12. C.J. SOAR, J. SPEIRS, S.M. MAFFEI, A.B. PENROSE, M.G. MCCARTHY, B.R.MOVEYS, 2006. Austr J Grape Wine R 12, 2.

13. http://www.onivins.fr/EspacePro/Economie/Statistiques. Accessed 12 October 2011.

Impact of microclimate on berry quality parameters of white Riesling (*Vitis vinifera* L.)

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ABSTRACT
Knowledge has been accumulated on the impact of microclimate, in particular berry temperature and irradiation, for a wide range of red varieties. However, little research has been dedicated on the effects of the same factors on the quality of white grape varieties.
In this study we present results of the effects of microclimate on the composition of white Riesling (*Vitis vinifera* L.) under different row orientations. The microclimatic parameters monitored in this study were canopy humidity and temperature, berry surface temperature using infrared thermography, ambient humidity, temperature, wind speed and irradiation parameters. Bunches of different exposure within the canopy of three different row orientations (North to South; East to West; South-West to North-East) were monitored. In addition to the natural environment, some bunches were sheltered in boxes to exclude any impact of light. Further, a defoliation treatment was established to provide maximum light interception.
Results of the study showed that bunches under higher radiation interception, had a faster malic acid degradation and berries were accumulating more flavonols, while the differences in sugar accumulation seemed to depend on leaf peak temperatures rather than on the exposure of the berries.

Keywords: Row Orientation, Riesling, Microclimate, Berry Temperature, Flavonoids.

1 INTRODUCTION

Within a single vineyard, grapegrowers seek to minimize heterogenicity of the grape material in order to maximise wine quality. One important source of variability in a vineyard is the canopy and bunch microclimate. The factors influencing the microclimate in the canopy include row orientation and spacing as well as canopy porosity, width and height [1]. Canopy microclimate has been shown to affect phenolic compounds of the berry skin [2, 3], concentration of organic acids [3], amino acids and minerals [1], juice pH, aroma precursor levels [4] and sugar concentration of the berries. However, most studies with respect to canopy microclimate have been conducted on red varieties. The aim of this study was to evaluate the effects of row orientation on berry microclimate and the effects of microclimate on berry quality traits of white Riesling (*Vitis Vinifera* L.).

2 MATERIALS AND METHODS

Field experiments using Riesling (clone Gm 198-25; grafted to rootstock 'SO4 Gm47') were conducted in 2011 in a vineyard located close to Geisenheim, Germany (49° 59'20'' N; 7° 55'56''E). Vines were trained to a VSP-type canopy system and the row orientation was: north-south (Row azimut 164°, N-S), east-west (Row azimut 254°, E-W) and southwest-northeast (Row azimut 209°, NE-SW). Row and vine spacing was 2.10 and 1.05 m, respectively. To obtain a homogenous canopy, the shoot number was adjusted to eight shoots per vine.
To measure canopy temperature and relative humidity, three EL-USB2 sensors (Lascar, UK) were placed just above the bunch zone in the center of the canopy. Temperature and humidity were recorded every five minutes from full bloom to harvest. Bunch and canopy temperatures were monitored by infrared thermography with a H2640 camera (NEC Avio Infrared Technologies, Munich). In addition to the natural environment, four bunches of each canopy side and row orientation were sheltered in boxes made from tetra brick foil to exclude any effect of light. The boxes were applied 33 days after full bloom (BBCH 75-77). The microclimate inside the boxes in the north-south row orientation was monitored by placing EL-USB2 sensors in the boxes. Further manipulation of the canopy microclimate was achieved by defoliation. For this purpose, all exterior leaves of the bunch zone were removed two weeks after full bloom (BBCH 73).
For HPLC analysis of berry phenolics, 20 berries per sample were picked and stored immediately under CO_2 atmosphere, frozen, and peeled. Skins were then freeze dried, ground and stored in an exsiccator until analysis.

All row orientations and treatments were sampled in triplicate.

To analyze the variability of berry compounds within one single bunch, one bunch from each canopy side and row orientation was divided into five regions (south, west, north, east and the cluster tip). Four berries from each region were sampled for single berry analysis by FTIR and another four berries for analysis of phenolics by HPLC.

For HPLC analysis, phenolic compounds were extracted from the freeze dried grape skin powder in acidified acetonitrile under SO_2 protection followed by vacuum distillation of the extracts. The extracts were analyzed by a ThermoFinnigan HPLC/DAD system (Dreieich, Germany). Chromatographic separation was achieved on a 150x2 mm i.d., 3 µm Luna 3u C18 100A column (Phenomenex, Aschaffenburg, Germany) protected with a guard column of the same material.

