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Photosynthetic activity in grafted and ownrooted Erbaluce grapevines trained to four trellis systems

by

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S u m m a r y : Photosynthetic activity of grafted (Kober 5BB) and ownrooted grapevines (cv. Erbaluce) trained to four trellis systems (alternate curtain, central curtain with one or two canes and pergola) was assessed for three years. The overall photosynthetic response to training, the seasonal and diurnal photosynthetic trends and the response of the training systems to different photosynthetic photon flux densities were evaluated. The training systems had a significant influence on the rate of photosynthetic assimilation: the two central curtains generally had higher rates of CO_2 uptake compared to the vines which were trained to pergola and to alternate curtain. With one exception Kober 5BB improved net assimilation rates.

K e y w o r d s : photosynthesis, quantum yield, training system, diurnal changes, grafted, ownrooted.

Introduction

The training system can be an effective technique to control the vegetative and productive potential of grapevines. Canopy manipulation can in fact modify the microclimate and thus the photosynthetic efficiency. The latter is notoriously influenced by light intensity (KRIEDEMANN 1968; KRIEDEMANN and SMART 1971; DÜRING 1988; FLORE and LAKSO 1989), air and leaf temperature (CANU *et al.* 1988), soil moisture and air humidity (DÜRING 1987; FLORE and LAKSO 1989), leaf age and position (KRIEDEMANN *et al.* 1970; SCHUBERT *et al.* 1992; SCHUBERT and NOVELLO 1992). Particularly, leaves growing at different light levels differ in their anatomy and physiology. In shaded leaves the lamina is thinner and the photosynthetic compensation and saturation points are lower than in sun leaves (GUCCI and CORELLI-GRAPADELLI 1989). Leaves of different age and shoot position are differently affected by clusters and apices which are the main sinks (FLORE and GUCCI 1988).

Moreover, the photosynthetic activity shows diurnal fluctuation reaching a maximum in the morning (LAKSO 1985; DOWNTON *et al.* 1987) and seasonal fluctuations often reaching a maximum during the periods of intensive growth in mid-summer (FLORE and SAMS 1986).

In this work, the photosynthetic activity of Erbaluce vines trained to alternate curtain, central curtain with one or two canes and pergola was compared. As Erbaluce is usually grown ownrooted in old vineyards, the photosynthetic performance of ownrooted and grafted vines was compared.

Material and methods

Vines of the Erbaluce clone CVT TO 55, grafted on Kober 5BB and ownrooted vines, were planted at Caluso (Turin Province) in 1983. The following training systems were compared:

- Alternate curtain (AC): it is similar to the double curtain system. Plant spacing was 3 m x 2 m. Each vine had three cordons (with one ten-bud cane per unit). The cordons were alternatively fixed to one of the two lateral wires (1.8 m above the soil, 0.6 m away from the row axis).
- Central curtain: in the one cane system (C1), plant spacing was 3 m x 2 m; one twenty-bud cane was fixed to a wire 1.8 m above the ground and shoot growth was not influenced. In the central curtain with two canes (C2), two ten-bud canes were fixed to a wire 1.8 m above the ground.
- Pergola (P): Vine spacing was 6 m x 2 m. Each plant had, at 1.8 m above the ground, three productive units called 'cords'. Each 'cord' consisted of three cordons each ending with a ten-bud cane; the three cordons and their canes were interlaced all together. The 'cords' were trained perpendicularly to the row axis; on alternate vines, two 'cords' were on the right and one was on the left of the row.

The vineyard achieved full production in 1987.

Photosynthetic parameters were measured from 1990 to 1992 by means of a portable infrared gas analyzer (ADC-LCA 3, Analytical Development Co. Ltd, Hoddesdon, UK). The following parameters were measured:

Net Photosynthesis (PN), $\mu mol\ m^{-2}\ s^{-1}$; Photosynthetic Photon Flux Density (PPFD), $\mu mol\ m^{-2}\ s^{-1}$; Quantum Yield (QY) = PN:PPFD ratio.

