4 CONCLUSION

Cette étude de long terme de suivi des propriétés biologiques des sols viticoles a permis de hiérarchiser les différents traitements en fonction de leurs impacts sur les communautés lombriciennes et la biomasse microbienne. Elle a aussi permis de déterminer le délai d'efficience de ces différents traitements, tout en mettant en évidence une forte variabilité inter-annuelle liée au climat. Les résultats obtenus sont propres à un contexte pédoclimatique donné (coteaux calcaires de la vallée de la Marne), et doivent être approfondis. Ainsi, il serait intéressant d'intégrer d'autres variables dans cette analyse telles la fréquence d'apport (variable selon les amendements) et la composition des amendements (qui a pu varier au cours des 16 années qu'ont duré l'essai).

En outre, une approche globale est nécessaire pour déterminer l'intérêt d'apporter tel ou tel amendements, celle-ci nécessite i) de coupler ces résultats aux paramètres physico-chimiques du sol (stabilité structurale, infiltrabilité, disponibilité des éléments nutritifs…) ainsi qu'agronomiques (état sanitaire de la vigne, rendement,…) et ii) de prendre en compte l'environnement socio-économique (coût-disponibilité des produits, possibilités techniques d'épandage, respect de cahiers des charges…).

Au sein du projet VitiEcoBioSol, ces résultats seront intégrés dans une synthèse concernant l'impact de nombreuses autres pratiques culturales étudiées depuis 1986 sur le vignoble de Champagne. Cette synthèse devrait permettre de mieux appréhender les effets sur la biologie des sols d'une grande diversité de pratiques (en terme de gestion des adventices, des maladies, des ravageurs, de fertilisation) liées à des contextes socioculturels et économiques mouvants.

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Unexpected relationships between $\delta^{13}C$, water deficit, and wine grape performance

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ABSTRACT

Water nutrition is crucial for wine grape performance. Thus soil investigation aims at characterizing spatial and temporal variability of available water. A possible strategy is to integrate monitoring and proxies of water availability. The carbon isotope ratio $\delta^{13}C$, measured in the alcohol of wine, is a promising tool to determine water stress during the vine growing season and vine performance. A research study was set up to evaluate the relationships between $\delta^{13}C$, soil water deficit, and wine grape viticultural and oenological performance. The trial was carried out for three years in the Chianti Classico wine production district (Central Italy), on not irrigated vineyards of a premium farm. The reference variety was Sangiovese. Eleven sites were chosen for vine monitoring and grape sampling. The performance parameters were alcohol and sugar content, sugar accumulation rate, mean berry weight, and extractable polyphenols. $\delta^{13}C$, stem water potential, and soil water deficit, as difference between soil water content, monitored during the veraison-harvest, and the standard wilting point, were measured. $\delta^{13}C$ resulted directly related to stem water potential and soil water deficit, and showed absence to only moderate water stress. However, the relationship with viticultural and oenological results was contrary to the expectation, that is, the performance increased when the water stress decreased. The explanation was that the viticultural husbandry was so competing for the plants (high plant density, high pruning, weak rootstock, grass cover) that the effects of water stress on grape quality were magnified. In conclusion, $\delta^{13}C$ cannot be directly used to estimate vine performance.

Keywords: Carbon, water availability, proxy, red grape, Tuscany.

1 INTRODUCTION

Water supply during certain phases of the vegetative cycle of the vine are considered essential factors of wine quality. However, soil water content has a strong spatial and temporal variability, and it is difficult to measure. A possible strategy is to integrate monitoring and proxies of water availability. It has been demonstrated that the carbon isotope ratio $\delta^{13}C$, measured in the alcohol of wine, is a promising tool to determine water stress during the vine growing season and to predict Sangiovese wine grape performance [1]. This research study was set up to evaluate the relationships between $\delta^{13}C$, soil water deficit, and wine grape viticultural and oenological performance.

2 MATERIALS AND METHODS

2.1 Experimental setting and soils

The trial was carried out for three years (2008-2010) in a premium farm of the Chianti Classico wine production district (Central Italy), on 9 not irrigated vineyards, which summed up about 40 ha. The reference variety was Sangiovese. Plant density was 5,500-6,600 per ha, the rootstock 420A (Vitis Berlandieri×Riparia), which is considered to be resistant to drought and active lime. Vineyards were planted in 1991, after slope reshaping by bulldozing and deep ploughing down to about 0.8–1.0 m. All vines were treated according to the integrated production system and the soil surface was periodically managed with mechanical tillage to limit weed growth, interrupt capillarity and reduce evaporation. Weather stations were placed near the selected vineyards.

