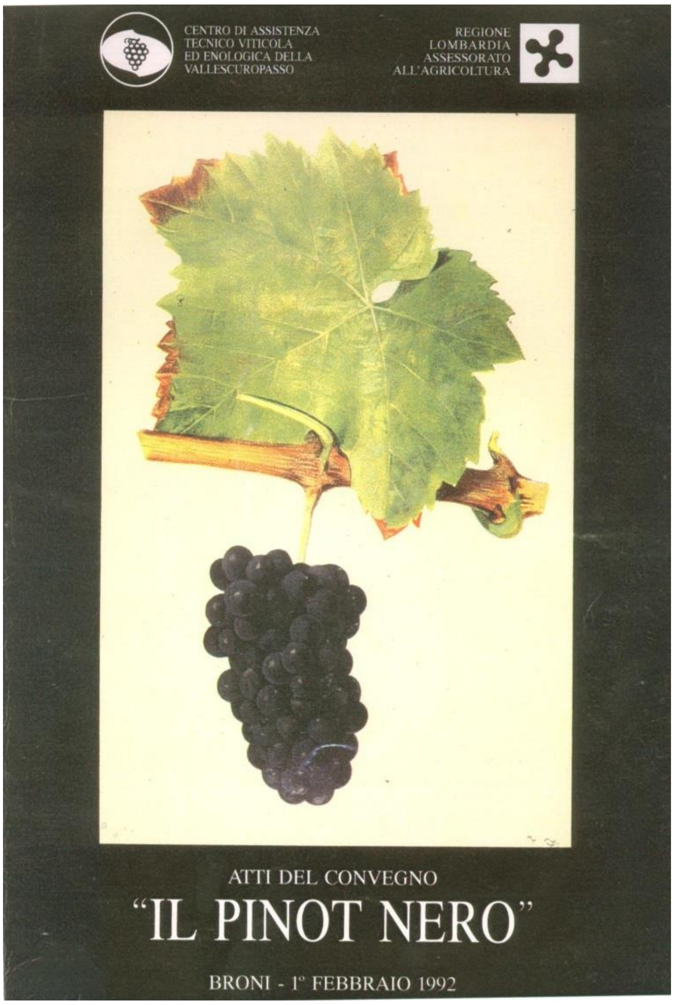

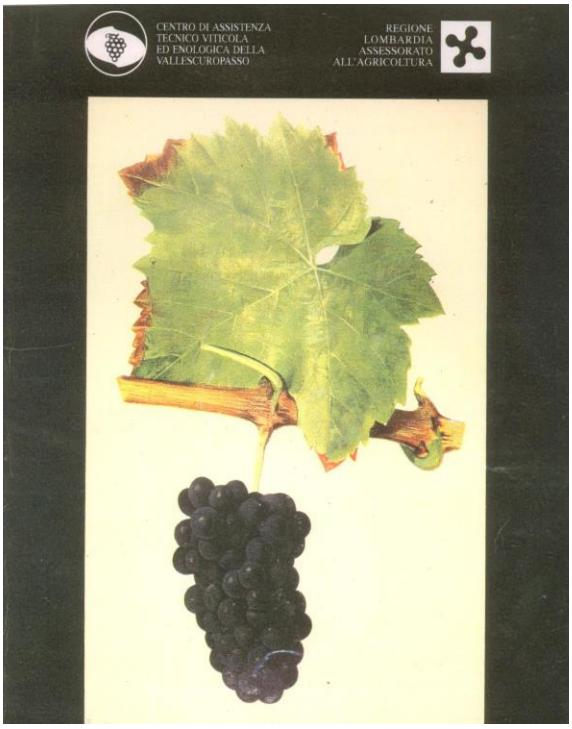

Conference on

"THE PINOT NOIR"

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VITICULTURAL VOCATION (SUITABILITY):
STUDY OF THE RELATIONSHIP GRAPEVINE VARIETY - ENVIRONMENT FOR “PINOT NOIR” IN THE VALLE SCUROPASSO (OLTREPÒ PAVESE, North-West Italy)

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INTRODUCTION
There has been a significant decrease in the annual consumption of wine in recent decades, from a hundred to a little over 50 liters *pro capita* (LECHI *et al., 1988*). The demand for wine has changed not only from the point of view of quantity but also of quality. In fact, the current market trend is ever more appreciative of high-quality products. Given this, above all in developed Western countries like Italy, characterized by high production costs, there is a need to improve the quality of the wines produced. To do this, it is essential to study the viticultural context to improve the quality of the grapes and their typical characteristics in order to obtain wines that can adequately and profitably satisfy market demand. It is, therefore, necessary to examine various factors that can influence the quantitative-qualitative response of the species of wine in order to identify optimal combinations of these factors; factors that are important for obtaining the best quality product.

Factors that influence qualitative-quantitative production of grapes for wine production
Climate, grapevine varieties, soil and techniques of cultivation are the principal factors that directly or indirectly impact the qualitative-quantitative response of the grapevines (FREGONI, 1985). The basic characteristics of some of these factors cannot be greatly changed (permanent) while others can be substantially modified by Man or can be selected (cultivation factors) (HIDALGO 1980). The influence of the grapevine variety is frequently of particular importance when establishing the priority of these different components of the viticultural system, above all if this is also considered in relationship to the conditions of soil and climate under study (SCIENZA, 1986; SCIENZA, 1987).
The establishment of a grapevine variety in a particular environment represents the ‘action’ that most conditions the resulting quality.

