« TERROIR » EFFECT, AS A RESULT OF ENVIRONMENTAL STRESS, DEPENDS MORE ON SOIL DEPTH THAN ON SOIL TYPE (*VITIS VINIFERA* L. cv. GRENACHE NOIR, CÔTES DU RHÔNE, FRANCE, 2000)

L'EFFET « TERROIR », RÉSULTANT D'UNE CONTRAINTE ENVIRONNEMENTALE, DEPEND DAVANTAGE DE LA PROFONDEUR DU SOL QUE DU TYPE DE SOL (*VITIS VINIFERA* L. cv. GRENACHE NOIR, CÔTES DU RHÔNE, FRANCE, 2000)

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Abstract: Among other elements of the natural environment, soil greatly influences vine behaviour and berry composition. Its influence is complex, because soil affects vine water and mineral uptake, as well as temperature in the root zone. In this research, investigations were undertaken to assess whether vine development and grape quality potentiel could be linked to specific soil types. 15 dry farmed plots planted with *Vitis vinifera* L. cv. Grenache noir were studied in 2000 on five soil types of the Southern Côtes du Rhône (France). No clear relationship could be established between soil type, vine growth, yield and berry composition. However, vine water and nitrogen status were related to soil depth. On shallow soils, vine water and nitrogen status were low, which resulted in early shoot growth cessation and moderate yield, as well as high berry sugar and anthocyanin content. Severe water stress is known for affecting negatively berry ripening. Nevertheless, although this study was carried out under dry, Mediterranean conditions, the grapes with the highest potential for making quality red wines were obtained on the soils with the lowest water holding capacity.

Résumé : Parmi les facteurs de l'environnement naturel, le sol influence fortement le comportement de la vigne et la constitution du raisin. Son effet est complexe, car le sol fournit l'eau et les mineraux à la vigne et détermine le pédo-climat thermique. La température du sol dans la zone explorée par les racines dépend de sa teneur en eau. Dans ce travail, il a été évalué si le type de sol influence le comportement de la vigne et la maturation du raisin. Quinze parcelles de vigne, non irriguées, ont été étudiées sur cinq types de sol dans les Côtes du Rhône du Sud (France). Certains types de sol présentaient des variantes superficielles et profondes. Les résultats présentés concernent l'année 2000, qui fût un millésime sec. L'état hydrique de la vigne a été évalué par des mesures de potentiel hydrique foliaire de base. Le statut azoté de la vigne a été déterminé par la mesure de la coloration des feuilles de vigne avec un appareil « N-tester ». Il n'a pas été possible d'établir une relation entre les types de sol, le développement de la vigne, le rendement et la composition du raisin. En revanche, l'alimentation en eau de la vigne et son statut azoté étaient liés à la profondeur du sol. Dans les sols superficiels, l'alimentation hydrique et azotée de la vigne a été modérée, ce qui a limité la croissance de la vigne et les rendements, et augmenté la teneur en sucres et en anthocyanes des raisins. Des déficits hydriques sévères sont réputés pour détériorer le potentiel qualitatif des raisins. Cependant, même si cette étude a été réalisée dans des conditions méditerranéennes au cours d'un millésime sec, les raisins avec le plus grand potentiel qualitatif ont été récoltés sur les sols avec la plus faible réserve utile.

Key words: vine, *Vitis vinifera*, soil type, soil depth, terroir, nitrogen status, water status, Côtes du Rhône, growth cessation, berry composition, sugar, anthocyanin

Mots clés : vigne, *Vitis vinifera*, type de sol, profondeur du sol, terroir, azote, état hydrique, Côtes du Rhône, arrêt de croissance, constitution du raisin, sucres, anthocyanes

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INTRODUCTION

Soil influences vine behavior and berry composition. It can be considered as one of the main factors in the « terroir » effect (SEGUIN, 1986; DELOIRE *et al.*, 2005; VAN LEEUWEN and SEGUIN, 2006). The objective of this research is to assess whether the soil type can be a reliable indicator for grape growing quality potential. The effect of soil on grape potential is complex, because the soil acts on vine water supply, vine nutrient supply and temperature in the root zone. The soil effect can only be quantified when broken down into a limited number of selected parameters. Previous studies have shown that vine water and nitrogen supply, depending on soil characteristics, are major factors acting on vine vigor and wine quality (carried out in the Bordeaux area by CHONÉ *et al.*, 2001).

