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Influence of some "Terroir Viticole" Factors on Quantity and Quality of Grapes

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Abstract

High wine quality can be only achieved with an appropriate vineyard management. However a lot of other factors will play also a decisive role: climate, soil, topography, micro-climate, human factors genetics, environmental and technological factors a.s.o.. Since years exists a discussion about the influence of the pedo-climatic system on wine quality. It can be summarized as "terroir". The purpose of this study is to delimit some micro-areas in the Cotnari region which warrant the production of a certain type of wine, a quality. This is the first study attempting to characterize the "terroir concept" for Cotnari vineyards. It is applied on the behavior of traditional varieties of wine grapes grown in the region: 'Grasa de Cotnari', 'Feteasca alba', 'Francusa' and 'Tamaioasa romaneasca'. In a first run it was found out that the two "Natural territorial base unit" exert a distinct influence yield, sugar content and must acidity. This system has to be improved with further research in order to judge the vineyards in that region more precisely. The results of this study can be used to determine with precision crop micro-areas and parcel level that will produce quality wines.

Keywords: terroir viticole, natural territorial base units, grapevine varieties, Cotnari

Introduction

The microclimate (canopy temperature, leaf and grape expostion) of vineyards may be positively or negatively influenced by macroclimate (geographical latitude and altitude, topography, relief) and mesoclimate (temperature, wind, precipitation, exposition, realtive humudity). Microclimate conditions may be also subject viticulture techniques but the influence of soil may be of minor importance. Changes induced by the type of soil may act on a medium sized scale as well as the mineralogical composition of the substrate (clay, marn, löess, sand etc.) (Morlat, 1983; Smart and Robinson, 1991).

During the last two to three decades an increasing awareness could be observed for wine quality and the guiding factors. Very early producers as well as consumers introduced for this complex the term „terroir", which can also found since that time in popular and scientific papers.

The term „terroir" dates back to the ancient world. Ancient farmers used it in order to describe a place where to go and obtain a mysterious advice called „d'humeur terrestre" (Martin, 2002). In France, from medieval times to the twentieth century, many interpreters report about wine quality in relation to the its production area. For the first time this term appears 1694 in the „Dictionnaire de l`Académie Françoise, dedie au Roy" and is defined as folow: «*TERROIR. s.m. Terre considérée par rapport à l'agriculture. Terroir fertile, bon terroir, mauvais terroir ... on dit que Du vin sent le terroir, qu'il a un goût de terroir, pour dire qu'il a une certaine odeur, un certain goût qui vient de la qualité du terroir*.»

As a concept of wide comprehension "terroir" is very diverse and embodies differing concepts: historical, socio-economic, cultural, climatic, geological, pedological. A lot of work has addressed the notion "terroir" in all aspects, but there exists currently no scientific based concept unit according the definitions (Vaudour, 2003). In France "terroir" is defined by INAO (body which certifies AOC regions) as a connection between a geographical area, a plant or animal species, tradition and specific technology of production. This imprints features on the product, which cannot reproduced in another place. All these features will produce the so-called "typicity"; recognized by consumers as the following conditions are met:

-the geographical territory has its own characteristics;

-interaction of the plant (animal) and the crop (production) is very close;

-the tradition and technology of production is met by producers.

The concept of "terroir" includes two categories of factors: on one hand side natural factors (climate, soil, rock) as a fundamental axis and on the other hand side human factors that can vary in their intensity and may affect production in different ways (Morlat, 1983; 2005). A scheme of the interacting components of a "terroir" is shown in Fig. 1.

A vineyard or subunits (depending on the area that is occupied) can be considered as a series of smaller areas called elementary areas (Morlat, 2005). These basic areas vary in the following components:

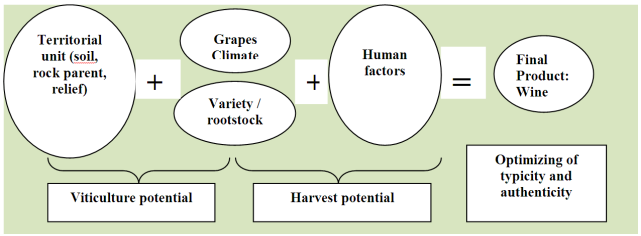

Fig. 1. Viticulture "terroir": factor chain and the resulting product (Salette *et al*., 1998)

-nature of the pedologic substrate (clay, marn, limestone, löess, sand etc.);

-type and subtype of land formed on a pedologic substrate, depending on the climate;

-local climate, as a result of the type of interaction (subtype) between edaphic factors and the secondary factors (topography, exposition, altitude, type of vegetation, presence of river water etc.).