Studies of the vocation of viticultural territories
Evaluation of the suitability of a particular area for the production of wine grapes is the estimate of the viticultural vocation and is the fundamental basis in defining the enological potential of the area. Furthermore, these studies are to be considered important requirements for programming the realization of the potential of the agricultural land and its management (FREGONI; 1981; STANGHELLINI, 1986) also in relation to environmental problems. In fact, environmental problems are increasingly important and need to be taken into consideration in the development of any human activity that could have an impact.
Many methods have been adopted over the last decades to estimate the viticulture and wine making potential of a particular territory. All these methods are based on measuring the variables that shown to be particularly linked to the quality of the grape production.
Particular interest has been given to studies aimed at defining the correlations between climatic characteristics and the chemical component of the grapes with the quality of the wine produced

(WINKLER 1962; HUGLIN 1978; HIDALGO, 1980). The results obtained from these studies have allowed bioclimatic indexes that can be used in characterizing the different regions of viticulture (TURRI *et al.,* 1987). Other studies have aimed to identify the enological potential of a given area giving priority to consideration of some specific characteristics of the soil that have been seen to significantly influence the quality of the grapes and of the wines. Correlations have been found between the level of active limestone and of some specific aromatic substances of the must (Moscato) (EYNARD *et al.,* 1987; ZAMORANI *et al.,* 1987). It is also interesting, in defining different viticultural vocations, to consider the chemical-physical characteristics, above all of the terrain: sand, clay, limestone, potassium content (Valtenesi Province of Brescia; Canneto Pavese Province of Pavia) (FREGONI *et al.,* 1985; ANTONIAZZI *et al.,* 1986), the macro-porosity and the conditions of the soil influencing the amount of water available for the plants (FREGONI, 1985).
Together, the experimental findings of recent years confirm that the grapevine varieties and the specific location or site are the most important factors in determining the quality of production (SCIENZA *et al.,* 1990). Among the more permanent environmental factors (climate and soil), however, climate has the biggest impact since the characteristics of the soil, in most cases, take on a certain importance only so far as they interact on the climatic characteristics to which the vine is subject.

Studies in the Oltrepò Pavese

Some important studies of the viticultural vocation have been carried out in the grape growing region of the Oltrepò Pavese. The first study was carried out in Canneto Pavese (FREGONI *et al.,* 1985), and the others in the Versa Valley in the center of the Oltrepò Pavese and in the western part of the area (SCIENZA *et al.,* 1990).
The study in Canneto Pavese divided the area into 22 homogeneous sub-areas in which the analyses of the soil were carried out. Data collected were used to evaluate indexes marking the probable potential of induction of chlorosis and rachis desiccation. The modified qualitative MERIAUX index was applied to judge the qualitative vocation of the different vineyard locations. This index takes into consideration the percentage of sand and clay, of active limestone, the amount of potassium in the terrain and its cationic exchange capacity, along with the aspect of the terrain. The experiments carried out by SCIENZA *et al.* in the areas of the high Versa Valley, and in the central and western areas of the Oltrepò Pavese, have mainly concerned the following grapevine varieties: Pinot Noir, Chardonnay, Riesling Italico, Barbera, Croatina and Cortese. Different results were found for the various varieties between the three areas considered. Among the varieties most used in the production of sparkling wines *méthode traditionnelle*, Chardonnay shows the greatest environmental adaptability compared with the superior response of Riesling Italico to the environment and the different conditions of drainage of the soil. Variations in altitude of the vineyards have a big impact on the acidic composition of the musts, above all in the western areas, together with some of the chemical-physical characteristics of the soil with regards to its greater or lesser capacity for water drainage.
The scientific study of the viticultural vocation carried out in the Oltrepò Pavese over recent years has been extremely significant and the quality of the results has allowed us to greatly widen our knowledge of land suitability. Besides forming the basis of a working method, achieved through a multidimensional analysis of the problems involved, this also allows a better interpretation of the results themselves.
It would be interesting to extend these studies to other areas of the north-eastern hills of the Oltrepò Pavese, where more than 30% of the vineyards are probably to be found. It is in these areas, that are those closest to the Po Valley, where we find a large part of the Oltrepò Pavese production of red

wines and where perhaps there is the greatest need to improve quality and product identity of the area.

Study aim

This study was developed by the Department of Viticulture of the Università Cattolica del Sacro Cuore di Piacenza, together with the Technical Viticultural and Enological Center of the Valle Scuropasso, in order to widen our knowledge of the different ranges of viticultural vocation of Pinot Noir in the Valle Scuropasso. The study aims to identify and describe the different types of grape production offered by Pinot Noir in the different areas of cultivation in the valley. The final objective is to provide information to help decision-making regarding quality in this area of significant expansion of this variety.

