4 CONCLUSION

In *P.viticola* infected leaves, we have described an abnormal starch accumulation in oil spots at the end of the dark period which can be explained by an increase of starch synthesis *via* an increase in AGPase activity, combined with a decrease of its degradation by modification of amylase activities. Together with these alterations in starch metabolism, we have observed an accumulation of hexoses, an increase of neutral cell-wall invertase activity, and a reduction of photosynthesis. Such events are typical of a source to sink transition and are common features of a compatible plant / biotrophic micro-organism interaction. These changes of starch metabolism occurred when the leaves were highly colonized and may be associated with the pre-sporulation stage of *P.viticola.*

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Comparing water relations and stomatal regulation of Touriga Nacional and Syrah under mild water stress

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ABSTRACT

Aiming to compare the physiological responses of the Portuguese red variety Touriga Nacional (TN) with Syrah (SY), we studied during the 2007 growing season five-year-old grapevines growing in a commercial non-irrigated vineyard located at the Lisbon winegrowing region. Predawn (Y_{pd}) and midday (Y_M) leaf water potential, leaf stomatal conductance (g_s) and photosynthetic rate (A) were periodically measured between fruit set and harvest. Y_{pd} displayed a decreasing pattern throughout the growing cycle from -0.10 MPa at flowering to -0.44 MPa at harvest. Both varieties showed similar values except during the two measurements made in August when TN presented significantly higher values than SY. Y_{mid} also showed a decreasing pattern from the end of June towards harvest date, with significant differences between varieties being observed during the ripening period, with SY showing lower values than TN. A measured either at mid-morning and midday presented, for most part of the cases, lower values in SY than in TN, although the differences were only significant during the ripening period. g_s pattern was parallel to A and, in general, the relative differences between varieties mirrored those reported for A. No significant effect of the variety was detected on the relationships between A or g_s measured at mid-morning and Y_{pd}. However, when analyzing the set of data collected at midday it was observed that the regression lines of the relationships between A or g_s (dependent variables) and Y_{pd} (independent variable) presented a significantly higher slope in SY as compared to those showed by TN. These results show that the rate of decrease of A and g_s with the decrease of Y_{pd} was lower in TN than in SY suggesting that the two varieties have different stomatal regulation, with a more “optimistic” behavior in TN.

Keywords: grapevine, leaf water potential, photosynthetic rate, stomatal conductance.

1 INTRODUCTION

Grapevines are generally considered resistant to water deficits due to an efficient stomatal control in response to soil and air dehydration that may protect against xylem cavitation [1] . However, as a result of the high genotypic diversity in grapevine, differences with respect to water use and resistance to drought have been observed among varieties [2,3,4]. Differences occur in the particular mechanism of defence [5,2] as well as in the velocity of response [6]. Among those differences are those relating to leaf size and indumenta, to the structure, density and functionality of stomata, and to the osmotic adjustment capability that may secure water uptake [7]. It is also clear that the density and distribution of the root system play a key role in vine response to water deficits. Despite being a very important subject very little is known about these responses namely in what concerns Portuguese autochthonous varieties.

The aim of the present study was to compare the physiological behaviour of the Portuguese red variety Touriga Nacional with Syrah in response to soil drying in a non-irrigated vineyard.

2 MATERIALS AND METHODS

The five-year-old field grown grapevines (*Vitis vinifera* L.) of the red varieties Syrah (SY) and Touriga Nacional (TN) grafted on SO4 rootstocks were studied in 2007 at a small commercial non-irrigated vineyard located 60 Km north of Lisbon within the coastal area of the Lisbon Winegrowing Region (39º 01' N; 9° 06' E). The soil is a sandy clay loam with 1.45% organic matter and pH 5.9. The vineyard has a planting density of 4.000 vines per hectare, spaced 1.0 m within and 2.5 m between north-south oriented rows. Vines were trained on a vertical shoot positioning with two pairs of movable wires and spur-pruned on a bilateral Royat Cordon system. The vineyard is a small varietal collection where the two studied varieties are planted side by side in three adjacent rows of 60 plants per variety under the same canopy and cultivation management. For data collection four blocks of 10 vines per variety were established along the central row.

Predawn (Ψ_{pd}) and midday (Ψ_{mid}) leaf water potential, net CO_2 assimilation rate (*A*) and stomatal conductance (g_s) were measured periodically from the beginning of June (flowering) until the middle of September (1 to 3 weeks before harvest) on clear and sunny days. Leaf water potential measurements were carried in 6 individual exposed mature leaves of each cultivar using a pressure chamber. *A* and g_s measurements were performed at mid-morning (~10:00 AM) and midday (~02:00 PM), at saturating light intensities, on six fully exposed mature primary leaves of each cultivar, using a Li-6400 portable gas exchange system (Li-Cor Inc., Lincoln, Nebraska, USA). The *A* and g_s values were used to calculate the instantaneous intrinsic water use efficiency (A/gs).

