Effect of "Terroir" on quanti-qualitative paramethers of "vino nobile di Montepulciano"

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INTRODUCTION

In this last ten years period, there has been many integrated and interdisciplinary studies to determine the aptitude of different zones to viticulture (Lulli *et al.*, 1989 ; Costantini, 1992 ; Fregoni *et al.*, 1992). The researches needed some different knowledges about environment characteristics (soil, climate), ecology, vineyard management, vine genetic, winemaking and sensory analysis. The interaction of all these knowledge produced the assessment about the environmental vocation (Scienza *et al.*, 1992). By means of this metodology, the "viticultural vocation"joined the word "zoning", that is the territory parting for its ecopedological and geographical characteristics in relation to adaptative answer of winegrape (Morlat, 1989).

MATERIAL AND METHODS

The study was carried out during the four years 1989-1993 in the classic wine territory of Vino Nobile di Montepulciano (Siena, Italy) about the red variety Prugnolo gentile, the most important winegrape of local production. The experimental plan individualised 54 experimental not irrigated vineyards homogeneous in soils (9 soils per 6 replications) where to perform the viticultural trials. Moreover it was produced the soil map of the Montepulciano hill on the scale of 1:25.000, as a tool of controlling soil variability of the whole territory. All the surveyed soils were evaluated physically, chemically and hydrologically. During the study, temperature and rainfall were monitored with 5 meteorological stations sited inside the study area and representative of all the vine-cultivation zones. About the winegrapes, some quanti-qualitative traits at vintage (yield per plant, cluster number, mean cluster weight) and the sugar accumulation rate in berries in relation to budding, flowering and veraison were recorded. The grapes of each experimental plot were analyzed at vintage for evaluation of total soluble solids, titratable acidity, pH, malic and tartaric acidity, potassium. At ripeness 50-kg samples of grapes were collected and processed by the standard technique for small-lot winemaking used at the experimental winery of the Istituto Agrario di S.Michele all'Adige, with the following steps : destemming, crushing, 50 mg/L SO_2, 20 g/hL dry selected yeasts, 7-day skin contact with temperature >24 C and 10 plungings of the cap, free run and pressing wine (2.5 bars) together, spontaneous malolactic fermentation, sulfiting, filtration (0.45 μm) and bottling. No modification of the natural content of sugar and acidity was performed.

Descriptor terms were defined after several taste sessions, and the relevant terminology underwent normalization. All data was standardized by judges to avoid the difficulty of elaborating data obtained from the use of different sales.

In the wines, by already reported methods (Mattivi *et al.*, 1991), it was evaluated the content of : total polyphenols (mg/L +cat.), proanthocyanidins (total and reacting with vanillin, mg/L cian.), free and total anthocyanins (mg/L malv.), colour intensity, nuance and Glorie's indexes (dAL, dTA, dTAT and their percentage).

Analysis of Variance (ANOVA) and the Principal Component Analysis (PCA) were performed with the statistic SAS/STAT version 6.0 package.

RESULTS

The temperature, rainfall and soil moisture regime characteristics of wine-producing area of Vino Nobile di Montepulciano were reported in table 1. Soils were found greatly differentiate in terms of genesis and functional characters (tabl. 2,3,4).Among the latter, AWC (Available Water Content) and AC (Air Capacity), distinguished soils different in degree of erosion , texture and firmness of the subsurface horizons. The hydrological behaviour of the soils could be grouped as follow : i) soils without water and oxygen stress during the whole vegetative activity of the vines, ii) soils with more or less pronounced summer water deficit, iii) soils with summer water failure and spring oxygen deficit. Cation exchange capacity, extract conductivity, total and active lime of the studied soils were also found to differentiate them significatively.

The several soil treatments showed a quite large differences on yield components (tabl. 5). The average yield varied from 7.34 kg/vine for Valiano soils to 2.70 and 2.61 kg/vine for Monte and Cusona soils. Yield differences were due to a combination of cluster number and cluster weight. In fact, the cluster number randged from 18.2 for Valiano hydromorphic soils to 12.0 for S.Gimignano soils, while the cluster weight varied from 467.2 g for Valiano soils to 189.8 g for Poggio Golo soils. Differences in fruit ripening were lower than in yield components. Brix measurements differed, on average, only for 1.9. The Valiano hydromorphic soils showed the highest TSS value (21.9 Brix), while the Valiano ones the lowest (20.0 Brix). The titratable acidity ranged from 7.5 g/l for Quercia soils to 8.7 g/l for S.Gimignano soils.