MATERIALS AND METHODS

A series of preliminary investigations were carried out on the basis of results obtained from analyses of the different terrains by the Technical Viticultural and Enological Center of the Valle Scuropasso. Analyses were also carried out on the musts from different areas of production of Pinot Noir. A set of maps were also examined. From these, a series of vineyards representative of the different viticultural contexts were then identified. This initial investigation allowed us to select 23 representative vineyards that formed the study sample for the three years 1988-1990. Soil samples were taken at depths ranging from 20 to 60 cm in each representative vineyards and these were then analyzed. These analyses examined: granulometric composition (% of sand, silt and clay), chemical characteristics (pH, cationic exchange capacity in meq/100g of soil, total limestone in %, active limestone in %, percentage of organic matter and the presence of: nitrogen, phosphorus, potassium, calcium, magnesium, iron and boron, in ppm (mg/kg), except for nitrogen measured in ‰, according to the methods set out by the S.I.S.S. (*Società Italiana della Scienza del Suolo*, Italian Society of Soil Science). The vineyards under study were located at altitudes of between 104 and 460 m a.s.l.. The exposure varied from those more favorable to maturing the grape (south-west) to those less suitable (north-east). The training system according to which the grapevines were grown was Guyot with 2 canes; this was by far the most common used in the Valle Scuropasso.

Within each vineyard, 12-15 representative vines were chosen and the vegetal-productive performances were analyzed and from which grape samples were taken for laboratory analysis.

The following were tested:

- number of grape clusters *per* grapevine, calculated to include the spurs and to exclude the grapes of the crown buds;
- number of buds *per* vine;
- fertility (obtained by dividing, for each grapevine, the number of grapes by the number of buds);
- average grape weight (g);
- yield *per* grapevine (kg).

A sample of 2-4 grape clusters was taken from each vine studied. These were chosen as representative of the average level of maturation of the entire production of the grapevine, favoring the selection of the basal bunch of the shoot of average vigor. The following analyses were carried out on these samples before pressing on samples of fresh and non-frozen must:

- sugar content (refractometric index, degrees Brix);

- titratable acidity (g/L, expressed in tartaric acid equivalents);

- pH;

- tartaric acid (g/L);

- malic acid (g/L).

The pruning was standardized with respect to plant vigor. The results obtained were used for an ANOVA (Analysis of Variance) to identify the significance and the importance of the effect of the year, the altitude and the exposure, and their interactions on the vegetal-productive characteristics of the grapevines. Multivariate analysis (discriminat analysis) was then carried out to study further the results.

RESULTS AND DISCUSSION

General considerations

In general, it was seen that the vegetal-productive habitat of the Pinot Noir vineyards in the Valle Scuropasso was particularly non-homogeneous. This was seen not only in the different approaches to cultivation on the part of the grape growers, above all in the way they applied the techniques most related to the production performance of the grapevines (Number of buds/vine left when pruning), but also by the particularly diverse genetic compositions of the grapevine genotypes. The different types of grape clusters that characterize the vines, related to the quality characteristics of the production processes, were to be found in different proportions in the different plots. The number of buds/vine on the grapevine when pruning was most frequently around 30-38. However, in some cases, this was over an average 50 grapes *per* grapevine. Furthermore, there was a dangerous tendency for grape growers to favor bigger yield by limiting pruning. In fact, yield *per* grapevine increased from 1988 to 1989-1990. However, the drought of 1990 reduced yield for that year.

The soils are characterized by a high content of clay, mostly between 40 and almost 60%.

The quantity of silt was much greater on the plains and hills near the Po Valley (north), reaching 30%, compared with an average of almost 20% in the other areas studied. Even higher percentages of silt were found in the areas at higher altitude (Canevino). The pH of the soil was always very high ranging between approximately 7.5 and 8.3. There was an even bigger range in the level of total limestone that went from less than 10% to peaks of over 40% (about 50% of the soils are rich or very rich) (TABLE 2).

Must sugar content was between 16 and 20 degrees Brix. Titratable acidity varied between 8.38 and 10.59. pH of musts was between 3.06 and 3.34. The major part of the organic component of acidity was represented by tartaric acid, compared to malic acid with a ratio between the two that went from a maximum of 7.0 : 3.4 to a minimum of 5.8 : 6.53 (TABLE 3). It should be noted that the analysis of the acidic components of the musts was carried out on fresh samples.

Description of the area

Substantial differences in soil composition were found between the various terrains in the Valle Scuropasso. In particular, the higher the altitude the more the percentages of silt making up the fine terrain tended to decrease, while the clay element increases. Soil pH progressively decreased as the altitude increases.

In particular, the highest levels of silt (approx. 30%), together with very high pH values (>8), were found in the area to the north-north-east of Pietra de Giorgi and Cigognola (vineyards: 1,3,12,20,14).

The lowest levels of potassium (exchangeable) and the lowest cationic exchange capacity were observed in the vineyards located on the valley floor. These particular edaphic conditions, above all the combination of high levels of silt with sub-alkaline pH, were also found in certain areas in Canevino at much higher altitudes (over 400 m a.s.l.). Most of the soil at medium or high altitudes that go from the south-east area of Pietra de Giorgi to Rocca de Giorgi always contain more clay (45-55%) and silt levels are around 20% (TABLE 2).
Climatic variables were recorded by meteorological stations of the *Rete Agrometeorologica del CI.VI.FRU.CE*. of the Region of Lombardy. These show that the lower values obtained by the summation of the active temperatures (average for the 3-year period 1988-1990, May-September) (TABLE 1) were observed at higher altitudes (Canevino) while higher values were obtained at intermediate altitudes (approx. 3,150 compared with 2,975 recorded at higher altitudes). The meteorological recording station at a lower altitude, but situated with a favorable exposure, however, showed lower thermal summation to that recorded at altitudes of between 200 and 300 m and situated with a favorable exposure (south). Rainfall was measured for the same period and was taken into consideration for the thermal summations. This was relatively higher at higher altitudes (210-220 mm) with respect to, above all, the lower areas (180 mm). The monthly temperature range, above all in August, was wider between the highest and the lowest altitudes (18°C and 22.6°C, respectively). A similar range was seen for humidity levels in the vegetative phase (67.9% and 72.7%, respectively).

