Vine-growing zoning of the municipal territories of Ronda and Arriate (Malaga, Spain), « Sierras de Málaga » registered appellation of origin mark

Zonage viticole des terroirs municipaux de Ronda et Arriate (Malaga, Espagne), appellation d'origine « Sierras de Málaga »

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Abstract: The aim of this communication is the study of the Ronda and Arriate municipal territories environment in order to define and to establish the main physical factors in relation to vine-growing land use. The vine-growing zoning proposed is based on geopedological and climatic features.
The methodology comprises the raster to vector convertion of the lythologic units of Ronda ad Arriate based on the Geology Maps from the IGME (1990), and the adaptation of the geomorphologic information of the Environment Council (Junta de Andalucía) and that from the elevation, orientation and slope maps of Ronda y Arriate.
Diverse field surveys made it possible the lithologic, geomorphologic and pedological examination, and to cartography the different Units enclosed in the territory; as well as the sampling, the analysis and description of the characteristic environments and an attempt of the diverse environments cartographic delimitation with the aid of an intense satellite images photointerpretation.
Climatic parameters and the most relevant bioclimatic indexes were determined by using dates from weather stations placed in the study area and nearby; these parameters and indexes were spatially distributed afterwards.
The use of the ESRI program ArcView (GIS), version 3.2, made it possible the handling of the basic georeferenced cartography to superpose the different layers and the territory zoning according to the vine-growing land use in areas which were defined by the association of previously established values.
The zones A, B and C, with different ranges of altitude (<650 m over sea level, 650-850 m and > 850 m, respectively), comprise typical geomorphologic units, with characteristic soil Groups in different lithologic and climatic environments.
The cartography elaborated (scale map 1:50000) made it possible to give very useful information to the different zones generated by the territory zoning; to study in depth the characteristic of the soil Groups which appear in different geomorphologic and climatic sectors on different lithologic materials; and to evaluate the existing vine-growing plots at present.
Three ranks of soils are proposed, each one enclosing three main soil Groups, according to the vine-growing diminishing aptitude: SV1 (LV, CL and $FL_{(B)}$); SV2 (RG, $VR_{(C)}$ and $FL_{(A)}$) and SV3 ($VR_{(B)}$, $VR_{(A)}$ and LP). (A) indicates in < 650 m altitude zones; (B) in 650-850 m altitude zones and (C) in > 850 m altitude.

Key words: Ronda, Arriate, lithology, soils, zoning

Introduction

In the province of Malaga (Spain) the wine activity dates back from very ancient; near Ronda, in the surroundings of the Roman city *Ocinipo* the grapevine was cultivated. Recently in the municipalities of Ronda and Arriate they have been established more than 85 ha of grapevine.
Cabernet-sauvignon and Tempranillo occupy 50 % of the total surface of the vineyard; Chardonnay and Syrah, 20 %; the rest, the varieties Cabernet franc, Merlot, Sauvignon blanc, Pinot noir, Garnacha and Petit Verdot. Every vine-grower possesses plots with 3 or 4 vine varieties; 15 of them have also cellar, and a similar number, only vineyards. Practically all the wines that are elaborated belong to the RAOM « Sierras de Malaga ».

There are bibliographical information about geology (IGME, 1990), soils (LUCDEME, 1995) and climate (RODRÍGUEZ, 1975; FUNDACION BANESTO, 1994; HIDALGO, 1993) of the region (*Serranía de Ronda*). There are absent studies of physical factors for the vine-growing zoning. This communication describes the methodology and the results for the geopedological and climatic zoning of Ronda and Arriate.

Material and Methods

Samples of soil, subsoil and of the geology of municipal territories of Ronda and Arriate. The analytical methods used were the official methods of the MAPA (1994); and the determined parameters are those in the tables 1 to 6. The profile classification of soils was done according to WRBSR (ISSS, ISRIC, FAO, 1998). The map of soils was elaborated by means of itineraries of field, description and analysis of samples together with the interpretation of satellite orthophotographs of the area. The geological map is an adjustment and raster to vector convertion of the lithological terms of the geological Map of Spain, scale 1:50000 (IGME, 1990). The geomorphological units were adapted of the corresponding Map for Andalusia of the Council of Environment (Junta de Andalucia). For the treatment of the georeferenced images and data the program ArcView 3.2 (ESRI) was used.

