Soil quality in Beaujolais vineyard. Importance of pedology and cultural practices

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Abstract

A pedological study was carried out from 2009 to 2017 in Beaujolais vineyard, to improve physical and chemical knowledge of soils. It was completed in 2016 and 2017 by the current study, dealing with microbial aspects, in order to build a reference frame for improved advice in soil management.
Microbial biomass was measured on representative plots of the six most common soil types identified in Beaujolais and, for each soil type, on plots with different levels of the main impacting parameters: total organic carbon, pH, cation exchange capacity, extractable copper. A total of 59 soil samples were collected.
Confirming the results of various trials carried out in Beaujolais over the past 20 years, the results showed that the soils were still alive, but exhibited a large variability of biological parameters, which appeared dependant on both pedological and anthropic factors.
Therefore, a good interpretation of biological parameters and advice for vine growers must rely on a pedologically-based referential with differentiated main driving factors. The use of biological parameters, such as microbial biomass, is of great potential value to improve advice on agro-viticultural practices (soil management, fertilization, liming, etc.), essential for a sustainable wine production on fragile soils.

Introduction

The sustainability of viticulture must rely on a good knowledge of soil physical, chemical and biological properties, as well as the effects of agricultural practices on these properties. This is especially important in Beaujolais vineyard, characterized by a huge diversity of soil types, main of them being rather fragile. A pedological study conducted from 2009 to 2017 by Sigales pedologists (Letessier & Marion, 2018), resulted in a good knowledge of physical and chemical properties of soils. In the present study, biological measurements were performed on selected plots, in order to build a reference framework of soil quality and to improve advice to vine growers about soil management.

Materials and methods

First microbial biomass measurements were carried out as part of a study conducted in 2002-2003 on 24 plots, allowing an initial approach of microbial biomass levels in relation to soil types (Chaussod et al., 2004). These first results were completed by measurements performed in 2016 and 2017 on selected plots based on the pedological study of Letessier & Marion (2018).
For this pedologically-based soil sampling, the selected plots were choosen among the 6 main soil "categories" identified by Sigales pedologists, gathering more or less closely related soil types originating from the same parent material, namely : 12 (granite soils), 22 (soils derived from the procession of blue rocks), 40 (soils derived

from hard limestone), 70 (clays with cherts), 81 (old alluvio-colluvium with predominantly clay texture), 83 (old alluvio-colluvium with predominantly sandy texture).
In April 2016, 20 plots were selected, as representative of the six main soil “categories”. For each of them, the pedological data set comprised between 65 and 300 plots. Therefore, the studied plots for biological measurements were selected among each soil category to be representative of the average value of main impacting parameters: organic matter (MO), pH, Metson cationic exchange capacity (CECm), extractable copper (Cu EDTA). Additional plots were also selected by varying the main impacting parameter within each soil category. For instance, plots with various soil pH were selected for soils 12 because this parameter varies from 5,4 to 6,2 while OM level is always low on these soils (< 1 %). Conversely plots with various OM levels were chosen for soils 22 because this parameter varies from 0,8 to 1,3 % while soil pH is relatively stable (6,4-6,8).
In April 2017, 12 other vine plots were selected from soil categories 22 and 81-83 (characterized by a high variability), varying the OM level and Cu content. In addition, 3 uncultivated “fallow” plots (having carried vines in the past but uncultivated for more than 10 years) were also sampled on soils 12, 22 and 40.
The distribution of plots sampled in 2003-2004, 2016 and 2017 (total=59) by soil type is shown in **Table 1**.

Table 1. Plots distribution by campaign and soil category

Soil category	12	22	40	70	81	83
2002-2003	13	4	2	4	0	2
2016-2017	7	8	4	3	7	6
Total	20	12	6	7	7	8

All soil samples were taken from the 0-20 cm soil layer with 16 to 18 cores per plot. Classical physico-chemical analyses were performed: texture, organic carbon (Corg), nitrogen, carbonates, pH_{water}, pH_{KCl}, CEC cobaltihexamine, Cu EDTA. Microbial Biomass (Jenkinson & Powlson, 1976) was determined by the Fumigation-Extraction method (Chaussod et al., 1988; Wu et al, 1990). This Living Organic Matter (LOM) is expressed as concentrations (mg C/kg) and as percentage of total organic carbon.

