CORRELATION BETWEEN GRAPE AND WINE QUALITY, LANDSCAPE DIVERSITY, ON-FIELD BIODIVERSITY, IN DOC GIOIA DEL COLLE, ITALY

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ABSTRACT

Analysis of aerial photos by using GIS tools and on-field surveys of flora are used to characterize territories from an agro-ecological point of view and to assess the level of diversity of given agro-ecosystems. More and more correlations between landscape characteristics, sustainability and quality of agriculture production were speculated. In last three years a study was carried out in the area of DOC "Gioia del Colle" in Apulia, South Italy, in order to characterize and investigate different vineyards and sites and find out possible interactions and correlations between the landscape diversity, the biodiversity of fields and the quality of grapes and wines.

In order to investigate such aspects and achieve a better knowledge of such correlations, 13 vineyards were continuously monitored for qualitative aspects related to grapevine phenology, growing and cultivation as well as for investigating quality of flora and biodiversity of spontaneous plants. A landscape analysis was carried out identifying a buffer area of a radium of 5 km around each of the vineyards and by carrying on the calculation of a set of indicators able to quantify landscape structure, composition and level of connection on the basis of the different shape, areas and cover of the patches.

Statistical correlations between values of the landscape indicators, biodiversity of spontaneous plants of the different representative vineyards and the specific characteristics of the grapes were analyzed. A preliminary better knowledge of the interactions between such elements of the landscape, the sustainability of grapevine cultivation and the quality of the grapes was achieved.

Keywords:

Landscape indicators, quality indicators, biodiversity indicators, multivariate analysis, ancient variety, Primitivo di Gioia.

1 INTRODUCTION

In the frame of a project of cooperation between research institutes and actors belonging to the whole supply chain of wine production of the area of DOC "Gioia del Colle" in Apulia, South Italy, in the last three years a study was carried out, aimed to: 1) characterize 13 different sites inside the area of cultivation of the ancient variety Primitivo di Gioia and to investigate different vineyards and sites and 2) find out possible correlations between the characteristics of the landscape, the quality of grapes and wines and the biodiversity of fields.

In order to investigate collect data about the quality of grapes and wines and the biodiversity of fields, 13 vineyards were continuously monitored for qualitative aspects related to grapevine phenology, growing and cultivation as well as for investigating quality of spontaneous plants.

The ancient variety "Primitivo" arrived in Apulia from the Balcan area, on the other side of the Adriatic sea, thank to Illiri population. It was marketed in all the Med area by Phoenicians and its cultivation spread in different areas of region Apulia. First document about Primitivo is of 1700 when the priest don Francesco Filippo Indelicati, of the churc of Gioia del Colle, described this variety because he noted that although its buds burst late in spring, clusters ripe in August, earlier than other varieties. Around 1820 the area of cultivation of the Primitivo expanded reaching the actual one where the variety settled down definitely. In last thirty years the habit of growing of such variety was modified and often its vineyards replaced by more productive varieties. In more recent years even the cultivation of table-grape started to compete for the same land but presently there is a renewed attention to this ancient variety because of the high quality of wine coming from it. Due to the change in landscape occurred after all these trends we wish to verify differences in the landscape presented by the sub-zones of cultivation and to investigate if these differences are connected to grape quality parameters.

Agriculture is a system of human activities (bio-physical and socio-economic) that finds in the farms the main and initial point of organization and /or aggregation of productive input. The result of the farm organization is reflected at spatial and temporal scale in the field systems, in the cropping systems (farm level) and in the structure of the landscape system.

Landscape analysis can be a good tool for ecological analyses, assessment studies on natural resources and consequently for investigating agroecosystems. The goal of this type of analysis is to provide information on a local and regional scale that can be used in many fields, integrating this new generation instruments with comprehensive databases on social, economic, political, and legal factors enables us to better understand the relationships between the biophysical environment and patterns of human use.

Components and natural processes (bio-physical) and components and anthropogenic processes (socio-economic) interact in determining the different types of landscape. The signs of the landscape, once identified and measured, may become important indicators to express opinions on the current state of management, to inspire design criteria and planning and to find out different kind of correlation between agriculture systems and many structural aspects of agro-ecosystem (fields, crops, animal species bred, infrastructure vegetation, etc..) that produce functional synergistic interactions.

2 MATERIALS AND METHODS

In order to investigate the possible correlation between the landscape and the quality of grapes and wines, 13 vineyards (Table 1) were continuously monitored for qualitative aspects related to grapevine phenology, growing and cultivation as well as for investigating vegetation, quality and structure of flora communities.