The response of the vine quantity and quality of the final products obtained in each elementary area results in a subsystem consisting of the elementary area and the produced wine. Such a system is called natural territorial base unit (Unitate Naturalle Terroir de Base). Identified on a specific part of land, natural territorial unit base (TUB) is a surface of variable size (from several ha, a few tens or even hundreds of meters), which keeps the viticulture ecosystem species in a stable regime.

Materials and methods

The investigations were done in the Cotnari vineyards. The following varieties are planted: 'Grasa de Cotnari', 'Feteasca alba', 'Francusa' and 'Tamaioasa romaneasca'. Productivity and production is characterized by yield (kg/vine), sugar content (g/l) and total acidity (as g H_2SO_4/l). Wines are characterized with a common wine analysis.

All varieties are grafted on Berlandieri x Riparia Kober 5 BB. Planting distances are 3,0 x 1,2 m, semi-high training, bilateral cordon and average bud load of 40-50 buds/plant. Soils are normally tilled according the local conditions.

Two territorial units were choosen for the investigation:

TUB 1- Cambic Chernozems with secondary calcium carbonate accumulation and

TUB 2- Calcarious Regosols with loamy texture formed on loessoide deposits.

Chemical characterization of the soils was done according the methods of the Romanian Soil Science Society, as well as the description of the soil profiles.

Results and discussion

The geographical position (47°13` and 47°35`) of the Cotnari vineyards correspond to other famous European vineyards like Tokay (Hungary), Rheingau (Germany), Champagne (France) belonging to the cool climate regions. In Romania it is included in the wine area of the Peri carpathian plateaux. The N-E Moldova plateau region is situated in a transition zone between the two main subunits of the North: Suceava Plateau in the N-W plains and the Moldova plateau to the N-E.

Therefore, the Cotnari vineyard has a geographically favorable „transition position" between the two European bio-pedo-climatic provinces: the temperate, moderately continental, central European forest zone (Suceava shelf) and the temperate, continental, of Eastern Europe, predominantly steppe zone (Moldova Plain). In the Cotnari vineyard four centers were delimited with the following shares: Cotnari 30-40%, 10-20% Harlau, Cucuteni and Frumusica, each with 5-10% of the total surface (Fig. 2).

The relief of Cotnari vineyard is very fragmented, with a general orientation to S-E, with some famous parts: Catalina Hill (395 m), Stanca Hill (360 m), Voda' s Hill (347 m) Piciorul Racului (337 m), Liteanca (330 m). The aver-

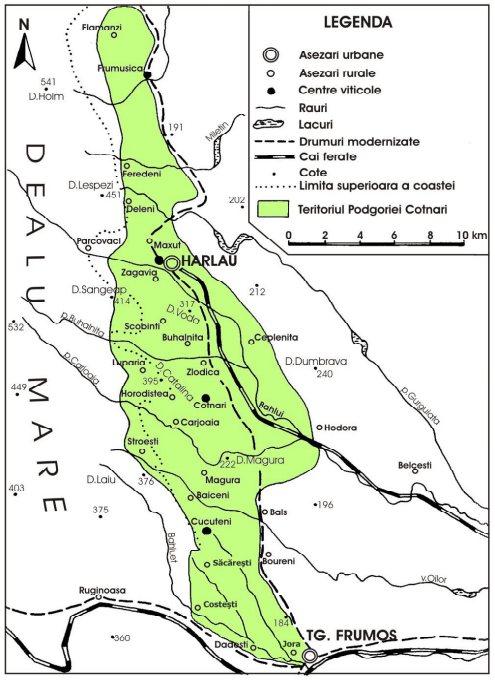

Fig. 2. The vineyard Cotnari (Cotea *et al*., 2006)

age slope does not exceed 20°. The geological substrate is „Sarmatiene", within which are two different stories: one in the lower floor whose altutide is around 250-260 m, composed of marle and clay and an upper floor consisting of limestone, marle, sand oolithe, sandstone, and fossile-rich elements (Fig. 3). The area is drained by the Bahlui River and its tributaries, which are gradually moving to S-E.