Mineral supply to the vines depends on soil pH and cation exchange capacity, in relation to clay and organic matter content. Vine development and vigor are highly dependent on nitrogen supply (DELAS *et al.*, 1991; KLIEWER, 1991; SPAYD *et al.*, 1993; SPAYD *et al.*, 1994; CHONÉ *et al.*, 2006). As long as nitrogen fertilization is limited, which is the case in most quality producing areas, vine nitrogen uptake depends largely on soil parameters: soil organic matter content and mineralization speed. The latter depends on soil humidity, temperature, pH, aeration and the C/N ratio of organic matter (VAN LEEUWEN *et al.*, 2000).

Vine water supply depends on climatic parameters, leaf area index and soil factors. Inside a limited area and for a given vintage, climatic factors can be considered homogeneous. However, vine water supply can vary to a considerable extent over short distances, depending on variations in soil type. Soil water holding capacity varies mainly with soil texture and soil depth. Vine behavior, berry composition and wine sensory attributes are closely related to vine water uptake conditions (HARDIE and CONSIDINE, 1976; DUTEAU *et al.*, 1981; MATTHEWS *et al.*, 1990, VAN LEEUWEN and SEGUIN, 1994, VAN LEEUWEN *et al.*, 2004).

This study was carried out on 15 plots in the southern part of the Côtes du Rhône (France). The plots are located on the 5 main soil types of the Rochefort du Gard area (LETESSIER, 1993 and 1998). Some of the soil types show variation in soil depth. Four out of the five soil types studied were represented by several plots (replicates). Vine nitrogen and water supply were measured and compared to vine development (precociousness, vigor, shoot growth cessation) and berry composition at ripeness. In the discussion, an assessment is made of the effect of soil type and soil depth on nitrogen and water supply, in an attempt to explain the effect of soil on grape quality potential.

Table I - Soil type, soil depth and geological origin of sediment of the 15 plots studied.

Type de sol, profondeur du sol et origine géologique du sediment dans les 15 parcelles expérimentales.

Soil type	Geological Origin	Stone content	Plot Code	Depth as measured by hand auger	
Marly soils (M)	Plaisancian marls	Low	M1	> 1 m	Deep
			M2	> 1 m	Deep
			M3	0.6 – 0.8 m	Shallow
		> 25%	Mx1	0.6 – 0.8 m	Shallow
			Mx2	> 1 m	Deep
Deep colluviosols (Cl)	Peri lacustrine	Low	Cl1	> 1 m	Deep
			Cl2	> 1 m	Deep
			Cl3	> 1 m	Deep
Sandy soils and reworked sandy soils (S)	Astian sands	Low	RS1	0.6 – 0.8 m	Shallow
			RS2	0.6 – 0.8 m	Shallow
		> 25 %	RSx1	0.6 – 0.8 m	Shallow
			RSx2	0.6 – 0.8 m	Shallow
Stony terraces (TX)	Fluviatile villafranchian	> 50 %	TX1	> 1 m	Deep
			TX2	> 1 m	Deep
Reworked sandy marls (RMS)	Pliocene intermediates	Low	RMS	0.6 – 0.8 m	Shallow

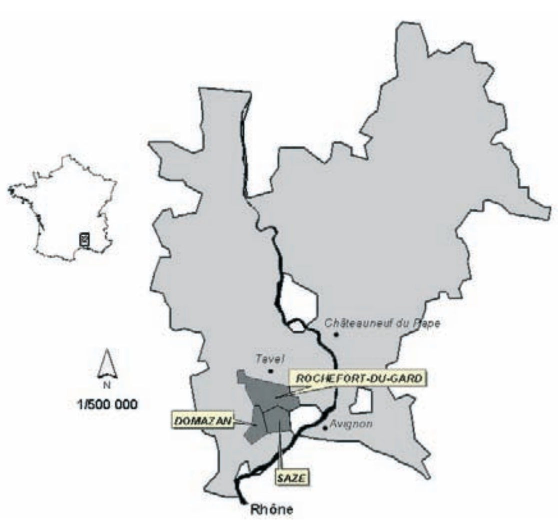

Figure 1 - Location of the administrative communes of Rochefort du Gard, Domazan and Saze (Southern Côtes du Rhône, France), where the 15 experimental plots are situated.