Results and discussion

On average the higher levels of LOM were recorded on soils 40 (**Figure 1**). Conversely, they were very low on soils 81 and 83 as well as soils 12 and 22 but to a lesser degree and with a greater variability. Soils 70 have intermediate levels of LOM.
When expressed as a percentage of total organic carbon, there are less differences between soil categories, pointing out the importance of organic matter on biological parameters. For soils 12 and 22, the values LOM % Corg are closer to that of soils 40 and higher than for soils 81 and 83. However, soil organic matter only partially explain LOM values and other parameters are involved.
Results of the simplified Partial Correlation Regression (i.e. with reducing variables number by taking into account correlations between them) based on soil data, showed that, in addition to carbon content, LOM is relatively well correlated with CEC, pH_{water} and clay content. Soils 40 are well differentiated, with higher values for these parameters. It is the same for soils 70, at a lower level. Soils 22 are intermediate with a high dispersion in relation with their greater variability, as mentioned above. Soils 12 and 81-83 are more difficult to differentiate (lower values of fine sand for soils 12).
A step-by-step multiple regression was performed, using the physico-chemical parameters to explain LOM: first globally, without differentiating soil types, and then by soil categories. The results are shown in **Figure 2**. The regression taking into account the soil types (by soil categories) gave better results (higher r^2) than overall estimation, thus showing importance of soil type, whatever the measured characteristics.
It can be noticed that uncultivated “fallow” plots follow the same regressions as vine plots.

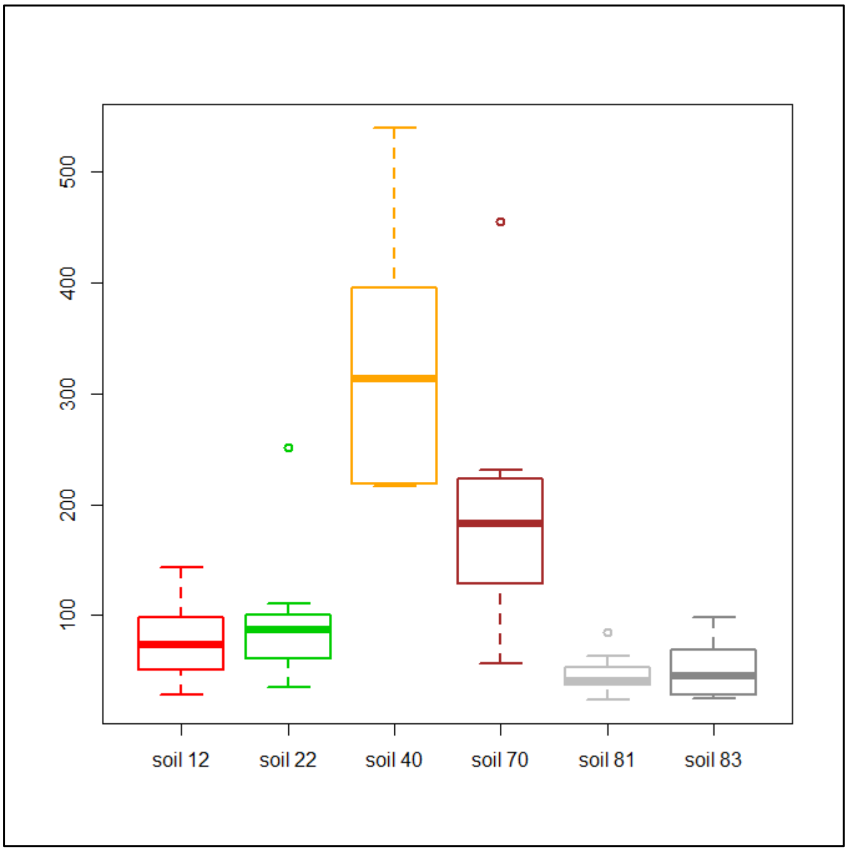

Figure 1. Distribution of Living Organic Matter by soil type (mg C/kg soil)

