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Effect of vine vigour of *Vitis vinifera* cv. Nebbiolo clones on wine acidity and quality [1]

A. Schneider [2], F. Mannini [2], V. Gerbi [3] and G. Zeppa [3]

[2]) Centro Miglioramento Genetico Vite, CNR, Via P. Giuria, 15, I-10126 Torino, Italy

[3]) Istituto Microbiologia e Industrie Agrarie, Università, Via P. Giuria, 15, I-10126 Torino, Italy

Summary: The grapevine cv. Nebbiolo grown in northern Italy produces high-quality red wines, of which Barolo and Barbaresco are the best known. During a clonal selection project, clones of this variety were assessed for their agronomical and enological value. Different degrees of vegetative vigour were found among them, and this was related to modifications of must and wine composition, with particular respect to the acidity. Over 4 years of observations, vigorous clones produced musts and wines of higher pH, regardless of the amount of titratable acidity. This was associated with a higher malic acid content in the juice and with a higher concentration of potassium in the wine. In addition, wines from vigorous clones showed an unbalanced ratio of colour components. They ranked at the lowest score in the sensory evaluation tests.

Key words: selection, clone, variety of vine, Italy, vigour, growth, shading, yield, must quality, wine quality, acidity, potassium, organic acid, colour, sensory rating.

Introduction

In the span of the last 10 years, in many grape-growing areas a progressive increase in pH of grapes and musts with the consequent production of lower quality wines has been noticed. With the rise in pH is always associated an increase in the content of potassium in the fruit and, sometimes, a decrease in the ratio of tartaric/malic acid. It is evident that early harvest of the grapes or drastic corrective interventions in the musts may not be considered workable solutions when the objective is to obtain wines of high quality.

Numerous causes, of physiological, agronomic and genetic nature, have been proposed to explain the occurrence of this phenomenon. Among these is noted the increased level of potassium fertilization of soil. It has been observed that high availability of K^+ in the soluble pool of the soil raises the absorption of this element by the plant, provoking an accumulation at the foliar level. However, K^+ accumulation occurs especially in soils deficient in this element (Christensen 1975), and in the majority of cases does not cause the same significant K^+ increase in the musts (Murisier *et al.* 1982; Morris *et al.* 1983; Dundon *et al.* 1984).

An increase in berry pH has also been associated with the use of rootstocks and/or scions having an elevated capacity of absorption, translocation and accumulation of K^+ in the fruit (Ough *et al.* 1968; Champagnol 1988). Much proof exists of the different K^+ uptake, translocation and metabolism aptitudes of rootstocks and scions (Hale 1977; Morard *et al.* 1981; Boulay 1982; Scienza *et al.* 1984; Hayes and Mannini 1988).

Even if the increased production per ha has influence on the numerous quality components of the grape, in the case of the pH increase it does not seem to play a direct role. What seems to have a preponderant role is the modification of the microclimate to which the plant is subjected. Acting directly upon the physiology of the plant, the microclimate will influence the metabolism of K^+, malic acid, tartaric acid, and the ion balance in general (Smart 1982; Smart *et al.* 1985). An increase in shading of the leaves, for example, has been positively associated with an increase of K^+ and of pH of the must (Smart 1982; Wolpert *et al.* 1983; Morrison 1988). An increase in leaf shading always accompanies an increase in the vigour of the plant, independently of other cultural

[1]) Contribution no. 210 of the Centro Miglioramento Vite, CNR, Torino.

Table 1: Canopy variable measurements of cv. Nebbiolo clones (1989)

Canopy variable	Clone 111	Clone 120	Clone 230	Clone 141
Total leaf area (m^2)/main shoot	10.9	9.6	8,5	6.9
Total lateral leaf area (m^2)/main shoot	6.9	5.8	4,9	3.7
Mean main shoot length (cm)	286	287	304	320
Mean lateral shoot length (cm)	46	42	32	33
Total leaf area (m^2)/vine	96.3	90.1	83,9	62.3
Total leaf area /canopy surface	2.67	2.50	2,32	1.73

conditions. High vigour may thus influence the metabolism of the plant during ripening, causing substantial modifications in the composition of the fruit. Among the factors which may lead to an increase in vigour, including rational pest control, irrigation and better nutritional state of the soil, the choice of rootstock and scion must not be forgotten. For the latter, the use of virus-free clonal selections is continuously increasing and is often identified with plants of good vigour.