As for the wines, polyphenols content (tabl. 6) is in accordance with the values reported in literature (Mattivi *et al.*, 1991) ; particularly, total polyphenols, proanthocyanidins, total anthocyanins, colour intensity and nuance showed values slightly higher than the variety mean, with statistically significant differences within the soils only for vanillin, nuance and dTAT%. Valiano and, in minor extence, S. Geminiano showed the lowest mean levels for various parameters of composition and colour and, at the sensory analysis (fig. 3), low astringency. Although statistically not significant, Strada soil gave the highest anthocyanins, Quercia and S. Quirico good levels of polyphenols and tannins, and Poggio Golo the highest values of the colour parameters.

The polyphenols content (tabl. 6) in obtained wines was in accordance with the values reported in literature (Mattivi *et al.*, 1991) ; particularly total polyphenols, proanthocyanidins, total anthocyanins, intensity and nuance showed values slightly higher than the variety mean. The wine differences was not very often statistically significative. The Valiano and S.Gimignano soils showed low total polyphenols, tannins, total anthocyanins, intensity and nuance. In according to the polyphenols content the astringency of Valiano and S.Gimignano wines was low. The Strada soil showed the higher total anthocyanins content. Quercia and S.Quirico noted good level of total polyphenols and tannins, while Poggio Golo showed the highest values.

CONCLUSIONS

This study showed the importance of environmental characteristics to define the quanti-qualitative answer of the winegrapes, in particular of the "Prugnolo gentile" variety. The interdisciplinary approach allowed to identify the pedological and climatic functional characters that conditioned the physiological behaviour of the vines and the oenological quality of the wines (fig. 1), in particular it specified the fertility conditions of different lots.

Soils ranged in fertility conditions between very fertile soils, like the San Gimignano soils, providing the crop of water, oxigen and nutrients for the whole year, without causing any stress to the vines, to soils with severe permanent limitations to crop cultivation, like the Cusona ones, in which plants showed the effect of lacking water supply in summer. On the other hand, soils like the San Quirico ones, provided intermediate grown condition, with some limitation due to an excess of water and an oxigen scarcity in early spring and a moderate water stress in summer.So, the most fertile solis, those lacking permanent limitations to crop cultivation, owing to excessive productivity, provided the worst viticultural and oenological results. On the other hand, the best results could be obtained in quite fertile soils, but with some pedological limitations. The least fertile soils, those wich have been more or less hydromorphic, produced always less than the better preserved ones, but with very variable oenological results, according to the influence of the year.

The winegrape production at vintage was strictly interactive with the different soils. In particular, the yield per vine, the mean cluster weight, the 100 berries weight were deeply influenced. The number of shoots in the various soils is significantly different for the adaption of pruning to the different potentiality of soils in relation to the water capacity. Also the sugar accumulation rate in berries (fig. 2) underlined the importance of the soil for a minimum sugar level of grapes, necessary to winemaking as Vino Nobile. In facts, vineyards on Cusona soils did not reach the minimum sugar content every years, but only in the more rainy ones. On the other

hand, every year grapes on San Gimignano and Poggio Golo soils only at late time reached the minimum sugar content.

The wine obtained in the distinct soil groups showed different organoleptic profiles (fig. 3). Good structure, typicity, high cherry and berry fruits notes, were found in San Quirico, Poggio Golo, Quercia, Cusona, Monte and Valiano eroded soils, with a fairly harmony of the product. The last three soils, however, manifested high variability of oenological results between years.

The natural resources knowledge of Vino Nobile di Montepulciano territory obtained from the research, beyond give indication for zoning, will permitt to find a good vineyards husbandry (tabl. 8) and to optimise the management practices for the best qualitative answer of Vino Nobile di Montepulciano.

