A MULTIDISCIPLINARY APPROACH TO GRAPEVINE ZONING G.I.S. TECHNOLOGY BASED: AN EXAMPLE OF THERMAL DATA ELABORATION

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Abstract
A large number of studies have been devoted to the quantitative assessment of the climate effects upon the quality of vineyards in many different climatic contexts. Generally the grapevine vocation of a territory may be studied through mono or multidisciplinary approaches.
Viticultural zoning approaches permit to increase our knowledge on the complex reality among grapevine and environment interactions, in order to evaluate the potentiality of an area necessary to obtain a data level of grape quality.
In this study we will to suggest a multidisciplinary approach to zoning, G.I.S.-technology-based. The presented method permit possible combinations of "information layers", for example: climatic data (air temperature, rainfalls, wind direction and velocity, global and direct radiation), with grapevine informations (thermal needs necessary to obtain a data maturation level of the grape, daily potential evapotranspiration), or soil informations (slope, geology, topography), in order to analyse their correlations. According the method, is possible to present the obtained results clearly on builted computer maps. The method may consider different preliminary approaches to the data elaboration (maked with a specific computer program) on the basis of the type of data (for example: a climatic factor) considered.
In the present contribute an example of thermal data elaboration (air temperature) combined with the information derived from the heat requirements of a group of 22 grapevines is presented, on the basis of an experience conducted in an area of the province of Benevento (Campania region, southern Italy).
In the proposed example, the method combine the said thermal informations with the Amerine–Winkler bioclimatic index, permitting to obtain a subdivision of the considered territory in five areas, according their thermal suitability (from less than 1200 to 2000 degree-days).
Through the model it was possible to elaborate a map of the thermal suitability of the considered grapevines, being possible to have an optimal placing of the grapevines in the various zones of the considered territory.

Resume
Un grand nombre d'études ont été consacrées à l'évaluation quantitative des effets de climat sur la qualité des vignes, dans différents contextes climatiques. Généralement, la vocation viticole d'un terroire peut être étudiée par des approches mono ou multidisciplinaires. Les approches viticoles de zonage, laissent augmenter notre connaissance sur la complexe réalité des interactions de la vigne avec l'environnement, afin d'évaluer le niveau potentiel de qualité du raisin.
Dans cette étude nous suggérons une approche multidisciplinaire au zonage, basée sur la tecnologie G.I.S. (system geographique informatisé). La méthode permet nombreuse combinaisons possibles des informations, par exemple: des données climatiques (température de l'air, précipitations, direction du vent, rayonnement global et direct), avec les informations de la vigne (les exigences de chaleur nécessaires pour obtenir un niveau de maturation du raisin, de l'evapotranspiration potentiel quotidien), ou les informations de sol (pente, géologie, topographie), afin d'analyser leurs corrélations.

La méthode peut considérer différentes approches préliminaires à l'élaboration de données sur la base du type de données (par exemple: un facteur climatique) considéré. Dans le présent contribuez un exemple de l'élaboration thermique de données (température de l'air), combinée avec l'information dérivée des besoins de chaleur d'un groupe de 22 varietees est présenté, sur la base d'une expérience conduite dans un secteur de la province de Bénévent (Campania, Italie méridionale).
Dans l'exemple proposé, lesdites informations thermiques avec l'index bio-climatique d'Amerine-Winkler, laissant obtenir une subdivision du terroir considéré dans cinq secteurs, accordant leur convenance thermique (de moins de 1200 à 2000 degrées-jours). Selon le modèle, il était possible d'élaborer une carte de la convenance thermique des varietees considérées, étant possible d'avoir un placement optimal des vignes dans les diverses zones du terroire considéré.

INTRODUCTION

A large number of viticultural aspects may be analysed through multidisciplinary approaches, as grapevine zoning; for example through such studies it's possible to evaluate the effects of different factors on the quality expression of the grapevine varieties.
The most frequently factors studied through multidisciplinary approaches that can influence the qualitative expression of the grapevine are climate (Hunter & Bonnardot, 2002; Scaglione *et* Al., 2003 a); soil aspects (Nadal *et* Al., 2002 ; Scaglione *et* Al.,,2002, 2003 b), topography (Sotes & Gomez-Miguel, 2002); degustation (Ubigli *et* Al., 2002). In this research we'd like to show an example of thermal data elaboration (air temperature) combining the information derived from the heat requirements of a group of 22 grapevines with the thermal availability of an area (Telesina valley) situated in the province of Benevento (Campania region, southern Italy).

