BOOK OF ABSTRACTS

Extracts: Models & DSS

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Agricultural sustainability encompasses economic, environmental and social dimensions. In the design of innovative cropping systems (CS), several alternatives can be proposed to achieve a specific goal like pesticide use reduction. The DEXiPM model (Pelzer et al., 2012) was developed for the multi-criteria assessment of the sustainability of arable CS and it is used as a support for designing innovative cropping systems. Indeed, the ex ante assessment of the sustainability performances estimated by the model allows researchers identifying strong and weak points and possible improvements of the cropping systems to be tested in field.

DEXiPM has been chosen as a key tool within the PURE project (http://www.pure-ipm.eu), supporting a multi-year loop which consists in the design, testing and adjustment of different typologies of CS with reduced pesticide inputs: arable, field vegetables, protected vegetables, grapevine and pomefruit. In this process, ex ante assessment of the proposed prototype systems and ex post assessment of their performances in the field are essential. Therefore DEXiPM has been adapted to: (i) the specificities of the each typology of CS and (ii) the frame of ex post assessment, in order to allow every year the identification of practices that should be modified and to provide a global evaluation of a system implemented in a given context.

DEXiPM evaluates the overall sustainability of a cropping system decomposing it into more and more specific attributes starting with environmental, social and economic sustainability. The model’s attributes are characterized by qualitative classes of values and their aggregation into more complex attributes is defined by utility functions (if-then rules). These functions are synthesized by relative weights which are affected to the involved attributes, reflecting their influence on the value of the upper one. The basic attributes of the tree represent the model’s inputs and they are related to the cropping system as well as the context of the assessment.

The purpose of DEXiPM goes beyond scoring alternative systems: it is also important to analyze their performances taking into account their complexity. The strength of the model is the comprehensive “dashboard” of sustainability indicators that is elaborated. It represents the value of all the assessed attributes enabling discussions on the alternatives compared. In this contribution we will give some examples of possible use of the model, showing the flexibility of the approach in a diversity of assessment objects and goals.

The research leading to these results has received funding from the European Community’s Seventh Framework programme (FP7/ 2007-2013) under the grant agreement n° FP7-26586
PARALLEL SESSION – MODELLING, DESIGN APPROACHES AND INDICATORS

X-PEST, AN ONLINE GENERIC MODELLING PLATFORM TO DESIGN MODELS THAT SIMULATE CROP LOSSES AS A FUNCTION OF INJURY PROFILES AND PRODUCTION SITUATIONS

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Limitation of crop losses (quantitative and qualitative losses) is the main objective of crop protection. However, there is a need to better quantify and analyse crop losses as a function of dynamics of injuries and production situations. Several models have been developed to represent damage mechanisms for a wide range of harmful organisms (weeds, plant pathogens, animal pests) on several crops. However, these models are crop specific, even if their conceptual basis is generic. In order to promote this modelling approach, an online interactive generic modelling platform is being developed. The platform is composed of 3 sections. The first section provides general information about yield losses, the overall purpose of the platform and references. The second section is an interactive forge allowing the user to design a specific version of X-PEST adapted to a given crop, using a common generic framework. This section allows the user to define the structure of the model that he is currently developing according to three steps. First, the user provides the number of organs considered, along with the dynamic of assimilate partitioning coefficients, as well as whether senescence and remobilisation will be represented in the model or not. The biomass production through photosynthesis is simply represented by the Monteith's equation. Second, the user has to provide a description of the dynamic variables that describes pest dynamics. For each considered pest, the user indicates which damage mechanism(s) is (are) associated with the considered pest. The damage mechanisms represented in X-PEST are fivefold. Pests can affect the Leaf Area Index (for light stealers), the Radiation Use Efficiency (for assimilate rate reducers), or reduce the pool of biomass (assimilate sappers), directly decrease organ biomass, or induce a loss in quality. Third, for each damage mechanism, the user has to describe the relationship between the injury and the variable(s) affected by this injury. Once the model fully defined, it can be run online through the last section of the platform (simulation center) or through a downloadable R package. The third section of X-PEST is the simulation center. Authorised users can use models embedded within X-PEST to launch simulations. Graphics and numerical results are available in a downloadable zip file, along with online visualisation. Simulations (input variables, parameter values, and model structure) are saved in a database in order to limit the time consuming operation of entering parameters and input variables. Models developed under X-PEST will help to perform diagnoses at the field scale, design durable cropping systems less vulnerable to damage caused by pests (if coupled with epidemiological models that take into account cropping practices) and rank pests according to the damages they cause at regional, national or continental scales.
DISCUSS, the Dual Indicator Set for Sustainable Crop protection Sustainability Surveys, was designed to help farmers achieve more sustainable crop protection, i.e. to achieve sustainability beyond IPM. The indicator set pairs a risk indicator with a response indicator. POCER, the Pesticide OCcupational and Environmental Risk indicator, assesses risk for human health and the environment exerted by chemical crop protection. An inquiry reveals farmers’ response to this risk, both in terms of their management actions and their knowledge, awareness and attitude. DISCUSS was designed for implementation in a social learning setting, i.e. in small discussion groups, coached by an advisor. Before taking DISCUSS off the design table into practice, we need to gain insight into its operational limits and conditions. We thus perform sensitivity analyses on both parts of the dual indicator set. Flemish fruit farms serve as a first case of implementation. First, the conditions for calculating POCER in the context of farm level sustainability assessment are examined. Questions are raised about comparing farms with different fruit crop mixtures. As each fruit species requires specific protection, one can discuss whether it is the farm’s sustainability or its crop mixture that is measured? What is the correct way of expressing the environmental pressure exerted by the pesticides used on a fruit farm if comparison to peers is the goal? Second, conditions for implementing the inquiry are considered. Is the inquiry specific enough to detect differences in crop protection management between fruit farms, who have already been using IPM for a decade? Analogously, can differences in knowledge, awareness and attitude between fruit growers be detected sufficiently? Can results from fruit farms be extrapolated to other farm types? Results from the first test implementation will be presented.
PARALLEL SESSION – MODELLING, DESIGN APPROACHES AND INDICATORS

FIELD-SCALE EVALUATION OF IPM TOOLS IN MAIZE: WHAT IS THEIR AGRONOMIC AND ECONOMIC IMPACT?