Localisation des communes de Rochefort du Gard, Domazan et Saze (Côtes du Rhône du Sud, France), où les 15 parcelles expérimentales sont situées.

MATERIALS AND METHODS

I - LOCATION OF THE PLOTS

The 15 experimental plots are located on the West bank of the Rhone River (figure 1) in three administrative communes: Rochefort du Gard (11 plots), Domazan (2 plots) and Saze (2 plots).

II - GEOLOGICAL ENVIRONMENT

Most of the area studied lies in a SW-NE geological graben (the Pujaut Graben), which cuts into the lower Cretaceous Barremian lime stones of the Urgonian facies (lime stones of the « Garrigues »). The graben was filled with Pliocene marls (Plaisancian) and sands (Astian) and covered by the quaternary Villafranchian stony terraces of the Rhone River. A late northeastward tilting of the graben allowed these terraces to be preserved on the highest western part of the area while a lake and its associated sedimentation developed on the lowermost eastern edge (figure 2).

III - SOIL TYPES AND SOIL DEPTH

The selected plots offer repetitions of the 5 most representative soil types of the region, as mapped by LETESSIER (1993, 1998) and cover the main geological units (table I). One sub group with a higher stone content has been considered for both the marly and sandy soils. All soils are calcareous, except the decarbonated Villafranchian stony terraces. Soil depth varies to a considerable extent. Seven plots have shallow soils, because of the appearance of bedrock or calcareous concretions at a limited depth. For some of the soil types studied, soil depth is variable (marly soils); others are consistently shallow (sandy soils) or consistently deep (colluviosoils, stony terraces). Soil depths were estimated with a hand auger.

IV - PLANT MATERIAL

The plant material consists of adult vines of *Vitis vinifera* L. cv. Grenache noir (14 to 34 years old), grafted on *Rupestris du Lot*. Vines are vertically shoot positioned and cordon pruned. Density is close to 4,000 vines/ha. All measurements were carried out on 15 adjacent vines, selected as healthy and representative of the plot.

V - CLIMATIC CONDITIONS

The study was carried out during the 2000 vintage. Temperature data were collected at the Tavel station, which is only a few kilometers from the area studied.