For juice analysis, samples of 100 berries were pressed and filtered. TSS, TA, malic acid and tartaric acid were analyzed by FT-MIR Spectroscopy on a FT2 Winescan spectrometer (FOSS, Denmark) using an in-house grape must calibration. N-OPA was analysed using the protocol of Dukes and Butzke [5]. Mineral content of grape berries was analyzed by optical emission spectroscopy (ICP-OES) on a Perkin Elmer 5200 dv simultaneous ICP. All samples were taken within seven days prior to harvest (22.09.2011).

Statistical analysis was performed in SPSS 15.0. Tests were two and three-way ANOVA, followed by a Tukey HSD-test.

3 RESULTS AND DISCUSSION

3.1 Microclimate measurements

Pronounced differences in canopy microclimate were observed between row orientations (figure 1A). Peak canopy temperatures were reached in the N-S row orientation at about 4 p.m., when ambient temperature was at its maximum and the sun position was at a 90° azimuth to the row orientation. Temperature and humidity monitoring in the boxes showed a microclimate similar to the canopy microclimate, as shown in figure 1B. Temperatures of exposed berries showed a trend similar to the one observed for the canopy temperatures. On a clear and hot day during the ripening phase, berry temperatures of west-facing bunches (N-S orientation) were elevated to 15°C over ambient temperature at 3:30 p.m., reaching 43°C. Leaf temperature measurements also showed peak temperatures on the west side of the N-S row orientation, indicating a reduced photosynthesis rate in the afternoon hours in N-S oriented rows.

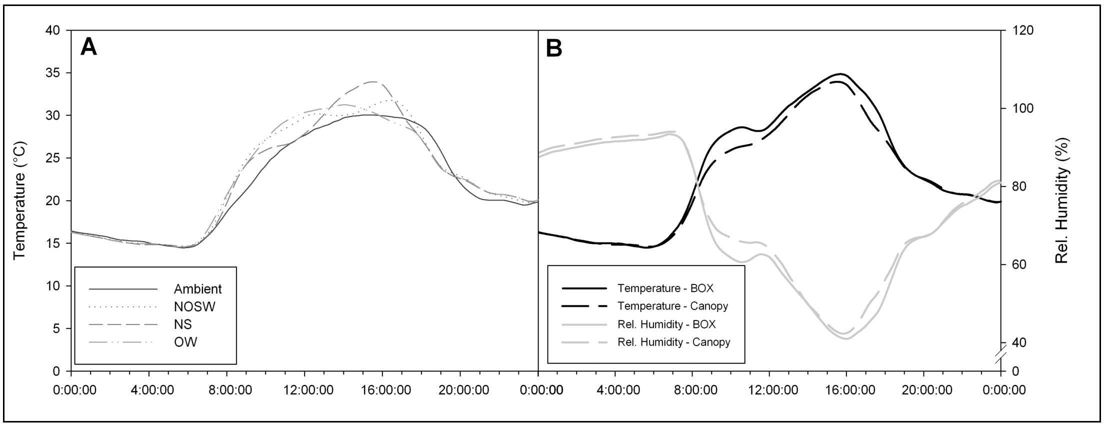

Figure 1. Canopy temperatures of different row orientations (A) and microclimate in N-S oriented Boxes compared to the canopy temperature of the N-S row orientation (B).

3.2 Berry compounds

Grapevine row orientation significantly affected the sugar accumulation in the berries. At harvest, east-west oriented rows showed the highest sugar concentration, followed by northwest-southeast oriented rows. North-south oriented rows showed the lowest sugar accumulation at harvest ($p<0.05$). Neither defoliation nor the sheltering of bunches in boxes affected the sugar accumulation significantly. Berry malic acid concentration was significantly affected by row orientation and microclimate manipulation. Sheltered bunches showed a significantly higher malic acid concentration as compared to control berries, while defoliation significantly decreased malic acid concentration at harvest. N-OPA was significantly reduced by bunch exposition to light ($p<0.05$). The mineral content of grape berries was not significantly influenced by bunch exposure to light, however a tendency towards lower total nitrogen and potassium concentration in the samples exposed to light was observed ($p<0.1$).

The most pronounced differences observed when manipulating the canopy microclimate were berry skin phenolics. A phenolic profile of Riesling, derived from 30 samples of different exposure is shown in figure 2A. Quercetin glycosides were the phenolic compounds with the highest variability in the phenolic profile, followed by caftaric and coutaric acid. The concentration of hydroxycinnamic acids correlates strongly with grape ripeness and is not significantly influenced by the grape light enviroment. The analysis of small sample volumes (four berries) of single bunches showed extremely high variance especially in quercetin glycosides. Note that the quercetin-3-rhamnoside varied by factor 35 in a south-facing bunch of the E-W row orientation (figure 2B).

