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THE EFFECT OF TRAINING SYSTEM AND CULTIVAR ON THE RATE OF LEAF APPEARANCE OF THE GRAPEVINE (*VITIS VINIFERA* L.)

EFFET DU SYSTEME DE CONDUITE ET DU CÉPAGE SUR LA VITESSE D'APPARITION DES FEUILLES DE LA VIGNE (*VITIS VINIFERA* L.)

C. PALCHETTI*, B. GOZZINI*, F. MIGLIETTA**, S. ORLANDINI*

*Ce.S.I.A. - Accademia dei Georgofili, Logge Uffizi Corti, 50122 Firenze (Italy)
**I.A.T.A. - C.N.R., Piazzale delle Cascine, 18, 50144 Firenze (Italy)

Abstract : The rate of leaf appearance was compared in two grapevine (*Vitis vinifera* L.) varieties (Sangiovese and Cabernet-Sauvignon) and in three different short pruning training systems (traditional cordon, single curtain and vertical cordon pruned). Results showed that there was no significant effect of training systems on leaf appearance. There was instead a significant effect of cultivar that suggested a different adaptive response of cultivars to climates they were selected for. A recently published simulation model of leaf appearance in grapevine was used to interpretate these differences.

Résumé : La vitesse d'apparition des feuilles a été confrontée pour deux cépages différents (Cabernet-Sauvignon, Sangiovese) de la vigne (*Vitis vinifera* L.) et pour trois différents systèmes de conduite à taille courte (cordon traditionnel, rideau simple, cordon vertical). Les résultats obtenus montrent que le système de conduite n'a pas un effet significatif sur l'apparition des feuilles, tandis que les cépages présentent des différences significatives qui peuvent être considérées comme une réponse d'adaptation différente des cépages au climat. Un modèle de simulation de l'apparition des feuilles dans la vigne, récemment publié (MIGLIETTA et *al.*, 1992), a été utilisé pour comprendre et interpréter ces différences.

Mots clefs : système de conduite - vigne - cépage - feuille
Key words : training system - grapevine - cultivar - leaf

INTRODUCTION

Grapevine (*Vitis vinifera* L.) growth and yield depend on the amount of solar energy converted into biomass and its partitioning between the different organs. Light interception by photosynthetic organs is critical in determining biomass growth rates and it depends on the amount of foliage present on individual plants forming the crop stand and its spatial arrangement (MIGLIETTA et *al.*, 1993). Leaf appearance and leaf extension rates regulate biomass accumulation during a large part of the vegetative growth period of grapevine, since during this period, the faster is the emergence of successive leaves, the larger is the amount of intercepted solar radiation (GOZZINI et *al.*, 1993). At first leaves appear as two small bumps in the apex meristem. These primordia give then rise to two rough stipules, while a new young leaf sprouts in the middle of them (EYNARD and DALMASSO, 1990). The young leaf grows until it reaches its final dimensions within 3 to 5 weeks (HUGLIN, 1986). The rate of leaf appearance has generally a symetric pattern in time: it progressively increases in the first weeks and then decreases to zero in the ripening period of grape. Nevertheless a strong relation was observed between leaf appearance rate and temperature (VERES et *al.*, 1978). Available soil water is a limiting factor for leaf expansion under drought conditions (HUGLIN, 1986), but in absence of severe stress leaf growth stops following an endogenous stimulus (FREGONI, 1985). In addition to temperature and water stress (VERES et *al.*, 1978; FREGONI, 1985; EYNARD and DAL-

MASSO, 1990) other factors have an influence on leaf appearance, such as pruning severity, growth direction, crop load, light exposure and nutrient availability (KLIEWER et *al.*, 1972; KLIEWER et *al.*, 1989). Pruning intensity modifies growth duration and vigour (FREGONI, 1985), but it has been observed that leaf number on a shoot is a nearly constant genetic factor during the different phenological phases (PRATT and COOMBE, 1978). Vegetation gradient can be affected by training: main shoots that grow straight up or horizontally are generally more vigorous than main shoots that grow straight down (KLIEWER et *al.*, 1989). Crop load and light exposure have instead little effect on leaf appearance (BUTROSE, 1969; MORGAN et *al.*, 1985). Experimental information obtained in the laboratory for several varieties clearly showed that there is no effect of photoperiod on leaf appearance (BUTTROSE, 1969). For a given training system, leaf appearance is mainly controlled by temperature with increase in temperature resulting in faster rates of leaf appearance (MONCUR et *al.*, 1989). A recently proposed model assumed that air temperature operates directly on cell division and expansion in the interval between temperature threshold (5° - 10°C) and optimum temperature (around 25 - 30°C), so that the appearance rate of a single leaf increases from zero to a maximum rate attained at the optimum temperature. However, due to an ontogenetic factor common to other species, leaf appearance rate declines with leaf number. This simple model is defined by the following equation (MIGLIETTA et *al.*, 1992) :

$$dF/dt = (a + bT)(1 - \alpha F)$$

where :

t = time
F = number of appeared leaves
T = mean air temperature (°C)
α = rate of increase in phyllocrone time per leaf
a, b = empirical coefficients

which does not take into account any effect of differences in pruning, training and cultivar on the rate of leaf appearance.