Results and discussion

The first phase of the study allowed to divide the territory in three zones (A, B, C).
The *A zone*, of altitude <650 m over sea level and slope <6%, includes important areas of flood and plains (alluvial-coluvial); as well as hills and soft hills. The materials are constituted by sands with gravels and conglomerates; silts and clays with limes silt of Quaternary and Tertiary Post-orogenics formations of the Ronda Basin. Clays with blocks are also present at the NW of this zone (*Tectosedimentary Formation*, Post burdigaliense) (IGME, 1990).
The *B zone* -which encloses the previous zone- has an altitude from 650 to 850 m and slopes between 6 and 18 %. This zone includes extensive areas of a platform with inclined tabular slope and flat reliefs constituted by biocalcarenites from the Ronda Basin (*Setenil Formation*, Messiniense - Tortoniense); and hills and hillocks with marly clays and slimes (*La Mina Formation*) or with marls, red clays and sandstones (*Aljibe Formation* and *sandy Flysch Formation*).
Finally, the *C zone* (altitude > 850 m over sea level and slope> 18%) is of calcaric crests, karstified platforms, mountains and structural hills with materials which belong to the *Subbetico Interno*. These are represented in the S by a layer of dark limestone and marls; in the oriental centre for limestones with bulky or massive stratification; and in areas of the NE, E and SE for nodulous limestones (end of the Jurassic). The latter having materials from the Cretaceous Superior which at the NE and SE of the zone appear as wide surfaces of red and white calcareus marls (« *red layers* » of biomicrite nature). In some areas at the NE, centre and SE a Flysch of reddish brown coloured sandstones and multicoloured clays appear covering the marls (IGME, 1990).
These characteristics are reflected in the main pedological systems. The map of soils (scale 1:50000) elaborated includes 26 soil cartographic units (SCU): 2 consociations (calcaric Regosols (ca RG) and litic Leptosols (li LP)); 7 associations of soils; and 17 associations of dominant soils with inclusions of other soils.
With the soils of the consociations together with the dominant ones of the associations it has been elaborated the 1:1000000 Map of Soil Groups: Fluvisols (FL), Regosols (RG), Leptosols (LP), Vertisols (VR) Calcisols (CL) and Luvisols (LV).
Of the whole of soils of the original map of soils (scale 1:50000), only some units are represented in the vine-growing plots. The horizons, depths and chemical and textural characteristics of profiles of soils are shown in the tables 1 to 6.

Table 1 - Horizons, depth (cm) and analytical results of « Sanguijuela Baja » eutric Fluvisol (eu FL).

Horizon	Depth (cm)	pH		CCE	O.M.	N	C/N	Sand	Silt	Clay
		H_2O	KCl		g Kg^{-1}			%		
Ap	0-50	8.54	7.60	70.1	17.6	1.35	10.2	58.8	14.0	27.2
B	50-125	8.70	7.51	6.3	7.8	0.65	6.9	59.4	12.4	28.2
C	> 125	8.75	7.53	22.8	5.3	0.51	6.1	57.8	17.5	24.7
Horizon	**Depth (cm)**	**K**	**Ca**	**Mg**	**Na**	**CEC**	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**
		ppm ass.					$cmol_c$ Kg^{-1}			
Ap	0-50	228	2529	156	19	14.3	0.58	12.62	1.28	0.08
B	50-125	77	3197	98	13	17.0	0.19	15.95	0.81	0.06
C	> 125	56	2489	101	14	13.6	0.14	12.42	0.83	0.06

Table 2 - Horizons, depth (cm) and analytical results of Cº San Juan calcaric Regosol (ca RG).

Horizon	Depth (cm)	pH		CCE	O.M.	N	C/N	Sand	Silt	Clay
		H_2O	KCl		g Kg^{-1}			%		
Ap	0-30	8.20	7.78	187.9	29.4	1.97	8.7	29.9	30.3	39.8
C_1	30-90	8.50	7.60	325.8	4.4	0.41	6.1	17.5	38.8	43.7
C_2	> 90	8.48	7.76	305.1	5.2	0.44	6.8	16.3	38.9	43.8
Horizon	**Depth (cm)**	**K**	**Ca**	**Mg**	**Na**	**CEC**	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**
		ppm ass.					$cmol_c$ Kg^{-1}			
Ap	0-30	840	3760	213	19	22.6	2.15	18.76	1.75	0.08
C_1	30-90	278	3838	160	17	20.2	0.71	18.16	1.32	0.07
C_2	>90	262	3390	150	24	19.6	0.67	16.92	1.24	0.10

Table 3 - Horizons, depth (cm) and analytical results of « El Chantre » calcic Vertisols (c VR).