Marl and calcareous oolithe are the substrate for soil formation in Cotnari area. Main soil types are (a) degraded chernozome, rich in limestone (50%), (b) podzolic soils (18%), (c) skeletal soils (12%), and calcareous rendzina (11%) (Cotea *et al*., 2006). The presence of limestone and

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Fig. 3. Issues on pedogenetic horizons and lithologic substrate of the Cotnari vineyard

sandstone fragments in the soil is very favorable for grapevine growing.

Soils can be characterized chemically as follows: weak-moderately alkaline (pH 7.2-8.5), base saturation 84-95%, $CaCO_3$ content up to 16%. Humus content is low-medium (0.8-3.6%), assimilable P-content varies between 7-108 ppm, assimilable K-content 160-400 ppm. Microelements: soluble B 0.25-3.69 ppm, mobile Mn 2.24-8.60 ppm, mobile Zn 3.42-4.99 ppm, total Cu 11.82-237.31 ppm, total Co 2.1-15.6 ppm. Highest microelement contents are found in the layer of 0-25 cm. The soils of Great Hill, Voda' s Hill-Buhalnita and Carjoaia Hill are best supplied with microelements (Tardea *et al*., 1981).

As described earlier Cotnari is situated in a climatic transition zone with cool climate elements in the Suceava Plateau and more continental in the Moldova Plain. In the region "foehn" may occur when cold air fronts from North meet hot air fronts coming from East. The average annual temperature reaches approximately 9.1-9.3°C; the amount of active temperature (°C>10) exceeds 3200°C each year, sunshine hours are more than 2100 and 340-390 mm rainfall/growing season (Barbu *et al*., 2002). In addition, the autumns are long, warm and dry, which favors the maturation of grapes, infection with *B. cinerea* is common. Consequently, the grapes accumulate large quantities of sugars (250-300 g/l), which allows the production of the renowned Cotnari wines.

In the farm Rotila which belongs to SC Cotnari SA two territorial unit soil are located: TUB 1-Cambic chernozems with secondary $CaCO_3$ accumulation and TUB 2-Calcareous regosols with loamy texture, formed on loessoide deposits (Fig. 3).

Description of TUB 1 (Tab. 1)

Ap 0-22 cm; clay, very dense, gray brown (10YR 2.5/2) wet, yellowish brown closed (10YR 4/4) dry. Structure: weak medium-grained, moderately developed; wet, friable when wet, moderate cohesive dry, loose, weak plastic and adhesive; macro pores medium-rare, few worms; common roots, gradual transition form right.

Amd1 22-33 cm clay, grayish brown very close (10YR 3/2) wet, brown closed yellow (10YR 4/4) dry; average globular structure weak-moderately developed; moist; friable when wet, moderately dry cohesive, compact weak, weak plastic and adhesive; macro pores medium-rare, few worms; common roots, gradual transition, the shape right.

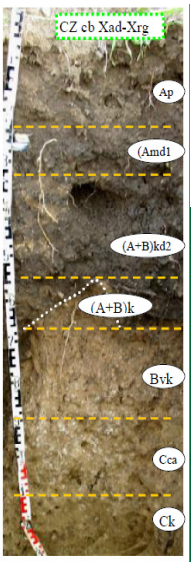
(A+B) kd2 33-54 cm clay, very close gray brown (10YR 3/2) wet, brown (10YR 4/3) dry; spots rare yellowish brown (10YR 3/4) structure average glomerular developed low-moderate, moist, friable when wet, moderately

Tab. 1. Chemical characteristics of Cambic Chernozems with secondary calcium carbonate accumulation (farm Rotila of S.C. Cotnari S.A.)