Temperature threshold for leaf appearance was set at 7°C and optimal model parameters were chosen when the mean absolute difference between observed and calculated number of leaves for all temperatures reached a minimum (a = -0.28, b = 0.04, α = 0.013).

This model is a bit different from an empirical model proposed by SCHULTZ (1992) that links leaf appearance to thermal time. It simulates the plastochrone development rate on the basis of a quadratic model dependent on degree days starting at bud burst.

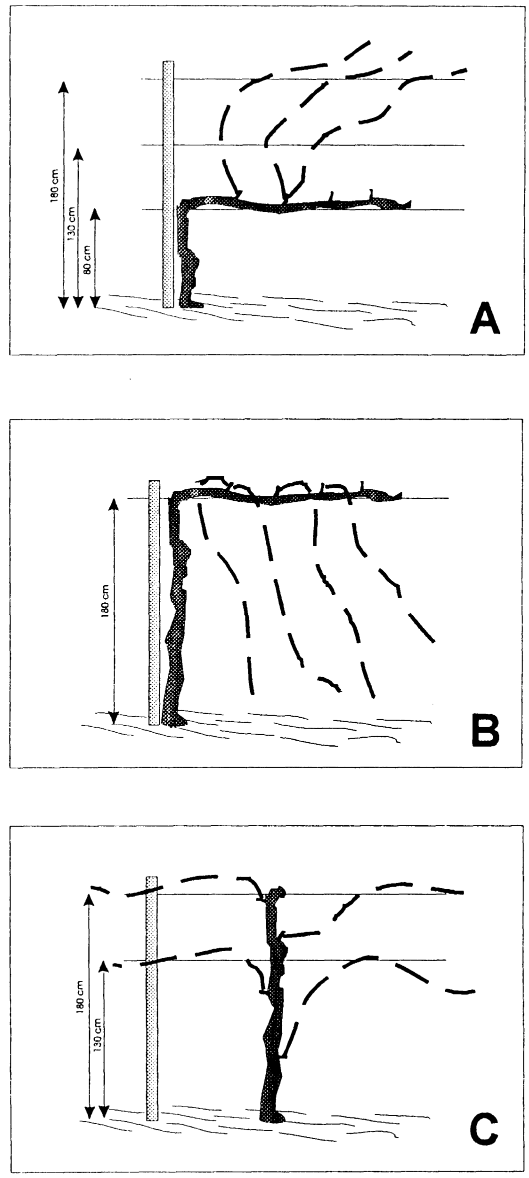

Fig. 1 — Schemes
of the three pruning training systems analysed

A : traditional cordon
B : single curtain
C : vertical cordon pruned

The study presented in this paper aimed to quantify the effect of major training systems used in North-Central Italy on leaf appearance of Cabernet-Sauvignon for potential incorporation into the simple model presented above, as well as to test the occurrence of significant differences in the rate of leaf appearance between Cabernet-Sauvignon and Sangiovese. For such a purpose, leaf appearance was monitored in the field on both cultivars, and for one of these (Cabernet-Sauvignon) the effect of three different training systems was investigated.

TABLE I

Multifactorial analysis of variance of leaf number of Cabernet-Sauvignon measured on shoots over two years, five dates and three training systems. Interactions were not significant.

Factors	Count	Average	Standard Error	d.f.[(1)]	Mean Square(e)	F-ratio[(2)]
Training system				2	2.2146	0.419 n.s*.
Traditional Cordon	66	22.078584	0.2865767			
Vertical Cordon	54	22.238812	0.3182699			
Single Curtain	58	21.843340	0.3088904			
Date				4	5282.5084	1000.37**
14 May	37	09.064156	0.3942203			
21 May	44	11.763337	0.3480352			
11 June	37	19.988705	0.3796597			
08 July	31	29.603061	0.4136413			
31 July	29	39.848636	0.4268574			
Year				1	406.8211	77.041**
1992	107	23.628382	0.2258681			
1993	71	20.478776	0.2774716			