The 13 vineyards growing Primitivo di Gioia variety were identified in different municipalities falling in the area of cultivation. Trough a GPS tool, geographical coordinated were recorded and a map set created reporting all information needed to create a map of the vineyards.

In order to carry on our analysis researchers have been working on two main scale of investigation landscape and field level.

Grape quality - When the period of veraison starts , every 7-8 days, samples of grape are collected from each vineyard to analyze the parameters useful to define the ripening curves: sugar content (°Brix), pH, total acidity, Tartaric Acid and Malic Acid. At the harvest substantial samples are taken, in order to determine not only the technologic maturation but also the phenolic one. Total flavonoids, anthocyanins, flavans, proanthocyanins, hydroxycinnamic acids are extracted from skins, seeds and grape juice and analyzed with a spectrophotometer UV-VIS (Di Stefano et al. 1989). Anthocyanins' profile was identified by HPLC-DAD (Di Stefano et al. 1991) and expressed in percentage of total anthocyanins.

Landscape quality - The ecology of the landscape was greatly motivated by the new perspective offered by aerial photography (Turner, 2003), because with this tool, a landscape can be described and studied as a patchwork of separate cards (habitats or ecotopes) (Wiens et al., 1993; Forman and Godron, 1986), each with an area of transition (ecotone) that is adjacent (Gustafson, 1998; Pickett and Cadenasso, 1995). The landscape is a mosaic of ecosystems more or less anthropized, whose fundamental unit or "cell of landscape" is the ecotope (patch) regarded as the smallest homogeneous space identifiable through aerial photography (Naveh and Lieberman,1994). Ecological systems spatially heterogeneous may be represented by categorical maps to quantify the variability of weaving components (Gustafson, 1998). As a consequence the landscape is formed by a mosaic of systems where agriculture has an important role (agro-ecosystems). Having in mind of making a characterization of the landscape related to the area of cultivation of Primitivo di Gioia, the first step was to describe the area and the zones of the area identifying and measuring the different elements of the landscape in a quantitative way. For this purpose different indexes and indicators are available in literature aiming to express or better focus on some specific aspect of the landscape in order to highlight many and different aspects.

Objectives of this research work are: To characterize 13 different areas, differently featured by the landscape elements, all falling in the area of DOC Primitivo di Gioia; To investigate if there is any correlation between the level of diversity of the landscape system around the fields and farms and the quality of the grapes that can be due to different assets of the territory. The first step of this research was to choose a set o f indicators to characterize the area of cultivation of the variety primitive di Gioia and the zones falling inside it. In order to achieve this first step we decided to focus on a wide set of indicators (Table 3) able to focus on aspect related to different categories of land use (Table 2).

Then the landscape analysis was carried on focusing at first on the whole area of cultivation, and then on the landscapes identified by drawing thirteen buffer areas (10 km of radius) around the same fields taken into consideration to investigate the aspects related to the quality of grapes, vegetation and flora.

The performed landscape analysis includes the following steps: 1) Analysis of data coming from official cartography on land use (SIT, 2014); 2) Cross checking of data coming from remote sensing with data recorded in the register of vineyards belonging to the DOC "Primitivo di Gioia del Colle"; 3) Interpretation of orthophoto by using Arc GIS; 4) Cross checking of data coming from photo-interpretation with data from land use (corresponding to CLC III, IV and V); 5) Ground check and field control; 6)Data validation and map editing; 7) Data Export in a database; 8) Calculation of indicators. As above reported at point 5, to complete the analysis, a stage for validation of data coming from data crossing of different cartographies and from photo interpretation is provided and implemented through checks occurring during the open field surveys for flora and vegetation. The analysis in question is an example of how landscapes can be classified to analyzed in function of their heterogeneity

Vegetation and flora quality - The list of species was built up step by step, according to several surveys made for floristic analysis and for an evaluation of the level of biodiversity, before and during each survey. In each vineyard, floristic analysis was carried out at two levels: the field, i.e., strictly the vineyard, and the ecological infrastructures falling inside or at the border of the cultivated area. The analysis was worked out by three different methodologies: (A) surveys in the fields were made according to the Raunkiaer method (Cappelletti 1976), i.e., using a metal frame of 0.25 m and performing a number of launches, that varied (from6 to 10) in function of the uniformity of the vegetation and the chance to detect new species; (B) samplings were performed in the ecological infrastructures according to the method of Braun-Blanquet (Braun-Blanquet, 1932); (C) visual and oriented surveys, based on the experience of the botanist, were made to detect species that could escape with A and B methodologies. The data collected with the first

two methods (A and B) were used to calculate the Shannon–Weaver's indices (Shannon-Weaver, 1949) used in our analysis.

