field to landscape

The framework proposed offers a holistic view of conservation biocontrol (CBC), explicitly identifying the most important elements of CBC and their interactions. The key aspect of the framework is the scale explicit separation of the conservation and biological control processes: conservation is viewed as the result of population and community level processes spanning scales from the local or field scale to the regional and landscape scale. The interactions between scales is important, particularly the colonisation of local habitats. Biological control is effected at the within field scale on crops and is mediated by behavioural processes. The framework places the emphasis on downscaling, as this is most relevant to understanding and implementing CBC which attempts to draw upon existing communities of natural enemies present within the region to affect control over pests that appear on the crop plants within a specific field or group of neighbouring fields.

The literature reviewed here largely supports the framework, demonstrating that natural enemy conservation is frequently achieved independent of any effect on pest populations, that altering the arable environment at any scale can increase natural enemy abundance, and that the effectiveness of conservation strategies at the local scale depends on the landscape at the regional scale. The localisation of biological control at the within-field scale as a behavioural process is perhaps the least certain conceptualisation of the framework. Though predation and parasitism of arthropod pests typically take place on the crop, it is possible for higher scale processes to influence biological control directly, without consideration of the intermediate stages being necessary.

The framework has been presented as a guide to understand CBC function but it may also prove useful as a check-list for the development for CBC strategies. For example:

- Landscape scale: Does the landscape support a rich natural enemy community?
- Local/field scale: Given the landscape, is local scale conservation needed, and if so what form will it take?
- Colonisation: Will colonisation be passive, can it be sufficiently influenced by the size and shape of the local habitat, or is some form of attraction needed?
- Biological control: What intervention is needed to ensure the trophic cascade operates? Should attempts to modify foraging behaviour be considered?

The answer to such questions will depend on the system being considered, However, if each element of the CBC framework is addressed, the chances of developing a successful strategy will be greatly enhanced.

In using the framework to set-out our understanding of CBC it serves equally to identify where the gaps in CBC knowledge lie. It is clear from the review conducted here that for both the conservation of natural enemies and their success in delivering biological control is uncertain. However, the empirical evidence contained in this review suggests that implementing one of a number of conservation strategies locally to reduce cropping intensity and provide beneficial habitats is likely to be effective as long as consideration is given to the surrounding landscape so that this might be used as a “black-box” approach without the need to fully understand the mechanisms operating. In this review we identify two factors responsible for the disruption of the biological control step: 1) spatio-temporal asynchrony in pest and enemy activity, and 2) disruption of the trophic cascade by alternate trophic interactions. In addressing these, the specifics arising from location, cropping system, and the prevailing pest and natural enemy communities will always create idiosyncrasies that demand case-by-case consideration.

Contact: graham.begg@hutton.ac.uk

For more information: http://www.pure-ipm.eu/node/317

Meta-analysis of habitat based manipulation for conservation biocontrol
Emerging technologies

Through air sampling and optical sensing analysis, the amount and type of pathogens present can be determined. With reflectance measurements in the field, deviations from a healthy crop can be identified. Potentially large geographical regions and relatively small positions (<1 m²) in crop fields can be identified where special attention at specific moments is required. These spatial data will allow improving decision making algorithms and forecasting models. Accordingly, task 1 of the ‘Emerging Technologies’ activity of the PURE project aims at developing optical sensing and airborne inoculum sampling methods for macro scale mapping and monitoring of crops to identify unhealthy regions in cropped fields. One deliverable reports air sampler improvements and optical sensing pilot results (for Month 24).

The use of air sampling combined with molecular diagnostics for both direct inoculum-based disease forecasts and as a survey tool was studied in this work. Two different platforms for molecular detection and quantification of pathogens were used. The two platforms are:
- Real-time PCR for selected pathogens relevant for arable crops.
- NGS (Next Generation Sequencing) platform based on 454 amplicon sequence analysis of fungal species composition.

The two platforms supplement each other as the NGS based platform is generic and will detect all fungal species both unknown and known whereas the real-time PCR based platform is targeted for selected pathogens.

