Sardinia terroir and Cannonau: a zoning approach to discover an ancient tradition

Terroir Sardaigne et Cannonau : le zonage comme approche pour découvrir une tradition antique

Diego TOMASI[1*], Antonio CALÒ[1], Paolo SIVILOTTI[1], Clelia TORE[2], Francesca FANTOLA[2], Orazio LOCCI[2], Elena GODDI[2], Ignazio CAREDDA[2], Serafino URRU[2], Paolo SCHIRRU[2], Anna SCANO[2], Onofrio GRAVIANO[3], Paolo CARDU[3], Aldo BUIANI[4] and Daniela BORSA[5]

1: CRA-Istituto Sperimentale per la Viticoltura, Viale XXVIII Aprile 26, I-31015 Conegliano (TV), Italy
2: ERSAT Sardegna, Cagliari (CA), Italy
3: Consorzio Interprovinciale per la Frutticoltura, Cagliari (CA), Italy
4: Cantina Antichi Poderi di Jerzu, Jerzu (NU), Italy
5: CRA-Istituto Sperimentale per l'Enologia, Asti, Italy
[*]Corresponding author: diego.tomasi@entecra.it, Tel. +39 0438 456733, Fax +39 0438 64779

Abstract: Cannonau variety is historically grown in a large Sardinia area (Jerzu district) and the vineyards are planted both in the plane and in the sloped hills reaching also 650 m of altitude a.s.l. Thus, in order to discover how climate, soil diversity and growing traditions could account for differences in grape and wine quality, this trial was carried out. Within the area of investigation, eight zones were isolated based on soil characteristics (drainage, depth and texture), altitude and climate. Processing climate data, an important differentiation in temperature and thermal range, was discovered between the vineyards sited in the plane and those located up in the hills. Moreover the plan zones are characterised by a heterogeneity in the distribution of the rainfalls. During 2004 and 2005 grapes were collected from veraison to harvest, and the technological maturity was investigated. An advance in the sugar accumulation and titratable acidity degradation was revealed by comparing the plane with the slopes, and this fact was even more evident with the higher vineyards. A first discrimination emerged between plane and high vineyards: the higher the altitude, the higher the anthocyanin content. The yields (higher in the plan) also contribute to partly explain these results. Opposite to these findings, in 2004 the grapes collected in the plane revealed to be much richer in aroma compounds. This fact is probably to be linked with the particular conformation of the valley that result in an increase of the thermal range at the lower altitudes. The sensory evaluation of the wines obtained processing the grapes collected in the different zones, revealed that a zone fingerprint was maintained. Starting on 2005, measurement of soil humidity was performed, and a relationship with grape quality was ascertained.

Keywords: Cannonau, zoning, climate**,** aroma, anthocyanins

Introduction

The concept of « terroir » has been many time reported as the combination of several factors like the environment (climate and pedology), the genetic resource (variety, clone and rootstock), the pruning/canopy management of the vineyard and the human being. The zoning studies tried to investigate the interaction effects of those parameters (Marais *et al.*, 1999; van Leeuwen *et al.*, 2004), but often it is difficult to separate the effects of each factor. Much easier the work if inside a area of investigation the interest of a zoning program looks at the performances of a unique grape variety.
A grape variety known as Cannonau was grown in Sardinia from time immemorial, and the vineyards were planted both in the bottom of the valley and in the top of the hills. It is well known that the variability of pedology, microclimate and water availability significantly affects grape quality; so that, this zoning program was developed in order to discover the performances of several areas with the aim to optimise grape destination as regard with its quality.

Materials and methods

The trial was carried out starting in the year 2004 in the Jerzu district in a central-east area of the Sardinia territory (Nuoro province), mainly grown with the Cannonau variety.
Within the area of investigation, three macro-areas are distinguished as regard to the orography and landscape. The coastal vineyards are situated at the bottom of the valleys and their altitude range between 25 and 300 m asl; the soils are deep, with a sandy texture and a low AWC (available water content). In the hilly versants the vineyards have been planted in plans or slopes (rarely steep) between 130 and 350 m a.s.l. of altitude; here soils are meanly deep, and the texture changes in sand-clay or loam-clay with a medium value of AWC. The grapevine is cultivated meanly on the south-east versants. Going up furthermore, the highest vineyards have been planted between 350 and 700 m a.s.l., in slopes and steep slopes mainly in the South exposition. Soils are characterised by a clay or loam-clay texture and a richness in coarse that promote water drainage. The three areas were sub-divided in nine zones (table 1) based on the different microclimatic characteristics (temperature, rain and wind) collected by several meteorological stations.