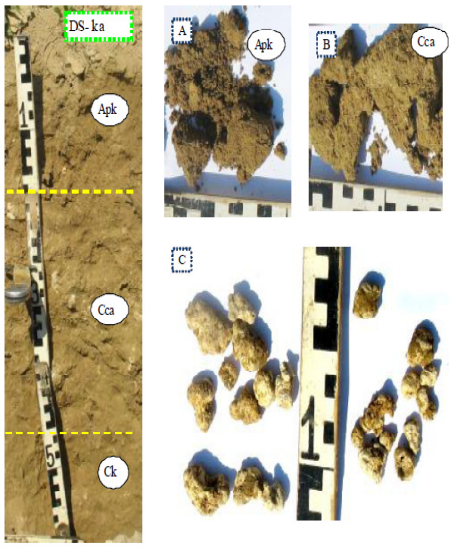
Depth (cm)	Pedogenetic horizon	$CaCO_3$ (%)	pH	C org. (%)	Nt. (%)	C/N	Humus (%)	P (ppm.)	K (ppm.)
0-22	Ap		7.0	2.5	0.220	11.4	4.28	14	263
22-33	Amd1		7.1	2.3	0.203	11.3	4.03	13	257
33-68	A+B		7.3	1.5	0.135	11.1	2.63	11	232
68-90	Bvk	1.88	7.5	1.03	0.090	11.4	1.77	15	234
90-110	Cca	9.57	7.6	0.65	0.060	10.8	1.12	18	196
110-140	CK	18.11	7.9	0.4	0.039	10.3	0.71	15	190

Tab. 2. Chemical characteristics of Calcaric Regosols with loamy texture from the farm Rotila of S.C. Cotnari S.A.

Depth (cm)	Pedogenetic horizon	$CaCO_3$ (%)	pH	C org. (%)	Nt. (%)	C/N	Humus (%)	P (ppm.)	K (ppm.)
0-18	Ap	4.7	7.9	1.05	0.089	11.7	1.80	29	283
11-42	Cca	14.9	8.6	0.6	0.021	9.60	1.02	7	177
42-60	Ck	7.8	8.3		0.125	10.10		4	153



TUB 1-Cambic Chernozems with secondary $CaCO_3$ accumulation



TUB 2-Calcaric Regosols with loamy texture located near the terrace slope; (A-glomerular structure, poorly developed layer, processed Apk; B-material soil with massive structure and efflorescence of calcium carbonate, C-$CaCO_3$ concretion)

Fig. 4. The two natural "terroir" base units TUB 1 and TUB 2

dry cohesive, compact weak, weak plastic and adhesive; macro pores medium-rare, few worms; very weak effervescence; common roots; passage clear, straight shape.

(A+B) k 54-68 cm, medium clay; closed brown (10YR 3/3) wet, yellowish brown to yellowish brown closed (10YR 5-4/4) dry, yellowish brown stains (10YR 3/4) when wet, yellowish brown (10YR 5/4) dry; polyedric structure subangular average low-and moderate-developed local columnoid prismatic structure; wet, friable when wet, moderately dry cohesive, compact weak, weak plastic and adhesive; macro pores medium-rare, few worms; common roots; passage clear form right.

Bvk 68-90 cm clay medium, yellowish brown (10YR 3/4) in wet, yellowish brown (10YR 5/4) dry; columnoid prismatic structure; wet, friable when wet, moderately dry cohesive; weak compact; weak plastic and adhesive; macro pores medium-rare, few worms; very weak effervescence; common roots; passage clear, straight shape.

Cca 90-110 cm clay medium, yellowish brown (10YR 5/6) wet, brown yellow (10YR 6/6) dry; structure columnoid prismatic average moist, friable when wet, moderately dry cohesive, compact weak, weak plastic and adhesive; macro pores medium-rare, few worms; weak effervescence; common roots; passage clear, straight shape.

Ck 110-140 cm, medium clay, yellowish brown (10YR 6/6) wet, very pale brown (10YR 7/4) dry, massive structure, moist, friable when wet, moderately dry cohesive; weak compact; weak plastic and adhesive; effervesce strong, very common efflorescence of calcium carbonate.