Statistical analysis –Multivariate statistical analysis in this project were performed by CANOCO statistical software (ver. 5; Microcomputer Power, Ithaca NY). In particular: The statistical analysis devoted to compare the different sites and areas in order to find out similarities or dissimilarities, data were analyzed applying Principal Component Analysis (PCA); A second typology of analysis carried on in order to summarize the variability of the quality parameters explained by landscape parameters. Was carried on applying an Redundancy Analysis (RDA).

StatPlus 2009 Professional (ver. 5.8.4; AnalystSoft) was applied to perform analysis of correlation in order to identify pairs of landscape indicator very strictly correlated to simplify the reading of achieved results from PCA.

3 RESULTS AND DISCUSSION

Grape quality - The results of the analysis of the parameters related to the quality of grape are summarized in the Tables n 4 and 5. The value of the quality parameters at harvest time (Table 4, 5) show that some vineyards have good quantity of sugars and contemporary high level of acidity, especially vineyard 9 (Conversano), 25 (Gioia del Colle), 11 (Sammichele di Bari), 16 (Acquaviva). The highest values of sugars were registered about field 30 (Adelfia), that in the meantime has a too high pH and too low acidity, characteristics that can give problems in the management of winemaking. The data coming from samples from fields 24 (Gioia del Colle) and 5 (Santeramo) are interesting, because they present good value in term of acidity and high amount of Malic Acid, this is probably due to climatic condition because Malic Acid decreases when the plant's breathing activity increases. Anthocyanins, related ripening stadium at harvest, are in good amount in 16(Acquaviva), 9(Conversano), 11 and 10 (both falling in Sammichele di Bari). The sample 30 (Adelfia) shows better content of anthocyanins though in condition of advanced ripening.

Landscape quality – In the present landscapes a large amount of original natural habitats has turned into a series of ecotopes, isolated from each other, in an array of different habitats, in the process of fragmentation of habitats (Fahrig, 2003). This process involves the loss of original habitat, and the creation of new types of habitats. Of particular significance in this process of fragmentation, is the creation of more areas of contact between different ecotopes, these are sharp areas of way, or interfaces, where the heterogeneity of physical conditions creates the conditions for a enhancement of biodiversity. From the analysis related to the whole area of cultivation of the DOC Primitivo of Goia we can appreciate that the structure of the landscape is quite diversified with a quite high number of different cover classes (98 if referred to CLC IV); of these about 36 are referred to land use related to natural areas and agriculture. In terms of quality some short indication can be given. The selected indicators (Table 3) refer to the dimension of the patches and the length of the ecotones of the different classes of cover and, on the bases of these value, calculate frequencies of surfaces, number of different patches, length of different kind of ecotones, etc. in order to report a whole detailed picture of the territory. In terms of composition of the landscape the area of primitive show a Land Use Sustainability (SUS) around 21.58%; this is very good value expressing the ration between land cover having low impact use with land cover presenting a higher intensity of use. Important information is given by the Crop Ecotope Composition (CEtopeC) and by the Crop Ecotone Composition (CEtoneC) that refer to the cropping systems, reporting the ratio between herbaceous crops and permanent crops patches; in the case of the whole area the value of CEtopeC is around 1 showing a good balance between these two different cropping systems. The value of the CEtoneC (of around 1.17) shows that ecotones of permanent crops prevail on those of herbaceous crop. Another important information related to the ecological quality of the landscape and to its ability to support natural biodiversity or biodiversity related to production is the Patch Average Area (PAA) that can be calculated either for the classes of cover as a whole, either for each of them; in order to have a good diversity of different patches and ecotones avoiding to incur in a depletion of biodiversity with consequent loss of ecological value due to high level of fragmentation, the value for PAA should present an average dimension between 1 and 5 Hectares (Vereijken, 1997; Vazzana et al., 1997). In the case of the area under investigation the PAA is of 4.99; the value of PAA for natural spaces goes from 2.16 of areas covered with herbaceous, shrubs and arboreous natural plants (ASN), to 8.25 assumed by areas covered with arboreous spontaneous plants (AN); the patches of agricultural areas report value of 7.81 for herbaceous crops and 5.25 for permanent crops (PC), associate crops (CA) report lower scores. In general this landscape reflects a good quality of structural elements. Based on the values of the indicator compared with values reported in literature this landscape (agro-ecomosaic) is well balanced, with great variety of ecotones, so that biological diversity and landscape quality result mutually consolidated (Blondel and Aronson, 1995).