Table 1 - Description of the areas involved in the Jerzu zoning program

Macro-areas	viticultural zones	Altitude (m asl)	texture	drainage	exposition
coast	Pelau Mannu	25-300	loamy sand - loam	mean-good	E-W
	Pelaeddu	25-300	loamy sand – sandy loam	mean-good-fast	E-W
	Quirra	30-80	clay loam - clay	good-fair	plan
	Flumini	40-300	loamy sand - sandy clay loam	mean-good	W
mean hill	Sacanna fondovalle	130-210	loamy sand	good-fast	plan
	Sacanna versanti	150-350	clay loam - sandy clay loam	mean-good	E
	Pardu	130-210	loamy sand	good	S-E
hill top	Vigne Alte	350-700	Loam - clay loam	good	E – SE - S

For each area a TDR devices and a temperature and rain recorder were installed. A representative number of vineyards was chosen, and during the seasons phenology (budburst, flowering and véraison), quantitative parameters (yield, cluster weight, pruning wood) and qualitative measurements (soluble solids, titratable acidity and pH) were collected. The accumulation of anthocyanins was assessed in the last period of berry ripening. Two 30-berry-samples were collected for each tested vineyard at each date, skins were carefully separated and anthocyanin concentration analysed (Di Stefano and Gentilini 1995).
At harvest, wine was made collecting 150 kg of grapes from each of the previous remembered areas. A sample of must was analysed for aroma compounds (Di Stefano R. 1991; Ummarino and Di Stefano, 1997).

Results and discussion

During the two years of investigation, meteorological parameters were collected in the different areas and several differences evaluated. In both years, Sacanna fondovalle showed the maximum thermal range with the highest levels of temperatures together with Flumini. Going up the hills, thermal range was shown to be reduced as expected and the minimum values were evaluated for Vigne alte. Pelau Mannu and Pelaeddu areas revealed lower values of maximum temperatures (average Aug-Oct); the see proximity could partly explain this behaviour, mainly for Pelau Mannu which is closer to the see.
Summarising meteorological data, temperatures and thermal range dropped down going up to the hills; the thermal excursion is higher at the bottom valley because cool air masses flow down to the hilltops during the night, accounting for a high thermal range. The cold winds coming from the see act reducing the differences between temperatures (lower max temp and higher min temp), so that also thermal range drops down end, it is a natural fact, that going up with the altitude less is the temperature.
Comparing the two seasons, the temperatures during the ripening period were much higher in the 2004 also with higher values of thermal range (figure 1). The months of May, June and July showed an opposite behaviour, since the highest temperatures were registered in the 2005 (both min and max temp.; data not reported). Annual Winkler index revealed that the year 2005 was much hotter than 2004 but without any

water stress problem also in the ripening period. This fact could account for the higher values of soluble solids and lower titratable acidity that were found in this year (figure 4).

