IMPACT OF PEDOCLIMATICAL CONDITIONS ON THE PRECOCITY POTENTIAL OF VINEYARDS IN THE CANTON OF GENEVA (SWITZERLAND)

S. Burgos[(1)], S. Almendros[(1)], E. Fortier [(1)]

[(1)] Oenological school of Changins, University of Applied Sciences of south-western Switzerland
Rte de Duillier, CH-1260 Nyon Switzerland
Stephane.burgos@eichangins.ch

ABSTRACT

Terroir studies are common nowadays but few have used precise pedoclimatic measures in order to evaluate the precocity potential. The objectives of this work were (i) to assess the effect of main terroir parameters (soil, climate and topography) influencing the phenological development of the vine, and (ii) to evaluate a geostatistic approach by using a high number of already existing plots (higher variability) to analyze the terroir parameters' impact. The results showed that the plots presented a different development concerning budbreak and concerning the speed of development during the growing season. These two components are not influenced by the same parameters. This emphasizes that the influence of the different terroir parameters can vary during the growing season. Some parameters derived from a digital elevation mode, like modelized incoming radiations, seem promising for estimating the precocity potential of the different zones. Finally, the results showed that the observation of a large quantity of already existing vineyards not intended for research is adapted to define the main factors of the terroir, despite natural variability or human influence.

KEYWORD

Phenology–meso-climate – PCA – precocity potential – GIS

INTRODUCTION

A lot of terroir studies have been made all around the world. The aim is usually the estimation of the viticultural potential in order to advise the growers. A lot of these studies focus on the soil and the geology (Bodin and Morlat, 2003). Others include also the plant and the climate (Murisier *et al.*, 2004, Barbeau *et al.*, 2004, Lebon *et al.*, 1996). It is generally agreed that the climate is one of the most important factors influencing the potential of precocity of a plot (Jones and Davis, 2000). The study of local climatic conditions is generally difficult due to a low density of meteorological stations. Moreover, precise soil information is often limited as well. The following study was performed in the canton of Geneva (SW of Switzerland), where an extensive soil survey had previously been done (1360 ha of vineyards) (Dakhel *et al.,* 2007). The objectives were (i) to describe the main terroir parameters (soil, climate and topography) influencing the phenological development of the vine (precocity potential), and (ii) to estimate the possibility of using already existing plots (higher variability) to analyze the terroir parameters' impact.

MATERIALS AND METHODS

The results presented in this paper are the 3 year-averages (2007-09) of data, collected on 49 plots of Gamaret grafted on 3309C, older than 8 years, mostly Guyot trained, and representative of the whole of Geneva's vineyard. Each plot contained four rows of 30 plants. Plants were treated according to the integrated production. Topography, soil type, soil temperature (2, 20 and 50 cm deep), available water (AW, depending on clay and stone content, and depth of the soil), and geology were assessed for each plot. Slope, geographic exposure, exposure to the north winds (joran (NW) or bise (NE)) and potential radiation were derived from a 5 meter digital elevation model (DEM, spatial analyst, Arcview 9.2).

Plant density and foliar surface were noted, date of budbreak, flowering and veraison (BBCH 09, 65 and 85 respectively) were recorded by the observation of 100 organs chosen on representative plants. A plant was considered at a given phenological stage when 50 % of the organs reached this stage. All bunches of three representative and consecutive plants of the plots were harvested and weighted separately to estimate the load. Two hundred grains were harvested on the same day analyzed with a Grapescan (FT120, FOSS electric). Sugar, acidity, pH and anthocyanin were assessed.

