EFFECT OF IRRIGATION REGIME ON CARBON ISOTOPE RATIO ($\delta^{13}C$) IN DIFFERENT GRAPEVINES

Authors:Juan Luis CHACÓN*, Jesús MARTÍNEZ, Adela MENA

Instituto de la Vid y el Vino de Castilla-La Mancha (IVICAM), Tomelloso, Spain

*Corresponding author: jlchacon@jccm.es

Abstract:

Context and purpose of the study - In Castilla-La Mancha as other winegrowing regions, vineyards suffer the effects of the global climate warming. Severe spring and summer droughts are increasingly frequent, which concur with the phenological stages most susceptible to water and temperature stress. Under these conditions, irrigation use is required in order to ensure the vineyard growing sustainability. However water resources are increasingly limited, for this reason is required to choose cultivars displaying high water use efficiency. Carbon isotope ratio ($\delta^{13}C$) of grape must sugar has been investigated as an integrating marker related to water use efficiency and water status in grapevines. The present study was aimed to explore water use efficiency in several cultivars subjected to different irrigation regimes, in order to know those that were more efficient and subsequently develop specific watering protocols for each of them, according to sustainable production and quality goals.

Material and methods - This study was carried out in 2017 and 2018. Variety response of $\delta^{13}C$ to different irrigation regime was assessed in a multivarietal vineyard. Grown on trellises, at a distance of 2.8m x 1.2m (row by vine spacing), the plants are trained to a single guyot system, with 110 Richter as rootstock. Orientation is 30°NE/210°SW and the vineyard is irrigated by a drip system with two drippers per vine-stock. Four treatments were considered: survival, 0.20 ET_0, 0.25 ET_0 and 0.30 ET_0. Determination of the carbon isotope ratios of grape must was carried out by on-line analysis using a ThermoQuest Flash 1112 elemental analyser equipped with an autosampler and coupled to a Delta-Plus IRMS (ThermoQuest) through a ConFlo III interface (ThermoQuest). In addition to $\delta^{13}C$ in must sugar, yield components and must quality parameters were determined for each treatment and variety.

Results - Irrigation promoted a decrease of carbon isotope ratio in must sugar. The relationship between $\delta^{13}C$ and water volumes used in irrigation treatments was negative and moderately significant. Considering the data of two vintages together and treatment as a variable, the effect of irrigation regime in carbon isotope ratio was observed in all cases with significant differences ranging from -22.58 for T0 to -24.48 for T3, whereas in WUE only T0 (30.15 g/L) stood out from the rest (12.86 g/L, 10.84 g/L and 10.32 g/L for T1, T2 and T3 respectively). On the contrary, when grapevine variety was a variable, there were only significant differences in $\delta^{13}C$ when considering vintages independently. It was in 2017, with values ranging from -23.52 for Airén to -24.69 for Moscatel de Grano Menudo. Regarding WUE, in neither of two vintages separately there were significant differences. Between $\delta^{13}C$ and agronomic parameters there were some correlations with different significance levels. This study contributes to improving knowledge about what of the cultivars grown in the areaare more efficient from the water use point of view, and the irrigation regimes that would have to be established to achieve sustainable production, both quantitatively and qualitatively, with the minimum water volume.

Keywords: Carbon isotope ratio, Grapevine, Irrigation, *Vitis vinifera* L., Water use efficiency.