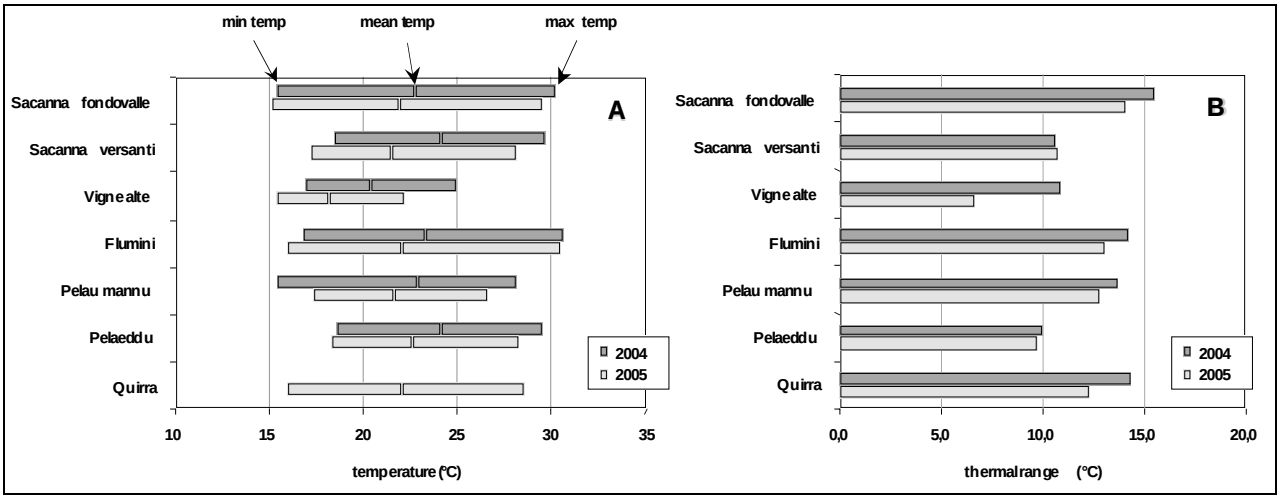

Figure 1 – A: patterns of minimum, mean and maximum temperatures (average Aug-Oct)
B: thermal range (average Aug-Oct) in the different areas of Jerzu district

Water deficit (figure 2b) was calculated by means of a water balance and ET_0 was estimated using Hargreaves model (Hargreaves and Samani, 1982). By comparing the two years of investigation, water stress was much stronger in 2004 and in the bottom of the valleys; going up with the altitude, it was shown that temperatures dropped down and so also the value of ET_c which is closely related. Rainfall can also explain water stress differences between the years, because it was lower in the year 2004, apart in the Pelau Mannu area (figure 2a). The rainfall was shown to be much effective in the high vineyards because ET_c is lower at those altitudes (temperatures change going up the hills).
The amount of water deficit was than coupled with the map of AWC (figure 3) in order to obtain a spatial representation of water stress hazardous areas (month by month) thus scheduling the irrigation.

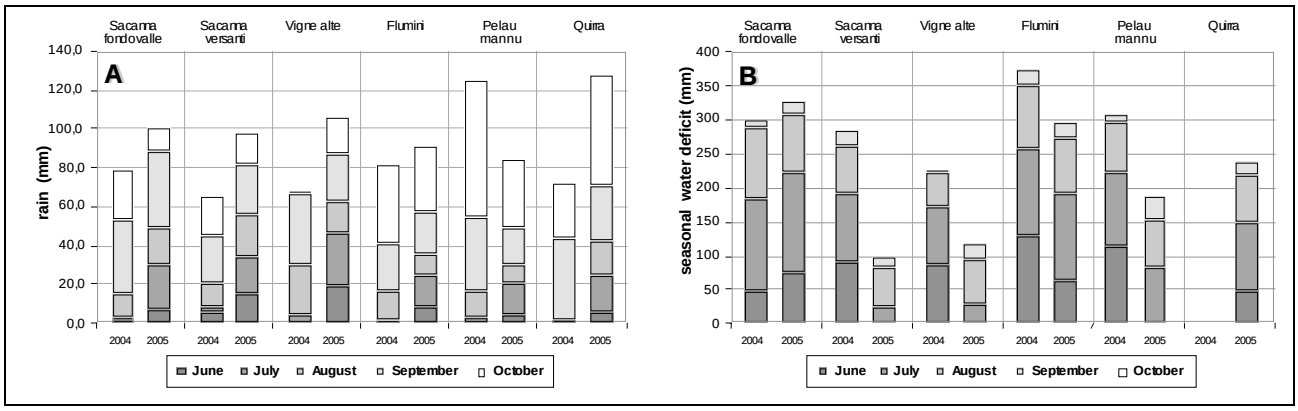

Figure 2 – A: amount of rainfall during the summertime
B: seasonal water deficit calculated as difference between ET_p and rain in the different areas of Jerzu district

Among the areas, the differences in soluble solids (and titratable acidity) at the beginning of the ripening (just after véraison; figure 4) could be explained by the difference in the soil texture, being the berries much richer in sugars (and lower in acidity) where the texture was much sandier and where the climate was wormer (i.e. Flumini). As expected, harvest time was closely related with the initial accumulation of sugars (table 2): the higher the soluble solids at post-véraison, the earlier the harvest. Sacanna versanti and Vigne alte reached in both years the highest values of sugars while Pardu the lowest.