Principal component analyses (PCA) and Bayesian information criterion (BIC) were performed to select parameters which sorted out the plots in relation to the vine phenology and the quality of the must. These parameters were then used in multiple linear regression stepwise models. The different proposed models were tested and chosen according to their biological significance. The canton of Geneva was divided in 8 geographic zones (Ani (n=8), Cho (n=4), Dar (n=8), Lul(n=10), Pei(n=5), Sat(n=8), Sor(n=6)). The measurements on the plots were averaged for each zone. The zones were then plot as supplementary qualitative variable on the PCA individual factor map. ANOVA and Tukey HSD tests were also performed to compare the different zones. Statistical analyses were performed using the package FactoMineR, Leaps, lattice and stats of the 2.10.1 version of R (© 2009 The R Foundation for Statistical Computing, ISBN 3-900051-07-0).

RESULTS AND DISCUSSION

Vine phenological development

The PCA performed on the phenological parameters of the vine showed two main principal dimensions (Fig. 1a and 1b). The first dimension (57.9% of the variance) was strongly correlated to the length of the period between budbreak and flowering (r=-0.91) and between flowering and veraison (r=0.79). The second dimension (30.1 % of the variance) was mostly correlated to the date of budbreak (r=0.87). A good distribution of the different plots was obtained, reflecting the high variability of the development of the vine.

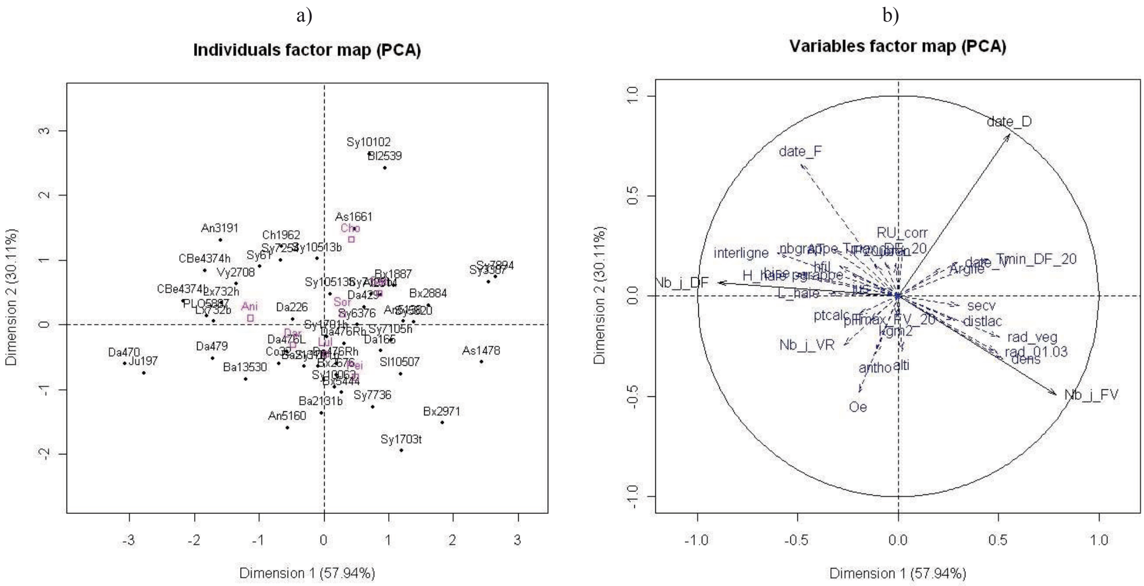

Fig. 1: Principal composant analyzis (PCA) of the gamaret plots (n=49) A) individual map, violet : geographical zones, blue : plots. B) variable factor map, black : discriminant variables, blue: supplementary variables.

The multivariate regression analysis of the first dimension (Fig. 1b) showed that the length of the period budbreak-flowering was influenced by the radiation between April and June, the plant density, the altitude and the date of budbreak, explaining respectively 29, 18, 18 and 4 % of the variance (total 69%). Simulated radiation seems to be a better indicator than the slope because it integrates slope and exposure. Indeed, parameters which integrated several single parameters like available water (soil depth and clay content) or potential radiation (exposure and slope) are more often present in the regression models. Those integrating parameters were also well-correlated with plant development in other studies (Murisier, 2004). The plots with an important amount of radiation between April and June, high plant density, low elevation and early budbeak showed the fastest development from budbreak to flowering. For instance, the zones Lul and Pei received a significantly larger amount of solar radiation between April and June with more than 4.95 10^5 Wh m^{-2} compared with a mean of 4.7 10^5 Wh m^{-2}, explaining their fastest development (Fig. 2a). Among all possible models given by the stepwise regression with a lower explained variance, a lot contained also the average of the soil temperature minimum at 20 cm or a lower exposure to the north-east wind as explicative factors. This shows the importance of the soil type.