Description of TUB 2 (Tab. 2)

Ap 0-18 cm clayey; dark brown (10YR 3/2); glomerular structure poorly developed, poorly purified in the interval between the row of vines and terrace slope, moderate compacted after tractor passes; moderate effervescence with HCl, common roots, a clear passage.

Cca 18-42 cm, clayey, yellowish brown (10YR 5/5), stained, efflorescence and pseudomycelia white, normal $CaCO_3$ content, massive structure, roots very seldom, local traces of vine roots with an uneven distribution; $CaCO_3$ concretions, irregular distribution of loess; effervesce.

Tab. 3. Characteristics of the vineyard eco-climate Cotnari

Bioclimatics indices	Cotnari Vineyard (altitude 350 m)		
	Period 1896-1955	Period 1999-2009	Difference
Average annual temperature (°C)	9.0	9.3	+0.3
Average monthly minimum air temperature (°C)	-23.3	-24.1	+0.8
Average monthly maximum air temperature (°C)	34.6	35.9	+1.3
Temperature sum (> 0°C)	3508	3685	+177
Active temperature sum (>10°C)	3103	3216	+113
Useful thermal balance (°C)	1320	1376	+56
Sunshine (h)	1438.5	1489.5	+51
Annual rainfall (mm)	525	510.2	-14.8
Rainfall during growing season (mm)	409.4	332.1	-77.3
Relative air humidity (%)	73	70	-3
Length of vegetation period (days)	180	184	+4
Heliothermal product (index Branas)	1.89	2.05	+0.16
Hydrothermal coefficient	1.31	1.03	-0.28
Bioclimatic index	6.05	7.84	+1.79
Oeno-climate index wine capacity (index Teodorescu, 1987)	4382.1	4623.4	+241.3
Huglin index	1685	1891	+206

Tab. 4. Average grape yield (kg/vine), sugar content (g/l) and total acidity of must (g/l H_2SO_4) for the varieties of the Cotnari vineyard

TUB	Soil type	Variety	Characteristics	2007	2008	2009	Average
1	Cambic chernozems with secondary calcium carbonate accumulation	'Grasa de Cotnari'	yield	2.7	3.2	2.9	2.93
			sugar	235	240	229	234.67
			acidity	5.5	5.2	5.6	5.43
		'Feteasca alba'	yield	3.5	3.9	4.2	3.87
			sugar	202	212	198	204
			acidity	4.8	4.5	4.9	4.73
		'Francusa'	yield	4.8	4.3	4.4	4.5
			sugar	199	195	192	195.33
			acidity	5.9	6.0	5.8	5.9
		'Tamaioasa romaneasca'	yield	2.6	2.9	3.0	2.83
			sugar	225	219	230	224.67
			acidity	4.6	4.8	4.5	4.63
2	Calcareous regosols with loamy texture	'Grasa de Cotnari'	yield	2.5	2.8	2.6	2.63
			sugar	240	247	238	241.67
			acidity	5.2	5.0	5.4	5.2
		'Feteasca alba'	yield	3.1	3.4	3.7	3.4
			sugar	210	219	206	211.67
			acidity	4.4	4.2	4.6	4.4
		'Francusa'	yield	3.7	3.9	4.0	3.86
			sugar	200	203	201	201.33
			acidity	5.4	5.5	5.4	5.43
		'Tamaioasa romaneasca'	yield	2.3	2.6	2.4	2.43
			sugar	230	222	238	230
			acidity	4.4	4.5	4.3	4.4

Ck 42-60; clayey; brown yellow (10YR 6/6), stained, efflorescence and $CaCO_3$ concretions, solid structure; few worms, strong very strong effervescence.

Soil is composed of horizons formed by soil tillage (approx. 18 cm). Below C horizon accumulation of $CaCO_3$. Color bright, tilled layer shows weak supply with humus and nutrients. Die-back of trunks is caused by gradual and continuous accumulation of $CaCO_3$. In addition it was favored both by low nutrients reserves which reduced frost resistance and accumulation of secondary $CaCO_3$.

Climate characteristics were observed over a period of 60 years (1896-1955) and a 10 years period from 1999-2009. The comparison of both periods allows an estimation if there exist differences and if they exert an influence on vine productivity and quality (Tab. 3).

It can be seen that in general the temperature regime increased and the rainfall was reduced.