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Previous analyses highlighted that the European corn borer (ECB, Ostrinia nubilalis Hübner) and weeds are among the major maize pests in Europe. Within the European Project PURE, fifteen field-scale experiments were set up in five European countries in 2011 and repeated in 2012, to evaluate two IPM tools for controlling weeds and ECB in grain maize, compared to the conventional strategy. Experiments were conducted in southern (Italy, 5 trials per year; France, 2 trials per year - no tool tested against weeds in 2011), central (Germany, 2 trials per year) and eastern conditions (Slovenia, 2 trials per year; Hungary, 4 trials per year). Different IPM strategies against weeds were tested according to the country context, whereas the biological control of ECB using Trichogramma brassicae was tested in all countries. The aim of the experiments was to test these IPM tools in real field conditions, therefore commercial farms were recruited and commercially available technologies and farm equipment were used. Replications were achieved by involving several farms (three plots per farm, each of 5000 m²) in each country rather than replicating within farms. Sampling procedures followed the same standard protocol, and economic data (i.e. crop and pest management costs) were collected for the Cost Benefit Analysis of the IPM tools tested. Results of 2011 showed that in Italy, the use of scouting and predictive models indicated no need for early post-emergence herbicide application, thus only hoeing was practised on IPM plots in four out of the five trials. Compared to the conventional strategy, this IPM tool resulted in an overall good weed control, lower total costs (minus 70-190 €/ha) and increased gross margin (plus 140-320 €/ha) in three out of five trials. In Slovenia, false seedbed plus harrowing at the 2-3 maize leaf-stage and combined with low dose spraying of post-emergence herbicide in IPM plots resulted in a control similar to the conventional strategy, lower total costs (minus 10-50 €/ha) and increased gross margin (plus 50 €/ha) in one out of two trials. In Germany, hoeing combined with band-spraying of post-emergence herbicide plus hoeing (when urea is applied) in IPM plots resulted in partial weed control, increased costs and decreased gross margin. In Hungary, early post-emergence herbicide in band spraying combined with hoeing in IPM plots resulted in a good weed control, lower total costs (minus ≈ 55 €/ha) and increased gross margin (plus 40-210 €/ha) in all trials. In all trials/countries, Trichogramma provided acceptable control of ECB, but also increased the total costs (plus 30-60 €/ha in almost all trials) and reduced the gross margin (minus 10-110 €/ha in almost all trials) compared to the conventional approach. However, the overall ECB population was low in 2011 and the efficacy of Trichogramma will be better evaluated by pooling the data of 2011 and 2012 (higher ECB population determined in 2012). The 2012
data from both tools tested in each country are currently being analysed and final results and evaluation will be presented during the conference.
The decision finding process in advanced pest management relies on precise timing of surveillance and control of pest populations. Thereby timing of monitoring measures assures reliability of results and saves time during decision finding. Precise timing of plant protection measures increases their efficacy, reduces side effects and may substantially reduce the number of treatments and thereby resources and money spent during pest management. The aim of according decision support tools should be to establish reliable and readily available information to be used by growers and consultants. Consequently they have to consist of a technical part to establish phenologies or population dynamics and of an end-user part to communicate the according decision support. As for the technical part, hitherto, temperature sums and more recently simulation models have been used to predict the phenology of pests. However, the technical tools are often not designed to be used by growers, consultants or extension services, they are often based on very different approaches and programming languages or require special driving variables, which makes them difficult to be used in practice. How these obstacles for application can be successfully circumvented is exemplified here by the forecasting tool SOPRA which has been developed to optimize timing of monitoring, management and control measures of major pests in Swiss fruit orchards. The system consists of a locally based user interface with the different species models (technical part) and a web-interface to provide simulation results and decision support to consultants and growers (end-user part). Applying time-varying distributed delay approaches, phenology-models were developed driven by solar radiation, air temperature and soil temperature on hourly basis for major pests of apple, pear, cherry and plum. In order to achieve most precise forecasts, insect body temperatures in those mechanistic models have to be based on studies of habitat selection of relevant developmental stages and according simulations using driving variables and structural orchard features. For validation, model predictions have to be compared with independent field observations from several years. On base of local weather data, age structure of the pest populations is simulated and crucial events for management activities are predicted by the SOPRA system. Through a web-interface, the simulation results are made available to consultants and growers (www.sopra.info). Phenology is directly linked to a detailed decision support and to extended information about pest insects as well as to control strategies and plant protection products. SOPRA is applied as decision support system for major pests of fruit orchards on local and regional scale and has a wide range of possible applications across Europe. The development, improvement add wide application of the system successfully show how forecasting tools may become essential parts of innovative IPM.
A plant disease model is a simplification of a real pathosystem (i.e., the relationships between a pathogen, a host plant, and the environment) that determine whether and how an epidemic develops over time and/or space. Different approaches have been used for the development of plant disease models, with relevant improvements in recent years. Empirical models have been elaborated using data collected under variable field conditions since the second half of the last century. The so called 3-10 rule for predicting first seasonal infection of grape downy mildew is a precursor of this empirical approach for understanding relationships between pathogens, plants and the environment. By using this approach, the model is developed by searching mathematical or statistical relationships between field collected data and these relationships do not necessarily have cause-effect meaning. Lack of knowledge, accuracy and, especially, robustness are the main weaknesses of these models, which impose accurate validation and, usually, proper calibration when these models are used in different environments or under changing climate. Recent methods of data analysis, like for instance neural networks, improve the capability of searching the mathematical structure of the model but they do not overcome the above mentioned weaknesses. Mechanistic models are a new class of models based on knowledge of biological and epidemiological behaviour of the system under study. These models (also referred to as explanatory, theoretical, or fundamental) explain the pathosystem on the basis of what is known about how the system works in relation to the influencing variables. Mechanistic models are dynamic, because they analyse the changes over time of the components of an epidemic due to the external, influencing variables. Dynamic modelling is based on the assumption that the state of the pathosystem in every moment can be quantitatively characterised and that changes in the system can be described by mathematical equations. These models overcome the weakness of the empirical models. Compared to the 3-10 rule, a mechanistic model for grape downy mildew increased the overall accuracy of the predictions from ~60% to ~90%. Complexity of mechanistic models has been regarded as a problem for the implementation of models in practical disease control, compared to the simplicity of the empirical models. This is a false problem, because confusing complexity of the mathematical framework of the model with complexity of model output is misleading. Indeed, it is possible to use complex models, able to depict the complexity of the biological systems, to produce simple, easy-to-use output for growers. Implementation of the above mentioned mechanistic model for grape downy mildew in a Decision Support System used by viticulturists clearly demonstrates the inconsistency of the “complexity paradigm”.

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PARALLEL SESSION – PEST AND DISEASE FORECASTING MODELS

BOTRYTIS ALERT SYSTEM IN ROSE: A DISEASE WARNING MODEL

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Botrytis cinerea is a major problem in greenhouse floriculture. In roses, the spores are deposited on the flowers during cropping but don’t germinate due to too low RH. After harvest, the spores germinate and cause spots and lesions on the flower petals. The disease needs to be tackled during the cropping period, but growers cannot base their decision to spray with fungicides on infection levels because disease only occurs after harvest. To help the growers, a disease warning system was developed to identify periods of good survival of the spores with subsequent risk of disease development in the post-harvest phase. First, experiments were conducted in experimental glasshouses of Botany B.V. (Horst, The Netherlands) in which untreated control plots were compared to plots sprayed according to a tentative model by Kerssies (1994) and plots sprayed according to a system based on combined literature data. The flowers were harvested regularly and treated the same as common post-harvest practice. Then the flowers were put on vases to simulate the situation in consumer’s houses and disease was rated several times. The experiment was conducted twice for 2-3 months with four replicates per treatment. The results were used to develop a new model based on temperature and RH which was validated with historical data from commercial growers and then tested in seven commercial production glasshouses in The Netherlands for a 4-6 month period. Post-harvest infection levels were compared for standard treatment and treatment according to the model. After adjusting the model with the results, it was tested again in the third year in four commercial glasshouses. In two glasshouses, a grid of 9 data loggers was installed in 10 by 10 m plots in which flowers were harvested separately, to establish in more detail the relationship between temperature, RH and post-harvest disease incidence. These data were used to fine-tune the model which was subsequently released with the acronym BAS (Botrytis Alert System). It is sold as a module in the climate computer and predicts the daily expected percentage diseased flowers. Installing extra data loggers will improve the reliability in glasshouses with large horizontal fluctuations in climate. BAS helps growers in timing of fungicide applications but also in preventively adjusting their climate settings.