Influence of the environmental variables on the quantitative-qualitative characteristics studied
Considering the grapevine species' homogeneity from a productive standpoint, we checked the simple linear correlations between the variables evaluating the soil and the principal qualitative characteristics of the sampled musts on harvesting (TABLE 4).
In particular, significant correlations were found between the amount of silt and the amount of exchangeable potassium in the soil with the pH of the berry juice on harvesting. The silt component of the soil was negatively correlated with the pH of the must that was itself positively correlated with the amount of exchangeable potassium in the soil. The other two important environmental variables considered were altitude and exposure, with exposure expressed in numbers in relation to the greater or lesser exposure to sunlight observed at this latitude. These variables were significantly correlated with titratable acidity and the two components that most characterize it (tartaric acid and malic acid). More precisely, we observed negative correlations between exposure and titratable acidity and malic acid, and positive correlations between altitude and tartaric acid; exposure values increased from north to south.
We considered a series of vineyard located at different altitudes (200, 300 and 350 m a.s.l.) with different exposures (generally north and south) for the three years under study (1988-1989-1990). For these vineyards, we evaluated the influence of the year, the altitude and the exposure on the principal vegetal-productive variables considered. The average number of grapes was between 30 and 35 bunches *per* grapevine. Bud fertility was weakly influenced by the sources of variation considered; significant levels were only observed between the year and the altitude. The average weight of the clusters differed significantly and to a similar degree under the influence of all the principal factors examined; lower altitudes and good exposure seemed to result in heavier grapes. Cluster weight was significantly lower for the drought year 1990. Altitude and exposure had significant effects on grapevine production, while the year and the interaction of the various factors were not significant. Grapevines grown at lower altitudes and with a better exposure were more productive (TABLES 5 and 7).
There was a significant difference in sugar content over the three years with higher levels observed in 1990 (on average 20.51 ° Brix). Higher sugar content was obtained at lower altitude (TABLE 8).

Most pH was significantly influenced by year and altitude, as well as by the interaction between these two factors. Aspect also has an appreciable influence on the overall evaluation of must acidity, but to a much more limited degree. Values of must pH decreased significantly according to altitude (3.21, 3.16 and 3.09 at 200, 300 and 350 m a.s.l., respectively). Year and altitude had a significant influence on tartaric acid content, while exposure had a negligible influence, if not in terms of its interaction with altitude. Also the interaction between year and altitude was significant. The differences in tartaric acidity values obtained over the different years and at different altitudes were all significant (TABLES 6 and 8).
However there was a big difference in malic acid values according to year and altitude, as well as to exposure: an important wide variability was explained by the year and its interaction with altitude, as well as altitude and exposure with similar explained variability. The amount of malic acid in the organic acidity recorded for 1990 was very low (3.73 compared with 5.4 for 1989) (TABLES 6 and 8).
A more detailed evaluation of those variables that best represent the acidic component of the musts, so important for the production of sparkling wines *méthode traditionnelle*, it was observed that in the three years under study pH values remained below 3.14 only at higher altitudes and at intermediate altitudes for those southern aspects. Average pH values of must remained close to or above 3.20 at exposure that favored grape maturation and in vineyards located at low altitudes. Only in 1989, which had the rainiest month pre-harvest, were must pH values lower than 3.14 seen also at intermediate altitudes and at the worst aspects at the lowest altitudes (TABLE 7).
Considering all the examined cases, in the average of the years, significant differences have appeared between the vineyards set to more than 300 m a.s.l. of altitude and the exposures predominantly toward north, with the remainders vineyards. The malic acid must content was higher in the exposures predominantly toward north. The organic acidity of the berry juice is structural different between north-exposures near 300 m of altitude and the zones of higher altitude.
While the first two cases show a greater similarity between the malic and the tartaric component, in the second case the tartaric value is higher.
By carrying out a discriminant analysis of the principal chemical components in the grapes in vineyards at different altitudes and exposures (also including the areas closer to the Po Valley with higher silt levels, but with similar yields) we can see that the biggest discriminating factor of the location (explaining 63.16% of variability) is pH, while the second discriminating factor is most influenced by sugar content and tartaric acid levels (TABLE 10).