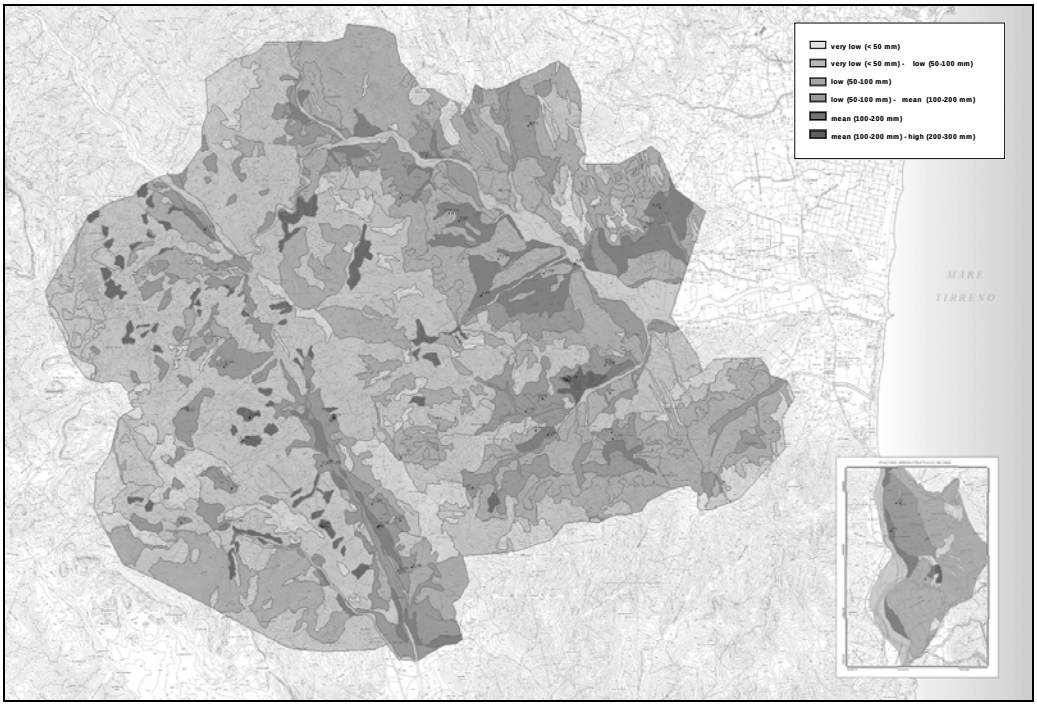

Figure 3 - Spatial representation of water stress hazard based on the values of actual ET_c and AWC

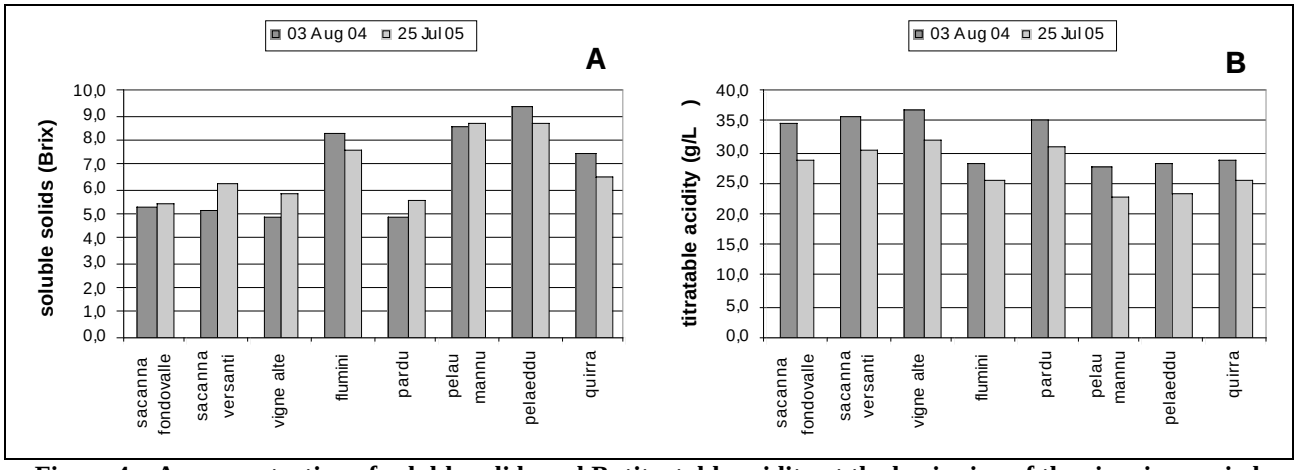

Figure 4 – A: concentration of soluble solids and B: titratable acidity at the beginning of the ripening period (just after veraison) in the different areas of Jerzu district