The number of days between flowering and veraison (Fig. 2b) was influenced by the plant density, the incoming radiation between July and September, the available water and the date of flowering explaining respectively 29, 11, 5 and 3 % of the variance (total 48%). The early-flowering plots, with high density, shallow soils (small AW) and a high incoming summer radiation showed the fastest development. All the factors which allow en increase in radiation and temperature are favorable to fast vegetation development, which is consistent with other studies (Lebon *et al.*, 1996).

The multivariate analyses of the second dimension of the PCA (Fig. 1b) showed that the main factors influencing the date of budbreak were the available water, the potential radiation from January to March, the exposure to NW wind and the elevation, explaining 9, 6, 4 and 2% of the variance respectively (total 21%). The regression models are not as good as for the first dimension. The earliest plots at budbreak were to be found on a steep slope or were exposed S or SE and were located on soil with a moderate available water capacity. The plots located on heavy soils, exposed N and with high elevation showed a significantly ($p < 0.05$) delayed budbreak of 3 days. This is the characteristic of the zone Cho which is significantly later at budbreak (Fig. 3a). Also, the differences in the plants phenological development by zones tended to be less important at the veraison (Fig. 3c) than at the budbreak and flowering (Fig. 3a and b).

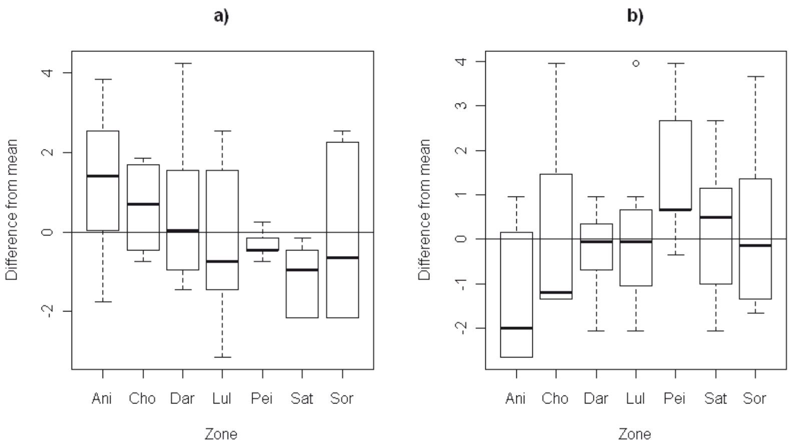

Fig 2. Difference between the length of the period a) budbreak-flowering and b) flowering-veraison for each zone compared to the mean average of the 49 plots.

