Decomposing the notion of vine vigour with a proxydetection shoot sensor: Physiocap®

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Abstract

The vigour and the vegetative expression of grapevines are parameters of great interest in viticulture, as they describe a general state of growth capacity. Understanding the impacts of agricultural practices on vine vigour, under particular soil and climate conditions, is essential to give a more accurate technical advice, especially on what soil management and vine nutrition are concerned. A shoot sensor called Physiocap®, designed and developed by the CIVC (Comité interprofessionel du vin de Champagne), is used during dormancy season to measure the shoot section, the shoot number and an estimation of the aboveground biomass. The sensor maps vigour spatial variability within a plot, among plots and over years. Physiocap database in Champagne has been analysed since 2011 at different scales, in order to determine the factors impacting the vine vigour. The vintage appeared to be the most impacting factor. For example, climate variability or accidents like dry springs and early spring frosts reduce vine vigour. Champagne vine varieties did not significantly impact vine vigour according to the database. At the scale of the Champagne vineyard, the aboveground biomass estimation of Physiocap® was strongly correlated with the yield of the following year, leaving a promising basis for analysing the impact of different factors on vine vigour. At the scale of the plot, winegrowers are able to compare their plot vigour to a Champagne threshold, which is being refined every year as the Physiocap database is enriched. They can therefore manage their fertilization and soil tillage program more accurately according to their objectives. The Physiocap® sensor appears to be an interesting multidimensional tool binding vine physiology, agronomy and precision viticulture at different scales. When coupled with other data, especially the one describing soil characteristics, it could even be the baseline for creating a decision-aid tool in Champagne for fertilization, tillage and pruning practices.

Introduction

Maintaining a balance between grapevine vegetative growth and grape production is one of the most important goals in viticulture. This goal has become even more challenging with the physiological evolutions due to climate change, especially the drier springs in Champagne, as well as the shifting regulations. Grapevines exhibiting excessive vigour are likely to produce less fruit of reduced quality, and vines with inadequate vigour will have negative effects on their potential yield.

Vigour management should be studied in a multifactorial way. It is the result of a set of factors such as climate and soil characteristics, which interact with grapevine in a given system that is itself modified by practices. This system can be observed under different space and time scales in Champagne. That is exactly were precision viticulture finds all its purpose: measuring vigour space and time variability. In order to define the notion of vigour, three terms are commonly used, based on the perennial character of grapevine [1]:

- The vegetative expression is the result of the annual metabolic activity during which shoots, leaves and roots grow and stock carbohydrates. It is characterized by the number of shoots during dormancy.
- The vigour is the intensity of this metabolic annual activity, characterized by the shoot section.
- The vegetative potential or potential reserve storage is directly linked to both vegetative expression and vigour. It is the result of the plant material, the previous vegetative cycles and of the pedoclimatic conditions.

A shoot sensor called Physiocap®, designed and developed by the CIVC (Comité interprofessionel du vin de Champagne), is used during dormancy season. Since 2011, the Physiocap® has crossed over 700 plots in Champagne. Data are collected and analysed in order to understand vigour variability among space and time. The aim of this paper is to present the latest analysis of this Physiocap database at different time and space scales in Champagne: within a whole region, among plots, among vintages and inside a plot. This scale decomposition could be seen as a ‘terroir’ analysis.

Material and method

Physiocap® is an optical laser embarked on an agricultural engine used during winter just before pruning [2].

The sensor is composed of a laser micrometer which consists of an emitter and a receiver positioned face to face, above wired linkers. It also has a GPS enabling

data mapping and a data recording box. Data is stored in a USB key (fig.1) [3].

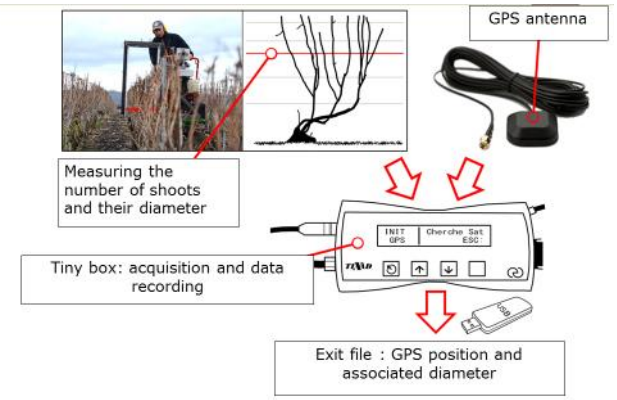

Figure 1: Components of the Physiocap® sensor

The sensor provides three key physiology variables of grapevine: shoot section, shoot number and an estimation of the aboveground biomass. The shoot section measurement is made by using the interruption section of the laser beam. It is instantaneous and does not depend upon shoot distance from the sensor nor the sensor's speed. The sensor therefore gives many measures of section each second. The second variable, the shoot number, is calculated out of the speed given by the GPS and the shoot section measurements. Finally, the shoot biomass indicator per vine or per meter square is calculated out of the shoot section and the shoot number, as well as a wood density fixed at 0.9 kg/dm^3 in Champagne.