The same kind of analysis was performed for each of the other 13 landscapes, indicator set was applied to all of them (60 landscape parameters include those related to urban areas). With the aim of comparing the different areas in order to find out similarities or dissimilarities, a first Principal Component Analysis (PCA) was performed including 43 indicators (data were analyzed with CANOCO 5; the PCA and allowed to explain 87.95% of variance in two axes. The different landscape grouped in two main groups, the first group includes areas belonging to Gioia del Colle and Conversano municipality (fields 4, 9a, 9b, 15, 25) and the other includes areas around fields 10a, 10b, 11,16, 29, 30 from Sammichele, Adelfia and Acquaviva municipality, very close to this group the field 24 falling in Gioia was positioned in the graph too; the area related to field 5 of Santeramo municipality fits the diagram alone in a distant position. The landscape of the area of Primitivo di Gioia is somehow very homogeneous. Landscape vary in a gradual way going from East to West and from North to South. Santeramo (and field 5) are located in a distant site in respect to the other areas; the place has different balance even in terms of cropping systems with prevailing herbaceous crops and

fields of slight larger dimensions. The variability of the landscape was quite well represented. The 43 environmental indicators showed to be very strictly correlated, therefore we performed a statistical analysis of correlation and we excluded from the analysis the pairs ones showing the higher degree of correlation (over 65%). We were so able to identify the main characteristics influencing similarities and/or dissimilarity in our landscapes (Figures 1and 2). The main variation is explained by Axis 1, this means that the landscapes mainly differentiates because of the group of indicators related to the CE cover typology. In particular the richness (number) of patches (RR CE) and the Patch Density (PD CE) and Ecotone Intensity (EI CE) characterize the areas around fields 16 (Acquaviva), 10a, 10b, 11 (Sammichele); the last three field are characterized by a high PD in all the cover. Fields 24, 15 and 25 (Gioia del Colle) present a higher Patch Average Area (PAA CE), Richness Area (RA CE) and Ecotone Lenght (EL CE). This is even in agreement with trend of Crop Ecotope Composition (CEtopeC) and of the Crop Ecotone Composition(CEtoneC). Site around 9a,9b, 4 present an intermediate position.

Referring to the **Permanent crops** (PC) cover class the a high number of patches (RR PC) characterize the landscape of Adelfia municipality (areas related to fields 30 and 29) and in some measure even Acquaviva (field 16 already mentioned), which are geographically very close; higher dimension of CP patches (PAA CP), presence (RA CP) and Ecotone lenght (EL CP) are more related to the area of Conversano (9a, 9b); Santeramo with its different landscape results characterized by CP in terms of higher ecotone intensity (EI CP) and Patch Density (PD CP).

Herbaceous natural areas (EN) are more present in the Santeramo landscape (RA EN and RR EN) (field 5) and arboreous natural areas (AN) better characterize the landscape of Gioia del Colle (EL AN, RA AN and RR AN) with fields 15,24 and 25.

The Axis 2 is characterized by the presence of **Water Course**s (LunCor Id). Actually there are not rivers in Apulia, bu we have ephemeral seasonal water that characterize the whole Region Apulia that run from highlands to the sea. These are like “blades” and have a peculiar microclimate the influence the surrounding landscape. From an ecological point of view they host a very rich flora and fauna. Such typology of cover characterize the landscape around vineyards 39, 30 (Adelfia) and 16 (Acquaviva).

On the base of the results coming from the analysis of the qualitative aspect of grape production a PCA was performed. Results showed the following graph in Figure 3. Score scaling is focused on quality parameter scores (standardized). There are two types of scores in this plot. The arrows representing each quality parameter that point in the direction of the steepest increase of the values for corresponding parameter. The angle between the different arrows (alpha) indicates the sign of the correlation between the quality parameters: the approximated correlation is positive when the angle is sharp and negative when the angle is larger than 90 degrees. The length of the arrow is a measure of fit for the quality parameter. The length of each arrow is the multiple correlation of that quality parameter with the ordination axes. Therefore the arrows explain the functional correlation between the quality parameters. The fields are represented by the small circles: the distance between the symbols approximates the dissimilarity of their quality parameter values as measured by their Euclidean distance. This means that in general some area are more correlated to some quality parameters. There is no a unique parameter able to express quality. The following step of our work was aimed to summarize the variability of the quality parameters explained by landscape parameters. This is a very important point because it correlates the characteristics of a given landscape to quality parameters. We applied an Redundancy Analysis (RDA) taking into consideration the 24 indicators used to characterize the landscapes and the 14 quality parameters. The result explained a wide amount of variability as it can seen from the graphs reported in Figure 4a and 4b reporting the result of the two step of the analysis.