In the course of clonal selection of cv. Nebbiolo, different levels of vegetative vigour have been observed among clones. Reported in the present work are the results of clone productivity and enological characteristics from 4 years of experimentation. In addition, the components of the vegetative vigour of the plants have been analysed.

Materials and methods

Vines of 4 clones of *Vitis vinifera* L. cv. Nebbiolo grafted on Kober 5 BB MI-K-9, free from the most harmful viruses, were grown in a comparison vineyard on a steep slope located in La Morra (north-west of Italy), a temperately continental area (mean annual temperature: 12.4 °C; annual rainfall: 813 mm).

The vineyard was planted in 1978 on a randomized block design in east-west rows, at 3.8 m x 1.0 m spacing in loamy soil of subalkaline pH (7.5) and total carbonate content of 33 %.

Vines were single cane-pruned on a multiwire trellis: the lowest wire carrying a 14-15 bud cane is positioned at 0.5 m from the ground and the highest one, on which the apical tips were twisted, at 2.0 m. Pest, disease and weed control, fertilization and green pruning were in accordance with local practices.

For 4 years, starting when the vines were 6 years old, pruning weight, yield, and juice composition were recorded. Must analyses included percent sugar, titratable acidity, pH, tartaric acid (colorimetric method according to Vidal and Blouin 1978), and malic acid contents (enzyme assays).

Table 2: Vegetative vigour, yield and juice composition of cv. Nebbiolo clones (averages 1983-86)

Clone	111	120	230	141	F Clones	F Years	F CxY
Pruning wt (kg/vine)	1.8	2.0	1.5	1.4	**	*	n.s.
Yield (kg/vine)	4.3	4.9	4.8	3.2	**	**	n.s.
Bunch wt (g)	273	301	334	271	**	**	n.s.
Sugar (%)	22.8	23.1	22.3	23.3	**	**	*
Titratable acidity (‰)	11.2	10.6	9.8	10.0	**	**	**
pH	3.08	3.10	3.06	3.04	**	**	n.s.
Tartaric ac. (‰)	7.1	7.0	8.3	8.4	**	**	n.s.
L-malic ac. (‰)	5.7	5.5	3.8	3.4	**	**	**

Wines were made on a small-scale basis (0.5 hl) from each clone, with 6-7 d of skin contact. The following spring, the usual chemical wine analyses were carried out following the official Italian methods. The colour of wines was evaluated for intensity and tint according to Sudraud (1958) and total anthocyan pigments were determined by means of the pH difference method (Ribéreau-Gayon *et al.* 1972). Sensory evaluations were performed by a panel of 11 experts using both a rank (Salgues 1977) and a score test (Mannini *et al.* 1988) at each tasting session.

In 1989, measurements of vine leaf area, shoot length and amount of lateral growth were carried out in order to better assess different levels of clonal vegetative vigour. For each clone, the average main and lateral shoot leaf area and length were measured in July from 6 shoots for each of the two 3-vine replications. This was done in a non destructive way by measuring length (l) and width (w) of each leaf on the wine shoot, and by adjusting the value l x w on the basis of the regression equation coefficients resulting from 100 leaf samples each of the clones collected from neighbouring vines and measured by an areameter (Smith and Kliewer 1984).

The distribution of the foliage and canopy shading was also measured on the basis of the leaf layer number by means of the point quadrant technique (Mueller-Dombois and Ellenberg 1974).

Results

The 4 clones considered in this study differed markedly for their vegetative vigour as shown by the canopy component values reported in Table 1 and by winter pruning weight (Table 2). Vines of clones 111 and 120 showed higher pruning weight compared with clones 230 and 141. Likewise the measurements of total leaf area, which included the main and the lateral shoots of the vine, gave decreasing values from clone 111 and 120 to clone 230 and 141, suggesting a gradient of plant leaf surface through the 4 clones. In contrast, the length of the main shoots showed the opposite growth trend; shorter shoots being born by the vigorous large-leaved clones 111 and 120, which had, in addition, more extensive lateral growth.