In order to analyze the relationships between physiological parameters a regression analysis was performed between *A*, g_s and Ψ_{mid} (dependent variables) and Ψ_{pd} (independent variable). Differences between means were assessed by one-way ANOVA ($P<0.05$) and the regressions and the slope comparisons were performed by covariance analysis using SAS®.

3 RESULTS

Predawn leaf water potential displayed a decreasing pattern from flowering to harvest (June to mid-September) in the two varieties. In the period flowering-veraison both varieties presented high and similar values (between -0.1and -0.25 MPa) but during the ripening period TN presented significantly higher predawn values than SY, differences that were annulated at the last measurement made at harvest (Fig. 1A). Midday leaf water potential also showed a decreasing pattern from the end of June towards harvest date, with significant differences being observed only during the ripening period, where SY showed lower values than TN (Fig. 1B).

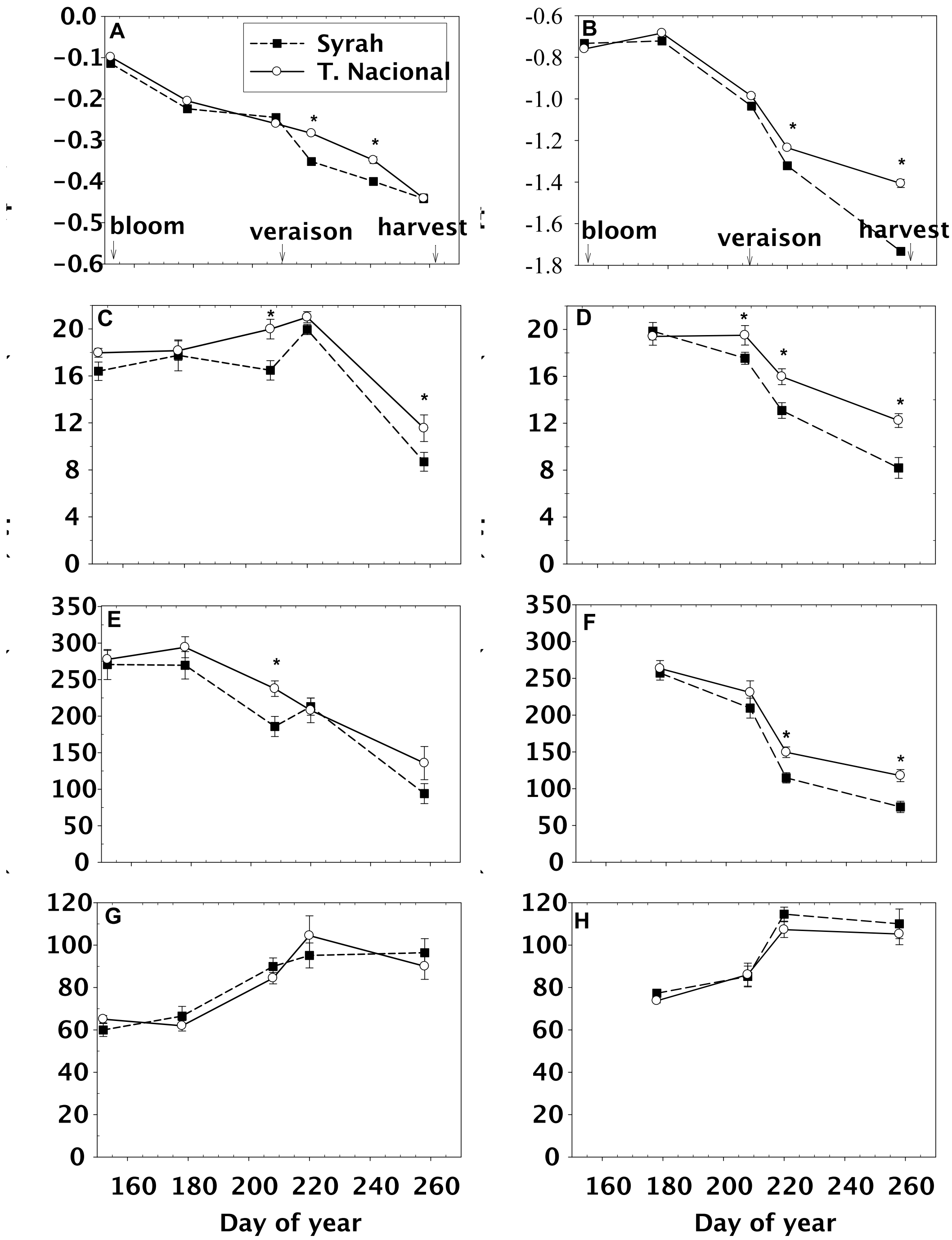

Figure 1. Seasonal changes of predawn (A) and midday (B) leaf water potential, net CO_2 assimilation rate (C, D), stomatal conductance (g_s) (E, F) and intrinsic water use efficiency (A/gs) (G, H) measured at mid-morning (10:00 h) (C, E, G) and midday (D, F, H). Data are shown as mean ± s.e. of 6 exposed leaves. Asterisks indicates significant differences (P < 0.05).