Six soil typological units were identified in the study vineyards, which had developed on Tertiary calcareous flysch, ancient fluvial and fluvio-lacustrine deposits (Plio-Pleistocene period), Pliocene marine clays. Soil belonged to Haplic Cambisol (Calcaric, Skeletic), Stagnic Cambisol (Calcaric, Clayic), Endogleyic Stagnosol (Eutric, Clayic), Brunic Arenosol (Calcaric, Eutric), Cutanic Luvisol (Hypereutric, Profondic, Clayic), and Cutanic Luvisol (Ruptic, Hypereutric), according to WRB [2]. The studied soils varied notably as for limitations for vine cultivation (profile thickness, stoniness, drainage, chemical fertility), but they were all not saline and showed low electro-conductivity values (<0.5 dS m^{-1}). Eleven plots, about 100 m^2 each, were selected on the basis of a detailed survey, to represent soil and plant spatial variability inside vineyards.

2.2 Field analysis

$\delta^{13}C$, stem water potential and soil water deficit were monitored. Stem water potential was measured with a pressure chamber, according to the methodology proposed by Choné and coll. [3], on non-transpiring mature leaves that had been bagged before measurement. Water deficit, expressed as the difference between measured soil water content and wilting point, was evaluated during the veraison-harvest phases. Monitoring of the soil water content was performed by FDR (Frequency Domain Reflectometry) sensors at 10 different sites, with intervals of about 15 days during the 3 growing seasons. Two reference depth (5-35 and 35-75 cm) were selected according to literature indication [4] about vine roots distribution. Moreover, for each site was calculated the 3-year average water content of the 5-75 cm depth layer, related to the veraison-harvest period. The vegetative behaviours of the grapevines were recorded, in particular the date of phenological phases, yield components (yield per vine, cluster and berry weight, number of clusters per vine).

2.3 Laboratory analysis

The isotopic ratio $^{13}C/^{12}C$ ($\delta^{13}C$) was measured in the wine ethanol by Isotope Ration Mass Spectrometry to assess possible water stress occurring during grape formation and ripening. The $\delta^{13}C$ was expressed in parts per thousand variations referred to the International standard (V-PDB) ratio [5]. Wines were analysed twice. Soil moisture content at -33 kPa and -1500 kPa of disturbed samples of the benchmark profiles were analysed in laboratory by the pressure-plate system [6], and bulk density with the core method on replicated samples. Soil description and routine analysis of the air-dried <2 mm fraction followed the official Italian methods. Traits of grape quality (alcohol content, titratable acidity, sugar content, total and extractable anthocyanins and polyphenols) were analysed in the berries and the musts according to OIV (2000) [7] and Glories (2001) [8].

2.4 The climate of «Brolio Castle» area

The research area is characterized by a mean annual temperature of 13.2°C, with remarkable seasonal and daily air temperature ranges, whereas long term total annual precipitation is 800 mm. Potential evapotranspiration is about 850 mm. Mean value of Winkler index is 1856 Degree Days.

Meteorological conditions during the trial were characterized by a spring-summer sum of temperatures slightly lower than long-term average in 2008 and 2010, while 2009 was higher (tab. 1).

Table 1. Climatic indices and rainfall during the growing season of the 3 years of study.

Year	Winkler index	Huglin index	∑ mm rain April - September
2008	1750	2279	332
2009	1969	2566	266
2010	1721	2282	437

3 RESULTS AND DISCUSSION

δ13C resulted directly related to soil water deficit and stem water potential, and showed absence to only moderate plant water stress. In particular, the three-year δ13C average data were significantly correlated with average soil water availability between 5 and 75 cm depth during the veraison-harvest phases. Values of water content turned into negative when they were less than that corresponding to the wilting point (Fig. 1).

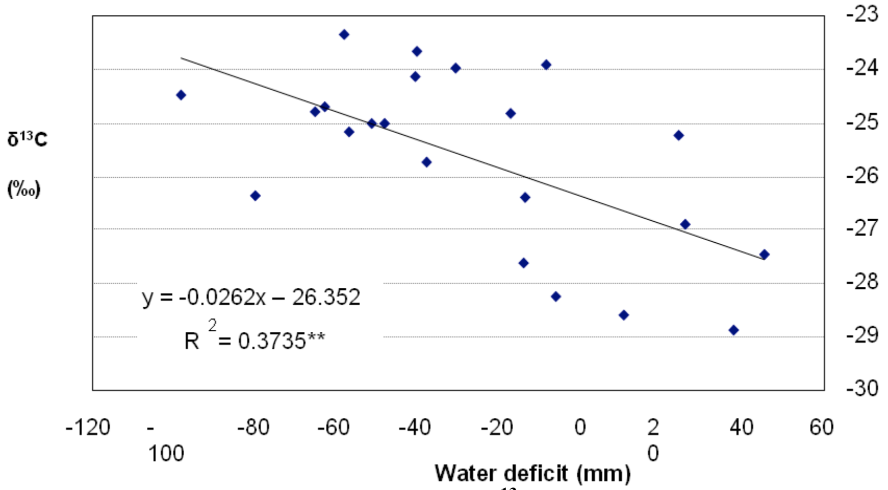

Figure 1. Relationship between δ13C and soil water deficit.