The crop level was lower only in the weakest clone, Nebbiolo 141, with an average yield/vine of 25 % less than the other genotypes. The bunch weight varied among the different clones but independently of their vegetative vigour and crop.

Regarding fruit composition, sugar accumulation was always considerable (higher than 22.3 %), as is necessary for producing the superior aged Barolo and Barbaresco wines made with Nebbiolo grapes.

The titratable acidity in the juice, however, was higher in the vigorous 111 and 120 clones, when compared to the weaker 141 and 230 clones, despite the pH, whose values were slightly

Table 3: Chemical and sensory analyses of wines from cv. Nebbiolo clones (averages 1983-86)

Clone	111	120	230	141
Alcohol (%)	13.3	13.3	12.7	13.2
Extract (‰)	24.2	25.5	23.6	24.1
Ash (‰)	2.5	2.9	2.2	2.2
Alkal. N.	12.2	11.3	10.4	10.0
pH	3.75	3.83	3.53	3.53
Titratable acidity (‰)	5.3	5.3	5.6	5.5
K^+ (‰)	1.27	1.33	0.80	0.89
Tartaric ac. (‰)	1.3	1.2	1.7	1.7
Origin. L-malic ac. (‰)	4.5	4.1	2.9	2.9
Total phenols (‰)	1.8	1.9	1.9	2.0
Total anthocyans (‰)	0.081	0.082	0.100	0.092
Colour intensity $(E_{420nm} + E_{520nm}) \times 10^3$	352	363	536	601
Colour tint (E_{420nm} / E_{520nm})	0.91	0.96	0.77	0 .77
Sensory score (%)	62	59	74	72
Sensory ranking sum * (1985-86)	27	35	21	19

* The higher is the ranking sum, the lesser the wine is appreciated.

higher. These results coincide with different contents of the major organic acids in the musts: the amount of malic acid was higher and of tartaric acid slightly lower in the vigorous clones, whereas the opposite situation was found in the weaker ones.

Table 4: Correlation coefficients (r) between colour (intensity and tint) and ion balance components of wines from cv. Nebbiolo clones

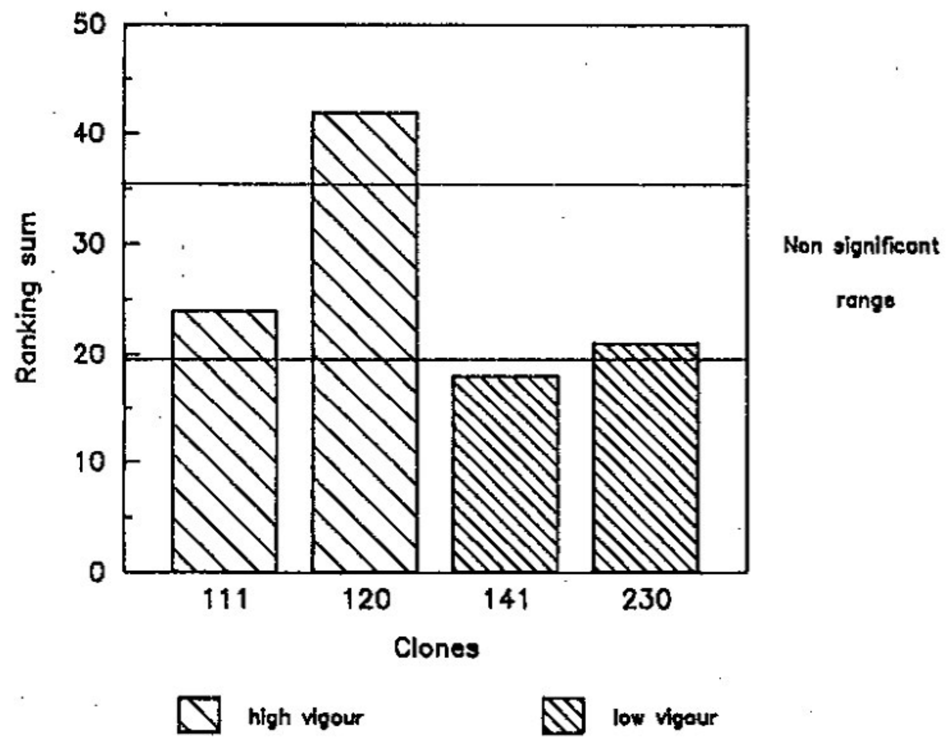
Parameters	Colour components	
	Intensity	Tint
Titratable acidity	+ 0,906 * *	- 0,559 n.s.
[H+]	- 0,810 * *	- 0,682 * *
Ash	- 0,677 * *	+ 0,847 *
Alcalinity N.	- 0,800 * *	+ 0,954 * *
K+	- 0,676 *	+ 0,869 * *
Tartaric acid	+ 0,900 * *	- 0,799 * *
Original malic acid	- 0,251 n.s.	+ 0,222 n.s.