CONCLUSIONS

The Pinot Noir grown in the Valle Scuropasso is almost always cultivated according to the Guyot training system. On winter pruning, the grape growers usually leave approximately 35-40 buds *per* grapevine, with a yield of 4-6 kg *per* grapevine and of 8-12 tons per ha. Only in rare cases was the yield much higher.
Considering the texture of the soil, it can be seen that most of the terrain has high levels of clay. In some areas, above all in the plains and in the low hills near to the Po Valley, higher silt levels are found (28-30%). Meteorological recordings of the area (*Rete Agrometeorologica del CI.VI.FRU.CE*. of the Region of Lombardy) showed a smaller summation of active temperatures was found at higher altitudes (2,975, south exposure, average 1988-89-90) accompanied by slightly higher rainfall than recorded at lower altitudes. Even though the complete data were not available, no great variations were observed, in comparison with the wide range in altitudes (from approx. 100 m to 400 m a.s.l.).
From the analysis of the principal qualitative variables of the musts obtained from vineyards at different altitudes and exposures for the years under study, it emerged that the year had a big influence on results (including also 1990, which for certain aspects, i.e. drought, was very particular). pH decreased in line with an increase in altitude (on average from 3.21 to 3.09) and was partly

influenced by exposure that had a greater influence on malic acid levels compared to tartaric acid, which seemed to be more influenced by altitude.
From an altitude of 200-350 m, there was an appreciable difference in pH between the northern exposures of the intermediate altitudes and higher altitudes compared with the other cases studied (with values of 3.15 and 3.20, respectively) (FIGURE 2). The organic acidity composition differed between higher altitudes (with more tartaric acid than malic acid) and the bad exposures at 300 m (with malic acid levels higher than tartaric acid levels) (tartaric: malic ratio = 7.7 : 4.2, at 350 m and = 6.7 : 5.2 at 300 m). Sugar content, strongly influenced by the year, was higher at low altitudes (19.18 at 200 m and approx. 18 at 300 and 350 m).
The areas at altitudes below 200 m merit separate attention. These areas have higher silt levels and favorable exposures, and demonstrate acidic levels similar to those areas at higher altitudes.
The optimal properties for the production of sparkling wines *méthode traditionnelle* are quite a low pH (3.0-3.15) with a good balance of the most important organic components (malic acid : tartaric acid= 1 : 1).
Altogether, the areas over 280-300 m showed the best vocations for the production of sparkling wines *méthode traditionnelle* for which the acidic characteristics are important. Those areas at the lower height of this range demonstrated the best vocations at unfavorable exposures. However, there are some areas at low altitudes that, due to their particular orographic location and the characteristics of the terrain (higher silt levels and probable lower temperatures, less potassium) provide interesting acidic levels while maintaining an adequate sugar content.
It would be interesting to consider the diffusion and greater attention to the red varieties in the areas at lower altitudes and better aspects, including also Pinot Noir for the production of red wines, even though in this case interactions with the environment should be studied.

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localities		esp		STa	TM	UR%	P
Vicomune	100	North	May	545	28.3	69.9	27.1
			June	595	30.7	70.6	51.3
			July	717	32.3	69.9	31.4
			August	696	32.0	72.7	37.4
			Sept.	541	29.0	75.4	33.1
			Oct.	**3095**			**180.3**
Pietra G.	250	South	May	560	28.0	70.0	45.3
			June	613	30.7	69.9	58.5
			July	744	33.7	69.7	41.6
			August	665	32.3	68.8	30.6
			Sept.	527	29.3	72.5	29.2
			Oct.	**3109**			**209.2**
Finigeto	300	South	May	567	29.0	71.0	39.7
			June	615	31.7	67.9	76.3
			July	753	34.7	67.7	35.7
			August	736	34.0	66.2	37.8
			Sept.	552	30.0	70.4	33.3
			Oct.	**3228**			**222.8**
Canevino	380	South	May	514	26.7	66.7	53.9
			June	575	29.3	69.7	61.8
			July	696	32.0	68.7	35.3
			August	685	30.7	67.9	21.3
			Sept	506	27.3	69.3	38.9
				2975			**211.2**

Table 1 – The Scuropasso Valley climate characteristics evaluated: STa = sums of the active temperate ∑(daily middle temperature >10 °C, from may to september) (Fregoni, 1985), TM = monthly maximum temperature, UR = air relative damp, P = rain (mm); alt = altitude (m above the sea level: a.s.l.), esp = exposure (data from meteorological stations of CIVIFRUCE – Regione Lombardia).

Zones	Loc.	alt.	exp.	Clay%	Silt%	pH	T. l. %	CEC	K ex (mg/kg)
A.	12	104	e	30	28	8.17	18.7	21.4	200
	14	120	e	38	30	8.11	32.7	24.3	253
	20	107	o	32	28	8.13	30.2	20.8	296
	1	175	se	33	27	8.12	33.6	20.7	252
	3	205	no	39	29	8.07	34.3	25.1	550
B.	16	120	o	42	20	7.94	19.9	30.4	528
	44	185	e	48	16	7.94	8.2	32.9	626
	15	200	n	50	18	8.02	7.5	36.2	636
	17	250	s	42	12	8.26	15.8	36.6	516
	18	290	n	56	18	8.01	30.3	33.3	691
	6	245	se	57	11	8.07	11.1	40.5	755
	5	320	se	54	16	8.02	14.1	36.5	500
C.	47	235	n	44	21	7.71	8.5	37.0	452
	19	274	ne	48	16	8.16	17.5	31.9	717
	24	300	so	50	18 7.9	20.9	30.7	548	
	26	335	ne	44	24	7.58	54.8	23.4	561
	45	358	se	46	20	7.65	5.4	38.7	310
D.	35	250	o	48	20	7.95	24.6	32.6	447
	36	290	e	54	22	7.61	36.4	28.3	482
	34	360	o	44	22	7.5	18.3	25.4	444
	32	425	se	54	20	7.81	35.9	26.0	470
E.	41	370	no	56	18	7.58	17.6	34.0	572
	38	460	se	48	28	7.71	29.2	24.6	503

Table 2 – Soil characteristics of the studied vineyards in the zones: A= hills and lowlands to north in Cigognola and Scorzoletta (Pietra de Giorgi), B = hills to South-West in Cigognola and Pietra de Giorgi, C = hills of Lirio, D = hills of Rocca de Giorgi, E = hills of Canevino). Loc. = locality, alt. = altitude (m a.s.l.), esp. = exposure (n = North, e = East, s = South, o = west), T.l. = limestone, CEC = Cation Exchange Capacity ex = exchangeable).