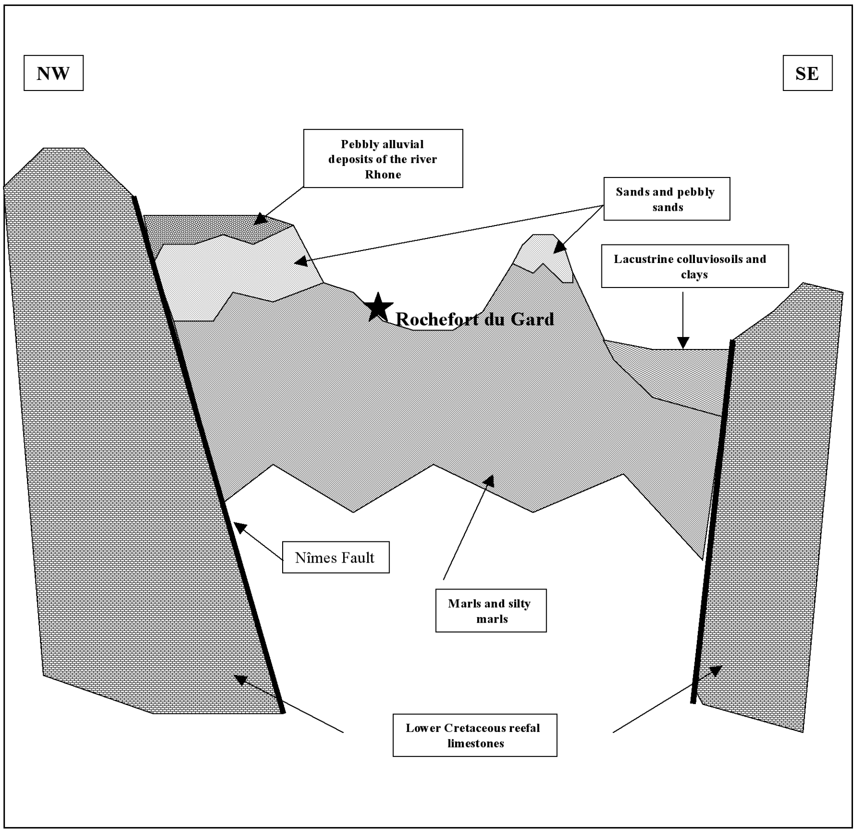

Figure 2 - Schematical geological section across the Pujaut Graben at Rochefort du Gard.

Coupe géologique schématique à travers le graben de Pujaut à Rochefort du Gard.

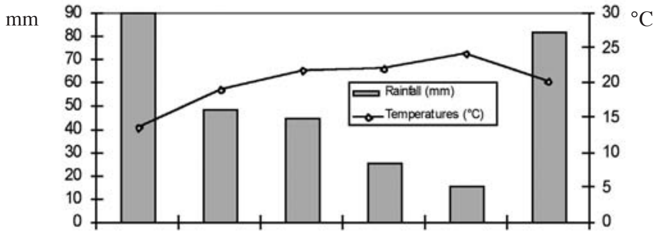

Figure 3 - Monthly rainfall (Rochefort du Gard) and monthly average temperature (Tavel) from April through September 2000.

Précipitations mensuelles (Rochefort du Gard) et temperatures moyennes mensuelles (Tavel) d'avril à septembre 2000.

Rainfall data were available at Rochefort du Gard and were preferred because of the extremely localized nature of the precipitation distribution in Mediterranean climate. Average temperature from April through September was 20.2 °C, which is close to normal values (figure 3). Rainfall was low during the winter 1999 - 2000, but high in April (90 mm, figure 3). July and August were dry, but significant rainfall was registered during September. The total rainfall over the season amounted to about 70 % of the average, indicating an unusually dry vintage.

VI - VINE WATER UPTAKE CONDITIONS

Five measurements of pre-dawn leaf water potential (SCHOLANDER *et al.*, 1965) were taken between June 20 and August 17 to assess vine water status. Each value represents the average of 7 to 10 replicates on different vines. Differences among plots were highest on July 20 (after a period of drought and before 18 mm of rain at the end of July) and on August 17. Because of the role of early water stress in vine development and berry composition (VAN LEEUWEN and SEGUIN, 1994) the data used for the statistical analysis were those collected on July 20 (ψb1).

VII - VINE NITROGEN SUPPLY

Intensity of coloration of leaf blades varies depending on nitrogen supply. This can be quantified with a device called « N-tester » (SPRING and ZUFFEREY, 2000; VAN LEEUWEN *et al.*, 2000), developed by the Norsk Hydro Company (Nanterre, France). Each value represents the average of measurements carried out on 30 leaves. High values indicate a deep green coloration of the leaves, thus a high nitrogen supply (Ntest).

VIII - VINE DEVELOPMENT

On several dates, between the beginning and the end of veraison, the percentage of veraison was estimated on 45 bunches per plot. The percentage of veraison on a plot for a given date was defined as the average of the 45 estimates. Curves were plotted from the progress in veraison; two indexes were then derived and used for the statistical analysis: the percentage of veraison on August 8 (Iver2, end of veraison) and the date for 50 % veraison (Halfver, day of the year).

Shoot growth cessation was evaluated from observations of the apex. On several dates, from June 28 through August 23, 45 apexes were sampled on each plot. A value of « 2 » was attributed to an actively growing apex, « 1 » to an apex whose growth was starting to slow down, « 0 » to a dried apex showing no growing activity. In the field, a value of « 1 » was given to an apex hidden by the folding of the two last established leaves. Two indexes were derived and used for statistical analysis: the percentage of apex value « 0 » on July 20 (Zero1) and an index calculated on August 23 (IApex2) with the formula: Iapex2 = (0*Apex 0 % + 1*Apex 1 % + 2*Apex 2 %).