Wine composition, in accordance to the juice analysis results, shows important differences between the more and the less vigorous genotypes, particular with respect to the ion balance and related parameters (Table 3). While extract values and alcohol percentages were similar (though ethanol was slightly lower in clone 230), pH, alkalinity number (ash alkalinity/ash), potassium, ash, and the original l-malic acid contents (calculated from the amount of l-lactic acid resulting from its biological transformation) were markedly higher in the wines from the vigorous clones 111 and 120. Tartaric acid content, in contrast, was slightly lower.

The effect of acidity components on wine colour is demonstrated by the correlations reported in Table 4. It is likely that the ion balance has a major effect on wine colour, thus affecting the visual evaluation in wine sensory analysis.

Wine colour intensity and tint were more favourable in the less vigorous clones, with a higher proportion of red colour components than yellow ones, although total phenol and anthocyanin amounts showed small differences between the 2 groups of clones. It is not by chance that wines from Nebbiolo 111 and 120 (vigorous) were judged lacking for aspect and taste more than for flavour and always ranked at the lowest score.

The ranking test indicated a similar evaluation trend. The results, referring to wines from the 1985 vintage, as shown in the figure, indicate that the wine produced from the moderately vigorous clone 141 was judged significantly better than the wine from vigorous 120.



Results of ranking sum test on 1985 vintage wines from clones of cv. Nebbiolo. The higher the histogram, the lesser the wine is appreciated.

Discussion

Among the clones of cv. Nebbiolo considered in this study, those showing a considerable vegetative vigour always performed very well in terms of yield and sugar accumulation, but produced wines of lower quality, mainly due to the higher amount of K^+ and the lower tartaric/malic ratio, which have a combined effect on both pH and colour of the wine.

In addition to a greater quantity of pruning wood, higher values of total leaf area were recorded in the vines of the vigorous clones. Having the training system of the same type, dimension and geometry for all the clones, this higher total leaf area resulted in a higher ratio of total vine leaf area/exterior canopy surface for the vigorous clones. In other words, their canopy was more crowded, as also confirmed by the fact that the main shoots were shorter despite the presence on them of larger main and lateral leaves and longer lateral shoots. Since the leaf layer number was rather consistent for all the clones (average of 7.4 at 1.8 m from the ground and 4.7 at 1.0 m), the more vigorous ones showed a higher proportion of shaded leaf surface on the total leaf surface caused by leaf overlapping.

Although physiological implications are not yet clear, the influence of leaf shading on grape composition has been already proved (Smart 1982; Morrison 1988), and our findings confirm the effects on pH, potassium and tartaric/malic ratio in the fruit.

In this experiment, only leaf interior canopy shading was involved, while no differences on bunch shading occurred among the clones, because of the traditional practice of leaf removal in the bunch zone for improving maturity.

Leaf shading, depending on clone vigour, has a genetic origin and this entails important implications for viticultural production. The selection of genotypes of high vigour, which is often coincident with virus-free status, may affect wine quality, not simply as a direct consequence of yield excess and delayed maturity as is sometimes reported, but as a consequence of fruit composition modifications, of which the anion-cation balance and related parameters are the more involved.

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