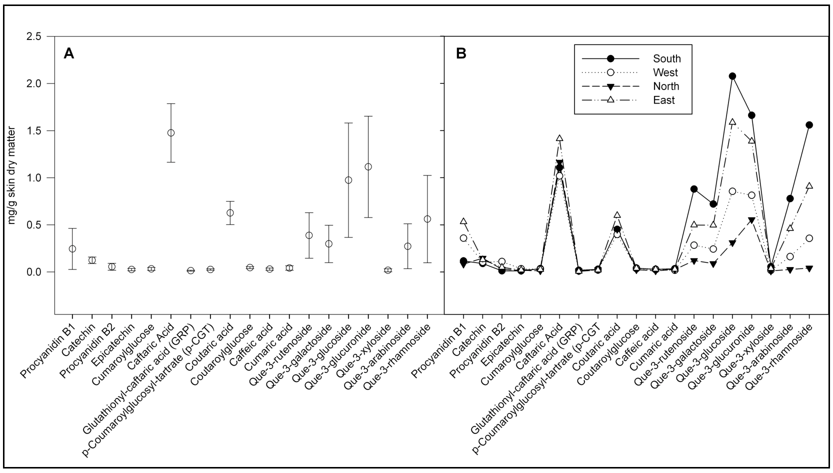

Figure 2. A: Phenolic profile of Riesling derived from 30 samples of different exposure; B: Variability of the concentration of phenolic compounds within a single, south-facing bunch in an E-W oriented row.

Complete defoliation of the bunch zone increased the concentration of quercetin-3-glycosides consistently by 40-50% (figure 3B, p<0.01). Czemmel *et al.* [6] showed that flavonoids are mainly accumulated during flowering and ripening, and that their synthesis is activated by light exposure. While a substantial concentration of que-3-glucuronide was determined in box treatment berries, only little que-3-glucoside and almost no que-3-rhamnoside were detected. It is therefore likely that que-3-rhamnoside and que-3-glucoside are synthetized mainly after veraison. The finding that almost no que-3-rhamnoside was found on the northern side of the investigated bunches and the ratio of que-3-rhamnoside to que-3-glucuronide was lowest in these berries (data not shown), could be explained by the fact that bunches become impenetrable to light after bunch closure and supports this hypothesis. We therefore speculate that, although flavonol synthase activity is high both at flowering and veraison, the activity of the various glycosidases stabilizing the flavonols in grapes may follow a pattern that is specific for the different growth phases.

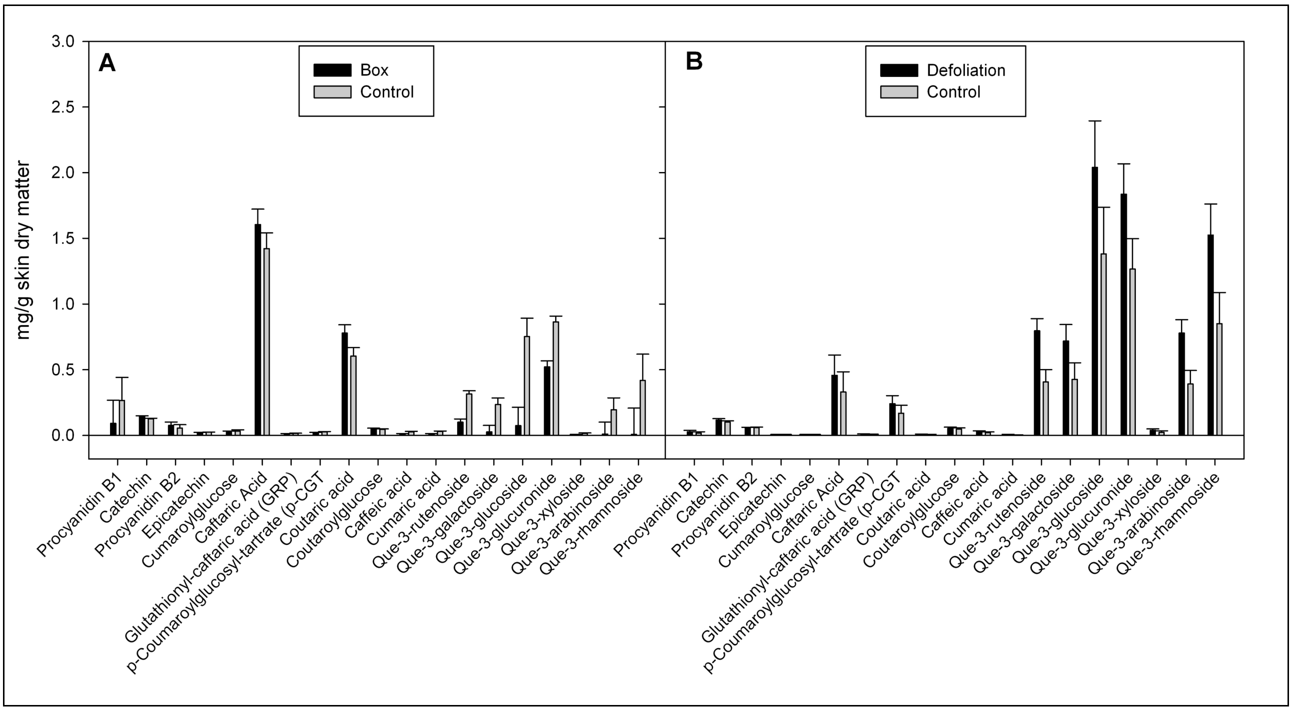

Figure 3. Comparison of skin phenolic profiles of sheltered berries to their control (A) and of south-facing berries from a defoliation treatment and control (B).