Data has been analysed in order to qualitatively weigh the factors impacting vine vigour. These factors are either not modifiable, like climate or soil, or can be changed through agricultural practices. They all impact vine vigour, which in turn has an effect on various agronomical performances (Fig. 2).

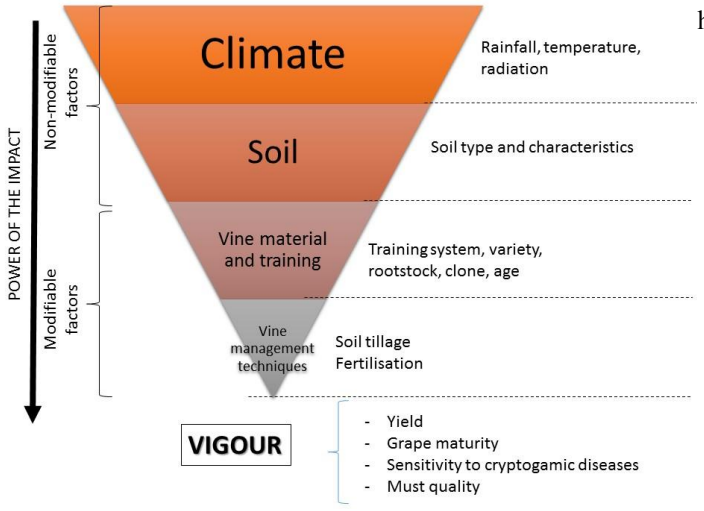

Figure 2: Analysis method of different factors affecting vine vigour

Results

Comparing vintages gives important information on how climate characteristics impact vine vigour [4]. Each vintage can be compared to the mean value of Champagnes shoot biomass on six successive years (fig. 3).

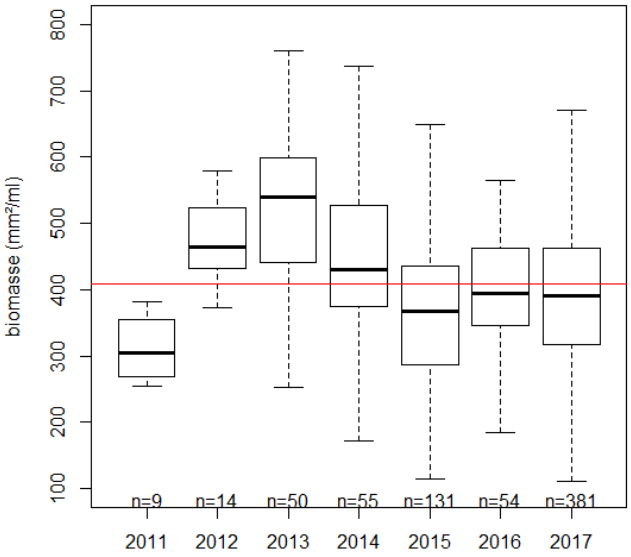

Figure 3: Boxplot of the shoot biomass in mm² per linear meter measured by the Physiocap sensor since 2011 and number of measured plots.

Rainfall is the most impacting factor. Since 2011, shoot biomass depicted by the Physiocap sensor seems to follow quite accurately the yearly rainfall at the Champagne region scale (fig.4) [5]. Dry years such as 2015 presenting a yearly rainfall of only 591 mm and a spring rainfall of 113 mm from the 1st of April to the 30th of June presents low shoot biomass. 2013 was a very wet year with a rainfall of 797 mm presenting the highest shoot biomass value from 2011 to 2017.

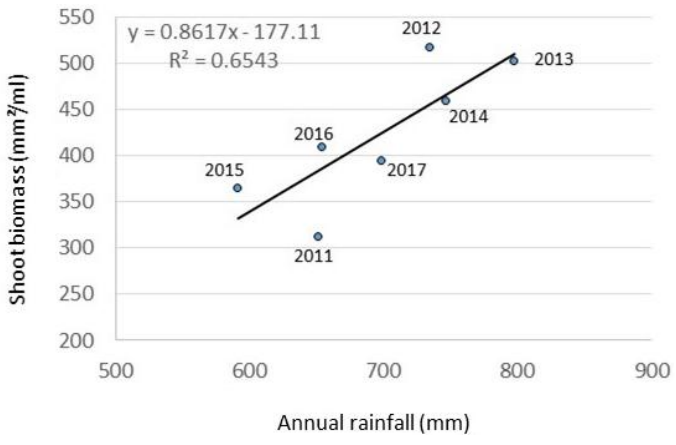

Figure 4: Link between annual rainfall and shoot biomass on 6 successive years.