Exposed leaf area (ELA) was calculated according to MURISIER and ZUFFEREY (1997). Exposed leaf area to fruit ratio (ELA/kg) was calculated using fruit weight measured at harvest (Yield). Theoretical production per hectare (Th_Prod) was calculated using fruit weight per vine and vine density.

Table II - Pre-dawn leaf water potential values measured on July 20, 2000.

Soil depth: D = Deep; S = Shallow.

Valeurs de potentiel hydique foliaire de base mesurées le 20 juillet 2000.

Profondeur du sol : D = profond ; S = superficiel.

Soil type	Plot Code	Soil Depth	Individual (Mpa)	Averages (Mpa)	
Marly soils	M1	D	-0.38	-0.45	-0.49
	M2	D	-0.40		
	M3	S	-0.56		
	Mx1	S	-0.70	-0.56	
	Mx2	D	-0.42		
Deep colluviosoils	C11	D	-0.34	-0.34	-0.34
	C12	D	-0.32		
	C13	D	-0.36		
Sandy soils	RS1	S	-0.40	-0.50	-0.43
	RS2	S	-0.60		
	RSx1	S	-0.38	-0.36	
	RSx2	S	-0.33		
Stony terraces	TX1	D	-0.34	-0.32	-0.32
	TX2	D	-0.29		
Reworked sandy marls	RMS	S	-0.45	-0.45	-0.45

IX - BERRY COMPOSITION

Berry weight and berry anthocyanin content (Method: Institut Technique de la Vigne et du Vin, LAMADON, 1995) were measured three times between veraison and harvest. Berry sugar content was measured concurrently by refractometry and sugar levels at 37 days after 50 % veraison were calculated (identical phenological stage for all plots).

X - STATISTICAL ANALYSIS

Principal component analysis was carried out with Statbox Pro and Microsoft Excel software.

RESULTS

I - VINE WATER UPTAKE CONDITIONS

Vine water uptake conditions are represented by means of pre-dawn vine water potential values measured on July 20 (table II). The deep colluvial soils and soils on the stony terraces were characterized by high pre-dawn leaf water potential, indicating low water stress. Pre-dawn leaf water potential was low on the marly soils, the sandy soils and the reworked sandy marls, indicating high water stress, but intra-group variability was high. Water stress was induced by limited soil depth rather than by a specific soil type. On the soils that can be characterized as shallow (n = 7), average pre-dawn leaf water potential was -0.49 MPa; on the deep soils (n = 8) average pre-dawn leaf water potential was -0.36 Mpa. The difference between pre-dawn leaf water potential on the shallow and the deep soils is significant at $\alpha = 0.05$.

II - VINE NITROGEN SUPPLY

Vine nitrogen supply was estimated from the intensity of the green coloration of the leaf blades, measured with an « N-tester ». Values given are averages of three measurements on 30 blades each, performed the same day, at a date chosen to represent approximately the same phenological state for each plot (table III). Deep green leaves and high nitrogen supply are indicated by high N-tester readings. No clear relationship can be established between soil type and vine nitrogen status, except for the

Table III - Vine nitrogen status assessed by N-Tester readings.

High values indicate non limited nitrogen uptake conditions.

Statut azoté de la vigne, évalué avec un appareil N-Tester.

Les valeurs élevées indiquent une alimentation en azote non limitante.

Soil type	Plot Code	Soil Depth	Individual	Averages	
Marly soils	M1	D	516	462	472
	M2	D	474		
	M3	S	396		
	Mx1	S	486	487	
	Mx2	D	488		
Deep colluviosoils	C11	D	501	494	494
	C12	D	493		
	C13	D	489		
Sandy soils	RS1	S	476	462	474
	RS2	S	448		
	RSx1	S	475	487	
	RSx2	S	498		
Stony terraces	TX1	D	501	440	440
	TX2	D	379		
Reworked sandy marls	RMS	S	478	478	478