[(1)]d.f. : degrees of freedom - [(2)] F-ratio : Fisher ratio - *n.s. : not significant - **significant for $p < 0.01$

TABLE II

Decades mean temperatures recorded during 1992 and 1993 in Mondeggi-Lappeggi and Santa Cristina farms

Month	Decade	Mondeggi-Lappeggi		Santa Cristina	
		1992	1993	1992	1993
May	1st	17.55	16.73	16.09	15.00
	2nd	18.55	16.96	17.08	15.78
	3rd	17.31	19.36	17.01	18.32
June	1st	17.00	20.95	16.93	19.77
	2nd	18.42	20.25	18.13	19.09
	3rd	19.71	22.46	18.87	20.91
July	1st	18.41	22.97	17.98	21.69
	2nd	22.04	20.80	21.29	20.07
	3rd	25.68	23.05	25.16	22.12

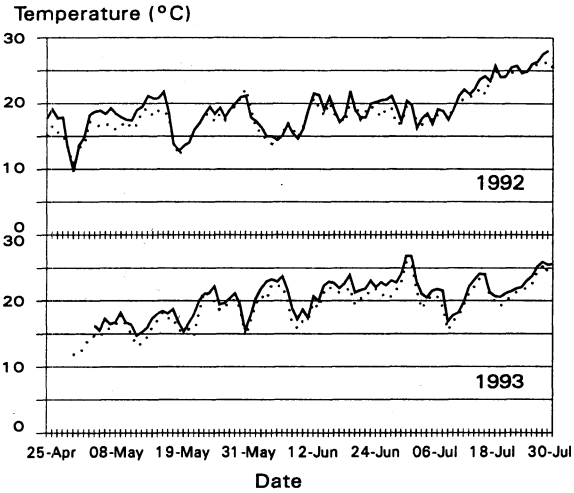

Fig. 2 — Climatic trends of mean daily temperatures recorded during 1992 and 1993 in Mondeggi-Lappeggi (solid line) and Santa Cristina (dotted line) farm

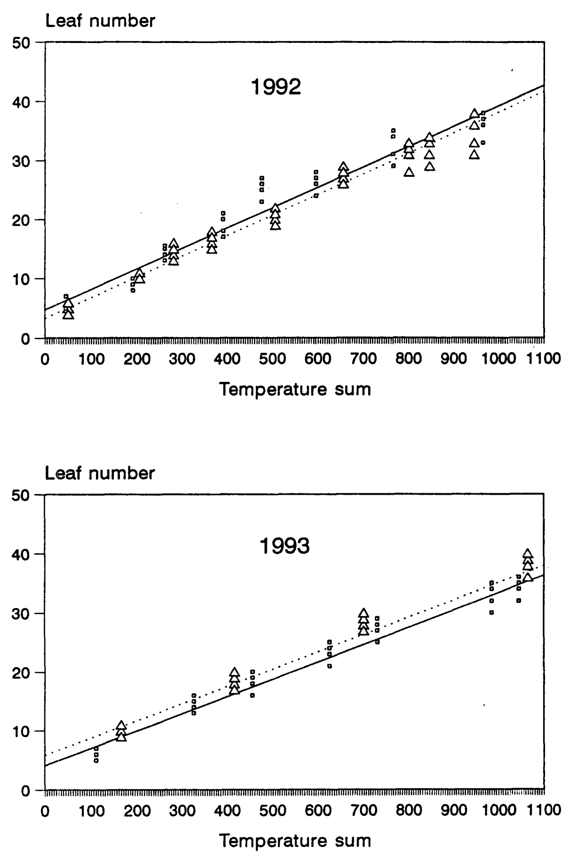

Fig. 3 — Comparison between leaf appearance rate in Sangiovese (square and continuous line) and Cabernet-Sauvignon (triangle and sketched line) varieties in 1992 and 1993

Field observations were then compared with model calculations to test the potential applicability of the model to a range of field conditions.

