THE GRAPESIM MODEL: A MODEL TO BETTER UNDERSTAND THE COMPLEX INTERACTIONS BETWEEN CARBON AND NITROGEN CYCLES IN GRAPEVINES

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Abstract:

Context and purpose of the study – Nitrogen fertilization is an important practice to guarantee vineyards sustainability and performance over years, while ensuring berry quality. However, achieving a precise nitrogen fertilization to meet specific objectives of production is difficult. There is a lack of knowledge on the impact of nitrogen fertilizers (soil/foliar; organic/mineral) and different levels of fertilization on the interactions between carbon and nitrogen cycles within the vine. Crop models may be useful in that purpose because they can provide new insights of the effects of fertilization in carbon and nitrogen storage. The objective of this study is to build a model to simulate grapevine carbon and nitrogen content in vines to evaluate the impact of different fertilization strategies in vine growth and yield.

Material and methods – The model GrapeSim has been designed to simulate dynamics of carbon and nitrogen content in organs over multiple years. The model runs at a daily time-step and it decomposes the plant in several compartments; Leaf, Berry, Shoot (annual), Perennial organs (trunk and roots) and Storage. Carbon production is based on the radiation use efficiency approach and carbon is allocated to organs according to their growth demand. When carbon production surpasses organ demand, the remaining carbon is stored in the storage compartment, otherwise, carbon is remobilized from the storage to satisfy organs demand. Nitrogen fluxes are simulated analogously to carbon fluxes by considering a nitrogen demand to reach a specific concentration in each organ. GrapeSim has been calibrated using organ growth trajectories obtained from a pot experiment using 'Sauvignon Blanc' grafted onto 'SO4'.

Results – GrapeSim provided an estimation of the carbon and nitrogen content in storage and their response to nitrogen fertilization, which is quite difficult to measure under field conditions. Several types and amounts of nitrogen were applied to evaluate the effect of nitrogen availability on plant growth, photosynthesis and yield and to validate specific outputs of the model. This work is an example of the relevance of combining field research with crop modelling to have a better understanding of vine responses to horticultural practices such as nitrogen fertilization.
Within the "NV^2" project (that brings together 4 private companies, 1 technical institute and 3 public institutes), the next step will be to understand how nitrogen deficiency can affect subsequent reproductive development (bloom return and fruit set) using GrapeSim.

Keywords: Grapevine, Carbon, Nitrogen, Growth, Yield, Fertilization, Model.

1. Introduction.

GrapeSim: A crop model for simulating grapevine C and N dynamics

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1 Introduction

Nitrogen fertilization is an important practice to optimize grapevine yield and berry quality over years. Since yield and quality are the result of carbon (C) and nitrogen (N) cycles interactions, modelling these interactions in a range of N supply is essential to optimize fertilization practices in vineyards.

In this scope, a mechanistic model (GrapeSim) to predict C and N cycles and their interactions in grapevine is being developed, with a particular focus to the prediction of storage dynamics which is key to predict multi year effects of fertilization.

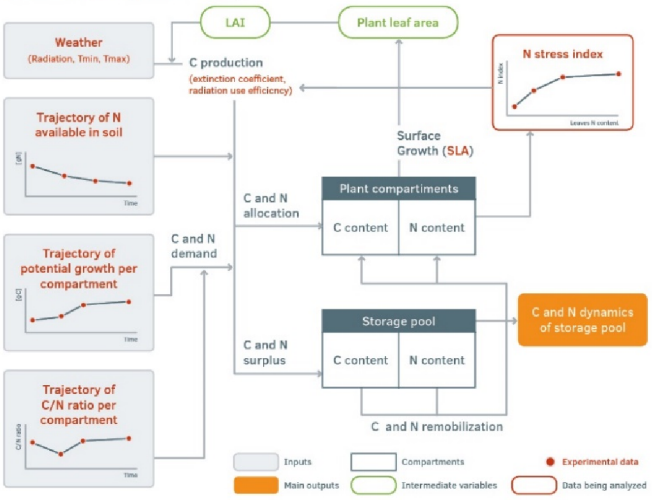
2 Material and methods

The model was calibrated using experimental data collected in 2018 on two-year-old potted grapevines ('Sauvignon Blanc' grafted onto "SO4").

Four mineral N treatments: 0 (control), 40, 80 (potential) and 160 (excessive) kgN.ha-1

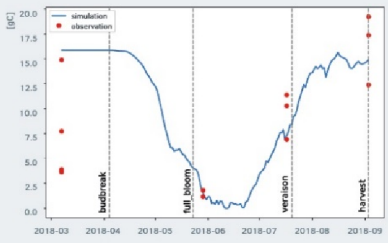
Model description

- Daily time step simulation
- Big leaf approach
- 4 plant compartments: Leaf, Berry, Annual shoot and Perennial parts (trunk + roots)
- 1 storage pool for all plant compartiments
- C and N allocations depends on demands



3 Preliminary result

Prediction of C storage dynamics on potential treatment (without N limitation)



4 Conclusions and perspectives

GrapeSim can simulate accurately the C storage dynamics under non-limiting fertilization conditions. Therefore the model is able to capture the post-budbreak storage remobilization and the storage accumulation between full-bloom and veraison.

The N stress index will be developed using experimental data, so the model will account for limiting N conditions on plant growth.

GrapeSim will be next adapted to commercial conditions (mature grapevines under field conditions) and will predict the yield characteristics and quality.

This study is part of the NV² project (FUI-21)