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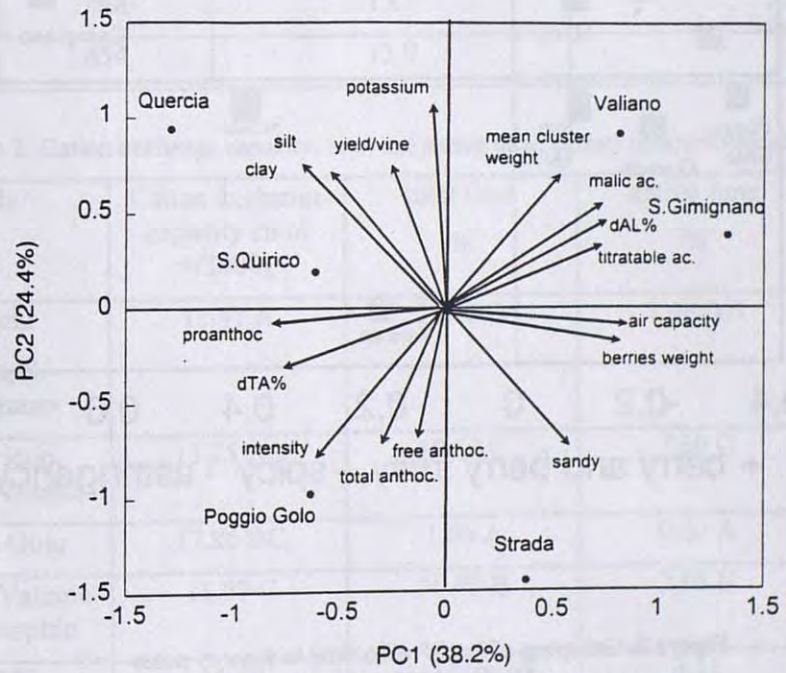