MATERIAL AND METHODS

The multidisciplinary approach to grapevine zoning utilised in the present study was GIS technology based.
In order to suggest the optimal area to obtain the best adaptability, the heat requirement of 22 varieties, all-autochthon of the Campania region, was calculated (Table 1). To determine the thermal need of such cultivars, their phenological stages were monitored, considering the period from the bud sprout to the ripening (18-20°Brix), having as reference the phenological stages described by Baillod *et* Baggiolini (1993) and Intrieri *et* Al., (1987), while the heat requirement of the cultivars was calculated having as reference the model proposed by Amerine and Winkler (1944), calculating the active thermal summation of each cultivar.
The thermal data (maximum and minimum temperature) were taken from 12 stations (from regional offices of the CEPICA of Telese Terme (Benevento province) and from the "Dipartimento per il Servizio Tecnico Nazionale - Servizio Idrografico e Mareografico of the Provveditorato di Napoli", during the 13-year-period from 1984 to 1996. Exclusively daily data, both taken from the stations inside and outside the area were utilised in the model, in order to have an homogeneous database and to produce, as final product, an "average year of the daily data" for each station. The missing values were re-builted through linear regression methods.

WINKLER'S INDEX

366 information layers or matrixes of the thermal data (a matrix per day of the year) in order to calculate the Winkler's index for the Telesina Valley, were builted.
To apply the Winkler's index to each point of the territory, two conditions was satisfied:
1) Time distribution of the data:
a database of the said averaged thermal data, according their time distribution, was created (as previously said, it was necessary to have all the thermal daily data from 1984 to 1986);
2) Spatial distribution of the thermal values:
it was obtained attributing, to each point of the Telesina valley, a thermal value (in particular, in our raster, the minimal element of the matrix corresponded to a square of 20 meters x 20 meters);

The spatial distribution of the data have been obtained through regression functions among elevation and daily data of mid temperature applied to a DEM (Digital Elevation Model) in this way, it was correlated the elevation of each point of the territory to a value of temperature.

RESULTS

The thermal need of the tested grapevines (Table 1), ranged from 1600-1700 to 1950-2050 degree-days (DD).

The application of the Winkler's index to the Telesina valley, permitted to have a subdivision of the territory in five areas, according their thermal availability; this ranged from less than 1200 to about 1900 DD (Figure 1).

Because an excessive thermal need, nine cultivars resulted not available with the area (Table 1).

Cerreto, Aglianico, Agostinella di C., Bianco Antico and Ripolo resulted mostly suitable (more than 35%) with the Telesina valley (Table 2) ; some cultivars as Coda di Cavallo, Fiano, Forastera, Sciascinoso and Trebbiano showed a low suitability (less than 15%), (Figure 3 a, b; Table 2). Catalanesca, Falanghina, Malvasia bianca di Candia (Figure 2), Piedirosso, showed an intermediate level of suitability that ranged from 17 to 28% (Table 2).

CONCLUSIONS

The use of the GIS technology for zoning studies represent an interesting method in order to study the effects of different factors on the response of the grapevines in different environments.

In the present study, that analysed the only thermal availability between grapevines and territory, it was possible to suggest the optimal territory for each tested cultivars.

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Table 1 - Thermal needs of the tested grapevines (period '92-2003). Areas evidenced by an asterisk, represent varieties not compatible with the thermal availability of the the Telesina valley.