Table 2 - Harvest time, soluble solids (Brix) and titratable acidity (g/L) in the different areas of Jerzu district

	year 2004			year 2005		
	harvest data	soluble solids	titratable acidity	harvest data	soluble solids	titratable acidity
sacanna fondovalle	12-ott	22,6	4,40	06-ott	23,4	6,33
sacanna versanti	12-ott	23,9	4,30	04-ott	24,6	4,83
vigne alte	20-ott	23,4	5,33	12-ott	25,1	6,06
flumini	07-ott	23,1	4,15	30-set	24,5	5,60
pardu	08-ott	19,8	5,32	07-ott	22,4	5,95
pelau mannu	06-ott	23,3	3,79	30-set	24,2	5,72
pelaeddu	07-ott	23,6	3,62	30-set	23,6	5,56
quirra	11-ott	22,5	3,42	05-ott	23,6	5,00

The occurrence of anthocyanins in the berries was shown to be negatively related with yield in 2005 and positively with the soluble solid concentration at harvest in 2004 (figure 5). This finding leads us to the same

result: too high yield or too low sugar result in a poor grape colour. The occurrence of anthocyanins was much higher when grapes came from the vineyards located at higher altitudes. Temperatures and thermal range drops down going up to the hills and this microclimatic change could account for the increase in the anthocyanin concentration. In opposition with soluble solid accumulation, the anthocyanin concentration was much lower in the sandy soils as compared with the clay soils.
Most metabolic reactions are strongly influenced by temperature and water availability, and also the aroma composition of the musts was found affected by climate conditions occurring during the year and within the place. Our experience led to a close relationship between aroma and grape origin in 2004, being fair in 2005 (figure 6). The higher temperatures recorded during ripening period and the occurrence of water stress in the 2004 resulted in higher concentration on aroma compounds mainly in the areas Pelau Mannu and Pelaeddu which are characterised by a sandier texture (more sensitive to drought). In the 2005, the lower temperatures measured over the grape ripening period, resulted in poorer aroma occurrence in musts and in a reduction of the differences among the areas of investigation. Only benzenoids compounds seems to be in some cases much higher in 2005. In these two year the thermal range effect on the aroma compound was not so clear as in other experiences, probably because the soil texture role were predominant. Comparing the different zones, Vigne Alte was the only one that maintained through the two years the same aroma composition, even if the seasonal climate data were different.

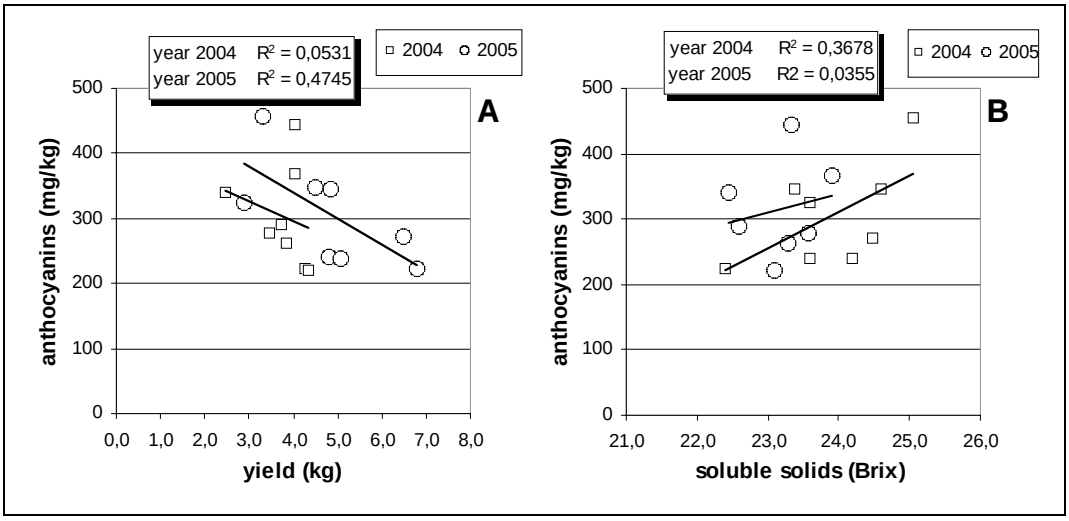

Figure 5 - Correlation between A: yield and anthocyanins and B: soluble solids and anthocyanins at harvest separately calculated in the two years of investigation.