This model was developed in collaboration with Verdict Systems B.V., Aalten, The Netherlands
Global warming will lead to prolongation of growing seasons in temperate regions and will have pronounced effects on phenology and life-history adaptation in many species. These changes were not easy to simulate for actual phenologies because of the coarse temporal and spatial resolution of the climate predictions. Seasonal and regional climate change signals were downscaled to the hourly temporal scale of a pest life-cycle and the spatial scale of pest habitats using a stochastic weather generator in combination with a re-sampling approach. The simulated synthetic hourly weather data for 10 meteorological sites in Switzerland consistent with a future climate scenario (2045-2074) was then analysed by a seasonal phenology model implemented in the forecasting system SOPRA (www.sopra.info).

Codling moth (Cydia pomonella L.) serves as a relevant model species for a key pest with multiple generations per year that already under present climate requires intensive control efforts. Under future conditions of increased temperatures the present risk of below 20% for a pronounced second generation (peak larval emergence) in Switzerland will increase to 70–100%. The risk of an additional third generation will increase from presently 0-2% to 100%. We identified a significant two-week shift to earlier dates in phenological stages, such as overwintering adult flight. The magnitude of first generation pupae and all later stages will significantly increase. The presence of first generation pupae and later stages will be prolonged. A significant decrease in the length of overlap of first and second generation larval emergence was identified. Such shifts in phenology may induce adaptation in life-history traits such as photoperiodic diapause induction to shorter day-lengths. The projected shifts in phenology and voltinism will extend the control season over at least one month and will have relevant consequences for codling moth management. The most suggested management strategy is based on pheromone mating disruption. With increasing temperature the present amounts of pheromone will most likely not cover the entire season anymore and the dispenser load has to be increased. The sole application of mating disruption and granulosis viruses alone may also no longer be sufficient to control codling moth because during multiple generations higher population densities may build up and because of the increased risk of resistances to granulosis viruses. Similarly, resistances to insecticides are expected because of the repeated treatment with the same group of ingredients. A future control strategy with insect growth regulators considers innovative products with new modes of actions, consequent anti-resistance management and precisely timed application as ensured by decision support systems.
Implementation of the ‘IPM’ Directive 2009/128/EC will boost demand for site-specific IPM solutions, decision-making and training, while at the same time, on-farm evaluation of local IPM scenarios is becoming increasingly expensive and, often, impracticable. However, modern IPM largely relies on manipulation of insect behaviour, hence in principle, customisable models simulating ‘on-farm’ pest behaviour could be used for ‘virtual’ pre-assessment of various localised IPM options, and thus serve as tools for training and decision-making. The proprietary PESTonFARM model is presented as an example of such approach. The model - agent-based, pattern-oriented with elements of cellular automata - was developed to simulate individual insect behaviour within seasonally changing mosaic of farming landscape, under the challenge of IPM actions. The model is based on a software construct (“virtual insect”), dynamically emulating daily behaviours, events and risks faced by individual insects, generating for each of them stochastically equivalent, but individually unique ‘virtual life-history’. The model operates according to an in-built set of explicit biological and behavioural rules describing the key aspects of pest biology, and is based on user-defined-and-managed spatiotemporal parameters reflecting local on-farm conditions and assumed/tested IPM regimes. Incompatibility among IPM treatments, e.g. pesticide vs biological control, also could be taken into account. Unit costs of IPM interventions and infestation-dependant reduction of crop values can be specified to obtain cost/benefit assessment for each IPM scenario. The model simulates only daily behaviours and events of individual insects, while the ‘higher-level on-farm phenomena’ with intricate spatiotemporal patterns, such as seasonal pest translocations with locally fluctuating population densities or evolving patterns of crop infestation, are neither programmed nor determined. They emerge as a consequence of the actions undertaken by individual ‘virtual insects’. The model emulates behaviour of pest population during a ‘virtual IPM experiment’, and, upon each run, generates stochastically equivalent, but unique set of results, presented in a format usually collected during real on-farm experiments. Currently, the model can handle ‘farm-area’ with at least 5 different multi-plot host zones, over 2,000 sectors, over 1,000,000 insects and 10 (or more) independent IPM treatments. In the presented example, the model was adjusted to represent behaviour of a univoltine pest, the cherry fruit fly, *Rhagoletis cherasi*, on a cherry farm, under the pressure of IPM treatments. The model was designed to assist IPM assessment and implementation, and to support localised decision-making and training. It can also be customised to test various farm configurations for optimisation of crop arrangement and landscape planning, assessment of effects of environmental barriers or wild hosts as pest reservoirs etc.
PARALLEL SESSION – PEST AND DISEASE FORECASTING MODELS
USING VITIMETEO-PLASMOPARA TO BETTER CONTROL DOWNY MILDEW IN GRAPE

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Downy mildew caused by the oomycete \textit{Plasmopara viticola} is one of the most important diseases of grapevine. Regular spraying with fungicides over the entire growing season is needed in order to protect the grapes. Even so, in years with difficult weather conditions like 2012 or 2008, downy mildew is causing yield losses. The implementation of disease forecasting models to control the main fungal diseases of grapevine according to their epidemiology is a central element of integrated pest management. The use of decision support systems (DSS) is increasing in importance among advisers and growers. The VitiMeteo-Plasmopara model is an expert system developed by the Grapevine Research Institute of Freiburg (WBI, Germany) and Agroscope Changins-Wädenswil (Switzerland), and programmed by the company GEOsens (Germany). Using relevant weather data VM-Plasmopara simulates the main development steps of the epidemiology of \textit{Plasmopara viticola}. The software generates graphics and tables freely available for the growers on the Internet. The model also incorporates weather forecasts data to simulate the development of the pathogen during the next 5 days. VM-Plasmopara is currently used over all vineyards of Switzerland, Germany and parts of Austria and northern Italy. Model validation during nine years in Changins (CH) has shown its high reliability. Outputs of the model were compared to observations made in the lab and in a small untreated experimental plot. Predicted downy mildew development was in accordance with disease appearance and progression in the experimental plot. However, improvement is still needed to better understand conditions required to have oospores maturation and germination in spring. Different protection strategies based on the model were tested in the field and allow to better control downy mildew and to decrease the number of fungicide applications. Growers using VM-Plasmopara are spraying more in accordance with the disease epidemic. They can objectively decide to delay the first spray or to enlarge spray intervals, thus reducing the number of sprays. The model allows them to evaluate the disease risk and decide of fungicide treatments opportunity on an objective basis.
New developments in Information and Communication Technology (ICT) that coincide with globalization are influencing several aspects of agriculture: market globalization has increased exports from producing to consuming countries where different food safety or pesticide residue regulations apply, and has raised awareness of global problems linked to agriculture production (i.e., chemical pesticide pollution). At the same time ICT development, in the form of the web and mobile technology makes knowledge dissemination easier than ever. Pests, diseases and weeds may cause significant damage to growers while the cost of pesticide increases. Environmental pollution and risk of unwanted residues on food has forced researchers to find ways to optimize pesticide applications. However, extension services and research in pest management is often fragmented and efforts to develop support tools for pest management are often duplicated. Furthermore, sometimes the knowledge does not spread from research centers to growers due to difficulties in knowledge transfer.