Vegetation and quality of flora - In the course of these first year of research focused on Primitivo di Gioia vineyards, surveys of vegetation and spontaneous flora were carried out in order to identify pattern of the flora community that characterize these areas. The span time of the project was too short to achieve a complete census of the flora species, mainly because of the habit of farmers to cultivate the soil eliminating spontaneous plants they consider just “weeds”. Nevertheless thanks to our sampling activities it was possible to calculate some indexes describing the diversity of the flora related to the vineyards. The average values of H’ indexes for the period of surveys are reported in Table 6. In the course of the statistic analysis aimed to identify common elements among the different landscapes (Figure 2) we included the average values achieved by the Index of Shannon (H’) in the vineyards (H'^{vign}) as an landscape variable and we observed that the vector corresponding to H’ is very close to the indicator of Ecotone Intensity of Areas covered with arboreous spontaneous plants (EI AN) and present the same distance from the Relative Richness number of permanent crops (RR CP) and from Crop Ecotope Composition (CEtopeC) and Agricultural Ecotone Composition (CEtoneC). The position of fields in respect to the vector H’ is in function of the score achieved by the vineyards falling in the area. In general the degree of biodiversity in agro-ecosystems depends on four main characteristics of the agro-ecosystem (Southwood and Way, 1970): a) the diversity of vegetation within and around the agro-ecosystem; b) the permanence of the various crops within the agro-ecosystem; c) the intensity of management; d) the extent of the isolation of the agro-ecosystem from natural vegetation. On the base of this first landscape analysis it was possible to measure the extent of three of the four point just mentioned, more surveys and analysis are needed in order to have an idea of the impact of cultivation of vineyards on the structure of spontaneous plant community inside and around these field.

4 CONCLUSIONS

The structure of the landscape of the area of cultivation of Primitivo di Gioia is quite homogeneous as can be seen by the Figure n 2. The quality of the landscape on the base of important indicators that summarize some ecological aspects (SUS, CEtopeC, CEtoneC, PAA,) is good and in line with the possibility for a sustainable management of agriculture and of vineyard.

In the Mediterranean, the development of ecosystems was intimately connected with human social systems for so long that the current situation, as indicated by signs of the landscape, in many cases reflects the organization imposed by rural communities more or less autonomous. In the history, the local population gave origin to agroecomosaics well balanced, with great variety of ecotones, so that biological diversity and landscape quality result mutually consolidated (Blondel and Aronson, 1995). In such cultural and ecological context the ancient variety Primitivo di Gioia settled down centuries ago and spread in the area of cultivation. The results of the analysis of the quality parameters related to characteristics of the different landscapes around the fields show complex relationships between the structure of the territory and the quality of grape. There is no a unique parameter able to describe the quality of grape for wine production. From this first preliminary analysis the whole areas is able to support a good quality of production especially for this long time adapted variety.

The value of the quality parameters at harvest time change every years, but repeated surveys can show that qualitative characteristics are repeatedly present in some situations having some landscape characteristics. From these first preliminary results a first correspondence with some indicators was found but the surveys have to be repeated year after year in order to be able to individuate a trend able to highlight the effect of microclimatic conditions, always present in larger areas, that can influence on grape quality and create a strong territorial link with production.

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TABLES

Table 1: list of field under survey and characteristics of vineyard plants

Field ID	Owners / Farms	Municipality	Training systems	Age of plant	Altitude (m)	Densità impianto ceppi/ha
16	Chiaromonte Nicola - Chiaromonte	Acquaviva	*Alberello*	60	288	7500
29	Gargano Angelo	Adelfia	*Alberello*	40	170	6600
30	Pirolo Costantino	Adelfia	Wire trellis	10	180	3900
9a	Pugliese - Coppi	Conversano	Wire trellis	10	307	3400
9b	Pugliese - Coppi	Conversano	Wire trellis	10	307	4100
15	Annio Marianna - Pietraventosa	Gioia del Colle	Wire trellis	10	373	2556,25
24	Colacicco - Lippolis	Gioia del Colle	Wire trellis	10	395	
4	Filippo Cassano - Polvanera	Gioia del Colle	Wire trellis	10	365	4200
25	Plantamura Mariangela	Gioia del Colle	Wire trellis	10	280	4500
11	Pastore Bovio Marina	Sammichele di Bari	Wire trellis	10	284	4100
10a	Pastore Bovio Sergio	Sammichele di Bari	Wire trellis	10	276	4132
10b	Pastore Bovio Sergio	Sammichele di Bari	Wire trellis	10	276	4132
5	Giovanni Zullo - Tenuta Viglione	Santeramo in Colle	Wire trellis	10	385	4200