It has been possible to obtain air samples containing fungal material from three different locations and from two sampling periods. Sequence data is now available and will be subjected to sequence analysis using a set of methods which have already been implemented at Aarhus University for identification of OTUs (operational taxonomic units). A range of TaqMan real-time PCR based assays for fungal species as well as genotypes (e.g. chemotype and mating type) within species has been identified. The results obtained so far form the basis for further analysis of air samples collected from several sampling periods.

Based on analyses of 70 existing decision support systems (DSS) for crop protection, which was executed in the EU project ‘ENDURE’ (2007-2010), best parts in terms of reducing the use of herbicides were identified in 3 DSS, and a decision algorithms and calculation functions were documented (Annex 1). A ‘proof of concept’ was also designed in Excel to test basic functionality. These results were elaborated in PURE in term of designing an online version of this DSS. By combining:
- A new component, which can evaluate needs for control, supplied by INRA, France
- An existing component, which can identify herbicides and accompanying dose rates, which meet specific needs for control, supplied by AU, Denmark
- A new component, which identifies the expected economic net return in the current crop of alternative herbicide treatment options

This DSS can receive field reports and return alternative treatment options. This DSS has been customized for weed control in maize in Slovenia, North Italy and Central Germany, including weed species, herbicides, conditions and data, which are relevant in these regions.

CDS system, the sprayer used is a KWH D-1000 orchard sprayer. The nozzles are divided over 5 sections left and right (Photo DLO)
In fruit crop spraying the goal is to come to a uniform spray deposition all over the leaves in the tree. Losses to the soil underneath the tree and outside of the orchard through spray drift are to be minimized. Canopy structure in orchards varies a lot, because of plantation systems, plant varieties, pruning systems and in time during the season. A new type of Canopy Density Spraying is being especially constructed to apply plant protection products on pear trees. With the use of sensors the right amount of ppp-s will be applied on the right place in the canopy depended on the amount of leaves. It is expected to reduce the amount of fungicides with 30-50%. This will be achieved by two fundamentals: Ppp-s will only be applied on tree-leaves and the application rate is depended to the growth-stage of the pear-tree. This gives a reduction in pear spindle of 53%, in pear V-hedge of 27% and in apple of 50%. So the machine gives a large reduction in use in spindle type trees. In V-hedge the reduction is less. This is not in the same order as the measured LAI and TRV. Maybe the sensor and algorithm should be made more appropriate for the V-hedge type of tree.

The objective of this work is to develop a novel mating disruption strategy based on substrate-borne vibrations, using S. titanus as a model insect species. Our results indicate that the principles from which the mating disruption with vibrational signals are valid and applicable even at field level, on mature plants. The disruption has been effective on more than 90% of tested pairs when some conditions were respected. In particular we found that mating is almost totally prevented when the device is working for periods of more than 19 hours. Indeed, we detected important losses and dispersion of the signal, due to numerous points of contact between vibrating wires/plants/poles. This limit must be eliminated or strongly reduced, by for instance by passing the signal or using dampers in correspondence of such critical points.

The main conclusions are:
• The method has a very high potential of success for field applications and the first prototype of the full device is already available.
• However, it will be necessary to find soon some new elements of implementation, in order to solve limits due to the progressive loss of signal intensity along the distance, in order to make the technology available for open field experiments in 2014.

Another objective is to monitor and develop pest control techniques (False Trail Following) based on innovative release method of semiochemicals. The case study chosen is Tuta absoluta in tomato. We evaluated prototype of biodegradable dispensers with different pheromone quantities and release rates. The main conclusions from the first two field trials are:
1) The application of the pheromone dispensers at the density of 2000 / ha containing 10mg of tuta pheromone resulted in effective confusion of males.
2) Based on these results in 2013, we will repeat the experiment on a larger scale and test at the same time the release rate of biodegradable dispenser prototypes.

Contact: ard.nieuwenhuizen@wur.nl
For more information: http://www.pure-ipm.eu/publication/8

Air sampler improvements and ability of optical sensing to detect diseases
NGS and BioTrove assays pilot results based on the first air samples
Concept decision engine designed for integrated weed management
Parameterized system for canopy adapted spraying and first prototype of cell sprayer in field vegetables
Vibration mating disruption and biodegradable pheromone dispensers for mating disruption first prototypes

Do not forget, you can find all upcoming events and news from PURE on our website (www.pure-ipm.eu/)

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