Decision support systems (DSS) are widely used in agriculture for assisting with integrated pest management (IPM), crop nutrition, and other aspects of information transfer. Developing highly portable and, especially, web-based DSSs that can be easily adapted to new environments is therefore desirable in view of the globalization of agriculture. Web-based models and DSSs have the major advantage of reducing software development, maintenance, and distribution costs, while making the relevant knowledge easily accessible to growers world-wide.

The talk will discuss the potential of harnessing recent ICT development to agricultural knowledge dissemination to farmers wherever they are.
PARALLEL SESSION – DECISION SUPPORT SYSTEMS
ENVIRO AN INNOVATIVE WEB MAPPING TOOL TO MONITOR AND FORECAST PLANT AND PESTS DYNAMICS BASED ON CLIMATE DATA

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Scientists and policy makers from the agricultural, environmental and socio economical sector need new Information and Communication Technologies (ICT) tools to study and understand the influences of climate and meteorology on the dynamics of agriculture systems. With this goal, we developed ENVIRO, an innovative WebGIS platform which integrates weather-driven, Ecosystem Modeling (EM) to monitor the effects of climate and study the impacts of climate change on Trentino’s major agricultural systems. Researchers and stakeholders can apply ENVIRO to map and overlay environmental, agricultural and socio-economic data. The platform is modular and it is designed to support the entire pipeline of implementation, validation of experimental models, based on high resolution climate data.

The backbone of ENVIRO system is enviDB, a spatial temporal database for vector and raster data which addresses the main objective of the system: i.e, to harmonize and to provide access to regional time series of weather-climate data, climate change scenarios, land use geodata and general administrative statistical data. The core of the system is a web geoprocessing engine where a library of models (Vitis Vinifera, Botrytis Cinerea, Lobesia Botrana, Erwinia Amylovora, Malus Domestica, Blumeria Graminis, Peronospora Farinose) is accessible to simulate and map the influences of weather and climate and to forecast the impact of future climate change scenarios on plant-pathology systems. EnviGrid is the a spatial temporal user panel to access the climate databases at different aggregation scales in time and space. Two web mapping interfaces complete the system: enviMapper, the interface for decision makers, a web client to monitor the influences of climate and the vulnerability to climate change on agricultural systems, and enviModel, the interface for researchers that provides tools for real time processing and models sharing.

All modules and technical components are Open Source and they build on software endorsed by the Open Source Geospatial Foundation (OSGeo). The implementation follows the international Open Geospatial Consortium (OGC) standards for geodata transmission and geoprocesses to ensure a complete interoperability with existing spatial data infrastructures (SDIs). Researchers can add the implementation of new models, as well as simulate in quasi real time life cycles of plants and pathogens and their interaction using the implemented models via web geoprocessing technologies. The platform includes also a rich metadata catalog to provide clear indications on quality and provenance of data. To sustain the requests for on line geoprocessing of large environmental models on climatic data, the ENVIRO scientific computing environment is based on high performance computing methods (GPGPU and Cloud Computing). In summary, ENVIRO is a state of the art ICT platforms for applied climate and climate change studies with a focus on modeling effects on agriculture
at high resolution, in space and time. The system was developed within the ENVIROCHANGE project funded by the Autonomous Province of Trento.
A WEB-BASED DECISION SUPPORT SYSTEM FOR THE MANAGEMENT OF INTEGRATED VINEYARDS

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The transition from conventional to integrated pest management and, more in general, to integrated production requires an increase of knowledge about the vineyard system and includes also an increase of limits and fulfilments. The vineyard manager needs to be more and more informed and has to take several decisions for the proper management of the vineyard. Therefore, a web-based Decision Support System (DSS) was developed for guiding decision about tactical management of the integrated vineyard. The DSS is provided by Horta srl, a spin-off company of the University of Piacenza (www.horta-srl.com), and is available for registered users via the internet in an interactive way. It is composed by: (i) a network of weather stations that send real time data, (ii) a server repository that stores the weather data; (iii) an user interface that makes it possible to readily input vineyard-specific information and obtain supports for informed decision-making; (iv) a set of mathematical models that use weather data and vineyard-specific information to predict the epidemiology of the main grapevine fungal diseases and the plant development. Output provides information on: (i) current weather conditions and 3-day forecasts; (ii) the growth stage of the plants; (iii) information and decision supports for primary and secondary infections of \textit{Plasmopara viticola} and \textit{Erysiphe necator}, causal agent of grapevine downy and powdery mildew, respectively. In particular, two weather-driven, mechanistic, dynamic models are used to provide the following information for \textit{P. viticola}: dynamic of the oospore population; occurrence of the main events for primary infections (oospores germination, zoospores release and dispersal, infection establishment and appearance of downy mildew lesions); infection severity and epidemic pressure of primary infections; fitness of the sporulating lesions and availability of the secondary inoculum; relative severity and epidemic pressure of secondary infections. Similar models provides information for primary and secondary infection of \textit{E. necator}: the dynamic of chasmothecia population, the release and dispersal of ascospores, the infection establishment and the symptoms onset, as well as the production of secondary inoculum and its efficacy in causing new infections.

Within the FP7-KBBE project "Pesticide Use-and-risk Reduction in European farming systems with Integrated Pest Management" (PURE) 16 commercial vineyards across Italy were managed so as to compare the management according to the DSS, the usual grower’s practice and an untreated control. Results collected during the first season confirmed the advantages due to the use of the DSS, in terms of rationalisation of fungicide schedule with a reduction of the number of treatments till to 36%. Other commercial vineyards will be managed according to the DSS in the following grapevine-growing seasons to further validate the DSS and demonstrate the benefits rising from its use.
PARALLEL SESSION – DECISION SUPPORT SYSTEMS
IDeMCroP: DEVELOPMENT OF AN INTEGRATED FINE SCALE SYSTEM FOR INFORMED DECISION MAKING IN SUSTAINABLE CROP PROTECTION