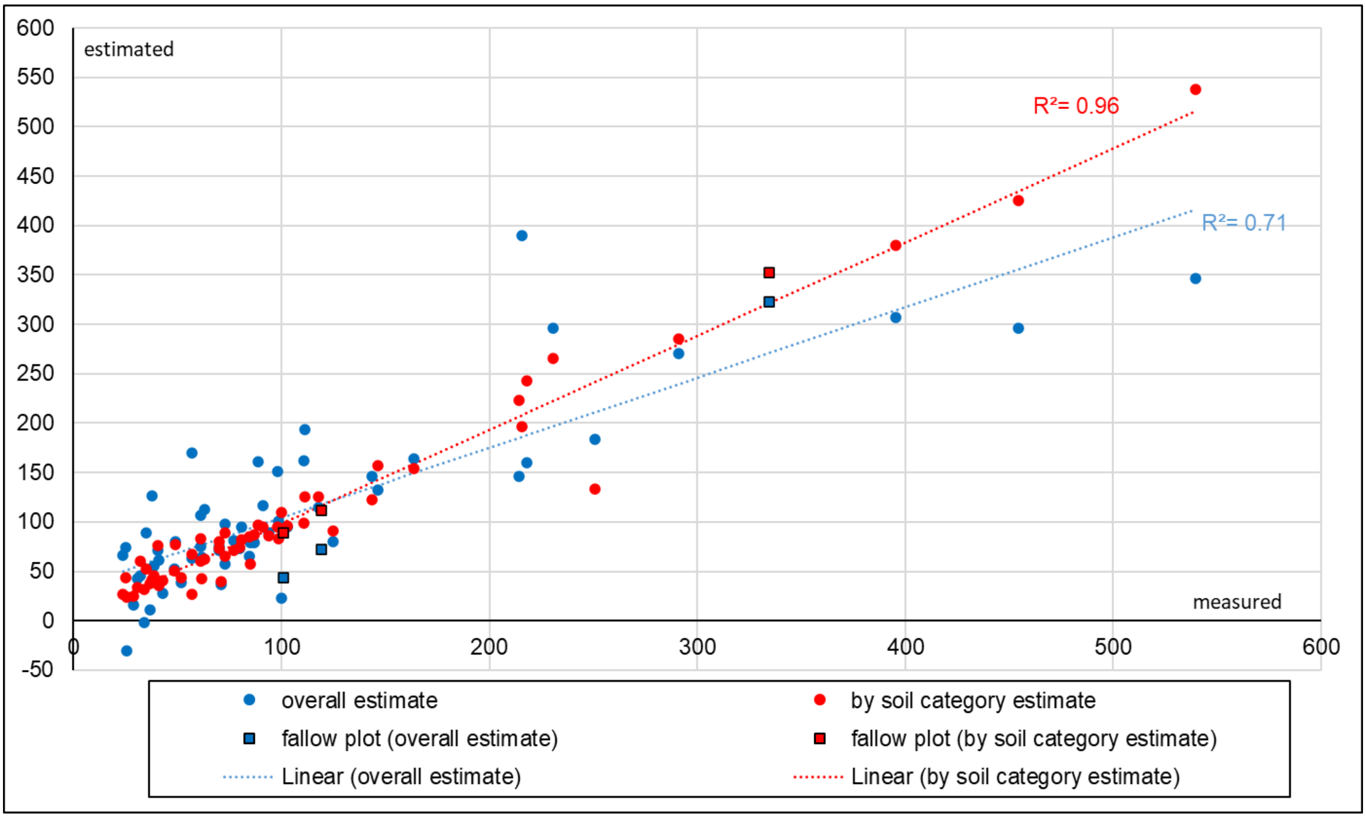

Figure 2. Comparison of multiple regression estimates, overall or by soil category, with measured values - LOM in mg C/kg soil

Table 2 shows parameters taken into account in the various regressions, affected coefficients and determination coefficients of these regressions. The lowest r^2 values were obtained for soils 12 and 22, which are affected by the greatest variability, and in spite of a great number of parameters for soils 22. On the contrary, LOM of soils 40 can be explained with a very limited number of parameters.
Indeed, the regression models presented above are restricted to the limited number of studied plots. In order to strengthen our observations, this first study should be completed using a greater number of plots.
Actually, this was done using the same protocols, microbial biomass being also measured on different trials dealing with organic matter and soil management (cover crops, tillage). Such results allow to take into account the influence of some cultural practices on measured parameter.
The results obtained on various trials in Beaujolais vineyard showed that LOM and other biological parameters were affected by soil pH, organic matter input (Chaussod et al., 2020) and soil management. Grass cover promotes microbial life by increasing inputs of organic matter, with noticeable effects even under the row. Results obtained on a comparison of 3 production systems (conventional, sustainable and organic) showed that soil management is more impactful than pest control strategy on soil biological quality (Chaussod et al., 2020). All these results are in agreement with those obtained in other vineyards (Nouaïm et al., 2019).

Table 2. Parameter coefficients and determination coefficients of the various regressions

Soil category	C	C/N	pH_{water}	Cu	CEC	Clay	Silt	Sand	r^2
12	10.6	1.5		-0.6	4.1				0.68
22		36.6	206.8	1.3	-15.2	76.6	76.1	77.3	0.66
40			36.6				1.5		0.98
70	18.4		-225.9	-0.5			1		0.97
81			19.1				-0.1	-0.3	0.98
83	8.7			-0.5	-10.8	-49.4	-49.3	-49.8	0.86
Overall	12.1	-2.3	12.9	-0.8	0.2	0.8	0.7	0.6	0.71

Conclusion

The pedologically-based soil sampling for measurement and interpretation of biological parameters is perfectly suited for the Beaujolais vineyard, characterized by a large diversity of soils. Our results showed rather large variations of living organic matter (microbial biomass) according to soil types, but whatever the situation life is still present at fair levels in Beaujolais soils (in other words, these soils are not «dead»).
Our studies pointed out the importance of soil type on soil biological parameters. Therefore, a reliable interpretation of biological values requires a minimum of knowledge of the corresponding soil “categories” as identified by pedological studies. Organic matter content and soil pH were also highlighted, allowing to improve advice on agro-viticultural practices (soil management, fertilization, liming, etc.), essential for a sustainable wine production on fragile soils. However, for quality production, it is necessary to seek a fair balance between the real needs of the vine and a good biological activity: the most is not necessarily the best.

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