MATERIAL AND METHODS

Validation test was performed during 1992 and 1993 in two farms located in the Chianti hilly region (central of Italy) and on two varieties : Sangiovese in Mondeggi-Lappeggi farm (Bagno a Ripoli - Firenze) and Cabernet-Sauvignon in Santa Cristina farm (San Casciano - Firenze). Both cultivars were grafted onto 420A rootstock. Sangiovese plants were sampled in a vineyard trained to the traditional cordon pruned system. Three different short pruning training system were instead imposed to Cabernet-Sauvignon : traditional cordon, single curtain and vertical cordon pruned. In the traditional cordon pruned, shoots are arranged straight up, because they lean on supported wires along the row. In single curtain shoots grow straight up at first, but then they bend down under their weight, because they are left in a free bearing. In vertical cordon pruned, only one supporting wire is present on the rows top, so that shoots grow straight up at first, but then they grow horizontally (figure 1). In all training systems, plants had five to six two-nodes spurs and not pruned in summer to allow a better evaluation of the rate of leaf appearance. 25 shoots were selected from the first bud and 25 from the second bud of the spur for each variety and for each training system (100 total plants). Measurements were made weekly since bud break. Leaf number was determined non destructively on every shoot by counting the number of visible unfolded leaves. Weather data were recorded throughout the season by two meteorological stations located inside the vineyards. Statistical analysis was performed with the multifactorial analysis of variance function by the Statgraphics software package (Statistical Graphics System ver.6 by the Statistical Graphics Corporation), using the 95 p. cent as confidence level.

RESULTS AND DISCUSSION

Statistical comparison of observations made at 8 times in 1992 and 7 times in 1993 showed that there was no significant effect of training system on leaf appearance rate in the cultivar Cabernet-Sauvignon (table I). At each sampling time, the mean number of leaves per day counted on shoots trained to the three system was not statistically different. This differs with previous observations reported by SCHULTZ (1992).

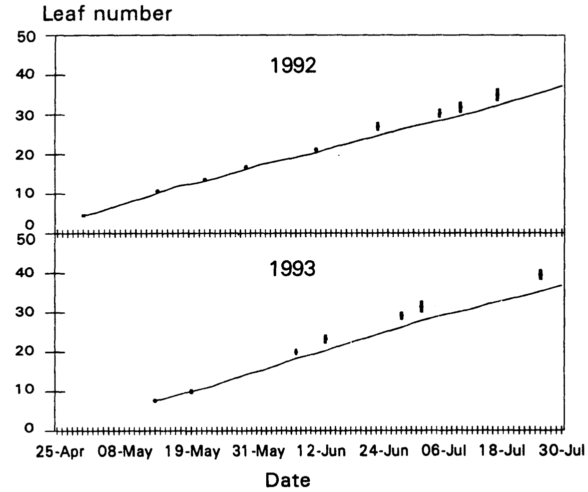

Fig. 4 — Cabernet-Sauvignon, S. Cristina farm, 1992 and 1993. Comparison between observed (dots) and simulated (lines) leaf number

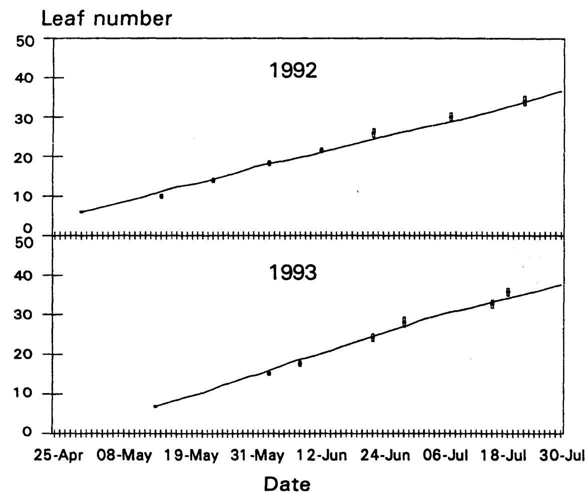

Fig. 5 — Sangiovese, Mondeggi-Lappeggi farm, 1992 and 1993. Comparison between observed (dots) and simulated (lines) leaf number

On the other hand he worked on «White Riesling» comparing four canopy systems with differences in the pruning methods (cane and spur pruned) and in the number of buds per vine (from 18 to 30), while in this paper the three training systems differ only in the geometry of the canopy according to the position of the shoots. KLIEWER et *al.* (1989) showed an effect of training system on leaf appearance in the cultivar Cabernet-Sauvignon cultivated under greenhouse.

In that study the comparison was made between plants trained upward and downward and such a dramatic difference in training may have had stronger influence on shoot vigour than the range of training system that have been compared in this study. From a modelling point of view, the absence of significant differences between the studied training systems seems to suggest that once a simulation model is well calibrated for a given variety it may allow accurate predictions of leaf appearance for the training systems characterised by a short pruning. The fact that leaf appearance is not affected by training does not, however, allows to conclude that leaf area growth rate was also the same among training system. Difference in training may have resulted, in fact, into a change of the size of individual leaves along the shoot, thus affecting the data of total shoot leaf area.