Zones	Loc.	alt.	exp.	pH (must)	Actit.	Actart.	Acmal.	Sugar	y/vine
A.	12	104	e	3.12	8.58	6.8	3.9	18.4	-
	14	120	e	3.06	8.61	7.13	3.16	19.3	5.5
	20	107	o	3.12	9.49	6.6	4.88	18.5	4.8
	1	175	e	3.24	8.38	6.51	4.24	18.5	7.3
	3	205	no	3.11	9.8	7.3	4.8	19.0	4.3
B.	16	120	o	3.3	9.64	5.8	6.53	18.5	5.9
	44	185	e	3.19	10.59	7.1	6.08	18.0	8.9
	15	200	n	3.16	9.9	6.3	6.1	20.0	5.7
	17	250	s	3.18	9.1	7.4	4.2	17.2	7.1
	18	300	n	3.15	10.21	6.73	5.51	16.3	5.4
	6	245	se	3.34	8.1	6.4	4.3	19.5	5.6
	5	320	se	3.10	9.48	7.63	4.01	18.4	5.5
C.	47	235	n	3.12	10.5 7	5.7	17.4	5.0	
	19	274	ne	3.15	9.7	6.54	5.43	17.0	8.8
	24	312	so	3.21	9.37	6.71	5.03	19.5	5.9
	26	335	ne	3.24	9.22	7.04	4.87	20.9	4.3
	45	358	se	3.05	9.4	7.1	4.1	19.0	4.4
D.	35	250	o	3.14	10.44	6.83	5.19	16.0	6.4
	36	290	e	3.15	10.05	7.09	5.31	17.1	7.3
	34	360	o	3.15	9.7	6.7	5.1	18.0	5.7
	32	425	se	3.11	10.3	7.3	5.2	18.5	5.4
E.	41	370	no	3.10	9.97	7.52	4.6	18.8	5.2
	38	460	se	3.13	9.7	7.7	5.1	18.5	6.0

Table 3 – Productive performances of the grapevines in the different localities (average of the years): A= hills and lowlands to north in Cigognola and Scorzoletta (Pietra de Giorgi), B = hills to South-West in Cigognola and Pietra de Giorgi, C = hills of Lirio, D = hills of Rocca de Giorgi, E = hills of Canevino). Loc. = locality, alt. = altitude (m a.s.l.), exp. = exposure (n = North, e = East, s = South, o = west), Actit. = titrarable acidity eq. tartaric acid (g/L), Actar. = tartaric acid (g/L), Acmal. = malic acid (g/L), sugar (°Brix), y/v = yield/vine (kg).

	Sugar	pH	Actit.	Actart	Acmal.
Silt %	–	-0.44 *	–	–	–
Clay%	–	–	–	–	–
K ex	–	+0.65 **	–	–	–
pH (soil)	–	–	–	–	–
active limestone	–	–	–	–	–
altitude	–	–	–	+0.65 **	–
exposure	–	–	-0.47 *	–	-0.51 *

Table 4 – The significant correlation coefficients (F, * = significant for p<=0.05; ** = significant for p<=0.01) between the environmental variables considered and some of the qualitative characteristic of the grapes (homogeneous vineyards according to the number of buds/vine and yield; years 1988, 1989, 1990). Actit. = titratable acidity eq. tartaric acid (g/L), Actar. = tartaric acid (g/L), Acmal. = malic acid (g/L), sugar (°Brix). , alt. = altitude (m on the level of the sea), esp. = exposure, a.l. = active limestone, ex = exchangeable, a.l. = active limestone.

Sources of variation	fertility SS		grape cluster A.V. SS		Yield/vine SS	
Year (Y)	0.76	–	19587.1	**	19.32	**
Altitude (AL)	0.50	-	15624.3	**	30.26	*
Exposure (Ex)	0.46	-	18853.5	**	46.48	**
Y x AL	3.30	**	9618.6	*	21.37	**
Y x Ex	0.18	-	3980.3	-	11.10	-
AL x EX	1.46	-	52058.9	**	17.67	-

Table 5 – ANOVA results about some of the productive variables considered. A. V. = average value, * = significant for p<=0.05, ** = significant for p<=0.01), - = not significant. SS = sum of squares.