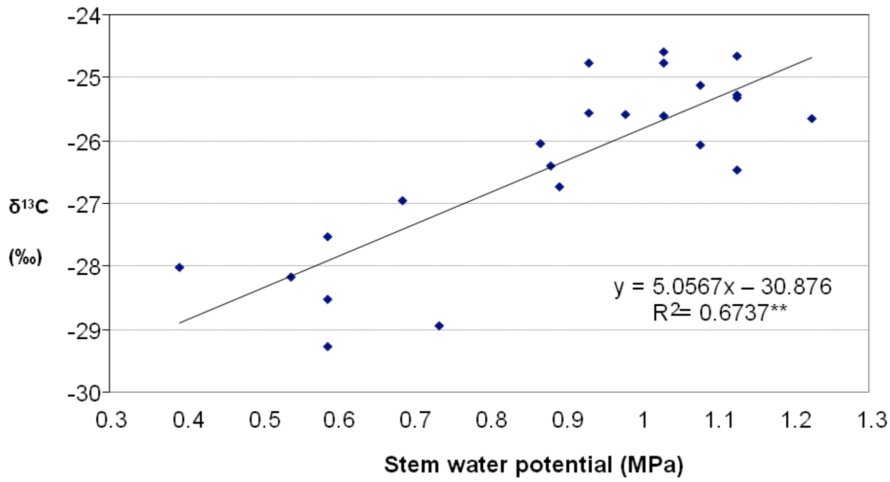

Figure 2. Relationship between δ13C and stem water potential in the year 2010.

The existence of a significant relationship between water availability and δ13C is then confirmed in this study. Nevertheless, the low determination coefficient indicates that the water deficit in the first 75 cm of soil is not the only parameter affecting plant water stress and δ13C.

A significant correlation (R^2=0.674) was found between the mean δ13C and the leaf water potential (Ψstem) values during the 2010 vintage (Fig. 2). Leaf water potential values between -0.80 and -0.90 MPa, indicating absence or beginning of moderate stress, corresponded to δ13C data between -26.8 ‰ and -26.3 ‰, broadly in line with reference values for the Sangiovese cultivar, as noticed in other areas of Chianti [1]. However, the relationship with viticultural and oenological results was contrary to the expectation, that is, the performance increased when the water stress decreased, as exemplified in figure 3 for the alcohol content.

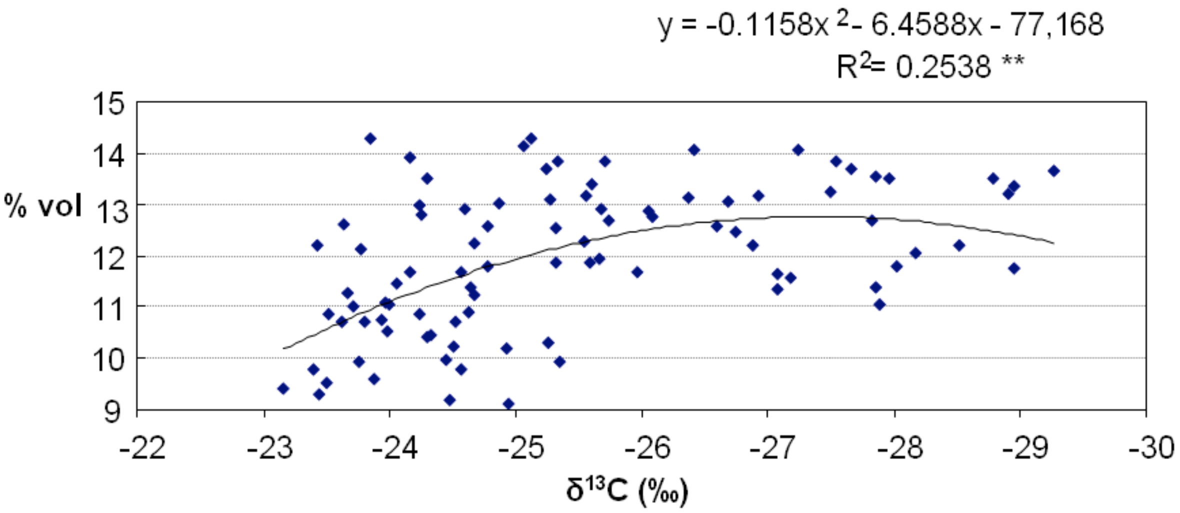

Figure 3. Relationship between alcohol of wines and δ^{13}C.

4 CONCLUSIONS

The soils of the vineyards were of low fertility, because of both their lithological nature and as a consequence of pre-plantation activities. In these conditions, the adopted viticultural husbandry (high plant density, high pruning, weak rootstock, grass cover) could be sometimes too competing for the plants, so that the effects of water stress on grape quality were magnified. In conclusion, δ^{13}C cannot be directly used to estimate vine performance in low fertility soils and under severe agricultural husbandry.

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