At an interplot scale, comparing the vigour variability among plots enables winegrowers to position their plot in relation to a threshold and better understand the impact of the terroir on their vine vigour. When comparing different regions we observe a great variety of values. These differences may be due to the type of soil, the mesoclimate within a region but also the vineyard management strategies. In other words, this variability is linked to the terroir of each region.
For example cover crop strategies in the Montagne de Reims vineyard tends to be frequent, thus lowering shoot biomass. On the contrary, the Côte des Bar region was heavily impacted by frost in 2016 and 2017, which may have increased shoot biomass measured at the end of 2017 from increased reserve accumulation [5].

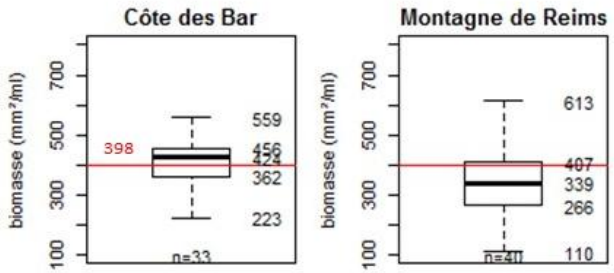

Figure 4: Shoot biomass boxplots of two different regions of Champagne: Montagne de Reims and Côte des Bar in 2017

The effect of vine material and training system is also significant at the whole Champagne vineyard scale since 2011. Chardonnay appears to be the variety which increases shoot biomass the most. The age also impacts vigor: it seems that beyond 40 years old age, we observe a drop of the number of shoots (mean value of 5.9 compared to 6.8 shoots). Furthermore 'guyot' training system increases shoot biomass compared to a Chablis or a Cordon de Royat training system (fig. 5). This could be due to an increasing shoot section as a consequence of the decreasing number of shoots.

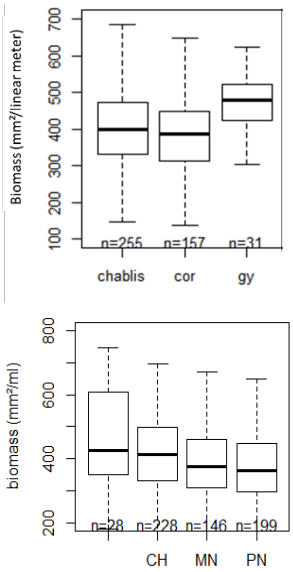

Figure 5: Boxplot of the shoot biomass according to training system. Cor = cordon de royat, gy = guyot and vine varieties. CH = chardonnay, MN = meunier, PN = pinot noir

At an intra-plot scale soil tillage management impact vine vigour significantly. In 2017, chemical weeding still show the highest shoot biomass with a mean value of 520 mm²/linear meter, whereas mechanical weeding show lower values (mean value of 361 mm²/ml).

Finally, there is an important correlation between the shoot biomass and the yield on year n+1 (fig. 6), thus showing the importance of the biannual time scale when managing vigour. Dry years such as 2015 present low shoot biomass and therefore low yield the year after. This correlation correspond to a leaf/grape ratio balance within the vine. At a more local scale, this correlation is not as good as in fig. 4, due to climate events such as frost or hail. These events create a disorder on the leaf/grape ratio the year after.

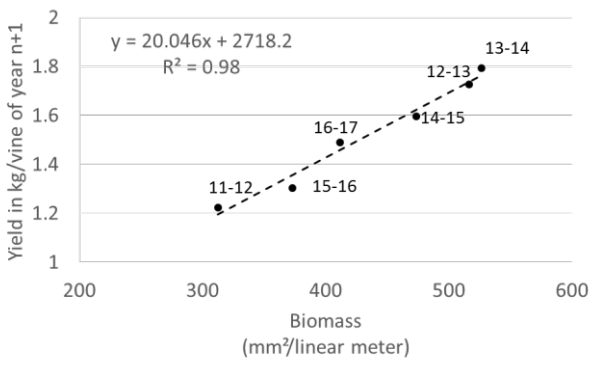

Figure 6: Correlation between the shoot biomass (mm²/lm) of year n and the yield of year n+1 on 6 successive years.

Discussion and conclusion

Physiocap® estimates the shoot biomass at the end of the year. It is an indicator of both what has been cumulated during the year as well as a storage potential for next year. This measure depends on various factors. The most important one is climate and more specifically annual rainfall. Vine material and training systems impact vigour at the region scale and on pluriannual time scale, while at the plot scale, it is more fertilization and soil tillage that can have an effect on vigour. These practices can therefore be the levers to be used for vigour management. Yield potential can be predicted using the biomass indicator defined by the sensor at a large space scale. Nevertheless, it is essential to take the climate events into consideration when analysing this type of correlation on a local space scale.

This is one of the first agronomical analysis on the Physiocap data which is being enlarged every year. On the basis of these preliminary results, Physiocap, coupled with other tools and indicators such as soil analysis, soil tillage and fertilization strategies as well as accurate climate data, seems to be a central component of a multidimensional and innovative vine management.

References

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