In 2004, the wines produced from the higher vineyards grapes (Vigne alte and Sacanna versanti), were evaluated as full-bodied and aged while the aromatic descriptors better depicted the wines from the plane (figure 7). Rose and violet notes (but also cherry, withered plum and jam) were much effective to characterise the aromatic pattern of Pelau Mannu zone according with the must aroma composition. The Pelaeddu and Quirra wines revealed a cherry note richness and a good structure and taste persistence. Because of the natural growth conditions characterising Sacanna fondovalle (bottom of the valley with sandy and stony soil), the average yield per vine (data not reported) and the medium sugar/ anthocyanins content, resulted in a fine wine without any particular excellence and with a vintage wine destination. Flumini wines showed a lack in structure and taste persistence, with an light body but with an elegant perfume.

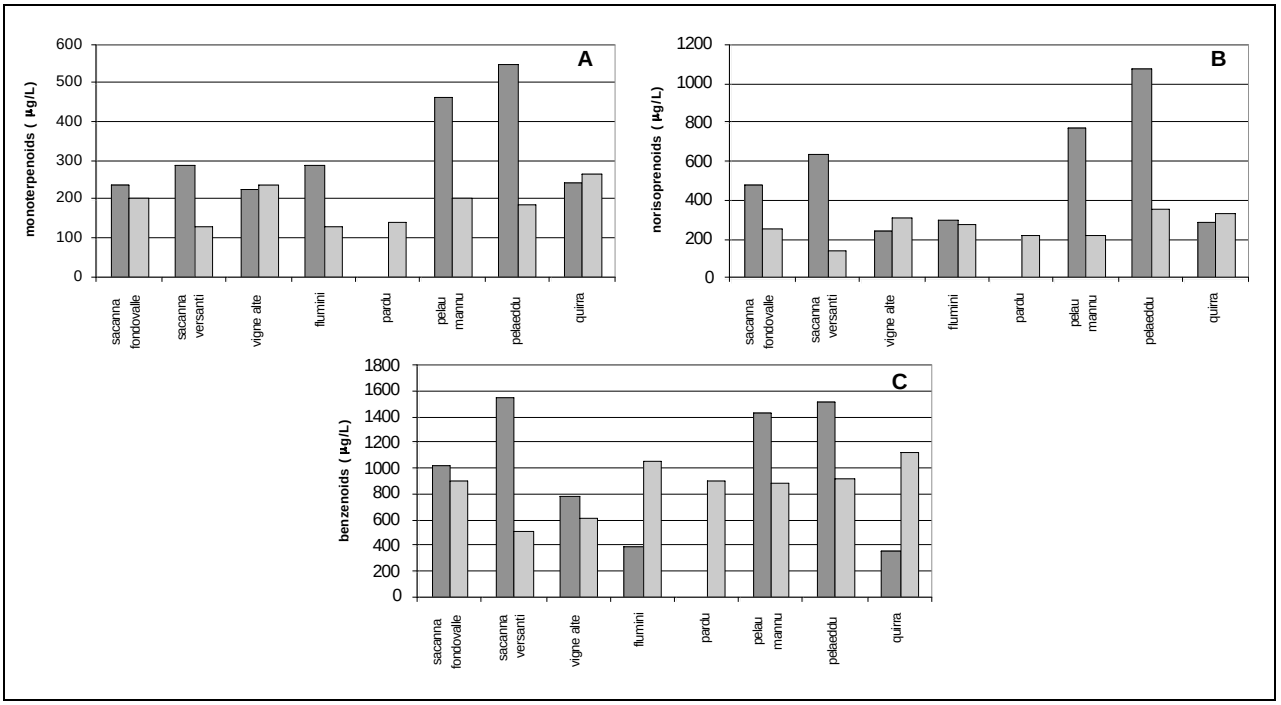

Figure 6 - Effect of year and zone on the must aroma composition:
A: monoterpenoids - B: norisoprenoids - C: benzenoids

