# A blueprint for managing vine physiological balance at different spatial and temporal scales in Champagne

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## Abstract

In Champagne, the vine adaptation to different climatic and technical changes during these last 20 years can be seen through physiological balance disruptions. These disruptions emphasize the general grapevine decline. Since the 2000s, among other nitrogen stress indicators, the must nitrogen has been decreasing. The combination of restricted mineral fertilizers and herbicide use, the growing variability of spring rainfall, the increasing thermal stress as well as the soil type heterogeneity are only a few underlying factors that trigger loss of physiological balance in the vineyards. It is important to weigh and quantify the impact of these factors on the vine. In order to do so, the Comité Champagne uses two key-tools: networking and modelization. The use of quantitative and harmonized ecophysiological indicators is necessary, especially in large spatial scales such as the Champagne appellation. A working group with different professional structures of Champagne has been launched by the Comité Champagne in order to create a common ecophysiology protocol and thus monitor the vine physiology, yearly, around 100 plots, with various cultural practices and types of soil. The use of crop modelling to follow the vine physiological balance within different pedoclimatic conditions enables to understand the present balance but also predict the possible disruptions to come in future climatic scenarios. The physiological references created each year through the working group, benefit the calibration of the STICS model used in Champagne. In return, the model delivers ecophysiology indicators, on a daily scale and can be used on very different types of soils. This study will present the bottom-up method used to give accurate information on the impacts of soil, climate and cultural practices on vine physiology.

## Introduction

In Champagne, the vine adaptation to different climatic and technical changes during these last 20 years can be seen through physiological balance disruptions. These disruptions seem to first appear on the vine nitrogen status. Since the 2000s, among other nitrogen stress indicators, the must total nitrogen has been halved, from 600 mg/L in the 90s to 300 mg/L in 2020 (Demestihas et al, 2022). This decrease precedes a worrying general vine decline, which finds its causes in different factors. Soil resource limitation is a reality and both climatic and regulation changes are drawing soils out of water and nutrient. Dry springs, especially during April (figure 1), cause high water constraint conditions for the beginning of leaf growth. Mild winters create a constant soil mineralisation before budburst, depleting organic matter from soils. Finally herbicide limitation and a whole new strategy on what soil management is concerned limit the availability of water and nitrogen for the vine, in competition with the grass, especially for Champagne's high-density plantations.

Furthermore, thermal constraints create vine phenology heterogeneity, triggering even more the loss of physiological balance in the vineyards when combined to water and nitrogen constraints.

This physiological balance varies according to the objectives of the winegrower. Mastering this balance throughout the three main vine organs (leaf, shoots and grape) is necessary.

Today, it seems that every combination of climatic conditions, soil type and set of practices must be studied differently in terms of soil management strategy. In this context, winegrowers ask for effective decision-making tools in order to find the right strategy for vine resilience and productivity. In order to do so at a large spatial and temporal scale, two-key tools have been reassembled: networking and modelization.