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Wide scale monitoring, real time data analysis for decision support and use of prediction models are major tools in implementing IPM. Growers, who need to make proper decisions according to IPM principles and, at the same time, safeguard their income, require relevant information constantly and timely in order to make effective informed decisions. Current crop protection warning systems are mostly using regional scale weather and environmental data, but can only partially relate to local variability which is affected by microclimate, actual field level of pest infestation and disease severity, crop varieties, pesticide and agronomic treatments, etc. On the other hand, Decision Support Systems (DSSs) which consider more detailed local data are usually operated on a single grower level, and their local data is not or poorly used on a regional/multi-growers level. A substantial aspect in promoting current IPM practice should be combining and securely sharing both local and regional data in a simple and flexible manner, in order to improve analysis and informed decision making. The required tool is an accessible web based and real time combined system, which should allow holistic decision making with data and analytics up to a plot level, serving growers, agronomists, extension, academy and authorities for IPM practice and overall supervision. The IDeMCroP project is developing such a breakthrough combined platform, based on two innovative systems: Italian Vite.net™ for providing decision support through modelling and Israeli AgriTask for monitoring/scouting and data sharing. These field proven systems present complementary approaches in providing comprehensive real time information and prediction for decision making. Vite.net™ is a web-based DSS for crop protection in vineyards which analyses real time meteorological data from real and virtual weather stations, uses advanced modelling techniques and formulates decision support for controlling fungal diseases, such as downy and powdery mildew, and insect pests, such as the grape berry moth and Mediterranean vine mealybug, according to IPM principles. AgriTask SaaS cloud platform and field scouting cellular application enable real time informed decisions, based on analysis and presentation of geo-referenced pest infestation field reports, crops and treatments history and infestation spatial and temporal trends. The system is already used for area wide multi-grower IPM projects of Mediterranean fruit fly, late blight and other pests in thousands of plots and various crops. The project will connect/integrate the two systems in order to provide a complete set of information and improve the performances of its single components. It will be designed to optimize scouting activities and crop protection treatments, and allow secure data sharing for improving both routine operations by growers and agronomists, and authorities supervision of IPM implementation according to the new directive.
We developed a Web-based Adaptive Management System (WAMS) within a research project, called “SMART VINEYARD”, which was funded by the Swiss Federal Commission for Technology and Innovation (Project 11307.1 PFES-ES). Goal of the project was to address the challenge of proposing a decision support system to provide real-time forecast of the life stages of *Scaphoideus titanus*, vector of flavescence dorée. The benefit of using the WAMS is to decide the timing of insecticide application and the planning of in-field monitoring tasks. After some laboratory tests done in 2010 and based on historical data, we performed some preliminary in-field tests of the system in the Canton of Ticino, Switzerland, between April-July 2011. The obtained results allowed us to developed a calibration algorithm aiming at setting up the initialization of *S. titanus* monitoring in new vineyards of regions with different micro-climate conditions. A first in-field validation of this calibration techniques was performed in Romandie, the french speaking part of Switzerland, in particular in two vineyards, in Changins and Satigny, in the Canton Vaud respectively Geneva. The obtained results were very promising. Even if the region was not “known”, our system was able to generate prediction windows about three weeks in advance and with an error rate of +/- 2 days. We strongly believe that end-users of our WAMS (i.e. wine growers, phytosanitary services, scouts) can benefit by operating in a cycle of system monitoring, data processing and adapting their activities to the current situation in their vineyards. End-users are given the possibility to interact with the monitoring system by means of a customizable web-based application able to provide real-time prediction windows, visualization of real-time temperature, as well as aggregated data like minimum, maximum and average temperature. Moreover, an alert feature regularly notifies the end-user about prediction windows via email or sms. The monitoring system can be easily interfaced with both weather station and wireless sensor networks. The engine of the monitoring system is a set of proprietary software implementing: (i) phenology models for predicting the life cycles of the vector and (ii) the auto-adaptiveness of the system based on machine-learning techniques.
PARALLEL SESSION – DECISION SUPPORT SYSTEMS

A DECISION-SUPPORT SYSTEM FOR MANAGING APHID-BORNE VIRUS DISEASES IN SEED POTATO

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Vector-borne virus diseases represent a major economic threat to the production of seed potatoes. Of the vast number of viruses causing infectious disease in potato plants, the aphid-transmitted Potato Virus Y (PVY) is of particular concern in many potato-growing regions worldwide. Controlling PVY indirectly through the application of insecticides targeting the aphid vectors has proven to be inefficient. Therefore, other virus control strategies must be explored and optimised, particularly in regions where vector pressure is high. We have developed a disease forecasting model for PVY adapted to the epidemiological situation in Switzerland. Predictions on the risk of virus transmission are based on vector pressure during the first 5-6 weeks following potato emergence, with vector pressure being estimated from daily captures of winged aphids in a suction trap. The statistical model was parameterised with high-quality data of PVY incidence in tubers, collected over two decades within the Swiss seed certification program. Cross-validation procedures showed that the model can predict virus risk with high accuracy. A parallel statistical analysis of the data on the spatio-temporal distribution of virus disease allowed to identify additional risk factors for dissemination of virus. This information can be used to adjust forecasts to particular epidemiological situations in a given year and region. Predictions of the forecast model are disseminated to growers on a weekly basis through the web-based national pest information platform “Agrometeo”. Such information on virus risk is invaluable for optimising virus control interventions, such as oil sprays. It also assists in making decisions concerning the optimal scheduling of haulm destruction, which aims to minimise virus risk while also maximising tuber yield.
According to the precision IPM approach, studies on spatial distribution and spatio-temporal dynamic provide crucial information for improving the pest monitoring and precision targeting control. Specifically, the precision targeting uses spatially explicit statistical methods to define pest distribution with a minimal priori knowledge of the pest behaviour and to provide with simple, documentable procedures for minimize direct control tactics. Geostatistic methods are among the most utilized statistical tools. Cases showing the importance of this approach, especially in heterogeneous and fragmented agro-ecosystems, were reported in the present paper. Studies interested some pests of fruit orchards and vineyards, such as the Lepidoptera *Grapholitha funebrana* Treitschke, *Cydia pomonella* (L.), *Lobesia botrana* (Denis & Schiffermüller) and the Diptera *Ceratitis capitata* (Wiedemann), monitored using traps or direct sampling. For each example, results relevant for the precision targeting application and the design of a pest management strategy were reported and discussed.
Tree crops production are highly dependent on external inputs, namely pesticides. Redesigning tree crop production on other bases becomes a necessity. Before being tested in an experimental station or in real farm conditions, the global sustainability of these newly designed orchards needs to be evaluated. Adapted on the DEXiPM® model, the DEXiPM-pomefruit tool has been designed to make an ex ante assessment of the sustainability of innovative orchard systems. This model is based on a decision tree breaking the decisional problems of sustainability assessment into simpler units, referring to the economic, social and environmental dimensions of sustainability. In the frame of the PURE European project, we tested DEXiPM-pomefruit relevancy to assess the sustainability of innovative orchards. Two apple production systems were compared: one with exclusion netting against codling moth and one without. Exclusion netting is an innovative control method, which decreases the number of treatments by 30 % since all treatments against codling moth are suppressed. Moreover, nets represent a good protection against yield loss risk due to climatic conditions (i.e. hail). However, its cost requires an important investment capacity. Assessed by DEXiPM-Pomefruit, the exclusion netting system globally ranked better than the uncovered system. Concerning the social aspect, the result was similar for both production systems. In contrast, economical performances were improved in orchards covered with nets, which are therefore protected against the climatic risk of yield loss. Moreover, the important decrease in pesticide use under nets contributed to improve all environmental impact indicators. DEXiPM-pomefruit helped selecting the most promising innovations in a given context. It was also used as a dashboard to determine strengths and weaknesses of the tested production systems and therefore to identify potential improvements.
**POSTER**

**METHODS FOR IPM: ADVANCES IN THE METHODOLOGICAL WORKPACKAGE OF PURE**


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The overall objective of PURE is to provide practical IPM solutions to reduce dependence on pesticides in selected major farming systems in Europe. This paper summarises methodological advances with regards to the design and assessment of IPM solutions. The presented case studies include major crops (cropping systems based on wheat or maize), field vegetables, orchards, vineyard and Controlled Environment Agriculture systems.