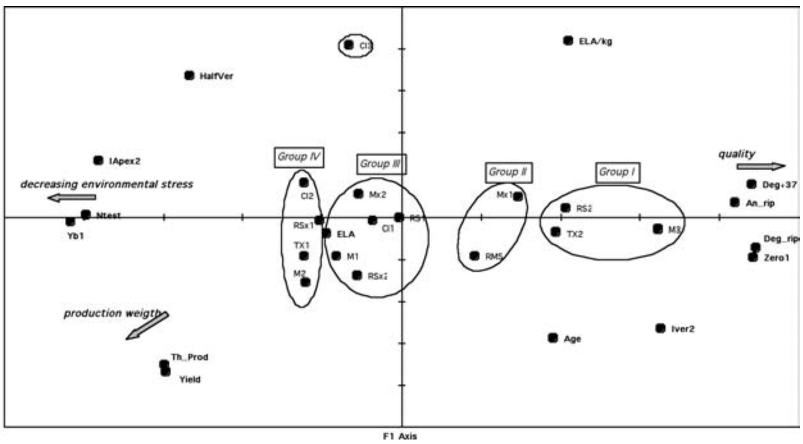

Figure 4 - F1 - F2 mapping of a Principal Component Analysis run with 15 plots as individuals and 14 measured variables.

Plan F1 - F2 d'une Analyse en Composantes Principales réalisée à partir de 14 variables mesurées sur 15 parcelles.

Table IV - Plots grouped by grape potential, according to the Principal Component Analysis of figure 4.

Parcelles regroupées suivant le potentiel qualitatif de leurs raisins à partir de l'Analyse en Composantes Principales de la figure 4.

	Soil type	Plot Code	Soil depth
Group 1	*Towards the highest possible berry potential*		
	Marly soil	M3	Shallow
	Sandy soil	RS2	Shallow
	Stony terrace	TX2	Deep
Group 2	*Towards high berry potential*		
	Marly soil with stones	Mx1	Shallow
	Reworked sandy marl	RMS	Shallow
Group 3	*Towards average berry potential*		
	Sandy soil	RS1	Shallow
	Deep colluvial soil	Cl1	Deep
	Sandy soil	RSx2	Shallow
	Marly soil with stones	Mx2	Deep
	Marly soil	M1	Deep
Group 4	*Towards low berry potential*		
	Sandy soil	RSx1	Shallow
	Marly soil	M2	Deep
	Deep colluvial soil	Cl2	Deep
	Stony terrace	TX1	Deep

deep colluviosoils, which seem to provide high nitrogen supply. Considerable intra-group variability can partly be attributed to soil depth (case of the marly soils). On average, deep soils (n = 8) show a tendency to higher N-tester readings (480) than shallow soils (n = 7, average N-tester reading = 465), although the difference is not statistically significant. The soils on the stony Villafranchian terraces, represented by two plots, induce extreme N-tester readings, very high in one case, very low in the other. Although nitrogen fertilization is, in general, very low in high quality producing French vineyards (under 30 kg/ha/year), this parameter was not controlled in this study and might have interfered with the results. Growers can negatively affect grape quality by too high nitrogen fertilization.

III - VINE BEHAVIOR AND BERRY COMPOSITION

A principal component analysis was run on 14 variables measured on the 15 plots. The variables are those described in « Materials and methods » and include indicators of vine water status, vine nitrogen supply, vine age, precociousness, vine development, production and berry constitution. The mapping F1-F2 (figure 4) explains 69 % of the variability. The F1 axis, representing 48 % of the variability, is constructed by quality parameters to the right (berry sugar and anthocyanin content) and vine water and nitrogen supply to the left. These groups of parameters are inversely correlated: low water and nitrogen supply leads to high berry potential. Early growth slackening (high values of « Zero1 ») and low produc-