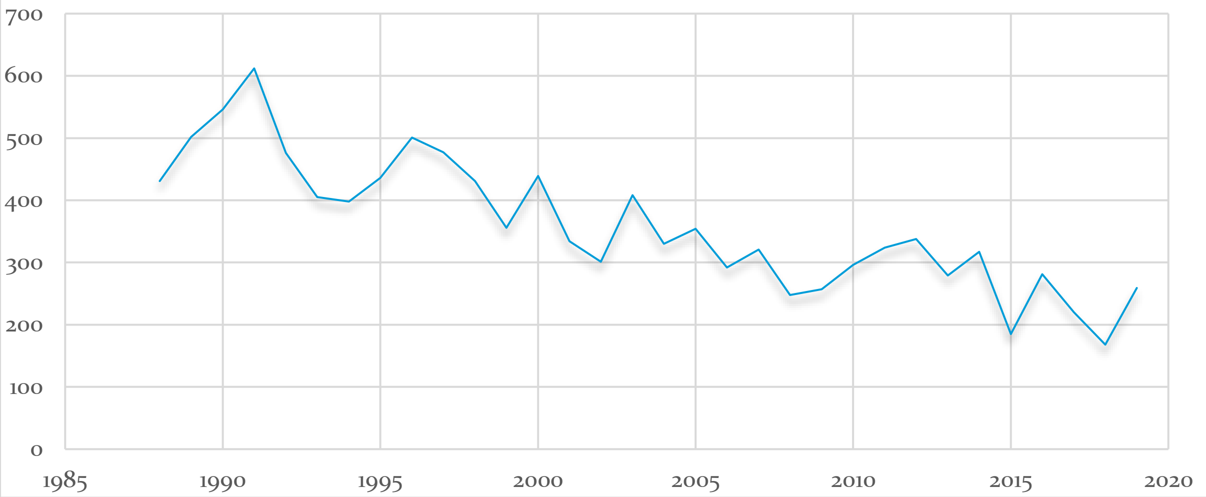


**Figure 1.** nitrogen must for 1990 to today in Champagne

## Materials and methods

### *The implementation of a physiology observatory*

Defining quantitatively a level of physiological balance requires to choose the right indicators. They must be generic and robust in order to be used by all Champagne users. The main goal is to define the biogeochemical cycles of nitrogen, carbon and water, through soil and vine.
Champagne's asset lies in a strong networking capacity. Therefore, a working group with different professional structures of Champagne has been launched by the Comité Champagne in 2019 to create a living physiology observatory.

Phase 1: A set of indicators describing leaf, shoots, grape and soil was studied during 4 years on different plots withing the Champagne appellation.

Phase 2: the indicators were redesigned in order to be easy measure and less time-consuming.

Phase 3: 10 Champagne structures were selected, representing different types of consulting : "Maisons" of Champagne, Agriculture chambers, private consulting companies as well as unions of vine cooperatives. The indicators were submitted to the structure through different meetings and technical participative courses.

Phase 4: the plots were selected in order to be as heterogeneous as possible in terms of region, grape variety, rootstock, soil management strategies and fertilisation strategy.

Phase 5: database structuring and analysis. Creation of yearly references.

### *The use of modelization to formalize decision making tools*

To broaden the physiology observatory on a larger spatial and temporal scale, the STICS model (Brisson et al, 1998) has been chosen to generate the same indicators. STICS simulate the functioning of a system including a plant and a soil, at a daily scale, enabling the generation of carbon, nitrogen and water indicators. The STICS model has been used on a plot scale, giving precise information on each of these plots.

## Results and discussion

### *Measuring agronomic heterogeneity*

The plots represented in the observatory were very heterogeneous. In total, 143 plots were followed up, representing 7 regions, all the soil texture possibilities, the 3 main grape varieties of Champagne (Chardonnay, Pinot Noir and Meunier) as well as very different type of soil management and fertilisation strategies (figure 2 and 3). The plots were mainly used for trials.

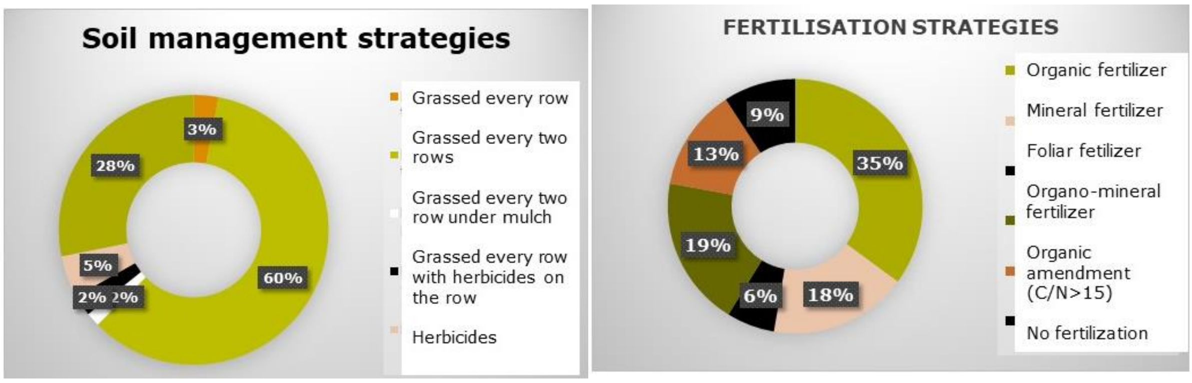



**Figure 2 and 3**

The indicators were chosen to describe leaf, shoots and grapes in terms of quantity (carbon biomass) and quality (nitrogen and water content) as well as soil nitrogen and water indicators. Moreover, some quality indicators on must were set.

A measurement calendar has been approved by all members of the observatory. The indicators were chosen among three types and set to be measured at key phenological stages (Figure 4).

### *Data analysis on 2 different vintages*

The data was analysed on two very different vintages. 2020 was characterized as dry and hot compared to 2021, wet and cold, which caused downy mildew to explode. Nitrates in soil were characterized as low both in 2020 and 2021 but for different reasons, one being dryness and the other cold. Therefore, it seems that leaf growth does not differe much in 2020 and 2021 (figure 5 and 6). However, nitrogen cycle within the vine had a higher status in 2021. After harvest, soi nitrate falls in 2021, presuming a lower reserve stock in the vine.