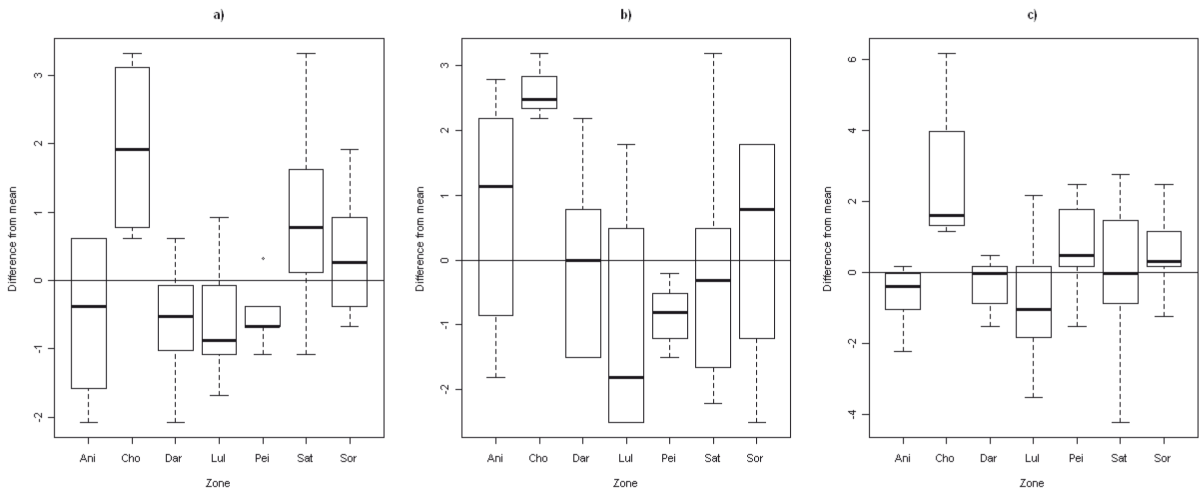

Fig 3. Difference between period of a) budbreak b) flowering and c) veraison for each zone compared to the mean average of the 49 plots.

These results showed that the plots presented a different development pattern concerning budbreak and concerning the speed of development during the growing season. These two differentiation components are not influenced by the same parameters. This emphasizes that the influence of the different terroir parameters can vary during the growing season. Some early plots at budbreak receiving a lower amount of radiation can, however, lose their advantage by a slower development. For instance, the zone of Ani, which was among the earliest at budbreak (Fig. 3a) probably because of its proximity to the Geneva lake, lost its advance (Fig. 3b) because of its north-west exposure.

Effect of phenology on the quality of the must

The sugar content expressed in Oechsle degrees was mostly influenced by the date of budbreak, the grape load (kg m^{-2}), the date of flowering and the available water capacity of the soil explaining 30, 13, 6 and 4% of the variance respectively (total 53%). There is a maximum yield over which high sugar content might not be reached (Fig. 4a). When the load gets past about 1.2 kg m^{-2}, it is difficult to obtain enough sugar. The plots with early budbreak showed a good maturity (Fig. 4b), even if the exposure was not the best (data not shown). If the budbreak is too late, it is difficult for the plant to overcome this delay despite a reduced load. If the exposure is not optimal, the date of budbreak should be early enough to keep an opportunity of high sugar maturity. Anthocyanine content was also influenced by the same factors as those for sugar content.

