A simple grapevine growth model: towards grape-pest, a x-pest model of damage caused by multiple pests on grapevine

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A SIMPLE GRAPEVINE GROWTH MODEL: TOWARDS GRAPE-PEST, A X-PEST MODEL OF DAMAGE CAUSED BY MULTIPLE PESTS ON GRAPEVINE

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Introduction

The pests and diseases developing on grapevine often induce the use of high amounts of pesticides as an insurance to limit yield loss. But social, environmental and regulatory pressures encourage growers to try to lower their use of pesticides. To help changing treatment strategies, we need a tool to understand and quantify the yield loss due to different pests and diseases, within a multi-pest context. Existing models usually describe one pest or pathogen dynamics, rarely the resulting loss. As a joint action between WP1 and WP6, we propose to build a model for that purpose.

Objective

The objective of this work is to develop a simple grapevine growth model that will be implemented within the XPEST platform in order to represent the grapevine growth and development along a growing, that will be used to simulate damage caused by multiple pests on grapevine.

Methods

The work consisted in adapting the Monteith's equation to grapevine using published data and genuine experimental data. The basic principal of the model is that intercepted solar radiation is transformed into assimilates that are allocated to three organs: leaves, stems, clusters. The model developed is deterministic. It works with a daily time step for 1 m^2 crop. Simulations start at budburst and end at harvest. Phenology is fully described using a continuous development stage scale as a function of thermal time (10 °C basis). Input variables are: mean daily temperature, incoming solar radiation, Radiation Use Efficiency and partition coefficient dynamics. State variables are: Leaf Area Index and organ biomass. The main output variable is yield (i.e. cluster biomass at harvest).

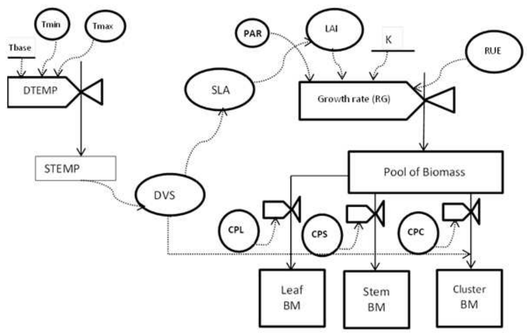

Figure 1: Schematic structure of the Grape-pest model. Rectangles are state variables, circles are intermediate variables and valves represent daily accumulation.

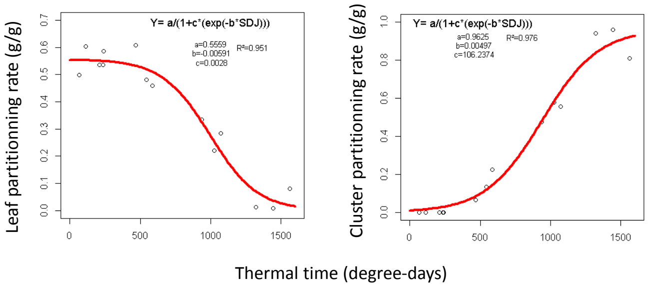

Figure 2: Estimated seasonal dynamics of the rates of biomass partionning towards leaf (left) and clusters (right). Circles represent data collected in South of France, parameters were estimated using R.

Results

A first version of this model was developed in R; its structure is presented on fig. 1. Its parameters were estimated using a three year dataset, collected in the south of France. Input variables were either entered by the user or calculated by the model. For example, the dynamics of part of the biomass allocated to leaves and clusters during the season is presented on fig. 2. The general shape of the simulated LAI and fruit biomass dynamics were similar to observed dynamics.

Comparing model outputs to data collected on other plots and cultivars allowed a first validation of the model structure, but highlighted the need to take into account so far neglected processes to better predict LAI (example for 2008, cv Shiraz, efficiency<0, bias=0.24, Root Mean Square error of Prediction=0.74) and grape biomass (efficiency < 0, bias = 52.1, RMSEP=180.4, fig. 3).

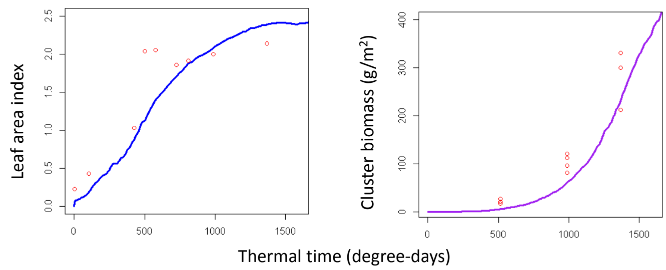

Figure 3: First validation of Grape-Pest: model simulations (curves) of LAI and cluster bioamss dynamics and comparison with data collected in 2008 in Montpellier (circles). These data were not used to estimate model parameters

Conclusion

This work is a first attempt to model grapevine ecophysiology in a simple way. In this first step, several simplifying assumptions were made that will need further attention. First, the stocking process was not taken into account. Second, it was hypothesized that no water stress occurred. This assumption is certainly not realistic for many production situations and will require the development of an additional sub-model. The model developed will be implement in the XPEST platform which will allow to couple this growth model to a set of damage functions of the main pests on grapevine in Europe: downy and powdery mildews, berry moth and grey mould.

References

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