- Ecological modelling. A software package (Universal Simulator) for collaborative ecological modelling is now available: http://www.ecolmod.org/.
- Modelling for ex-ante and ex post assessment of IPM solutions. A multi-criteria model (DEXIPM) for sustainability assessment of innovative crop protection strategies has been developed along with SYNOPS, a web-based model for scaling up ex-post pesticide risk assessments at the individual crop level to the farm and regional levels. In addition, a model for ex-ante evaluation of IPM solutions is currently under development specifically for orchards (PREMISE).
- Multiple pest modelling. An interactive generic modelling platform to help design models that simulate yield losses caused by an injury profile in a given production situation (X-PEST) is currently under development. Moreover, theoretical mathematical modelling approaches are conducted to represent the interactions between generalist biological control agents and multiple pests.
- Optimisation techniques. Reinforcement learning methods have been adapted and applied to IPM. Multiobjective optimisation algorithms for model-based design of IPM solutions are being developed. The Graph based Markov Decision Process framework is being used for the optimisation of sequential decisions under uncertainty in a spatial context.
- Cost-benefit analysis and consumers' willingness to pay. Cost-benefit analyses are conducted for IPM solutions tested in the PURE project. An experimental approach is planned to characterise consumers' willingness to pay for agricultural goods produced under IPM solutions as a function of their level of information on the mode of production.

It is important to state that the methodological breakthroughs produced in this work package will not only benefit to the PURE project, but also aim at contributing to the design of practical IPM solutions to reduce dependence on pesticides for a wider range of farming systems. This is made possible by ensuring as much as possible genericity in the developed approaches.
POSTER

MODELLING IPM STRATEGIES AT THE LANDSCAPE SCALE

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There is plentiful evidence that pest regulation should be considered at spatial scales beyond that of the cultivated field; weeds (Roschewitz et al., 2005), arthropods (natural enemy and pest species) (Tscharntke et al., 2008) and microbial pathogens (Plantegenest et al., 2007) all respond to broad landscape characteristics such as fragmentation and complexity. These results suggest that pest-suppressive landscapes could be designed in a way which is consistent with the pattern-process-design paradigm of landscape ecology (Nassauer and Opdam, 2008). However, such studies have yet to provide sufficient knowledge of either the pattern or processes in order to direct the design phase. Because of the limited capacity to manipulate and observe pest systems at a sufficiently large spatio-temporal scale, we must rely heavily on modeling approaches to tackle both the process and design steps required (Begg et al., 2010). To address this we have been developing software for the implementation of a class of spatially explicit models, capable of simulating the dynamics of pest populations across farmed landscapes. Our objective is to be able to simulate the response of a broad range of pest systems to spatio-temporal patterns in the deployment of IPM control strategies across farmed landscapes, including the dynamics of secondary pests and natural enemies as necessary. To achieve this, a spatially explicit population model (SEPM) framework has been adopted, which couples matrix population models with an explicit representation of the farmed landscape. In this presentation we introduce our approach; describing the class of models, outlining their implementation, and listing some potential applications. A model of the Western corn rootworm (Diabrotica virgifera virgifera) has been developed for illustration; here we present some simulations to show the response of this major pest to the deployment of IPM-related control measures at the landscape scale.
Economic threshold (ET) is an important part of integrated pest management. ET differs according to pest and crop. ET varies with economical parameters as cost or price. A model of ET enabling to take into consideration agronomical and economical parameters was established. Model of ET or economic injury level (EIL) were established as: ET (EIL) = 100 × C × e × i/ D(Pd) × Y × P, where damage curve was D = A0 + A1 · Pd, D = damage (decrease of yield in %), Pd = population density of pest, C = cost of pest control, e = efficacy index (e = 100/efficacy in %), i = impact on the environment (from 1 to 3), Y = yield, P = price of product. Damage curves were established for cereal beetles and European corn borer based on field experiments. According to damage curves it is possible to predict yield losses according to population density of pest. According to model of ET and damage curve it is possible to determine population density of pest as a criterion for pest control. Model of ET takes into consideration efficacy of pesticide and economically evaluate negative impact of used pesticide on the environment. Model of EIL enables to evaluate economical efficacy of pest control. For European corn borer, model of EIL enables also evaluate economical efficacy of Bt-maize growing. The work was supported by the project of the Technology Agency of the Czech Republic, no. TD010056.
Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola*, is the most economically important foliar disease of sugar beets (*Beta vulgaris*) in Italy. It can be controlled with the integrated use of resistant varieties, crop practices and foliar fungicides. Environmental conditions strongly influence the activity of *C. beticola* in the field; they can be used to guide fungicide applications once the relationships are understood. To assist growers in making profitable decisions regarding the application of foliar fungicides for CLS control, a predictive model, developed and improved by researchers at the University of Minnesota and North Dakota State Universities, was adjusted to Italian conditions and evaluated. The model was designed to predict the time when the infection by *C. beticola* was likely to occur based on hourly temperature and relative humidity data. CLS control is currently based on treatments scheduled using a “calendar” programme. This system recommends to start fungicide applications on a fixed date and continue regularly every 18-20 days. Three years of field trial evaluation of the CLS prediction model at several experimental sites, compared with the calendar programme, has resulted in a savings of 1.5 fungicide treatments (corresponding to 130 €/ha) without a significant loss of yield. To control CLS, multiple applications of the same fungicide during a growing season are unfortunately common. This practice provides the target fungus with the conditions to evolve resistance. Sensitivity assays of *C. beticola* to DMI and QoI fungicides were carried out on isolates collected in 2009 and 2010 in Northern Italy by the University of Bologna and North Dakota State University, respectively. Isolates principally came from trial plots but also from commercial sugar beet fields and were tested for sensitivity to tetraconazole, difenoconazole, pyraclostrobin and trifloxystrobin using radial growth and spore germination assays. All samples collected in 2009 showed EC50 values for QoI ranging from 0.0008 to 0.2195 µg/ml. The percentage of isolates collected in 2010 with EC50 values >1 for tetraconazole was 44%, for difenoconazole 84%, for pyraclostrobin 27% and for trifloxystrobin 34%. For isolates with EC50 values >1 µg/ml, the range of EC50 values (µg/ml) for tetraconazole was 3.4-70.0, for difenoconazole 2.0-69.5, for pyraclostrobin 1.5-43.6, and for trifloxystrobin 3.8-77.1.
Knowledge of the biophysical mechanisms underlying the development of the greenhouse climate, particularly climate prevailing at the ecological niche of beneficial insects and pests, is of particular interest if you want to implement alternative methods to chemical control. With this in mind, the work developed in this paper aims to use Computational Fluid Dynamic software CFD to model the climatic parameters inside greenhouses and especially in the boundary layer of leaf-level, natural habitat of pests who inhabit plants. This approach allows providing information about the climatic conditions prevailing at the ecological niches of biological agents. This is a prerequisite to an action that targets the control of the local climate in order to fight against plant pests. The tools used in this study combine fine measurements of microclimate and distributed climate modelling in the leaf boundary-layer by means of analytical and numerical approaches. Experiments were conducted in a 922m² multi-span greenhouse covered with a 200 μm thick thermal polyethylene plastic. The greenhouse was located in the INRA experimental Unit of Sophia Antipolis in South France. The cultivated crop was a rose watered by a drip irrigation system. The climatic conditions prevailing near the under leaf surface were determined by means of a set of small thermo-hygrometers (model EE06, Intertechnique) whose protection caps were removed to determine more precisely the temperature and humidity conditions at distances of 5 and 15mm from the leaf surface. The temperature and humidity patterns inside greenhouse were simulated using the commercial software solver: Fluent with the choice of a classical k-e turbulence model to model the turbulent constraints. In addition, this CFD code was customized for simulating, the sensible and latent heat exchanges between the air and the crop (assimilated to the solid matrix of the porous medium) within each mesh of the crop canopy following the procedure described by Fatnassi et al. (2006). The temperature and air humidity distributions in the boundary layer of the leaves were deduced from velocity profiles depending on the Prandtl and Schmidt numbers (Schlichting, 1974). The results showed that the microclimate (air temperature and humidity) close to the lower leaf surface is different from the climate inside the greenhouse, particularly during daytime when crop transpiration is maximum.
**POSTER**