Figure 1. Biplot on the Principal components

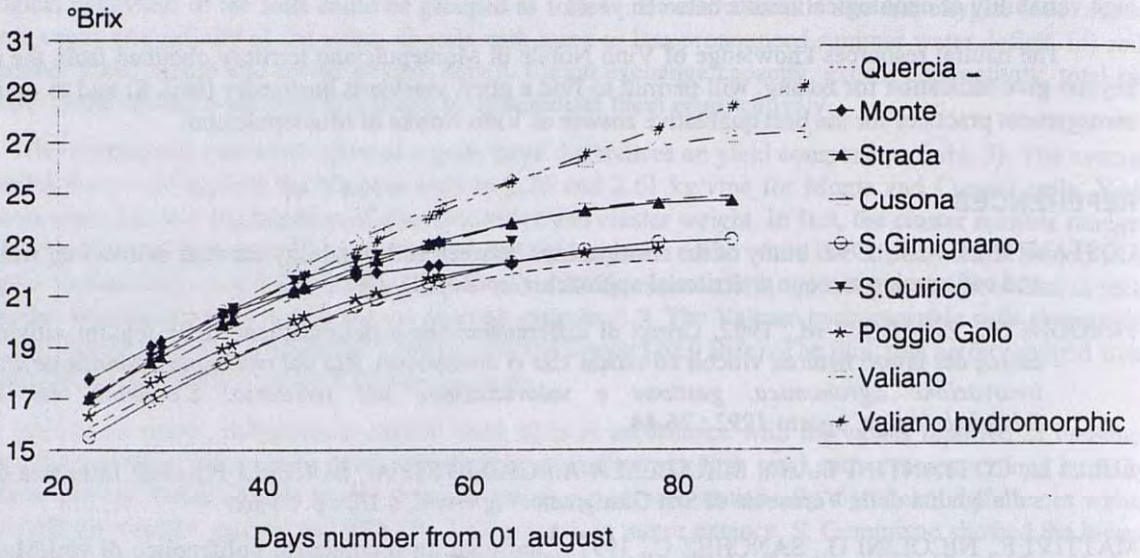

Figure 2. Sugar accumulation rate in berries during ripening average 1989-1991

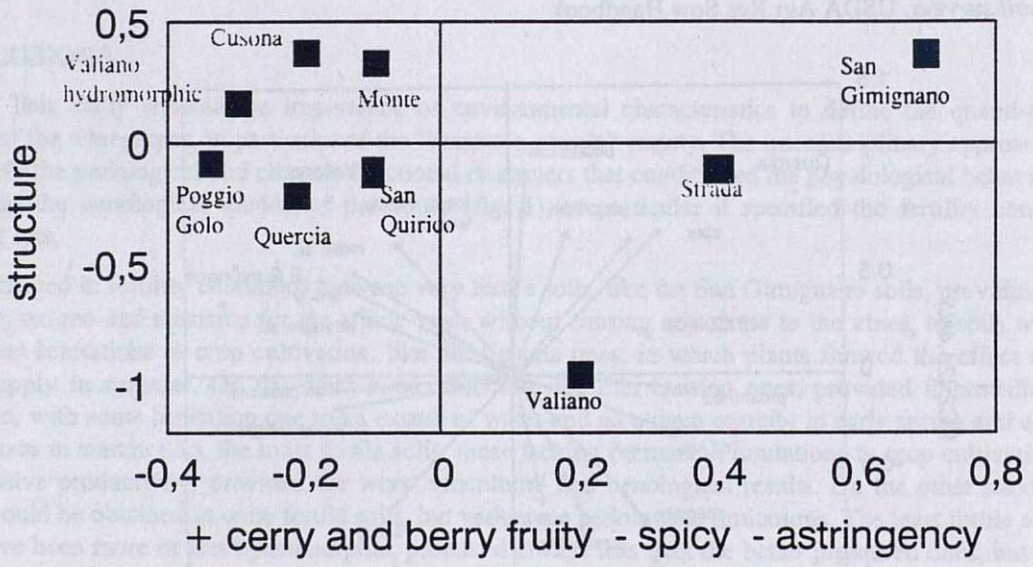

Figure 3. Grouping of "soils" according to sensory notes
Vintage 1989-1992

Tableau 1. Rainfall, temperature and soil moisture regime in 1967-1986 period

year	rainfall (mm)	year mean temperature (°C)	soil moisture regime (Soil Taxonomy)
1967	504	14.6	Xeric
1968	699	13.8	Ustic
1969	748	13.7	Ustic
1970	635	14.1	Xeric
1971	490	14.1	Xeric
1972	731	13.7	Ustic
1973	552	14.2	Ustic
1974	618	14.2	Ustic
1975	593	14.5	Xeric
1976	927	13.8	Udic
1977	689	14.3	Ustic
1978	773	14.0	Xeric
1979	861	14.0	Xeric
1980	731	13.0	Xeric
1981	656	13.9	Ustic
1982	670	14.1	Xeric
1983	504	13.7	Xeric
1984	801	12.8	Udic
1985	403	14.4	Xeric
1986	488	13.7	Xeric
MEAN	654	13.9	

Tableau 2. Cation exchange capacity, total and active lime, extract conductivity of experimental soils

Soils	Cation exchange capacity cmol +/1000g	total lime %	active lime %	extract conductivity dS/m
Cusona Strada, S. Gimignano	11.97 A	12.16 B	1.48 AB	115.5 A
S. Quiricop, Quercia, Monte	13.35 AB	18.63 C	7.59 C	561.6 B
Poggio Golo	17.95 BC	1.66 A	0.60 A	165.5 A
Valiano, Valiano hydromorphic	18.67 C	10.03 B	2.98 B	225.8 A
MEAN	14.49	10.76	3.16	267.1

Values with the same letter are not statitically different (Student-Newman-Keuls's Test $P<0.05$)

Tableau 3. Mean Available Water Content (A.W.C.) of different experimental soils

Soils	A. W. C. (mm)
Monte, Cusona	84 A
Poggio Golo, S. Quirico, Valiano hydromorphic	142 B
Valiano, Quercia	167 BC
S. Gimignano, Strada	176 C
MEAN	152

Values with the same letter are not statitically different (Student-Newman-Keuls's Test $P<0.05$)

Tableau 4. Mean Air Capacity (A.C.) of different experimental soils

Soils	A.C. (%)
Cusona	16.2
Strada	10.9
S. Gimignano	10.6
Valiano	9.7
Valiano hydromorphic	5.5
S. Quirico	3.8
Quercia	3.0
Poggio Golo	2.3
Monte	1.4
MEAN	7.0

Tableau 5. Effect of "soils" on some quanti-qualitative traits at vintage (mean 1989-1992)