Dates of emergence of individual leaves as well as the number of leaves present on a shoot at a given calendar date differed between years. Such a difference was mainly due to an earlier bud break occurred in 1993 as compared to 1992 (in 1992 bud break time was about the 27 of April while in 1993 was about a week before) since the mean rate of leaf appearance calculated for the two years between May and July was faster in 1993, as likely result of comparable thermal regimes between the two seasons that shows higher mean temperatures in 1993 (table II).

Direct comparison of measured rates of leaf appearance between « Cabernet-Sauvignon » and Sangiovese was impossible as the two varieties were grown into two different vineyards having a significant different mesoclimate. However, even if plants of Sangiovese were exposed to higher mean temperatures than plants of Cabernet-Sauvignon both in 1992 and 1993 (figure 2), a comparison was made normalizing the mean rates of leaf appearance with respect to the temperature sums (figure 3). The rates observed in the two cultivars and in the two years were not significantly different. In fact, the slopes of lines fitted between the number of leaves counted on shoots and the temperature sums calculated after budbreak on the two cultivars were not statistically different in both years.

This observation suggested that for the same temperature Cabernet-Sauvignon had a higher rate of leaf appearance than Sangiovese probably due to a lower temperature threshold for leaf growth. As a convergence when the model of equation [1] was used, it underestimated leaf number in Cabernet-Sauvignon (figure 4), while it provided accurate predictions for Sangiovese (figure 5). However, the differences between Cabernet-Sauvignon and Sangiovese varieties can largely derive from the climate, being the first adapted to the lower spring temperatures of the North of Europe and the other to the higher temperatures of

Italian peninsula. This suggested that most of cultivar differences in the rate of leaf appearance are related to a response of cultivars to climates they were selected for. Although there is need of experimental confirmation, it may be inferred from this that temperature threshold for leaf growth may significantly decrease with increasing latitude of cultivar selection provided that mean spring temperature also decreases with increasing latitude.

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REFERENCES

BUTTROSE M.S., 1969. Vegetative growth of grapevine varieties under controlled temperature and light intensity. *Vitis*, **8**, 280-285

EYNARD I., DALMASSO G., 1990. *Viticoltura moderna. Manuale pratico*. Hoepli (Milano), 112-116.

FREGONI M., 1985. *Viticoltura generale, compendi didattici e scientifici*. Reda (Roma), 177-187.

GOZZINI B., MIGLIETTA F., ORLANDINI S., 1993. Simulazione della velocità di apparizione delle foglie nella vite (*Vitis vinifera* L.). *In Proceedings of International Symposium « Fisiologia della vite »*. San Michele all'Adige, Torino, 11-15 maggio 1992, 513-516.

HUGLIN P., 1986. *Biologie et écologie de la vigne*. Payot Lausanne Technique & Documentation (Parigi), 59-76.

KLIEWER M.W., LIDER L.A., FERRARI N., 1972. Effects of controlled temperature and light intensity on growth and carbohydrate levels of Thompson Seedless grapevines. *J. Amer. Soc. Hort. Sci.*, 97, 185-188.

KLIEWER M.W., BOWEN P., BENZ M., 1989. Influence of shoot orientation on growth and yield development in Cabernet-Sauvignon. *Amer. J. Enol. Vitic.*, **40**, 259-264.

MIGLIETTA F., GOZZINI B. ORLANDINI S., 1992. Simulation of leaf appearance in grapevine. *Vitic. Enol. Sci.*, **2**, 41-45.

MIGLIETTA F., GOZZINI B., ORLANDINI S., 1993. An ontogenetic model for the simulation of leaf area development in grapevine : I. Model development. *Vitic. Enol. Sci.*, **2**, 51-54.

MONCUR M.W., RATTIGAN K, MACKENZIE D.H., MCINTYRE G.N., 1989. Temperature threshold for budbreak and leaf appearance of grapevines. *Amer. J. Enol. Vitic.*, **40**, 20-21.

MORGAN D.C., STANLEY C.J., WARRINGTON I.J., 1985. The effects of simulated daylight and shade-light on vegetative and reproductive growth in kiwifruit and grapevine. *Hortic. Sci.*, **60**, 473-484.

PRATT C., COOMBE B.G., 1978. Shoot growth and anthesis in Vitis. *Vitis*, **17**, 125-133.

SCHULTZ H.R., 1992. An empirical model for the simulation of leaf appearance and leaf area development of primary shoots of several grapevine (*Vitis vinifera* L.) canopy system. *Scientia Horticulturae*, **52**, 179-200.

VERES A., POLAKOVIC A., VALACHOVIC A., 1978. Influence des facteurs climatiques sur les recoltes de raisins dans differents conditions écologiques en Tchecoslovaquie. *Symp. Int. Ecologie de la Vigne,* Constanta.

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