**DEVELOPMENT OF A RISK FORECAST MODEL FOR THE BARLEY DISEASE RAMULARIA LEAF SPOT**

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*Ramularia collo-cygni* is now one of the most economically important fungal pathogens which attack barley (*Hordeum vulgare*) crops in temperate countries around the world. The epidemiology of this disease is only slowly being elucidated. Seed borne infection has been revealed to be the primary source of early *R. collo-cygni* infection in crops. The effectiveness of seed treatments is currently under evaluation. Later *R. collo-cygni* spore release events were found to be related to periods of maximum leaf surface wetness. The effect of *R. collo-cygni* on yield has also been studied by analysing Area Under Disease Progress Curves (AUDPC) and yield figures from untreated crops over a number of years and sites. A relationship between yield and AUDPC was established for winter and spring barley crops. A risk forecast scheme for *R. collo-cygni* severity in a cropping season based on surface wetness at GS 31 has been devised. The risk forecast is compiled for Scottish growers and disseminated early in order to allow control programmes to be tailored accordingly.
PERFORMANCE AND SIDE EFFECTS OF IPM SOLUTIONS USING MODEL-BASED TOOLS TESTED BY GREENHOUSE TRIALS

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Up to now, alternatives to chemical pesticides using biological control strategies have been implemented empirically at the cost of huge experimental efforts in order to provide wide-test ranges of biological control agents (BCAs). Satisfactory answers to pest problems require a shift in understanding, such as promoting biological agents as well as more widely ecologically-sound practices. Despite being poorly biodiversified, many complex interactions can occur among biotic components and between biotic and abiotic components in agro-ecosystems such as protected cultivation systems. Understanding these interactions is a major hurdle to overcome for the development of future IPM strategies. Within this framework, we have, first, investigated aerial plant systems via spatio-temporal modelling of the abiotic environment. Distributed climate modeling specially at leaf level provide crucial information on pests and BCAs ecological niches. Similarly, abiotic transfers are considered to be likely pest vectors. By applying the expertise gained in the study of energy and mass transfers between the greenhouse and its environment, the threefold objective was to provide satisfactory habitat for plant growth; to restrain pest encroachment through use of prophylactic techniques such as insect-proof nets; and to promote environmental acceptability of the plant growth system by controlling power consumption. From the biotic point of view, a panel of diversified pests is also currently present at the same time to which all the biocontrol agent species released by the grower have been added. Therefore studies have focused on the mechanisms underlying the outbreak and the dynamics of pests and diseases in the canopy. In this case, the ecological approach, based on both theoretical and applied studies, is of major interest to describe the biotic interactions taking place between the crop, pests and BCAs, as well as to refine pest control methods, specially through the use of multiple natural enemies. Research is not only carried out on the creation of new technical routes for crop protection (IPM) but also, by means of models, noticeably, on better understanding the greenhouse ecosystem and the corresponding communities, i.e. cultivated plants, pests and biological control agents. The objective is both to assess and promote the ecological services among a complex network of manifold biotic interactions. More generally, the integration of the huge amount of interacting entities and control tools of the greenhouse agro-ecosystem requires multicriteria model based assessment in order to set up the most appropriate crop protection strategies. Therefore, this study presents very diversified modeling approaches, each of them playing an important role in the implementation of robust IPM strategies under greenhouses.
POSTER

PESTICIDE NON POINT SOURCE POLLUTION RISKS: AQUAVALLEE®: A GIS BASED DIAGNOSIS TOOL

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This poster introduces a unique method to pinpoint Non Point Source (NPS) pollution risks at field level. Based on the rigorous CORPEN methodology, ARVALIS developed a user-friendly GIS based tool. The resulting decision-making tool efficiently locates zones where risks of NPs are present, even within rather large watersheds. The methodology encompasses saturated and unsaturated behaviour of both superficial and groundwater aquifer system analyzing transfer types, and makes wide use of the following key parameters:

- Field location and land-cover
- Soil composition
- Slope and orientation
- Hydrographic network
- Location and nature of phreatic aquifers
- Pervious and impervious zones

Aquavallée® allows suitable solutions for each type of pesticide transfer to be found: buffer zones, changes to agricultural practices, reduction in pesticide doses, spray period and modification of pesticide type. This tool has been applied on more than 1 000 000 ha in France and in some European countries. Aquavallée® has allowed for the diagnosis of diffuse pesticide transfers on 41 areas of water supplies. As part of the European TOPPS Prowadis project, the use of Aquavallée® has been extended to Germany, Denmark, Poland, Belgium, Italy and Spain. The system has proved to be efficient in reducing workload by targeting only fields where NPS is real. In addition, it allows an homogenization of risk ranking when several surveyors are used within a single watershed. The Aquavallée® map, with the localization of the plots, is a good educational tool to help farmers to appropriate the results of risk diagnosis and mitigation measures.
A WEB-GIS DECISION SUPPORT SYSTEM FOR PARASITE CONTROL IN ALPINE REGIONS: APPLICATIONS TO GRAPEVINE PHENOLOGY AND MODELLING OF EUROPEAN GRAPEVINE MOTH

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Environmental variability in mountain regions like Trentino makes WEB GIS a precious tool for decision support systems (DSS). In the cultivated alpine valleys, where a complex temperature pattern exists, monitoring activities and phytosanitary management can greatly benefit from web-based simulation tools. Furthermore, collecting biological samples is time-consuming and expensive. A phenological model of each growth stage of grapevine cv. Chardonnay was overlapped with the time of flight of each generation of the European grapevine moth (Lobesia botrana) to optimize timing of intervention. L. botrana is one of the most important pest in Italian vineyards. Larvae feed on flowers during the first generation, and then on grape berries during the second and third generations. Since 1998, the common control is mating disruption and the viticultural area is treated with pheromones. Overlapping models of flight time and grapevine phenology is the key factor to decide when and where starting controls. Host and pest phenology was reproduced in maps at 200 meters of resolution with daily steps in Trentino. Model outputs were run into a friendly modular WEB GIS called ENVIRO and the impacts of the climate change at regional level was evaluated.
IPSIM, INJURY PROFILE SIMULATOR, A HIERARCHICAL MODELLING FRAMEWORK TO PREDICT AN INJURY PROFILE AS A FUNCTION OF CROPPING PRACTICES, SOIL, CLIMATE AND FIELD ENVIRONMENT.