To investigate the overall photosynthetic rate of vines measurements were performed on 5 mature leaves of the medium part of the shoot arising from the middle of the cane.

Measurements were taken every 2 h, between 10:00 and 18:00 from July to September and between 12:00 and 16:00 in October, because of the weather conditions. Measurements were normally taken at light saturation level; in 1993 they were also performed at different PPFD levels.

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Data were statistically processed by means of GLM procedure of SAS package (SAS Institute Inc., Cary, NC, USA).

Results and discussion

Overall photosynthetic response: All variation sources were significant for both grafted and ownrooted vines. By testing non-orthogonal contrasts (P *vs.* AC, P *vs.* C1 and C2, AC *vs.* C1 and C2), P *vs.* AC did not exhibit any difference in both kind of vines.

In grafted vines the two central curtains (C1, C2), as well as AC and P showed similar rates of assimilation; the latter two had lower values. Quantum yield was similar in C1, C2 and P but lower in AC (Table).

For the ownrooted vines AC and P had, again, lower rates of CO_2 uptake; comparing the central curtains, C2 exceeded C1. Quantum yield had the same trend as PN.

Table

Net photosyntesis (PN) and quantum yield (QY) obtained with different trellis systems using grafted and ownrooted vines

Training systems	PN (μmol m^{-2} s^{-1})	QY (PN/PPFD)·1000
Kober 5BB		
AC, alternate curtain	4.65 B	3.63 B
C1, central curtain, 1 cane	5.52 A	4.29 A
C2, central curtain, 2 canes	5.80 A	4.43 A
P, pergola	4.81 B	4.08 A
Ownrooted		
AC, alternate curtain	3.95 C	3.08 C
C1, central curtain, 1 cane	5.20 B	4.05 B
C2, central curtain, 2 canes	6.80 A	5.16 A
P, pergola	4.15 C	3.46 C

Means followed by the same letter are not significantly different at P=0.01 (Tukey test).

It has been suggested that, for the central curtains the light interception is improved and that the canopy allows a better light penetration than in the alternate curtain (NOVELLO *et al.* 1992). Moreover, shoots of shorter canes (C2) seem to be more efficient than those from longer ones (C1), the bud number per vine being equal (NOVELLO 1994).

The interaction between trellis system and grafting combination was highly significant (P= 0.001): in contrast to all the other systems, C2 showed higher rates of photosynthesis and quantum yield in ownrooted vines (Table).

Diurnal photosynthetic trends during the season: During all the season, the photosynthetic activity appeared to be depressed in the afternoon (Fig. 1). This has been thought to be the consequence of a reduction of stomatal conductance due to an increment of temperature and vapour pressure difference (SCHULZE *et al.* 1974; KRIEDEMANN *et al.* 1976; DOWNTON *et al.* 1987), or as a consequence of diurnal changes of hormones (HOAD *et al.* 1977; LOVEYS *et al.* 1987). Non-stomatal factors have also been hypothesised to play a role: the accumulation of carbohydrates in the leaves can cause a feed-back effect on PN (HEROLD 1980; AZCON-BIETO 1983) or an inhibition of PN by ABA, which affects stomatal closure (CORNIC and MIGINIAC 1983; RASCHKE and HEDRICH 1985).