Table 2: Categories or classes of land cover

Macro categories	Description
MA	Urban areas
EN	Areas covered with herbaceous spontaneous plants
AN	Areas covered with arboreous spontaneous plants
ASN	natural areas covered with herbaceous shrubs arboreous plants
W	Water (wetlands, inner waters, rivers, channels,...)
SW	Areas with salt water (salt wetlands, marshes, marine coastal areas,..)
CP	Permanent crops
CE	Herbaceous crops
CA	Associated crops

Table 3: Set of the indicators selected for the landscape analysis

Indicators of Compositions	Relative Richness number (RR)	Turner et al. 2001
	Relative Richness Area(RA)	Turner et al. 2001
	Land Use Sustainability (LUS)	
	Crop Ecotope Composition (CEtopeC)	
Indicators of Fragmentation	Patch Average Area (PAA)	Elkie et. al.,1999; Saura e Martinez-Millan, 2001;McCarigal et. al.,2002; Caporali et. al., 2003; Rutledge, 2003
	Patch Average Area (for individual classes)	Elkie et. al.,1999; Saura e Martinez-Millan, 2001;McCarigal et. al., 2002; Caporali et. al., 2003; Rutledge, 2003
	Patch Density (PD)	McCarigal and Marks,1995; Saura e Martinez-Millan, 2001;McCarigal et. al., 2002; Caporali et. al., 2003; Rutledge, 2003
	Patch Density (for individual classes)	McCarigal and Marks,1995; Saura e Martinez-Millan, 2001; McCarigal et. al., 2002; Caporali et. al., 2003; Rutledge, 2003
	Sustainability of the Ecotope System (SUS)	
	Agricultural Ecotope Composition (CEtopeC)	
	Road Density (RD)	B.E.F., 2000
Indicators of Connection	Agricultural Ecotone Composition (CEtoneC)	
	Water Body Density (WBD)	UNEP, 2001
	Ecotone Length (EL)	Ritters et. al., 1995; Corona et. al., 2004
	Ecotone Intensity (EI)	

Table 4: Data collected from veraison to harvest

	*	pH	Sugars (°Brix)	Total Acidity g/l	Malic acid g/l	Tartaric acid g/l
16	I	2,88	13,1	18,8	2,84	18,14
	II	3,21	20	8,7	2,12	8,85
	III	3,4	21,1	6,1	1,76	3,29
	H	3,43	22,5	5,9	N.D	N.D.
29	I	3,21	18,4	9,2	4,85	6,95
	II	3,36	20,3	7,2	3,21	7,42

	*	pH	Sugars (°Brix)	Total Acidity g/l	Malic acid g/l	Tartaric acid g/l
24	I	3,17	18,1	13,87	4,52	10,9
	II	3,26	18,7	10,42	4,41	5,4
	III	3,29	19,5	9,22	4,25	4,97
	H	3,3	23	8,25	4,1	4,52
25	I	2,81	13,1	21,6	2,66	8,75
	II	3,24	21,9	10,5	2,66	8,75

	III	3,41	20,9	5,4	1,35	5,14
	H	3,45	22,2	4,6	1,1	2,98
30	I	3,3	17,4	6,8	2,1	5,96
	II	3,39	18,2	5,5	1,12	5,32
	III	3,45	22,6	4,2	1,04	4,87
	H	3,51	24,3	3,5	0,85	2,89
9	I	3,04	15,9	16,2	5,17	12,72
	II	3,21	18,9	9,67	1,34	9,82
	H	3,44	25	7,87	1,95	4,08
4	I	3,02	13,3	19,1	2,99	19,36
	II	3,31	15,7	10,5	2,99	10,45
	II	3,38	19,6	7,7	2,54	6,78
	IV	3,4	21,1	7,4	2,26	5,49
	H	3,42	21,5	5,4	1,91	3,48
15	I	2,98	17,5	11,23	3,97	9,85
	II	3,17	19,3	8,9	2,15	7,62
	III	3,25	21,3	7,4	1,11	6,53
	H	3,28	21,6	6,09	1,02	6,1
	III	3,39	23,9	7,8	2,89	3,21
	IV	3,4	26,9	6	2,69	3,18
	H	3,41	27	5,95	2,25	3,1
10	I	3,01	13,5	20,4	2,91	20,32
	II	3,27	18,9	10,7	2	10,97
	III	3,48	19,3	8	2,94	6,65
	IV	3,53	19,5	5,3	2,21	3,56
	H	3,54	21,3	5,2	1,95	3,24
11	I	3,14	21,2	9,9	1,49	9,81
	II	3,35	20,8	7,4	2,39	5,62
	III	3,47	20,9	6,5	2,1	5,04
	H	3,51	24,7	5,6	1,62	4,82
5	I	3,17	17,2	12,82	4,21	9,59
	II	3,17	19	11,25	4,3	4,07
	III	3,2	22,8	9,37	4,16	3,56
	H	3,29	24,7	6,22	2,6	2,15
*I,II, III, IV= number of sampling; H= data at harvest						