Horizon	Depth (cm)	pH		CCE	O.M.	N	C/N	Sand	Silt	Clay
		H_2O	KCl		g Kg^{-1}			%		
Ap	0-20	8.33	7.63	282.6	20.4	0.91	11.8	20.7	26.3	53.0
Bss	20-90	8.55	7.62	270.0	11.7	0.68	10.0	21.8	23.7	54.5
C	> 90	8.62	7.68	272.4	7.1	0.58	7.1	20.7	21.0	58.3
Horizon	**Depth (cm)**	**K**	**Ca**	**Mg**	**Na**	**CEC**	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**
		ppm ass.					$cmol_c$ Kg^{-1}			
Ap	0-20	381	2291	725	131	23.2	0.97	14.93	6.49	0.57
Bss	20-90	180	2586	922	169	23.5	0.75	14.01	7.65	0.74
C	> 90									

Table 4 - Horizons, depth (cm) and analytical results of « Los Descalzos, Los Molinos and Cerro del Águila » calcaric Calcisols (ca CL).

Horizon	Depth (cm)	pH		CCE	O.M.	N	C/N	Sand	Silt	Clay
		H_2O	KCl		g Kg^{-1}			%		
Ap	0-20	8.51	7.73	271	15.5	0.60	15.0	39.0	30.0	31.0
C_1Ap	20-60	8.62	7.66	279	7.2	0.55	7.4	37.0	32.1	30.9
C_2	> 60	8.74	7.68	337	3.8	0.53	4.1	40.0	35.0	25.0
Horizon	**Depth (cm)**	**K**	**Ca**	**Mg**	**Na**	**CEC**	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**
		ppm ass.					$cmol_c$ Kg^{-1}			
Ap	0-20	241	1857	115	15	14.2	1.84	11.83	1.00	0.09
C_1Ap	20-60	113	2101	106	11	11.7	0.75	10.00	0.81	0.04
C_2	> 60									

Table 5 - Horizons, depth (cm) and analytical results of « Chinchilla, Baco y San Jacinto » cromic Luvisols (cr LV).

Horizon	Depth (cm)	pH H_2O	pH KCl	CCE	O.M. g Kg^{-1}	N	C/N	Sand	Silt %	Clay
ApB	0-30	8.37	7.57	0	15.7	0.96	9.5	52.9	15.1	32.0
B	30-60	8.36	7.31	0	5.4	0.60	5.1	52.3	13.7	34.0
Bk	> 60	8.71	7.73	334	3.6	0.40	5.1	67.4	8.3	24.3
Horizon	**Depth (cm)**	**K**	**Ca**	**Mg**	**Na**	**CEC**	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**
		ppm ass.				$cmol_c\ Kg^{-1}$				
ApB	0-30	167	3062	88	38	20.2	0.42	18.2	0.72	0.16
B	30-60	115	4290	98	15	23.0	0.29	21.41	0.81	0.07
Bk	> 60	48	3164	88	6	17.3	0.12	15.79	0.72	0.03

Table 6 - Horizons, depth (cm) and analytical results of « El Calero and El Olivar » profundic-rhodic Luvisols (pf-ro LV).

Horizon	Depth (cm)	pH H_2O	pH KCl	CCE	O.M. g Kg^{-1}	N	C/N	Sand	Silt %	Clay
Ap	0-30	6.72	6.00	0	15.6	0.80	11.2	40.6	30.9	28.5
B_1	30-60	7.59	6.31	0	11.3	0.61	10.6	33.7	30.3	36.0
B_2	60-120	7.32	5.95	0	6.3	0.46	3.7	44.3	28.1	27.6
B_3	120-200	7.68	6.25	0	3.7	0.47	4.5	40.3	33.2	26.5
Bk	> 200	8.92	7.46	166	5.3	0.50	6.2	41.0	32.5	26.5
Horizon	**Depth (cm)**	**K**	**Ca**	**Mg**	**Na**	**CEC**	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**
		ppm ass.				$cmol_c\ Kg^{-1}$				
Ap	0-30	134	2066	120	13	11.8	0.34	10.31	0.99	0.05
B_1	30-60	87	2392	159	10	14.1	0.22	11.93	1.31	0.05
B_2	60-120	64	2395	165	9	15.9	0.16	11.95	1.36	0.04
B_3	120-200	35	3459	183	9	19.0	0.09	17.36	1.51	0.04
Bk	> 200									