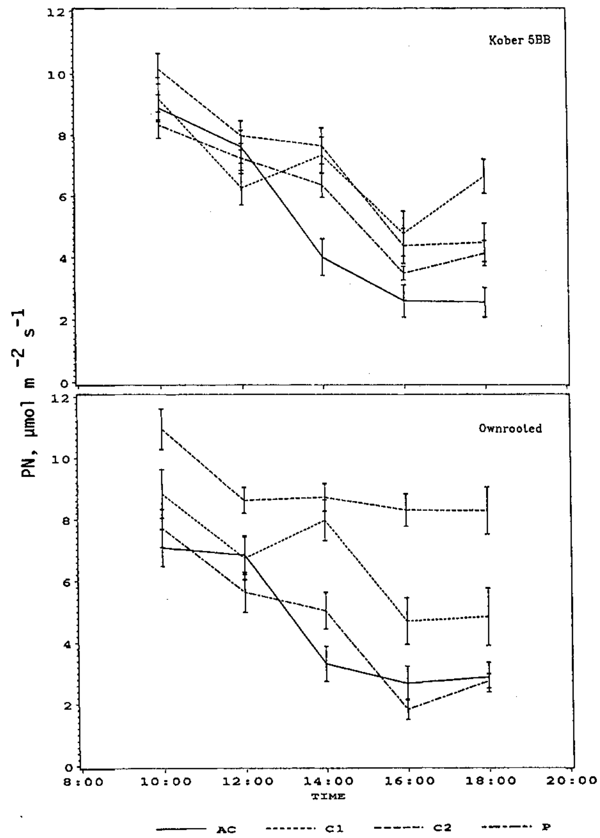

Fig. 1: Diurnal changes of net assimilation (PN) of leaves of grafted (Kober 5BB) and ownrooted vines trained to four trellis systems in July. AC, C1, C2, P: see Table.

For the grafted vines, the central curtains had the highest photosynthetic rates in July (Fig. 1) and October, but the same tendency was found in the other months. Quantum yield generally followed the PN trend during the first part of the day. Among trellises, the main differences became evident, except for October, at the end of the day (e.g. July, Fig. 2) when C1 became the most efficient system in the late afternoon.

Within the ownrooted vines, the central curtains generally reached higher values than AC and P, especially in the afternoon, except for October; C2 was often found to be superior to C1. In October although at the end of the growing season, all trellises still showed considerable photosynthetic rates which can be compared with those observed in the previous months. The quantum yield trend was very close to that found for PN.

Extending the measurements to October, i.e. after harvest, allows to evaluate the effect of fruit on the photosynthetic process. In many woody species, the absence of fruit has been found to depress photosynthesis (HANSEN 1970; AVERY 1977; LENZ 1979; MONSELISE and LENZ 1980; FUJII and KENNEDY 1985; DE JONG 1986; DOWNTON *et al.* 1987). These results seem to be related to an accumulation of carbohydrates in the leaves, which leads to the above mentioned feed-back effect on PN and which can possibly be ascribed to the lack of active sinks (Azcon-Bieto 1983).

In our experiments, on the contrary, the photosynthetic process did not appear to change after harvest; to our knowledge, there are no similar experiences we can refer to.

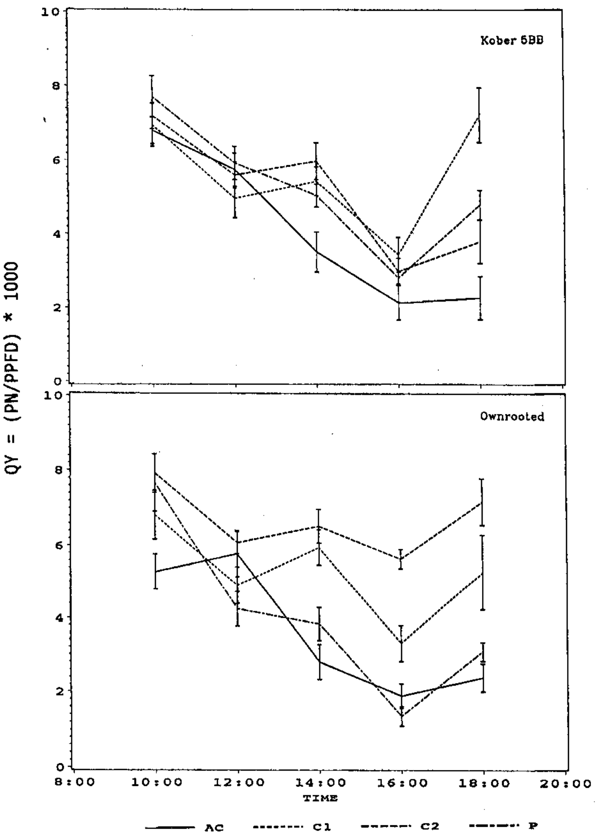

Fig. 2: Diurnal changes of quantum yield (QY) of leaves of grafted (Kober 5BB) and ownrooted vines trained to four trellis systems in July. AC, C1, C2, P: see Table.