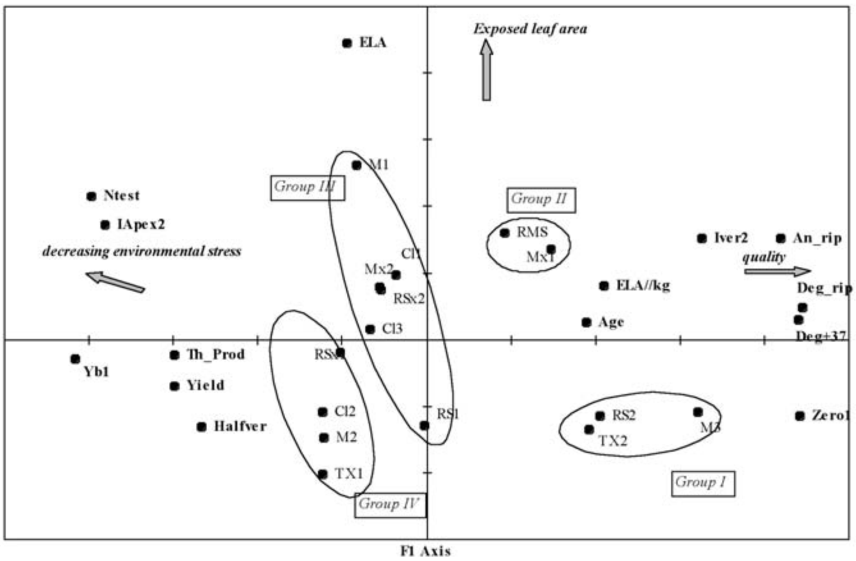

Figure 5 - F1 - F3 mapping of a Principal Component Analysis run with 15 plots as individuals and 14 measured variables.

Plan F1 - F3 d'une Analyse en Composantes Principales réalisée à partir de 14 variables mesurées sur 15 parcelles.

Table V - Precocity of veraison and shoot growth cessation, yield, leaf area, vine age and grape composition on the 15 experimental plots.

Précocité de la véraison et de l'arrêt de croissance, rendement, surface foliaire, âge de la vigne et constitution du raisin sur les 15 parcelles expérimentales.

Soil type	Plot code	Soil depth	Halfver (DOY)	Iver2 (%)	Zero1 (%)	IApex2 (%)	Yield (kg/vine)	Th_Prod (kg/ha)	ELA (m^2/m^2)	ELA/kg (m^2/kg)	Deg_rip (%)	Deg+37 (%)	An_rip (g/kg)	Age (years)
Marly soil	M1	Deep	210	90.6	0	71	4.683	18013	1.188	0.66	13.6	13.2	0.816	29
Marly soil	M2	Deep	213	68.4	8	33	5.940	25011	2.203	0.88	13.4	12.2	0.701	32
Marly soil	M3	Shallow	208	97.2	34	0	2.317	7608	1.077	1.42	15.2	15.0	1.192	34
Marly soil	Mx1	Shallow	206	100.0	10	9	1.693	6773	1.178	1.74	14.0	13.2	0.940	24
Marly soil	Mx2	Deep	211	80.6	0	76	2.683	11157	1.331	1.19	13.2	13.1	0.764	29
Deep colluvial soil	C11	Deep	211	87.8	0	67	2.987	11532	1.273	1.10	13.9	12.8	0.856	34
Deep colluvial soil	C12	Deep	214	70.6	0	62	3.430	12704	1.156	0.91	13.0	12.7	0.727	22
Deep colluvial soil	C13	Deep	219	59.1	0	71	1.172	4652	1.375	2.96	13.3	13.3	0.780	16
Sandy soil	RS1	Shallow	210	88.9	12	7	2.837	12280	1.268	1.03	12.9	12.8	0.819	21
Sandy soil	RS2	Shallow	209	95.0	24	4	1.787	7147	1.052	1.47	14.5	14.1	0.879	33
Sandy soil	RSx1	Shallow	210	83.4	0	49	4.203	16403	1.245	0.76	13.1	12.7	0.669	14
Sandy soil	RSx2	Shallow	208	92.8	0	47	4.517	18067	1.369	0.76	13.6	13.2	0.767	31
Stony terrace	TX1	Deep	210	84.7	4	47	5.407	14418	1.022	0.71	13.2	12.5	0.423	28
Stony terrace	TX2	Deep	207	96.7	20	20	3.359	12700	1.124	1.19	15.0	13.9	0.748	34
Reworked sandy marls	RMS	Shallow	206	96.1	24	22	3.370	12036	1.277	1.06	14.0	13.3	0.945	29

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tion (low values of « Th_Prod » and « Yield ») are positively correlated to high quality.