Sources of variation	pH SS		Actit. SS		Actart. SS		Acmal. SS	
Year (Y)	0.364	**	88.24	**	113.31	**	56.43	**
Altitude (AL)	0.33	**	22.83	**	50.4	**	24.02	**
Exposure (Ex)	0.08	**	27.68	**	1.29	-	22.51	**
Y x AL	0.30	**	8.69	-	12.39	*	25.79	**
Y x Ex	0.03	-	28.39	**	14.32	**	8.65	-
AL x EX	0.04	-	4.78	-	0.72	-	10.33	*

Table 6 – ANOVA results about some of the acidic variables considered. A. V. = average value, F, * = significant for p<=0.05, ** = significant for p<=0.01), - = not significant. SS = sum of squares. Actit. = titratable acidity eq. tartaric acid (g/L), Actar. = tartaric acid (g/L), Acmal. = malic acid (g/L), sugar (°Brix).

Table 7 – Average values of the productive variables. Values followed by different letters are different according to LSD test for p<=0.05. exposure 1 = favorable for the sugar content (predominantly to south), 2 = unfavorable (predominantly to north).

		Fertility		grape cluster A.V. (g)		Yield/vine (kg)	
Year	88	1.60	a	124.34	a	5.58	a
	89	1.57	b	111.14	a	6.30	b
	90	1.52	ab	101.36	b	5.70	ab
Altitude	200 m	1.45	a	134.27	a	6.53	a
	300 m	1.57	a	111.14	b	5.69	b
	350 m	1.55	a	113.80	b	5.52	b
Exposure	1	1.47	a	129.11	a	6.42	a
	2	1.57	a	108.64	b	5.34	b

Table 8 – Average values of the qualitative variables. Values followed by different letters are different according to LSD test for p<=0.05. exposure. 1 = favorable for the sugar content (predominantly to south), 2 = unfavorable (predominantly to north).

		Sugar (°Brix)	pH	Titratable Acidity (g/L)	Tartaric Acid (g/L)	Malic Acid (g/L)
Year	88	18.54a	3.21a	9.28a	6.03a	4.50a
	89	17.27b	3.13b	10.34b	7.92b	5.40b
	90	20.51c	3.09c	8.51c	6.69c	3.73c
Altitude	200 m	19.18a	3.21a	8.94a	6.29a	4.93a
	300 m	17.87b	3.16b	9.70b	6.76b	5.25a
	350 m	18.06b	3.09c	9.85b	7.66c	4.23b
Exposure	1	18.75a	3.17a	9.09a	6.29a	4.93a
	2	18.27a	3.13b	9.97b	6.84a	5.24b

Table 9 – Average values of the acidity variables considered. Values followed by different letters are different according to LSD test for p<=0.05. exposure 1 = favorable for the sugar content (predominantly to south), 2 = unfavorable (predominantly to north).

		Altitude		
	exposure	200 m	300 m	350 m
pH	1	3.24a	3.20a	3.08b
	2	3.17a	3.13b	3.10b
Tartaric acid (g/L)	1	6.43a	6.78a	7.87b
	2	6.12a	6.74a	7.52b
Malic acid (g/L)	1	4.27ab	5.02c	3.88a
	2	5.73d	5.47d	4.60bc

Table 10 – Discriminant Analysis with the variables of the must composition evaluated.

Discriminant functions	Relative percentage	Significant of the derived functions
1	63.16	
2	24.01	0 **
3	7.66	1 **
4	3.70	2 -
5	1.46	3 -

Standardized coefficients of the first three functions

	1	2	3
Sugar	-0.62	0.93	-0.09
pH	0.72	0.40	0.77
Titratable ac.	0.44	-0.07	0.68
Tartaric acid	-0.48	0.64	0.79
Malic acid	0.14	0.54	-0.39