4 CONCLUSIONS

Our study shows exposure to light accelerates malic acid degradation and diminishes the concentration of berry amino acids. Sugar accumulation was affected by row orientation, but not by manipulation of the bunch microclimate. Bunch exposure to light significantly increased flavonoid concentration in the berry skin. Furthermore, our data suggest that the accumulation of queretin-3-glucuronide occurs mainly during flowering, while after veraison quercetin-3-glucoside and quercetin-3-rhamnoside are accumulated.

ACKNOWLEDGEMENT
We would like to thank the FDW ("Forschungsring Deutscher Weinbau") and the "Gisela" foundation for financial support of the project.

REFERENCES
1. G.E. PEREIRA, J.P. GAUDILLÈRE, P. PIERI, G. HILBERT, M. MAUCOURT, C. DEBORDE, A. MOING, D. ROLIN, 2006. Journal of Agricultural and Food Chemistry, 54, 6765.
2. S.F. PRICE, P.J. BREEN, M. VALLADAO, B.T. WATSON, 1995. American Journal of Enology and Viticulture, 46, 187.
3. N.K. DOKOOZLIAN, W.M. KLIEWER, 1996. J. Amer. Soc. Hort. Sci., 121, 869.
4. S.M. BUREAU, R.L. BAUMES, A.J. RAZUNGLES, 2000. Journal of Agricultural and Food Chemistry, 48, 1290.
5. B.C. DUKES, C.E. BUTZKE, 1998. American Journal of Enology and Viticulture, 49, 125.
6. S. CZEMMEL, R. STRACKE, B. WEISSHAAR, N. CORDON, N.N. HARRIS, A.R. WALKER, S.P. ROBINSON, J. BOGS, 2009. Plant Physiology, 151, 1513.

ECA&D: A high-resolution dataset for monitoring climate change and effects on viticulture in Europe

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ABSTRACT
Climate change will lead to persistent changes in temperature and precipitation patterns which will affect the characteristics of wine produced in each region. The European Climate Assessment and Dataset (ECA&D) is a web-based database and tool to monitor climate variability and trends over Europe. This tool is used in this study to analyse the viticulture-specific Huglin Index and averaged temperature over the growing season.
The study quantifies the timing and the extent of the expansion of the regions in Europe
where two selected grapes can be used for viticulture. For the two grape varieties analysed, the expansion is northward and eastward and areas in southern Europe are indicated where climate is becoming too hot to produce high-quality wines.

Keywords: Europe, climate change, Huglin Index, growing season averaged temperature.

1 INTRODUCTION

Temperatures in Europe are rising faster than the global average [1]. With the warming of Europe, hot summers have occurred in the recent past which were unprecedented in the instrumental record, like the 2003 summer [2], surpassed in extremity by the recent 2010 summer [3].
The increase in frequency of extremely hot summers will affect viticulture and the general trend towards warmer conditions in Europe will impact on the extent of the area where vine cultivation is possible. Climate of new areas, which used to be not, or only marginally, suited to produce high-quality wines, now become warm enough to compete with the traditional wine-producing areas [4]. Moreover, the areas which have been associated with a particular grape variety for centuries may face the situation of adverse climatic conditions for this particular grape.
There are numerous efforts to capture the suitability of a region and its climate in terms of relatively simple climatic indices claiming to reliably describe the potential of grapes to grow and ripen [5], while others identify more complex processes, like vine water stress, which relate climate and soil to the quality of grapes [6]. In this study we confine ourselves to the popular, temperature-based Huglin index [7] (HI) and growing season averaged temperature [5, 8] (Tavg).
Jones et al. [5] remark that future climates may bring 'potential geographical shifts and/or expansion of viticulture regions with parts of southern Europe becoming too hot to produce high-quality wines and northern regions becoming viable'. Here we test if a change in viticulture regions can already be observed from the ECA&D station data focussing on two selected grape varieties.

2 MATERIALS AND METHODS

2.1 Description of the dataset

The data used in this study are from the European Climate Assessment & Dataset (ECA&D, http://www.ecad.eu [9]). ECA&D is a collection of daily station observations of currently 12 elements and contains data from nearly 6600 European stations and is gradually expanding. Data from the station network