The F3 axis (figure 5, representing 10.5 % of the total variability) is mainly constructed by the exposed leaf area parameter (« ELA »). In this mapping, the F1 axis remains nearly unmodified in comparison with the F1-F2 mapping.

On both the F1-F2 and the F1-F3 mapping, four groups of plots can be identified (table IV). The various soil types are scattered among the four groups. However, in groups one and two, which are characterized by high berry potential, most soils are shallow, and in groups three and four (low berry potential) most soils are deep. Plot C13 (deep colluvial soil) is apart from these four groups. It is strongly correlated to the F2 axis. On axis F1, it is situated towards low quality.

DISCUSSION

This study confirms the role of water and nitrogen supply in grape quality potential. Previous research in the Bordeaux area has shown that high quality potential in red grapes is related to the existence of environmental stress, either a limited water supply or moderate nitrogen deficiency (CHONÉ *et al*., 2001, VAN LEEUWEN *et al*., 2004). Here, this relationship is confirmed for *Vitis vinifera* L. cv. Grenache noir in Mediterranean conditions, in a dry vintage. The intensity of the water stress is correlated to high berry anthocyanin content ($R^2 = 0.37$, significant at $\alpha = 0.05$). Low N-tester readings, showing limited nitrogen supply, are correlated to high grape sugar ($R^2 = 0.62$, significant at $\alpha = 0.001$).

It should be noticed that even in dry Mediterranean conditions the soils with the lowest water holding capacity performed particularly well. On plot Mx1, which faced severe water stress (pre-dawn leaf water potential = -0.70 Mpa on July 20 and -0.91 Mpa on August 17), grape quality was not depreciated. This confirmed results obtained by KOUNDOURAS *et al*. (1999) on *Vitis vinifera* L. cv. Saint-Georges in dry Mediterranean conditions in Nemea (Greece). It should be noted however that on plot Mx1 the yield was low (6.8 Tons/ha); it is likely that at a higher production level the intensity of the water stress would have negatively affected grape quality.

Limited water and nitrogen supply are related to early shoot growth cessation (correlation ψb1 - Iapex2: $R^2 = 0.37$, significant at $\alpha = 0.01$; correlation Ntest - Iapex2: $R^2 = 0.40$, significant at $\alpha = 0.01$). Intensity of water stress is also correlated to production level (correlation ψb1 - Yield: $R^2 = 0.29$, significant at $\alpha = 0.05$), but nitrogen supply is not (correlation Ntest - Yield: $R^2 = 0.07$, n.s.). Environmental stress enhances grape quality, probably because it limits vine vigor. It further anticipates growth cessation and limits yield.

No relationship could be established in this study between grape quality potential and a particular soil type, except for the deep colluvial soils; on these soils, grapes are systematically characterized by low sugar and anthocyanin content (table V, figure 4). This was true even in the case of plot C13 (deep colluviosol), where yield was reduced by a spring frost. However, a clear relationship exists between soil depth and grape quality potential: high potential is almost always associated with shallow soils. The only exception was plot TX2, a deep soil producing high quality grapes. This plot was characterized by very limited nitrogen uptake. The behavior of this plot in 2000 confirms that one factor limiting vine vigor (in this case low nitrogen availability) is enough to ensure high grape potential.

In this study, no relationship could be established between the age of the vines and grape quality potential. The range in vine age (14 to 34 years) was probably not great enough to produce such an effect. Similarly, precociousness of veraison was not linked to grape quality.

CONCLUSION

The aim of this study was to assess the influence of the soil on vine behavior and berry composition in dry Mediterranean conditions. Fifteen plots were studied on five soil types of the Southern Côtes du Rhône. Vine water and nitrogen status were monitored. Vine growth, yield and berry composition at ripeness were measured. Vine growth and yield were related to high vine water and nitrogen status. High sugar and anthocyanin content in the berries were related to low vine water and / or nitrogen status. Though there was no relation between grape quality and a specific soil type, there was a clear relationship between soil depth and grape quality. Shallow soils provided little water and nitrogen to the vines; this limited vine growth and yield and promoted grape quality potential.

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