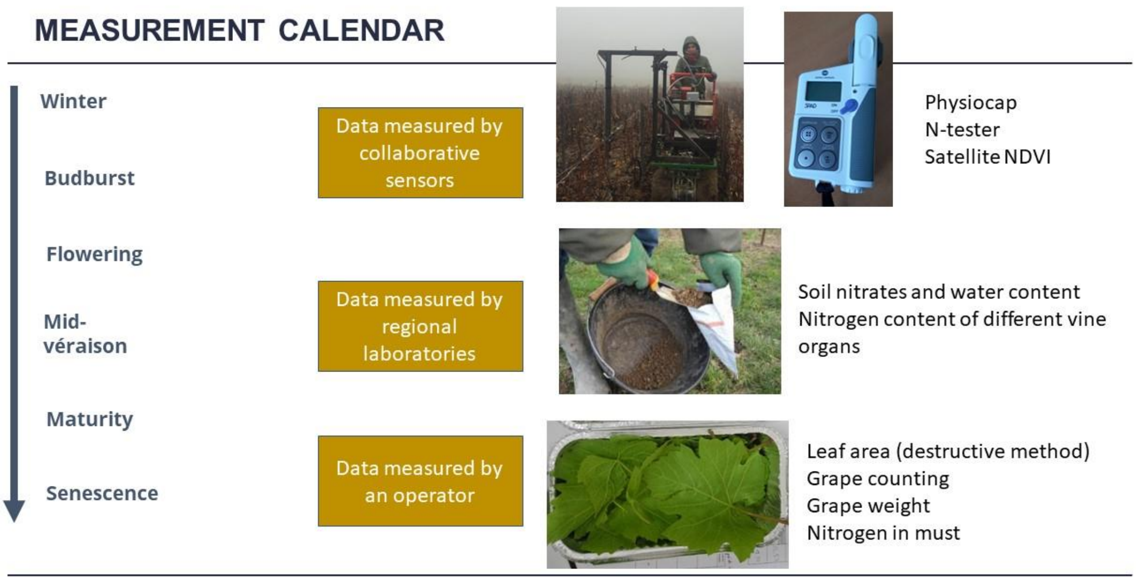
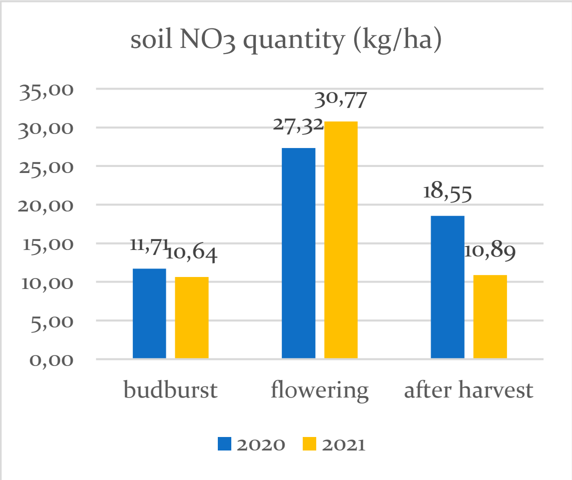



**Figure 4.** observatory measurements according to different types of measurements and different phenological stages. (Demestihas et al, 2022)

### *Linking modelization to networking*

STICS has already been used on a plot scale with trial plots well defined in terms of soil, climate and practices. The goal of the linkage with the observatory database is to calibrate the new version of STICS (v10), which takes into account the perennial organs. The next step is to be able to simulate different carbon, nitrogen and water indicators out of the STICS model, on an appellation scale. These simulations will be based on the Comité Champagne soil databases as well as its climate station network in order to create climate x soil combinations for STICS inputs to be used for large-scale simulations.



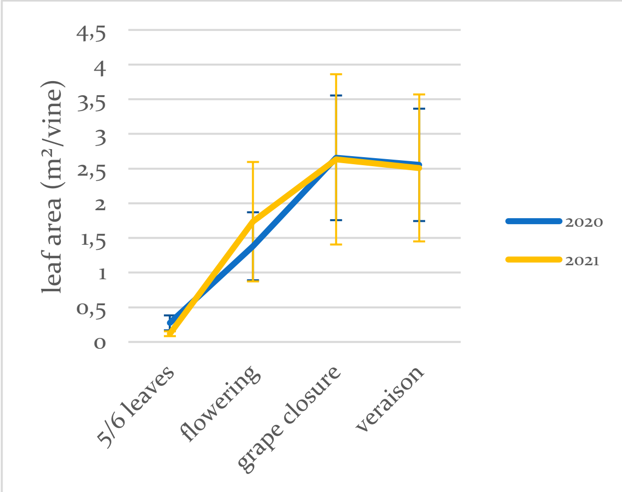




**Figure 5 and 6**

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