Response to different PPFD levels: At increasing light intensity both, grafted and ownrooted vines trained to central curtains reached, once more, higher photosynthetic values than those trained to pergola and alternate curtain (Fig. 3). Within grafted vines, this trend was evident starting from PPFD >200 µmol m^{-2} s^{-1} (C2) and from PPFD >700 µmol m^{-2} s^{-1} (C1). Within ownrooted vines, the same trend was already evident at values lower than 200 µmol m^{-2} s^{-1}.

Moreover, in ownrooted vines trained to central curtain, CO_2 uptake increased with PPFD even at light intensities exceeding 800-900 µmol m^{-2} s^{-1} (Fig. 3), which is commonly assumed to be the point of light saturation in grapevines and in many other C_3 species (Lakso 1986; Carbonneau 1987; Düring 1988; Gucci *et al.* 1990).

Conclusions

Training systems were shown to significantly influence the photosynthetic assimilation .

The photosynthetic response of vines trained to pergola and to alternate curtain was similar; as the pergola is

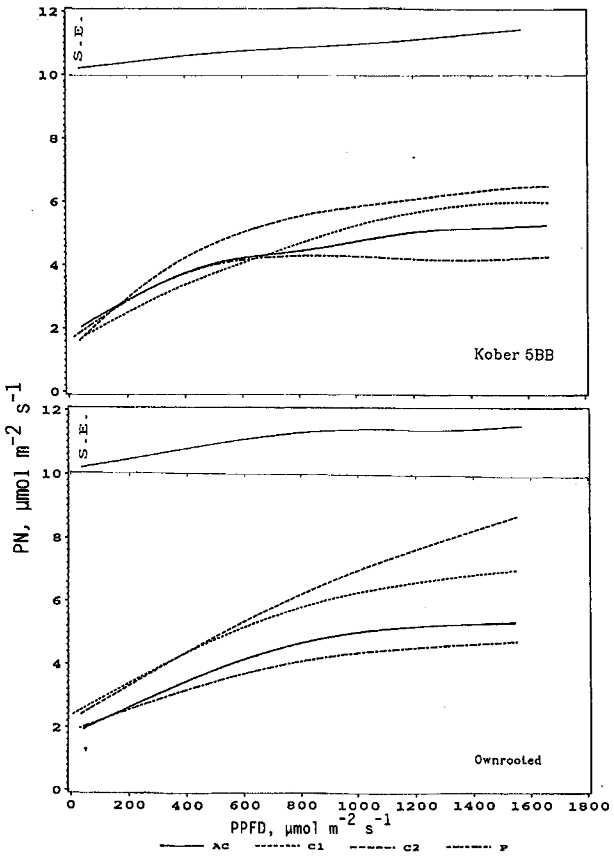

Fig. 3: Net assimilation (PN) response to different PPFD levels of grafted (Kober 5BB) and ownrooted vines trained to four trellis systems. The width of the standard error (S. E.) curve corresponds to the standard error at each point of the plot.

the only trellis used for Erbaluce, the alternate curtain, which is a less complicate and a less expensive trellis to establish and to maintain, could be proposed as an alternative.

The two central curtains generally induced higher rates of CO_2 uptake; in C2, this was particularly significant.

With regard to pergola, the low net assimilation is normally compensated by the total leaf area which greatly exceeds that of the curtains, thus allowing to achieve a high CO_2 uptake per vine (Novello *et al.* 1992).

The use of the rootstock Kober 5BB improved the Erbaluce net assimilation with one exception in comparison to ownrooted vines: similar results were achieved by Düring (1994) with Riesling. Further investigations with Erbaluce have been planned in order to evaluate the effect of other rootstocks.

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