Mathematical Modelling for Sustainable Management of Crop Health
A short course. January 13-17 2014. Volterra, Italy

Context and issues

There is a pressing need to improve the social, environmental and economic performances of farming systems worldwide. World population increase, coupled with yield and arable land area stagnation, calls for new agroecosystem management strategies. Food and feed have to be produced in sufficient quantity and quality, while, at the same time, the preservation of the environment is now an urgent challenge, notably in terms of pesticide reduction. Pests (plant pathogens, weeds and animal pests) are responsible for important direct and indirect crop losses. These quantitative and qualitative losses can be limited using a combination of cultural, biological, genetic, physical and chemical control methods. Sustainable management of crop health requires to explicitly consider much of the complexity of agroecosystems. We must deal with crop production as affected by management, and with interactions between pests and crops, between different pest populations and between pests and beneficials, at various spatial and temporal scales. Modelling is a key tool for representing the complexity of dynamic biological systems, and for testing various management strategies. Mathematical models can i) help understand how the underlying processes interact leading to pest regulation services and disservices (*i.e.* crop losses) and ii) help design sustainable crop health management strategies.

Objectives

➢ To present a panorama of modelling approaches and their use for sustainable plant protection. The approaches include simple statistical models, dynamic system models, agent-based models and network models. Major emphasis will be on dynamic system models

➢ To present the principles of model evaluation and model calibration, which are fundamental aspects of modelling

➢ To provide hands-on experience in going through the various stages of a modelling project, starting from a description of the problem, developing the model and obtaining numerical results. Throughout the course, the students will be given practical work that will provide elements of the project. The final day will be devoted to putting these elements together, to finalise the project

➢ To teach the R programming language, which is free and is widely used in the scientific community. The modelling project will use the R language

Audience

PhD students, post-doctorates or researchers who want to better understand the use of models for plant protection, either because they will be interacting with models or modellers, or because they intend to develop models themselves. There are no prerequisites; the modelling and programming involved will be taught in the course.

Dates and location

January 13-17 2014, the International School of Advanced Education located in Volterra, an historic Etruscan village in the hills of Tuscany, Italy: http://www.siafvolterra.it/en/

Fees

➢ **INRA employees (including PhD students)**
  Registration fees will be covered by the FormaSciences departement. Transportation costs must be covered by INRA units.

➢ **Others**
  - 1200 € for early registration (before October 1, 2013)
  - 1500 € for late registration (the dead-line for online registration is November 1, 2013)
  - 120 € for a limited number of applicants selected according to i) their country's standard of living; ii) the potential benefit of the course for their PhD or research project; iii) the need for scientific support with regard to the local research organisations

The price covers the course, a single room and full board for the 5 days of the course, plus coffee breaks. It also includes the round trip from the Pisa international airport to Volterra by bus. Inscriptions will be definitive only after payment. There is no charge to cancel inscriptions up to 15 days before the start of the course (up to December 27, 2013). Fees cannot be reimbursed beyond that date.

Lecturers

Lecturers are confirmed modellers in the field of epidemiology, crop protection, ecology or in the methodology of modelling, with extensive experience in organising international short courses on modelling:

Jean-Noël Aubertot (INRA, France), François Brun (ACTA, France), Tito Caffi (Università Cattolica del Sacro Cuore, Italy), Marie Gosme (INRA, France), David Makowski (INRA, France), Marco Pautasso (CNRS, France), Wopke van der Werf (Wageningen University, The Netherlands), Daniel Wallach (INRA, France), Jonathan Yuen (Swedish University of Agricultural Sciences, Sweden).

Provisional program

I. Basics. The problems, the tools
- General introduction to the course
- Overview of the course program
- What's it all about? An example of a dynamic system model
- Review of the varied objectives of modelling for plant protection
- Types of models, principles and uses: dynamic system models, statistical models, agent-based models, networks
- Explanation of modelling projects

II. The R programming language, our (free) programming tool
- Introduction to R
- Basic R commands
- Writing a program in R
- Exercises

III. Model examples and exercises

The examples present problems in sustainable pest management and models to address those problems. The exercises involve programming basic recurring elements in models of animal pests and diseases (disease development, disease propagation, predator-prey interactions, population age structure)

- Disease forecasting using a statistical model
- Tactical disease management using a system model
- Tactical disease management using a point model (accumulation of favourable periods)
- Understanding the dynamics of systems with multiple pests using a system model
- Network models for disease management
- Strategic weed management using a system model
- Assessing management options using an agent-based model
- Durable management of cultivar resistances

IV. Generic methodological problems
- Dimensional analysis
- Parameter estimation for models
- Model uncertainty
- Model evaluation

V. Modelling project, by group

Several project subjects in plant protection will be provided (issues and data) at the start of the course. During the course, students will develop elements for the projects as exercises. The last day will be devoted to finalising the project. Groups will have to define the system, define the objectives, build a model, estimate the parameters, do the simulations.

Registration

Please fill out the pre-registration form available at:

www.inra.fr/reseau-pic_eng/Seminars/Modelling-for-crop-health

The registration deadline is November 1, 2013. The number of participants is limited to 30. The organising committee may select applications based on information provided in the application form and on the date of application. For any inquiry, please contact the organising committee by email.

Requirements

Participants are required to bring their laptop.

Organising committee

Sandra Arrault (FPN, INRA, France); Jean-Noël Aubertot (UMR AGIR, INRA, France); François Brun (ACTA, France); Daniel Wallach (UMR AGIR, INRA, France)

Contacts

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This short course is an initiative of the INRA Metaprogram "Sustainable Management of Crop Health", in collaboration with the European Research Group ENDURE (DURable Exploitation of Crop Protection Strategies), the European project PURE (Pesticide Use-and-Risk Reduction in European farming systems with Integrated Pest Management), the INRA/CIRAD Integrated Pest Management network, and the INRA/ACTA Mixed Technological Network on Modelling.