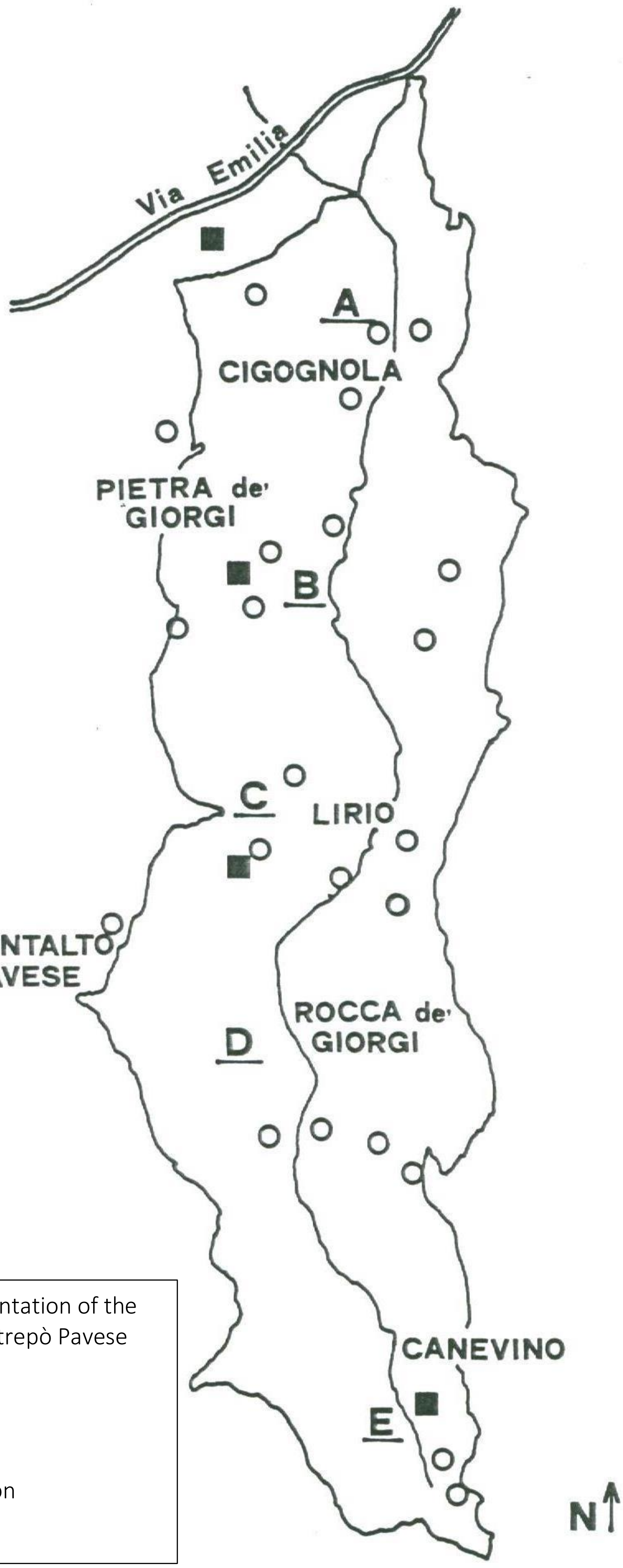

Figure 1- Graphical representation of the Scuropasso Valley in the Oltrepò Pavese DOC zone

○ = experimental vineyard

■ = meteorological station

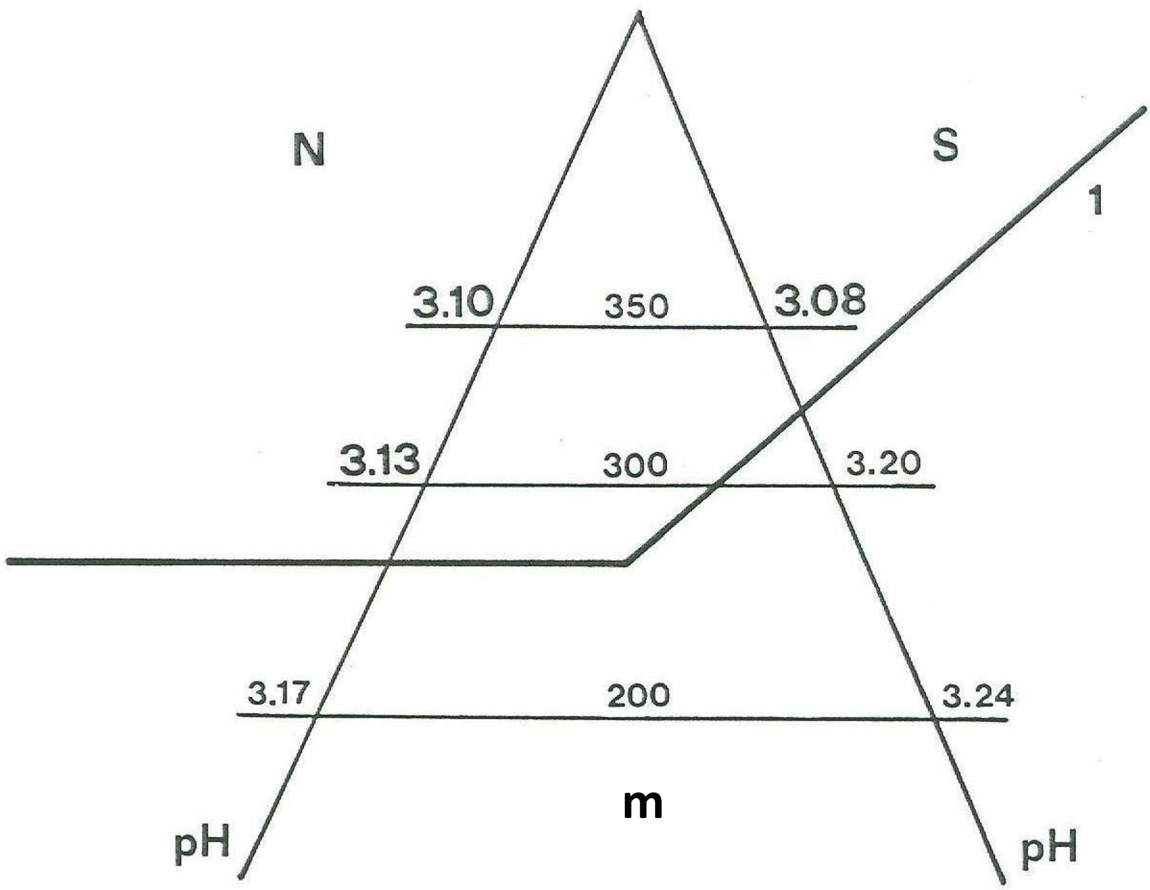

Figure 2 – Graphical representation of the Pinot noir relationship with the altitude and the exposure of the vineyards, according to the pH of the musts, in the Scuropasso Valley (Oltrepò Pavese): S = the favorable exposure to the sugar accumulation in the berries (predominantly toward south); N = the unfavorable exposure (predominantly toward north); m = meters a.s.l., altitude. The areas above the line 1 are considered the more vocates to the production of sparkling wine *methode traditionnelle* (Metodo Classico).