PROJECT MIMYCS: A SIMULATION MODEL SYSTEM FOR SIMULATING MYCOTOXIN CONTAMINATION IN MAIZE GRAIN IN EUROPE

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Abstract
Mycotoxins are toxic compounds produced by fungi infecting crops starting from the field phase. Maize is one of the crops subjected to the most critical mycotoxin problems. The FP7 Marie Curie Project MIMYCS aims at the development of a simulation model system to simulate mycotoxin contamination in grain maize. MIMYCS is being implemented using the component-oriented paradigm both for model and utility components. It will be composed of three sub-models simulating maize, insect borers and fungi development. First results of the project include i) the development of a generic insect phenological model parameterized for the maize borers *Ostrinia nubilalis* and *Sesamia nonagrioides*, and applications under climate change scenarios; ii) the development of a biophysical model for the simulation of maize grain moisture during development and maturation. The sub-model simulating fungi development is under development.

Keywords: MIMYCS, mycotoxins, grain maize, insect borers, climate change.

Introduction

Mycotoxins are toxic compounds, produced by fungi, recognised as the main cause of chronic intoxications in the world (CAST, 2003). Maize is one of the crops subjected to the most critical mycotoxin problems throughout the world (Logrieco *et al.*, 2003). Limitations by the European Commission (Commission Regulation, 1126/2007, Commission Recommendation, 2006/576/EC) and by other nations of the world on the maximum levels of mycotoxins in cereal grain have had an important socio-economic impact on the global cereal market (Wu, 2007). As a consequence, producing maize grain with acceptable mycotoxin content and maintaining at the same time profitability has become more and more difficult, with important socio-economic consequences.

Mycotoxin contamination in maize grain is the result of a complex pathosystem formed by maize plants, toxigenic fungi and insect borers. Fungi development and mycotoxin synthesis is influenced by climatic conditions and by the fungi competitive relationships, which determine their prevalent geographical distribution. As a consequence, warming of the climate system could have an important impact on the pathosystem and the potential effects are very difficult to foresee.

The modelling of mycotoxin contamination in maize grain during the field phase could represent a great opportunity for maize producers, policy makers, and for scientists, to manage the mycotoxin problem in maize and to study the pathosystem and the effects of climate change. The project MIMYCS (Maize Infection and MYcotoxin Contamination Simulator) have started in 2010 and aims at the development of a simulation model system to simulate the complex pathosystem which leads to mycotoxin contamination in maize grain.

Matherials and Methods

MIMYCS is being implemented as a component of the framework BioMA (Biophysical Models Applications), the modelling platform used at JRC-AGRI4CAST (http://agsys.cra-cin.it/tools/bioma/help/). Models are implemented using the component oriented programming paradigm, which is based on the concept of encapsulating a solution of a modelling problem in discrete, replaceable, interchangeable and interfaceable software units called components. Models are implemented as discrete model units of fine granularity, called *Strategies*. Simple *Strategies* can be composed to build *CompositeStrategies*. Both can be used to build *ContextStrategies* in which the model (a *Strategy*, simple or composite) can be used according to the state of the system. The fine granularity of model implementation allows an easier verification, maintenance, and composition using the same interface but keeping a solid and transparent underlying modelling structure.

In BioMA all model components share the same architecture which provides many features that facilitate their re-use, from explicit ontology of the interfaces to the capability of extend them autonomously (Donatelli and Rizzoli, 2008). MIMYCS is being developed as composed by three main sub-models: MIMYCS.Maize, MIMYCS.Borers, MIMYCS.Fungi (Figure 1). The Maize model integrates the CropSyst simulation model to simulate maize phenological development and include an original model to simulate maize grain moisture development and maturation. It implements the impact of

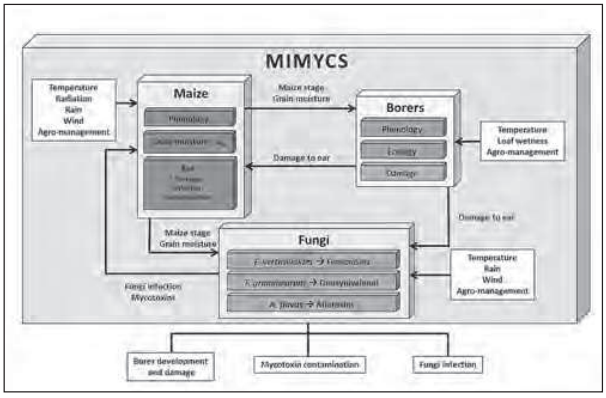

Fig. 1 - Structure of the MIMYCS Framework.

insect borers damage to the ears, fungi infection and mycotoxin accumulation in maize grain. This model gives information both to MIMYCS.Borers and MIMYCS. Fungi on maize phenological stage, in order to activate processes and synchronize events (damage to the ear, infection, and contamination). MIMYCS.Borers simulates insect borer phenological development and feeding activity which produces the damage to the ear, enhancing fungi growth and development. MIMYCS.Fungi simulates fungi development and their interactions, using information received from the other two models. As a result of these interactions MIMYCS simulates mycotoxin synthesis, insect borers phenological development and damage, maize phenological development and grain moisture.

Results and Discussion

First results of MIMYCS include the development of a generic phenological model (Maiorano, 2011) that has been parameterized for *Ostrinia nubilalis* and *Sesamia nonagrioides* using data from literature and from field surveys. The model has also been applied under climate change scenarios for comparing different methodological approaches (Maiorano *et al.*, 2012) and for analysing potential distribution in Europe under different climate scenarios (paper in preparation). The structure of the MIMYCS.Borer software model component is showed in Figure 2.

The model simulating maize grain moisture during development and maturation has been developed and currently it is being tested using data from field surveys.

Conclusions

The MIMYCS project aims at providing a first operational tool to simulate at EU scale mycotoxin contamination in grain maize in different climatic, environmental, and agro-management situations. In this contest, the development of MIMYCS will allow an easy re-use of it for performing simulations (i) to inform European policy makers of the effects of European mycotoxin policies and help them to fix safe and, at the same time, feasible contamination limits, (ii) about climate change scenario effects on the pathosystem and on future maize-based food and feed products safety, (iii) to assist maize producers in controlling mycotoxin contamination through agro-management. The MIMYCS project is supported by private companies, and public extension services like Veneto Agricoltura (Italy), and the Spanish working group GENVCE.

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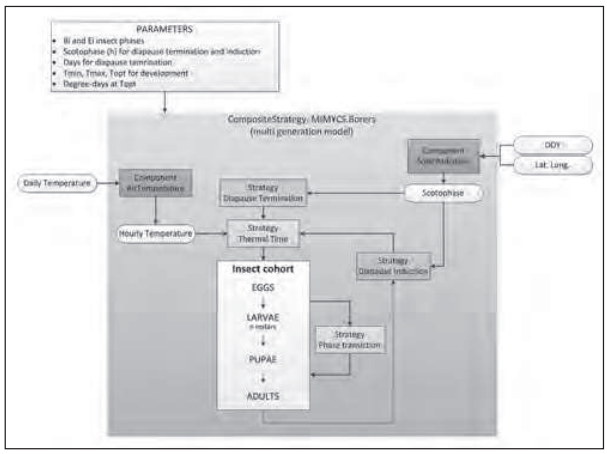

Fig. 2 - Structure of the MIMYCS. Borers software model component.

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