Grapevines	Place of observ. (province)	Years of observ.	Thermal need (DD)	Range applied to zoning
Aglianico (b)	Avellino, Benevento	'93,'94','95,'96	1804	1754-1854
Agostinella di C. (w)	Salerno	'97, '98, '99	1798	1748-1848
Bianco antico (w)	Salerno	'98,'99,2000	1794	1744-1844
Biancazita (w)*	Salerno	'98,'99,2000	2011	1961-2061
Camputese (w)*	Napoli	2000,‘01,‘02,‘03	1958	1908-2008
Cannamelu (b)*	Napoli	2000,‘01,‘02,‘03	1958	1908-2008
Catalanesca (w)	Salerno	'98,'99,2000	1865	1815-1915
Cerreto (w)	Salerno	'98,'99,2000	1790	1740-1840
Coda di cavallo (w)*	Salerno	'98,'99,2000	1903	1850-1950
Coda di pecora (w)*	Salerno	'98,'99,2000	1946	1896-1996
Falanghina (w)	Salerno	'98,'99,2000	1736	1686-1786
Fiano (w)	Avellino	'93,'94','95,'96	1625	1575-1675
Forastera (w)*	Napoli	2000,‘01,‘02,‘03	1950	1900-2000
Guarnaccia (w)*	Napoli	2000,‘01,‘02,‘03	1980	1930-2030
Malvasia di C. (w)	Benevento	'92,'93	1880	1830-1930
Pepella (w)*	Salerno	'98,'99,2000	1916	1866-1966
Piedirosso (b)	Avellino	'93,'94','95,'96	1700	1650-1750
Ripolo (w)	Salerno	'98,'99,2000	1829	1779-1879
S. Nicola (w)*	Salerno	'98,'99,2000	1952	1902-2002
S. Pietro (w)	Salerno	'98,'99,2000	1896	1846-1946
Sciascinoso (b)	Salerno	'93,'94,'95,'96	1650	1600-1700
Trebbiano tosc. (w)	Benevento	'92,'93	1650	1600-1700

Table 2 – Available territory with the adaptability of the tested cultivars, esteemed with GIS method.

Grapevines	**Potential surface (ha)**	**Potential surface (ha)**
Aglianico (b)*	8109.7	40.32
Agostinella di C. (w)*	7962.3	39.59
Bianco antico (w)	7694.1	38.26
Biancazita (w)	0.0	0.00
Camputese (w)	0.0	0.00
Cannamelu (b)	0.0	0.00
Catalanesca (w)	4859.2	24.16
Cerreto (w)	9460.7	47.04
Coda di cavallo (w)	1305.7	6.49
Coda di pecora (w)	0.0	0.00
Falanghina (w)	5586.6	27.78
Fiano (w)	0.0	0.00
Forastera (w)	1872.4	9.31
Guarnaccia (w)	0.0	0.00
Malvasia di C. (w)	3523.9	17.52
Pepella (w)	0.0	0.00
Piedirosso (b)	4043.5	20.10
Ripolo (w)	7049.2	35.05
S. Nicola (w)	0.0	0.00
S. Pietro (w)	1599.2	7.95
Sciascinoso (b)	2469.6	12.28
Trebbiano tosc. (w)	2469.6	12.28

Figure 1 – GIS layer of the Winkler's index classes; the numbers represent territories characterised by different thermal availability.

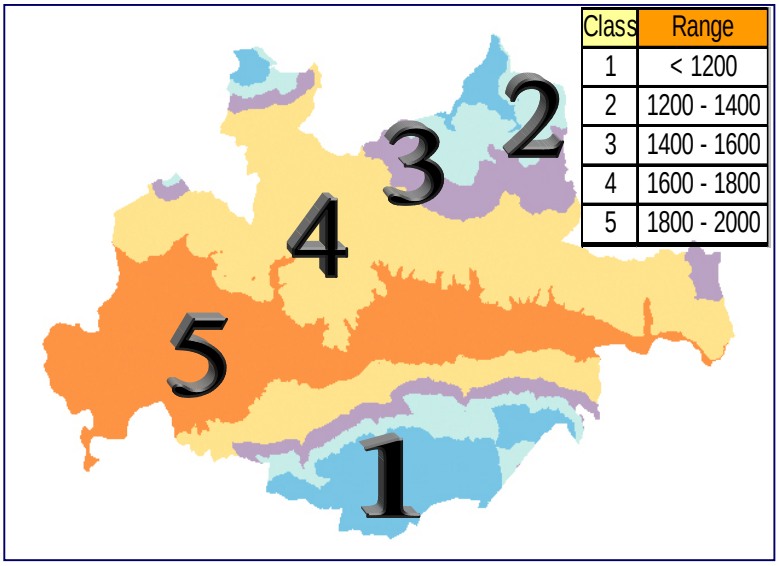

Figure 2 – Territory of the Telesina valley available with an optimal Malvasia bianca di Candia adaptability (the central area "A", characterised by the highest thermal availability, represent the optimal area for the thermal need of the cultivar and is situated in the the most part of the valley).

Figure 3 a b – Territory of the Telesina valley available with an optimal Fiano (a) and Sciascinoso (b) adaptability (the areas indicated with arrows represent the optimal territory for the thermal adaptability of the cultivars: notice how, because of a lower thermal need, on the contrary of the Malvasia bianca di Candia the areas are situated on the hills, around the valley).