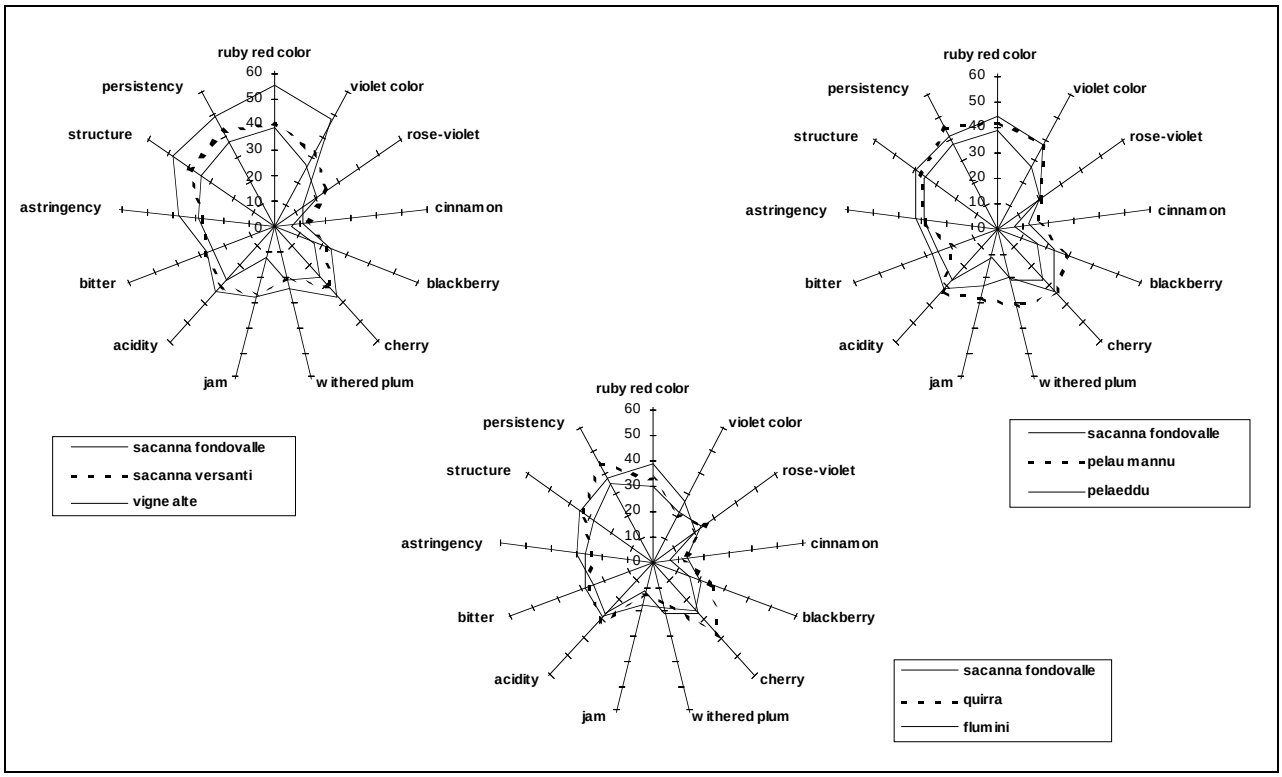

Figure 7 - Zones and wine scores as attributed by the panel test

Conclusion

There is a significant relationship between climate, soil and wine scoring. The climate features are related with the altitude, the exposition, the slope and the see proximity. As regard to the soils, their characteristics are linked with the geological origin. So that, the wine is a combination of these different elements, but also human choices have a great importance. Summarising the results, the different zones emerged to greatly affect grape and wine quality, thus providing an important tool to wineries in order to select the enological destination of the grapes. Moreover, based on these results a new grape rewarding system would be proposed

at the biggest local cooperative winery known as « Antichi Poderi di Jerzu ». The season appeared to be strongly affecting wine quality, but also the environment demonstrate to be important (i.e. much more colour for the grape collected above 350-400 m a.s.l., much more aroma compound at lower altitudes). In Cannonau, a moderate lack of water during ripen period, can greatly modify the grape aroma composition resulting in a better wine sensory appreciation. A third year of observations needs to confirm the first findings above mentioned and to better understand the complexity of the natural factor that leads to the growth zone characterisation.

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