	Soils								
	Quercia	**Monte**	**San Gimignano**	**Poggio Golo**	**San Quirico**	**Strada**	**Cusona**	**Valiano**	**Valiano hydromorphic**
cluster n.	12.1 b	13.9b	12.0b	15.1ab	12.3b	13.3b	12.2b	15.9ab	18.2a
yield/plant Kg	3.95 bcb	2.70d	4.59bc	3.15cd	3.96bcd	4.33bc	2.61d	7.34a	5.21b
100 berries weight g.	180.8c	144.6d	223.1a	187.7bc	174.3c	211.9ab	186.5bc	214.9bc	178.1c
cluster weight g.	336.1bc	209.0d	405.8ab	189.8d	340.8bc	336.6bc	208.4d	467.2a	261.6cd
pH	3.21abc	3.26 a	3.15cd	3.13d	3.16cd	3.12d	3.19bcd	3.24ab	3.18bcd
TSS (Brix)	20.6bcd	20.5cd	20.5cd	20.5cd	21.4 abc	21.0abcd	21.6ab	20.0d	21.9a
titratable ac. g/l	7.5b	8.0ab	8.7a	7.7b	7.8b	7.6b	7.6b	8.2ab	7.6b
malic ac. g/l	2.1bc	2.4bc	3.2a	2.0c	2.2bc	2.2bc	2.2bc	2.9ab	2.6abc
tartaric ac. g/l	7.5ab	7.9a	7.1ab	7.2ab	7.1ab	7.1ab	6.8b	7.0b	7.2ab
potassium g/l	1.45a	1.34ab	1.38ab	1.26ab	1.40ab	1.25b	1.39ab	1.44a	1.42ab

Tableau 6. Effect of "soils" on polyphenols content in obtained wines (mean 1989-1992)

soils	alch.degree %vol.	tit.acidityg/l	pH	total polyphenols	proanthocyanidins	pronanthocyanid insreactt.with vanillin	total anthocyanins	free anthocyanins	colour intensity	nuance	dAL%	dTA%	dTAT%
Quercia	13.1 a	5.77 a	3.41 a	1591 a	1789 a	831 ab	268 a	99 a	4.89 a	28.9 d	11.5 a	53.2 a	35.3 c
S.Quirico	12.8 a	6.06 a	3.41 a	1507 a	1795 a	851 a	302 a	122 a	5.11 a	34.2 b	11.3 a	53.9 a	34.8 d
Strada	13.2 a	5.18 a	3.46 a	1593 a	1675 a	812 ab	316 a	126 a	5.31 a	31.0 c	13.1 a	51.1 a	35.8 b
S.Gimignano	12.1 a	5.79 a	3.37 a	1484 a	1524 a	847 a	237 a	97 a	3.80 a	19.4 f	12.9 a	50.5 a	36.6 a
Poggio Golo	12.1 a	6.24 a	3.31 a	1646 a	1768 a	883 a	276 a	108 a	5.93 a	43.8 a	9.5 a	57.7 a	32.8 e
Valiano	12.2 a	5.27 a	3.44 a	1327 a	1448 a	650 b	261 a	114 a	4.01 a	25.1 e	13.5 a	49.9 a	36.6 a
Mean	12.5	5.70	3.40	1517	1657	806	276	111	4.81	30.2	12.0	52.6	35.4

Values with the same letter are not statistically different (Duncan's test $P<0.05$).

Tableau 7. Nobile di Montepulciano grape productivity and wine quality according to soils and relative constraint level

Soil	constraint level	grapes yield	harvest time	wine structure	wine tipicity	wine harmony	year stability
S.Quirico	moderate	***	oooo	**	**	**	**
Poggio Golo	moderate	**	oo	**	**	**	**
Quercia	moderate	***	ooo	**	**	**	**
Monte, Cusona	severe	*	oooo	**	**	**	*
Valiano hydromorphic	few	****	ooo	**	**	**	*
S.Gimignano, Strada	none	****	o	*	*	*	**
Valiano	none	*****	o	*	*	*	**

o = late harvest oooo = hearly harvest

Tableau 8. Criteria to optimize the management practices for the best qualitative answer of Vino Nobile di Montepulciano

Soils	management practices				vineyard establishment			
	grass cover	irrigation	fertilization	canopy management	drainage	cow manure	green manure	vigorous rootstock
Quercia	*	**	**	*	***	*	***	*
Monte	*	***	***	*	***	*	***	***
S.Quirico	*	*	**	*	***	*	***	*
Strada	**	*	**	**	*	**	**	*
Cusona	*	***	***	*	*	***	***	**
S.Gimignano	***	*	*	***	**	*	*	*
Poggio Golo	**	*	**	*	**	*	**	*
Valiano	***	*	*	***	**	*	*	*
Valiano hydromorphic	**	*	**	**	**	*	**	*

* unwary practice ** suggested practice *** exhorted practic