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The limitation of damages caused by pests (weeds, plant pathogens and animal pests) in any agricultural production requires integrated management strategies. Even if significant efforts have been made to develop the combination of genetic, biological, cultural, physical or chemical controls in Integrated Pest Management (IPM) strategies (vertical integration), there is a need for tools to help manage injury profiles (horizontal integration). Farmers design cropping systems according to their goals, their cognition and their perception of socio-economic and technological drivers as well as their physical, biological, and chemical environment. In return, a given cropping system, in a given production context will lead to a unique injury profile, defined as a dynamic vector of the severities of all injuries occurring on a crop. This simple description of agroecosystems has been used to develop IPSIM (Injury Profile SIMulator), a modelling framework to predict injury profiles on arable or perennial crops as a function of cropping practices, soil, climate and field environment. Due to the tremendous complexity of agroecosystems, a simple aggregative framework was chosen to develop this model. In order to provide a proof of concept, a model, named IPSIM-Wheat-Eyespot, has been developed according to the conceptual framework of IPSIM to represent final incidence of eyespot on wheat. IPSIM-Wheat-Eyespot’s modelling approach consists of designing a model with an aggregative hierarchical and qualitative tree of attributes. The predictive quality of the model was assessed using a dataset embedding a wide range of climates, soils and cropping practices (526 observed sites-years). IPSIM-Wheat-Eyespot proved to successfully represent the annual variability of the disease, as well as the effects of cropping practices (Efficiency = 0.64, Root Mean Square Error of Prediction = 25%; bias = 6.2 %). IPSIM-Wheat-Eyespot does not aim at predicting precisely the incidence of eyespot on wheat. It focuses on the ex ante evaluation of the risk of eyespot on wheat for a cropping system in a given production situation or on the diagnosis of commercial wheat fields. Its structure is simple and permits to combine available knowledge in the scientific literature (data, models) and expertise. IPSIM-Wheat-Eyespot is now available to help design cropping systems with low risk of eyespot on wheat in a wide range of production situations, and can help perform diagnoses of commercial wheat fields. IPSIM-Wheat-Eyespot will be one of the sub-models of IPSIM-Wheat, a model that will predict injury profile (main diseases, weeds and animal pests) on wheat as a function of cropping practices and the production situation.
Grapevine downy mildew, caused by *Plasmopara viticola*, often requires numerous chemical treatments in order to reduce serious damages on leaves and clusters. The management strategy suggested by the Italian extension services is based on the occurrence of meteorological conditions suitable for *P. viticola* infections and the calculation of the incubation period. However, various treatments executed following this strategy could be avoided in presence of low infection risk. EPI (Etat Potentiel d’Infection), an heuristic model designed for the assessment of infection likelihood of *P. viticola*, can be used to define a rational treatment strategy against the pathogen. The aim of this work is to compare the treatment schedule based on the EPI simulations with the extension service strategy in vineyards located in Lombardia, by assessing the corresponding infection indexes and the number of treatments applied in the different plots. Twenty experimental assays were carried out from 2008 till 2012 in Oltrepo Pavese, Valtellina, Sirmione (BS) and in the Mantova province, at Monzambano (MN) and Mantova (MN). In each experimental vineyard, the treatments corresponding to the two strategies were carried out in two plots, consisting of three rows, 80 m long. An analogous plot was not treated against *P. viticola*. The downy mildew epidemic development was assessed weekly in the untreated plots on 100 leaves and 100 clusters located in four subplots and at the end of the season on the treated plots. Each grapevine organ was classified in one of the following classes: 0- healthy; 1: 0.1-2.5 % symptomatic surface; 2: 2.5-5 % symptomatic surface; 3: 5-10 % symptomatic surface; 4: 10-25 % symptomatic surface; 5: 25-50 % symptomatic surface; 6: 50-75 % symptomatic surface; 7: 75-100 % symptomatic surface. The percentage infection indexes (I%I) per treatment and grapevine organs were calculated and compared using one-way ANOVA. The I%I assessed on the plots treated according to the different strategies were analogous, but the EPI strategies required a lower number of treatments. Overall, the treatment number was reduced by 57 % by EPI and in three vineyards no treatments were applied against *P. viticola*. Therefore, the simulations obtained by using the EPI model represent a valuable indication for defining a sustainable and rational treatment schedule against *P. viticola*.
There is strong social and political pressure to reduce pesticide use in European crop production systems. Evaluating the overall sustainability of cropping systems is a complex task due to the conflicting objectives underlying the economic, social and environmental dimensions of sustainability. The development and use of models that assess different Integrated Pest Management (IPM) scenarios and evaluate the most sustainable practical options at regional, national and European level is essential. Within the EU Project PURE, a working group was formed aiming to design, assess and compare ex-ante (before testing them in field experiments) the sustainability of advanced (AS) and innovative (IS) maize-based cropping systems (MBCSs), using different IPM levels, for three European regions (northern Italy, southern France, eastern Hungary), against the conventional approach (CS). The systems’ design derived from expert-based surveys that were performed during the EU project ENDURE and from further discussion with different stakeholders in each region. The DEXiPM model for arable crops, a qualitative and multi-attribute model developed within ENDURE and based on DEXi software, was used to evaluate and compare ex-ante the sustainability of these systems. In France, the AS and IS consisted of a maize/soybean rotation with different levels of IPM against the continuous maize that is the dominant system in southern France. In Italy and Hungary, the AS consisted of maize/winter wheat/soybean rotation and the IS of maize/winter wheat/ (cover crop) soybean (cover crop) rotation, both against the conventional maize/winter wheat rotation. IPM-based strategies used in all AS and IS aimed at the reduction in or sustainable use of pesticides (i.e. band application of herbicides, mechanical weeding, insecticides selective towards beneficial organisms or bioinsecticides to control *Ostrinia nubilalis* Hubner). Results of the ex-ante assessment using DEXiPM showed that in France, the AS maintained the same high economic sustainability as the CS, whereas the IS had a lower score, mainly due to an increase in the production risk (lower potential yield). However, both AS and IS increased the social sustainability with a better landscape social value and higher contribution to employment, while the IS even improved the environmental sustainability compared to the other systems. In Italy, the AS was the most sustainable system compared to the CS and IS, improving the environmental and social sustainability. However, the IS had the same overall sustainability as the CS because, although the economic sustainability decreased the environmental sustainability increased. In Hungary, AS and IS had an overall sustainability similar to that of CS, since although the economic sustainability was reduced the social sustainability was greatly improved. In conclusion, the overall sustainability of all AS and IS designed by the partners and assessed with DEXiPM maintained or even had higher sustainability than the CS, indicating that these MBCSs are acceptable for further consideration and testing in field experiments.