Table 5 : Data collected at harvest for each vineyard

Field id	pH	Sugar (°Brix)	Total Acidity	Malic acid	Tartaric acid	SKINS				JUICE	SEEDS		
						Total Anthocyanins	Total Flavonoids	Proanthocyanins	Flavans	Hydroxycinnamic acids	Total Flavonoids	Proanthocyanins	Flavans
		g/100g	g	g	g	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
16	3,53	24,85	5,60	2,29	2,76	810,64	2546,66	1014,67	39,66	47,02	1073,09	2090,88	335,53
29	3,51	23,00	5,20	1,35	3,42	1023,73	3209,92	1217,65	65,24	56,05	1748,91	1988,45	973,15
30	3,73	26,95	4,87	2,12	3,77	1080,58	3169,79	1676,66	233,55	70,02	1789,46	2152,76	861,29
9	3,63	25,45	7,15	1,41	4,59	821,56	2241,33	1489,62	239,54	47,72	574,15	1019,98	411,02
4	3,60	22,40	5,59	1,46	3,95	1403,53	4167,68	1289,74	598,53	79,18	2245,57	2497,85	1066,10
15	3,63	21,50	5,69	0,46	4,51	690,60	2085,80	895,90	131,10	105,95	2508,12	2339,73	0,00
24	3,35	24,00	7,91	3,61	4,16	679,48	1656,65	825,28	86,55	39,79	1190,57	1563,22	673,46
25	3,35	25,50	6,61	2,48	3,67	357,87	2096,32	229,03	453,95	47,44	1311,69	1989,95	818,92
10	3,60	22,35	5,94	1,34	4,29	786,95	2348,59	880,70	644,51	55,30	846,89	1147,27	399,71
11	3,56	24,65	6,14	1,17	5,08	893,91	2639,94	2315,72	127,07	49,88	1066,04	1607,59	683,36
5	3,37	24,05	7,06	3,50	2,49	487,67	1765,22	893,91	437,72	40,08	1595,48	1913,82	978,71

Table 6: The average values of H' indexes for the period of surveys

N. ID	Municipality	Location	Training system	Age of plant	Altitude (m)	Plants/Ha	H' average value
16	Acquaviva	Barbatto	Alberello	60	288	7500	3,76
29	Adelfia	Votano Volpi	Alberello	40	170	6600	3,7
30	Adelfia	Annetto	wire trallis	10	180	3900	
30	Adelfia	Annetto	wire trallis	10	180	3900	3,18
9a	Conversano	Marchione	wire trallis	10	307	3400	3,14
9b	Conversano	Marchione	wire trallis	10	307	4100	3,27
15	Gioia del Colle	Parco longo	wire trallis	10	373	2556,25	2,355
24	Gioia del Colle	SP per Santeramo	wire trallis	10	395		3,14
4	Gioia del Colle	Marchesana	wire trallis	10	365	4200	2,165
25	Gioia del Colle	S. Pietro	wire trallis	10	280	4500	3,3
11	Sammichele di Bari	Sant'Antonio	wire trallis	10	284	4100	3,26
10a	Sammichele di Bari	Parco delle Monache	wire trallis	10	276	4132	3,76
10b	Sammichele di Bari	Parco delle Monache	wire trallis	10	276	4100	3,76
5	Santeramo in Colle	Viglione	wire trallis	10	385	4200	3,14

FIGURES

13 fields; 24 landscape parameters

Analysis 'Unconstrained'
Method: PCA
Summary Table:

Statistics:	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	0.6977	0.1475	0.0897	0.0332
Explained variation (cumulative)	69.77	84.52	93.49	96.81