During the period flowering-veraison the *A* measured at mid-morning (A_{max}) shows very high and similar values on both varieties, ranging from 16 to 20 mmol m^{-2} s^{-1}. During the ripening period, with the exception of the measurement made at 8th August, SY presented a significantly lower A_{max} than TN (Fig. 1C). The *A* measured at midday (A_{mid}) presents a plateau from berry pea size to veraison and then a decreasing pattern till harvest in both varieties. With the exception of the first measurement made at the end of June TN presented always a significantly higher A_{mid} than SY (Fig. 1D).

Stomatal conductance pattern was parallel to *A* and, in general, the relative differences between varieties mirrored those reported for *A* (Fig. 1E,F). The intrinsic water use efficiency (*A/gs*) presented an increase from flowering to veraison and then a small decrease till harvest with no significant differences between varieties (Fig. 1G,H). Regarding the relationships between physiological parameters, the *A* and g_s were significantly positively correlated with predawn for

both varieties. No significant effect of the variety was detected on the relationships between *A* or g_s measured at mid-morning and Y_{pd}.
However, when analyzing the set of data collected at midday it was observed that the regression lines of the relationships between *A* or g_s (dependent variables) and Y_{pd} (independent variable) presented a significantly higher slope in SY as compared to those showed by TN (Fig. 2). These results show that the rate of decrease of *A* and g_s with the decrease of Y_{pd} along the season was lower in TN than in SY suggesting that TN has a more "optimist" behavior than Syrah.

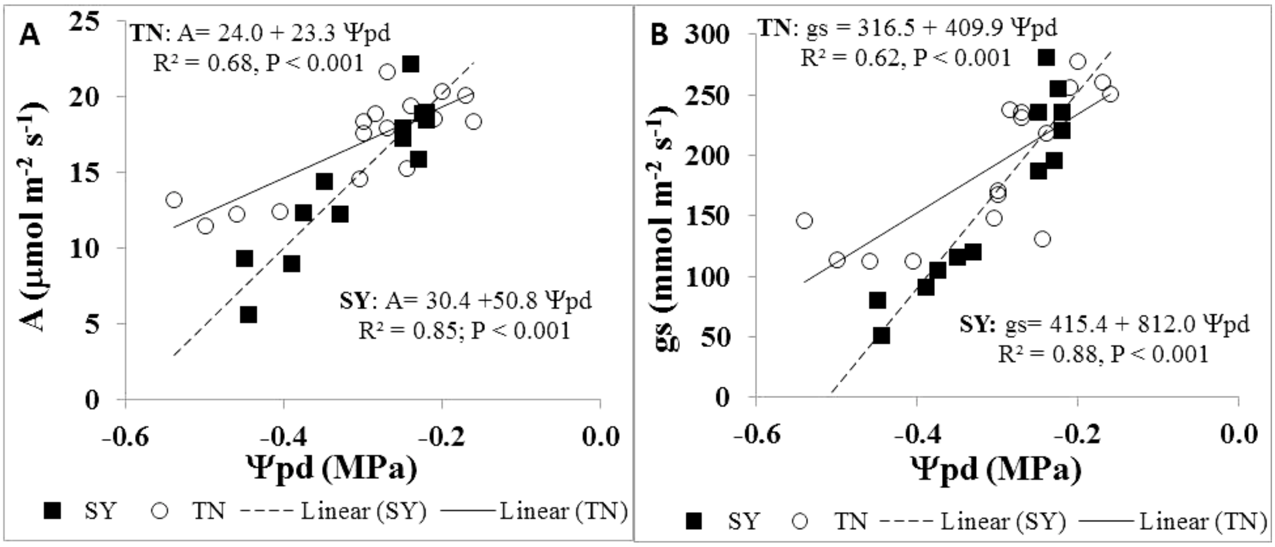

Figure 2. Relationships between net CO_2 assimilation rate (A), stomatal conductance (B) measured at midday (dependent variables) and predawn leaf water potential (Ypd) (independent variable). Regression lines were fitted to each variety (TN – Touriga Nacional; SY – Syrah), n=16.

4 DISCUSSION AND CONCLUSIONS

These results confirm previous ones by [4] taken in a Portuguese hotter region (Alentejo) during three consecutive years, showing that TN tends to keep their stomata open for a longer period during the growing season when compared to SY. This response leads to cooler leaves in TN than in SY.
In general, we would say that there is an important variability among varieties in what concerns regulation of stomata. This means that depending on the region and the predominant stress, we may be able to choose a variety that down-regulates or up-regulates stomatal aperture. In the first case, vines will save water but will experience increased leaf temperature, whereas in the second case heat tolerance will be improved due to evaporative cooling but this will decrease long-term water use efficiency.

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