The climatic information indicates that January is the coldest month with monthly mean temperature between 3,4 and 8,6 ºC, followed by February (8,8ºC) and March (10,7ºC). These temperatures reach 25ºC in July and August; and they descend from September until January.

The annual mean rainfall is close to 860 mm. Two periods exist with important rainfalls; one of winter-spring and the other from the second half of September until the end of autumn. During the summer the rainfalls practically are nonexistent. The table 7 shows the mean values of some bioclimatic indexes for the area; and those according to HIDALGO (1993) for the vine-growing Andalusian region.

Table 7 - Mean value of some bioclimatic indexes for the Ronda-Arriate (R-A) territory in comparison to those of HIDALGO (1993) for the Andalusian vine-growing region (RVA).

	Ita	Ite	PH	IH	P	IBC	IBc
R-A	4483	2083	5.2	2181	2018	9.2	8.6
RVA	5684	2597	10.5	2711	2029	17.3	20.4

The isohyets and the isotherms were projected on the map of altitude. The rainiest areas are those at the NW sector with altitude higher than 750 m; the rainfalls descend progressively towards the centre-W, the least rainy and hottest. The N, NE and NW sectors and those at the S have rainfall and annual mean temperature values between those at the NW and centre-NE.

It results of great interest the division of the territory of Ronda and Arriate in three zones (A, B, C). In the first one the Quaternary and Tertiary materials of the Ronda Basin represent the 49,30 % of the surface; the red and green marls, clays with blocks, the « *red layers* » and sandstones (Flysch) and marls account for 37,86 %, and diverse materials for 13,84 %. Vertisols, Regosols and Leptosols; and Luvisols in a minor extension form the soil cover. The uses are agricultural (cereals, leguminous and horticultural) and forest (holm oaks, cork oaks, bushes). Vine-growing plots do not exist.

In the *B zone*, the biocalcarenites account for the 35,9 % of the surface, and clays and silts for the 18,77 %. This is, approximately 50 % of the surface are constituted by Miocen materials from the Ronda Basin. The biomicrites ("red layers") accounts for the 10.53 % and the rest, diverse materials. The first two formations are important besides because they contain diagnostic materials of soils with a wide capacity of use (holm oaks, olive grove, cereals, oleaginous…) They are Luvisols, Regosols, Calcisols and Vertisols; in a minor extension Leptosols and Fluvisols. Except for Leptosols, all the vine-growing plots are on soils of the remaining mentioned groups.

Finally, the *C zone* belongs structurally and lithologically to the *Subbetico Interno*. The "*red layers*", the stratified and nodulous limestones account for the 53 % of the surface. It is a high, abrupt zone with cold and humid climate in which the most representative soils are litic and eutric Leptsols and calcaric Regosols; others soils are Calcisols and Cambisols. The uses are forests (holm oaks, cork oaks, gall oaks, bushes) and meadows for cattle. Vine-growing plots do not exist.

Conclusion

There are certain relations among the physical factors of the environment (altitude, slope, geomorphology and lithology) that advise to differentiate in the territory three zones (A, B and C). The 1:50000 map of soils together with the support of the detailed study (1:25000) of the areas in which they exist vine-growing plots, allowed the vine-growing zoning of the territory.
The different sectors of the zones A, B and C can be divided in subzones or areas taking the cartographic units of soils over the lithologics ones together with the rainfall and mean annual temperatures isolines as a base for the map of zoning.
Finally, all the used information allows the arrangement of the Soil Groups in three ranks according to their vine-growing diminishing aptitude: SV1 (LV, CL and $FL_{(B)}$); SV2 (RG, $VR_{(C)}$, $FL_{(A)}$); and SV3 ($VR_{(B)}$; $VR_{(A)}$ and LP). The last two ones of scanty or void aptitude.

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