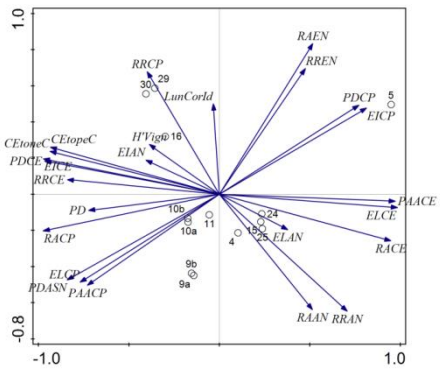

Figure 1: Similarity of landscape areas according landscape indicator

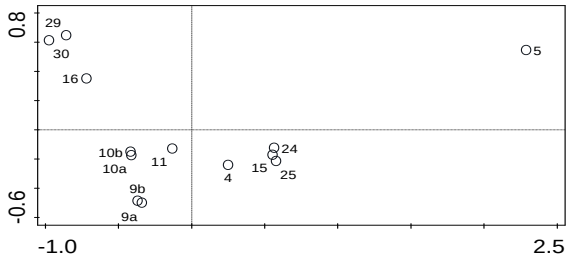

Figure 2: Clustering of landscape areas according landscape indicators

11 samples; 10 functional traits				
Analysis 'Unconstrained'				
Method: PCA				
Total variation is 110.00000				
Summary Table:				
Statistics:	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	0.3848	0.2413	0.1362	0.0975
Explained variation (cumulative)	38.48	62.61	76.22	85.98

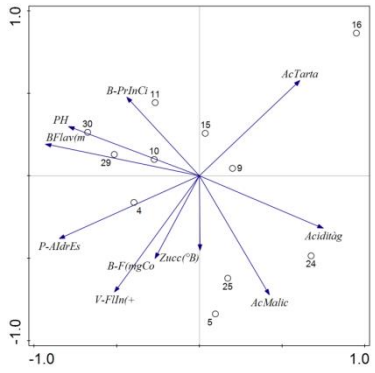

Figure 3: Similarity of fields according the values of the quality parameters

24 landscape indicators (characterizing the different areas); 14 quality parameters				
Analysis 'Interactive-forward-selection',				
step 'Forward Selection				
Method: RDA				
Total variation is 312.00000, explanatory				
variables account for 80.5% (adjusted				
explained variation is 61.0%)				
Summary Table:				
Statistics:	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	0.4529	0.1833	0.0977	0.0342
Explained variation (cumulative)	45.29	63.62	73.39	76.80
Pseudo-canonical correlation	0.9298	0.9758	0.9036	0.9012
Explained fitted variation (cumulative)	56.26	79.03	91.16	95.40

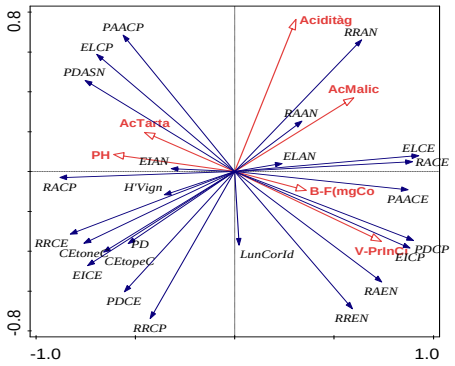

Figure 4a: RDA: first graph summarizes the variability of the quality parameters explained by landscape parameters

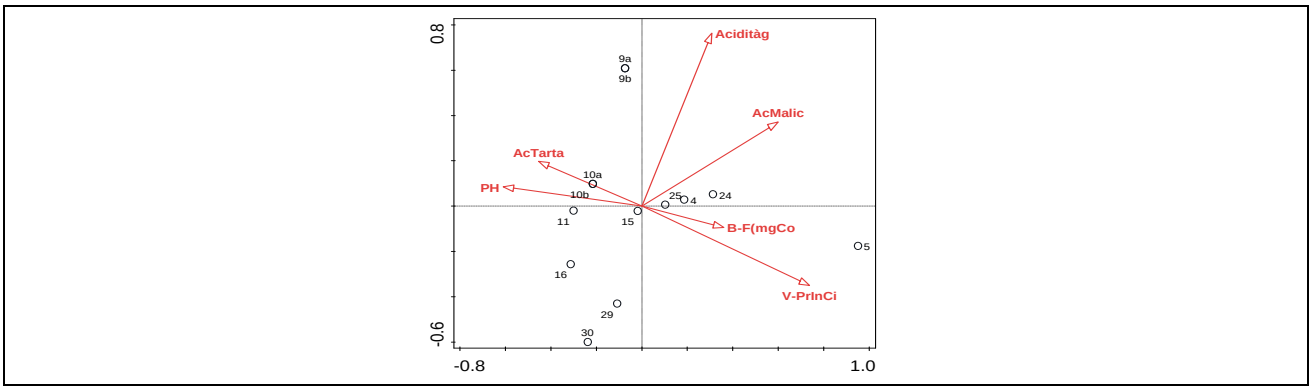

Figure 4b: RDA: second graph to summarizes the variability of the quality parameters explained by landscape parameters selected according their ability to explain variation