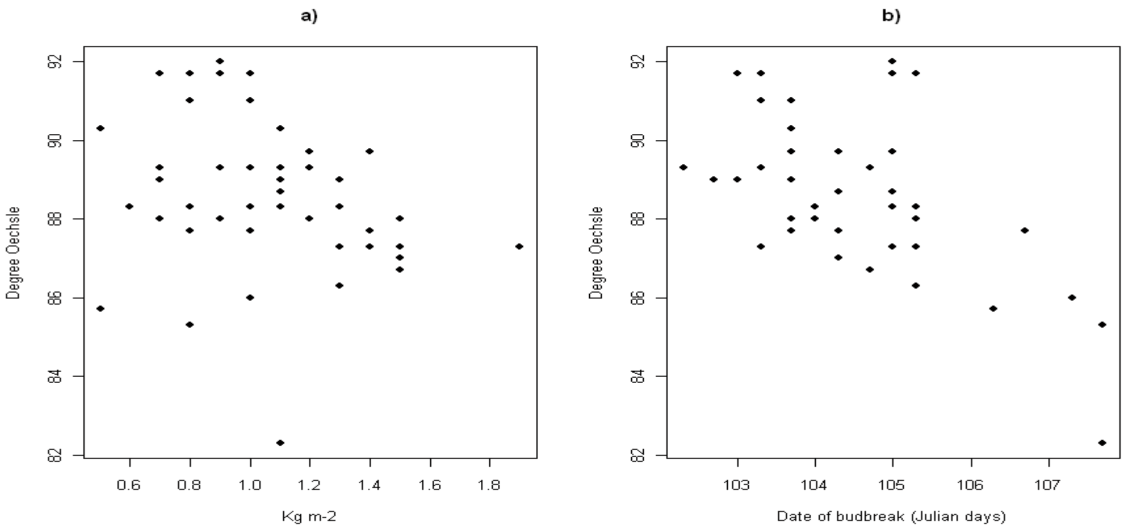

Fig. 4 Degrees Oeschle as function of a) the mean load of 3 plants per m^2 and b) budbreak.

Using already existing parcels for complete terroir analyses

The results showed that the observation of an elevated number of already existing plots can be used to study local effect of the climate and so, even if the study area is spatially limited and presents low relief variability. The number of plots for each zone varied from 4 to 10. This seems to be sufficient to compare the zones with an accurate statistical precision. The high degree of variability of the different plots inside a zone is still smaller than the variability between the zones. The choice of gamaret, a variety derived from one clone, is a good tool to reduce the plants variability. Moreover it is necessary to measure a great number of organs for the phenological stadium in order to get enough precision. The effect of the annual climate could be removed by observing 3 different seasons. However, the earliest and latest plots were generally the same over the 3 years.

CONCLUSIONS

The results presented here show that the parameters influencing the plant at budbreak, and the length of the period budbreak-flowering and flowering-veraison are not the same. The potential radiation and the exposition to the north winds play an important role during the vegetative plant development. The combination between observed variable and data derived from a digital elevation model allows the classification of the different zones in a vineyard, despite the variability of the plots. This variability can however be taken as an opportunity to produce a wide varieties of wine by choosing an adapted couple variety-rootstock specific to a given plot. It might be also possible to extrapolate these results on other zones or adjacent plots. This kind of terroir studies can be useful for advising viticulturist**s** on several decisions. A geostatistic approach with a lot of plots but quite simple parameters seems to be a promising tool to evaluate the environmental differences, even in a region with quite low variability in altitude. This is important in a period of climate evolution (Jones and Davis, 2000).

ACKNOWLEDGMENTS

We are grateful to all people who worked principally during the harvest, to Irene for the laboratory analyses and all the growers who kindly allowed us the use of their vineyards. We also thank Elayne Wehrlin for her linguistic support.

BIBLIOGRAPHY

Barbeau G., Bournand S., Champenois R., Bouvet M.H., Blin A. and Cosneau M. 2004. The behaviour of four red grapevine varieties of Val de Loire according to climatic variables. *Journal International des Sciences de la Vigne et du Vin*, **38,** 35-40.

Bodin F. and Morlat R. 2003. Characterizing a vine terroir by combining a pedological field model and a survey of the vine growers in the Anjou region (France). *Journal International des Sciences de la Vigne et du Vin*, **37,** 199-211.

Dakhel N., Docourt M., Schwarz J-J. and Burgos S. 2007. Carte des sols viticoles genevois. Report of study. Site internet : http://etat.geneve.ch/geoportail/geovit/.

Jones G.V. and Davis R.E. 2000. Climate influences on grapevine phenology, grape composition, and wine production and quality for Bordeaux, France. *American Journal of Enology and Viticulture*, **51,** 249-261.

Lebon E., Dumas V. and Morlat R. 1996. Réponses de la vigne à différentes situations pédoclimatiques du vignoble d'Alsace. *Revue Française d'Oenologie*, **156,** 22-25.

Murisier F., Briguet C., Letessier I., Pythoud K. and Zufferey V. 2004. Etude des terroirs viticoles vaudois. *Revue suisse Vitic.Arboric.Hortic.*, **36,** 1-20.

Van Leeuwen C., Gaudillere J.P. and Tregoat O. 2001. The assessment of vine water uptake conditions by C-13/C-12 discrimination in grape sugar. *Journal International des Sciences de la Vigne et du Vin*, **35,** 195-205.