On soil with a higher fertility status (TUB 1) grapevines show a higher productivity: the yield per vine is higher compared to TUB 2 (Tab. 4).

Analyzing the data in Tab. 4 show that grape yields were higher on cambic chernozems compared to those obtained in soils with lower fertility (Calcareous regosols with loamy texture. Average yield of 'Tamaioasa romaneasca' was 2,83 kg/vine and 4,5 kg/vine for 'Francusa' (TUB 1). On TUB 2, with a lower water storage capacity, average yield levels are lower: 2,63 kg/vine for 'Grasa de Cotnari', 3,4 kg/vine for 'Feteasca alba', 3,86 kg/vine for 'Francusa' and 2,43 kg/vine for 'Tamaioasa romaneasca'.

Tab. 5. Composition of wines made from the different varieties in the Cotnari vineyard

TUB	Soil type	Variety	Alcohol % vol	Acidity g/l	Sugar free extract g/l	pH	Glycerol g/l
1	Cambic chernozems with secon-dary $CaCO_3$ accumulation	'Grasa de Cotnari'	12.75	5.10	24.16	3.55	18.72
		'Feteasca alba'	11.40	4.15	22.71	3.46	15.87
		'Francusa'	11.36	5.62	18.42	3.64	13.30
		'Tamaioasa romaneasca'	11.80	4.25	23.13	3.47	17.25
2	Calcareous regosols with loamy texture	'Grasa de Cotnari'	13.08	4.91	26.22	3.49	19.21
		'Feteasca alba'	12.00	4.12	23.17	3.30	16.23
		'Francusa'	11.87	5.10	19.26	3.70	14.40
		'Tamaioasa romaneasca'	12.35	4.08	23.99	3.50	18.25

The average sugar content in musts was higher on TUB 2. This may be a result of the yield/quality relationship. If it is also dependant on stress which may be exerted from the soil is matter of further research. Largest sugar accumulation is observed in Grasa Cotnari with 241,7 g/l, which will give wines of the category DOC-CT or DOC-CIB.

Highest must acidity is found in TUB 1 with 'Francusa' (5.9 g/l H_2SO_4) and Grasa Cotnari with 5.43 g/l H_2SO_4. In general all varieties had higher must acidities on TUB 1 compared to TUB 2.

The composition of the wines produced from the different varieties and TUB's is listed in Tab. 5. Wines from TUB 2 have highest alcohol contents; had also highest sugar contents in berries. Sugar free extract is highest in 'Grasa de Cotnari'.

With exception of the variety 'Francusa' glycerol content exceeds 15 g/l. On TUB 2 the glycerol content is higher in all wines; this may indicate that the infection of the berries with B. cinerea during the autumnal ripening phase is favored by the specific terroir.

Conclusions

The Cotnari region which is famous for its unique wines was characterized by two "Natural Terriroial Base Units" (TUB). The four characteristic varieties 'Grasa de Cotnari', 'Feteasca alba', 'Francusa' and 'Tamaioasa romaneasca' were cultivated on both TUB's. Pedoclimatice conditions characterizing the Cotnari vineyards are described and they indicate that a successful production is possible in order to achieve high quality wines. However, weather conditions of the last ten years show that rainfall in the growing season is reduced and temperatures are increasing; drought risk is a new phenomenon.

Soil type has a significant influence on the productivity of the different varieties. This may be true for the more productive variety 'Francusa'. High-quality varieties, like 'Grasa de Cotnari' or 'Tamaioasa romaneasca' show only a reduced reaction.

A careful delineation of the basic territorial units may be helpful in order to figure out which wine type can be produced. For example, high quality wines with great finesse (DOC-CIB) can be achieved on TUBs with loamy texture, high $CaCO_3$ content and medium fertility (Calcareous regosol), while DOC-CMD or DOC-CT types can be produced on Cambic chernozems.

Climate change may have a great impact on viticulture production and in consequence also on the future wine types. Therefore is it necessary to improve the knowledge about the "terroir" and the interaction between pedo-climatic elements and quality wine production. In that case it may be possible to overcome adverse influences in viticulture production and save the specific qualities of Cotnari.

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