# Advances in multiple pests modelling: IPSIM (Injury Profile SIMulator) a hierarchical qualitative modelling framework to predict injury profiles as a function of cropping practices, soil, climate and field environment.

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# INJURY PROFILE SIMULATOR (IPSIM), A MODELLING PLATFORM TO DESIGN QUALITATIVE MODELS PREDICTING INJURY PROFILES AS A FUNCTION OF CROPPING PRACTICES AND PRODUCTION SITUATIONS

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## INTRODUCTION

In order to reduce the reliance of cropping systems on pesticides, tools to help "vertical integration" (combination of several control methods) and "horizontal integration" (simultaneous management of several pests) in Integrated Pest Management strategies are needed. Wheat is the main arable crop in France in terms of cultivated area. We propose **an innovative modelling framework in order to help design qualitative models to represent the impact of cropping practices, soil, climate and field environment on injury profiles caused by multiple pests** (plant pathogens, weeds and animal pests). The basic principles of the approach and an application to wheat, the main arable crop in Europe in terms of cultivated area is presented here.

## MATERIALS AND METHODS

IPSIM is a simple generic hierarchical qualitative modeling platform based on the DEXi software (Bohanec, 2009). The main assumption is that each injury profile that can be observed in a given field only depends on the associated cropping system and part of the production situation (soil, climate and field environment). Figure 1 represents the conceptual scheme of IPSIM-WHEAT. In order to provide a proof of concept, the method was first applied to a single disease: eyespot on wheat (Robin et al., 2013). IPSIM-WHEAT-EYESPOT, a sub-model of IPSIM-WHEAT, was designed and its predictive quality was assessed (Figure 2). Utility functions were defined using available knowledge in the literature. It must be stressed that no calibration was performed. A large dataset (525 site-years) was used to assess the predictive quality of IPSIM-WHEAT-EYESPOT .

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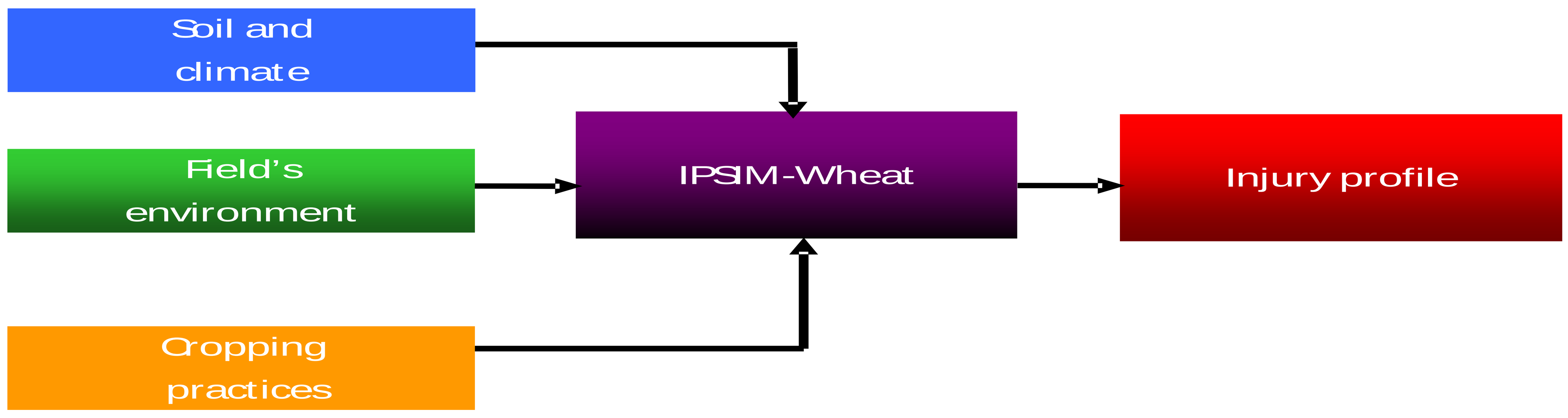


**Figure 1. Schematic representation of IPSIM-WHEAT. In blue, green and orange: production situation components affecting the injury profile of a given wheat field. The injury profile is the output variable of IPSIM-WHEAT. Its input variables are embedded within the three following components: soil and climate, field's environment, cropping practices.**

Bohanec M., (2009). DEXi: Program for Multi-attribute Decision Making, Version 3.02 Jozef Stefan Institute, Ljubljana (2009)
Robin, M. H., ColbachN., L. P., Monfort F., Cholez C., Debaeke P., Aubertot J.N. (2013). Injury Profile SIMulator, a hierarchical aggregative mod framework to predict an injury profile as a function of cropping practices,and abiotic and biotic environment. II. Proof of concept: design and evalu... IPSIM-Wheat-Eyespot, a model that predicts eyespot injuries on winter wheat. PLoS ONE 8, Issue 10, e75829.

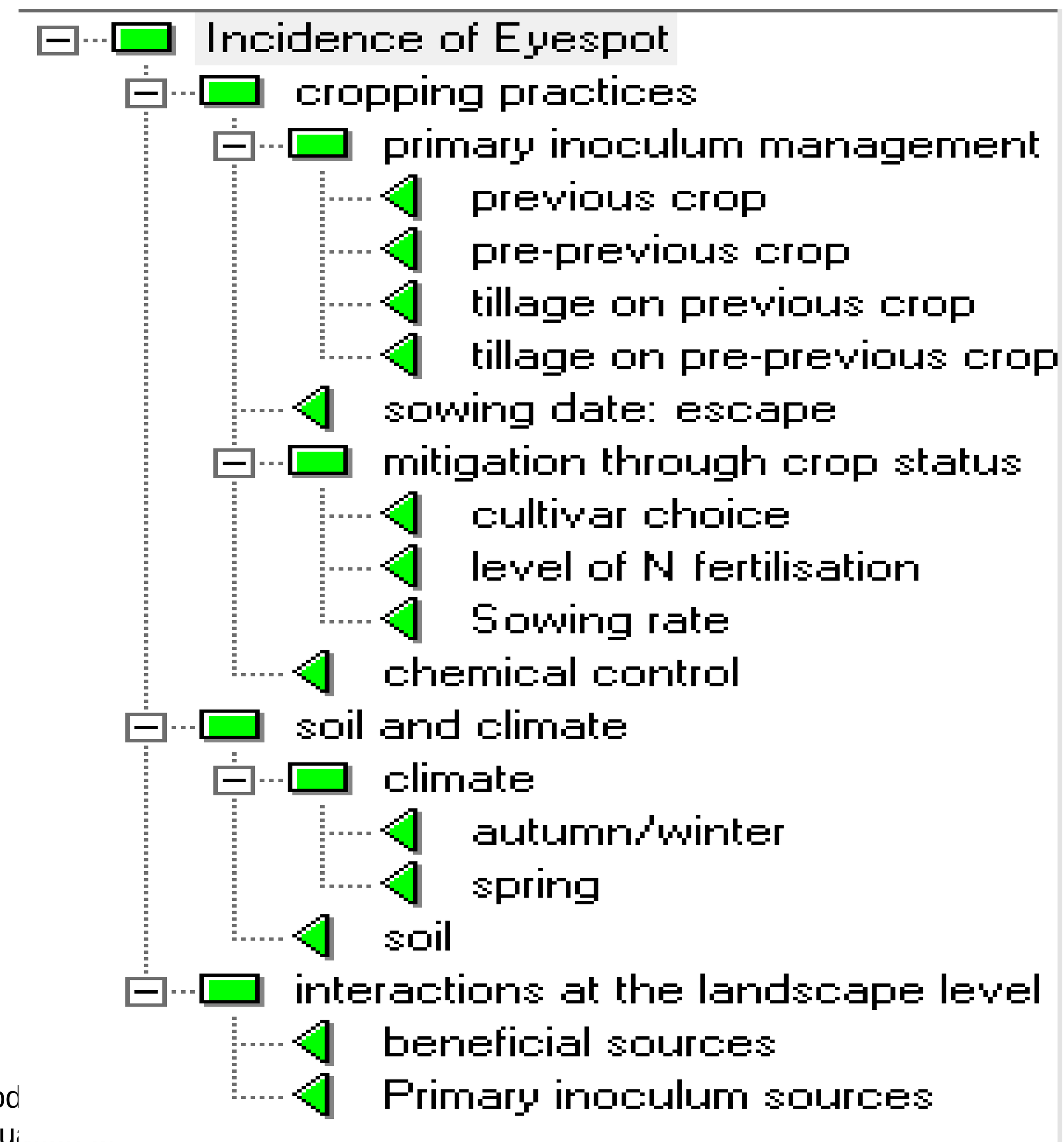


**Figure 2. Structure of IPSIM-WHEAT-EYESPOT**.

## RESULTS AND DISCUSSION

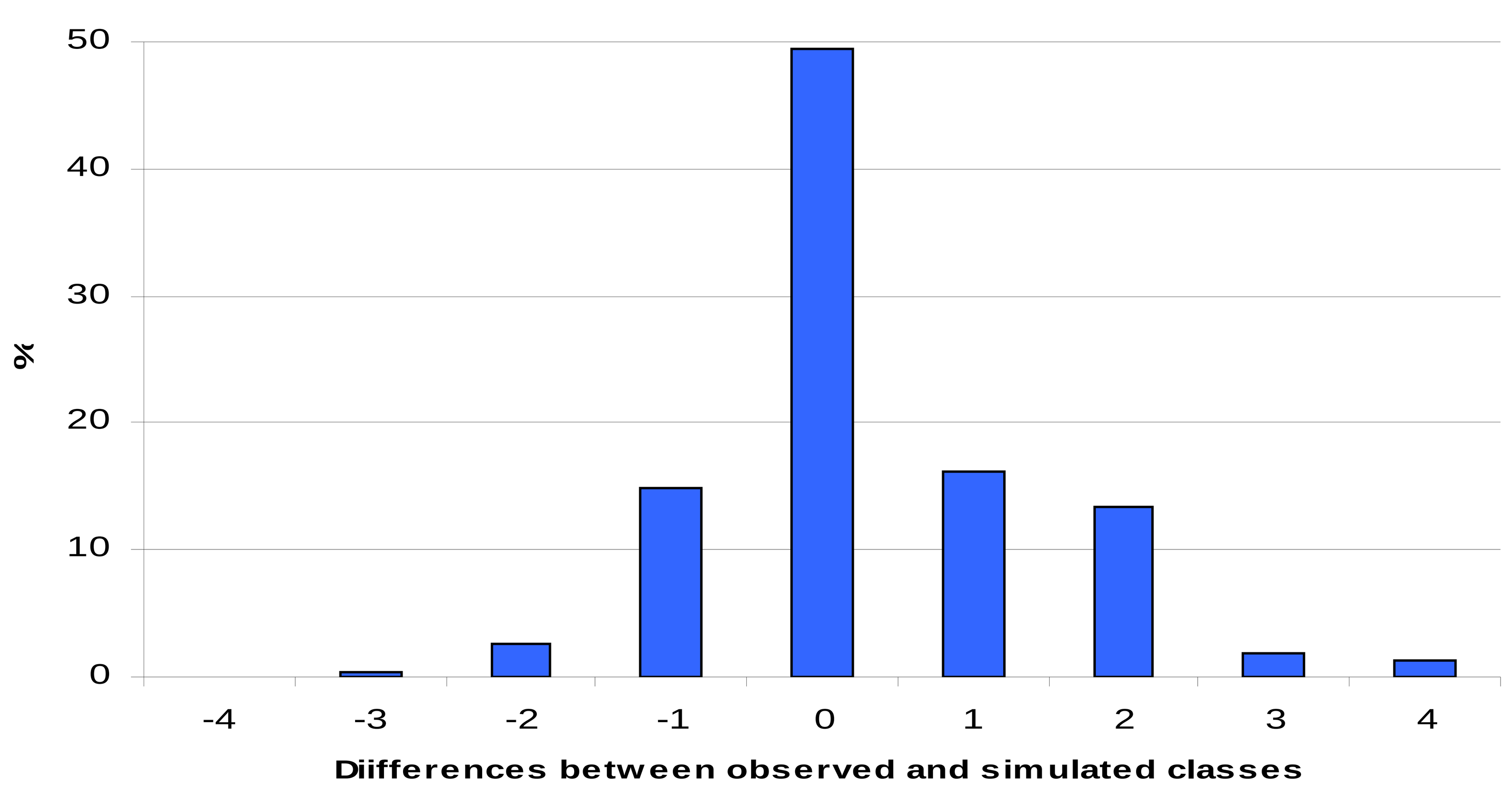


**Figure 3. Distribution of differences between observed and simulated final eyespot incidence (0-20%, 20-40%, 40-60%, 60-80%, 80-100%; 525 fields, over 9 years and 19 French regions)**

| Observed \ Simulated | 0–20% | 20–40% | 40–60% | 60–80% | 80–100% | Total |
|---|---|---|---|---|---|---|
| 0–20% | 217 *41.3* | 49 *9.32* | 5 *0.951* | 1 *0.190* | 0 *0* | 272 *51.7* |
| 20–40% | 61 *11.6* | 9 *1.71* | 14 *2.66* | 0 *0* | 1 *0.190* | 85 *16.2* |
| 40–60% | 41 *7.79* | 3 *0.570* | 13 *2.47* | 4 *0.760* | 9 *1.71* | 70 *13.3* |
| 60–80% | 10 *1.90* | 2 *0.380* | 17 *3.23* | 3 *0.570* | 11 *2.09* | 43 *8.17* |
| 80–100% | 7 *1.33* | 0 *0* | 27 *5.13* | 4 *0.760* | 18 *3.42* | 56 *10.6* |
| Total | 336 *63.9* | 63 *12.0* | 76 *14.4* | 12 *2.28* | 39 *7.41* | 526 *100.* |

Quadratic weights: 0, 0.4375, 0.7500, 0.9375, 1.000

**Figure 4. Confusion matrix of the IPSIM-Wheat-Eyespot model and marginal distributions. Numbers in italic are overall percentages.**

**The predictive quality of IPSIM-WHEAT-EYESPOT is satisfactory**, even if slightly biased. Half of the simulated values are similar to observations and 80.5% differ at most by one class (Figures 3, 4). In addition to this evaluation, the predictive quality of IPSIM-WHEAT-EYESPOT was characterised with statistical criterion using the 5 class centers as representants of simulated final incidence classes, and the observed final incidence values instead of classes. IPSIM-WHEAT-EYESPOT proved to fairly represent the effects of cropping practices as well as the regional and annual variability of the disease (Efficiency = 0.51, Root Mean Square Error of Prediction = 24%; bias = 5.0%). Other sub-models are under construction.

The platform IPSIM appears to be an innovative tool to design qualitative models predicting injury profiles to help design agroecosystems less reliant on pesticides

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