1. Introduction.

EFFECT OF IRRIGATION REGIME ON CARBON ISOTOPE RATIO ($\delta^{13}C$) IN DIFFERENT GRAPEVINES

Juan Luis CHACÓN, Jesús MARTÍNEZ, Adela MENA
Instituto de la Vid y el Vino de Castilla-La Mancha (IVICAM), Ctra. de Albacete, s/n, 13700 Tomelloso (Spain)

INTRODUCTION AND OBJECTIVE

In Castilla-La Mancha as other winegrowing regions, vineyards suffer the effects of the global climate warming. Severe spring and summer droughts are increasingly frequent, which concur with the phenological stages most susceptible to water and temperature stress. Under these conditions, irrigation use is required in order to ensure the vineyard growing sustainability. However water resources are increasingly limited, for this reason is required to choose cultivars displaying high water use efficiency. Carbon isotope ratio ($\delta^{13}C$) of grape must sugar has been investigated as an integrating marker related to water use efficiency and water status in grapevines. The present study was aimed to explore water use efficiency in several cultivars subjected to different irrigation regimes, in order to know those that were more efficient and subsequently develop specific watering protocols for each of them according to sustainable production and quality goals.

MATERIALS AND METHODS

LOCATION: Tomelloso (Castilla-La Mancha region) YEARS: 2017-2018
VARIETIES: Airén, Macabeo, Malvar, Moscatel de Grano Menudo, Temprarillo, Syrah, Garnacha Tintorera y Bobal.
TRAINING AND PRUNING SYSTEM: Single Guyot
WATER TREATMENTS: Survival (T0), $0.20ET_0$ (T1), $0.25ET_0$ (T2) and $0.30ET_0$ (T3)
EXPERIMENTAL DETERMINATIONS: Carbon isotope ratio, yield components and must quality parameters.

RESULTS

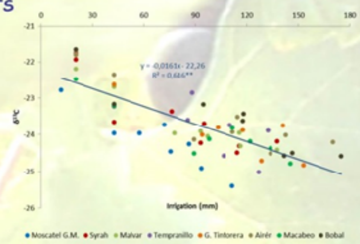

Figure 1. Relation between carbon isotope ratio ($\delta^{13}C$) and irrigation (n=64).

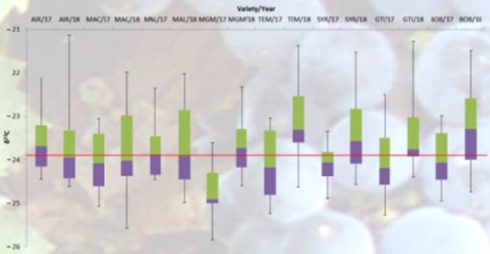

Figure 2. Comparison of $\delta^{13}C$ in eight varieties, in 2017 and 2018. The red line represents the median of the medians of all varieties.

Table 1. Pearson correlation coefficients between different parameters: Irrigation (mm), Carbon isotope ratio ($\delta^{13}C$), Water use efficiency (g/L), Yield (kg/vine), Berry weight (g), Soluble solids (° Brix), pH, Total acidity (g TH_2/L), Malic acid (g/L), Pruning weight (g/vine) and Ravaz index (kg grape/kg wood) (n=192).

Pearson r	Irrigation	$\delta^{13}C$	WUE	Yield	Berry W.	Sol. S.	pH	Total A.	Malic A.	Prun. W.	Ravaz I.
Irrigation	1	-0.727**	-0.694**	0.419**	0.482**	0.057	0.215**	-0.278**	0.132	0.139	0.324**
$\delta^{13}C$	-0.727**	1	0.604**	-0.321**	-0.253**	-0.196**	0.016	-0.036	-0.321**	-0.291**	-0.143*
WUE	-0.694**	0.604**	1	0.076	-0.146*	-0.297**	-0.117	0.136	-0.141	-0.076	0.111
Yield	0.419**	-0.321**	0.076	1	0.632**	-0.399**	0.220**	-0.370**	0.070	0.207**	0.749**
Berry W.	0.482**	-0.253**	-0.146*	0.632**	1	-0.295**	0.452**	-0.532**	0.150*	0.064	0.569**
Sol. S.	0.057	-0.196**	-0.297**	-0.399**	-0.295**	1	0.012	0.310**	0.329**	0.150*	-0.443**
pH	0.215**	0.016	-0.117	0.220**	0.452**	0.012	1	-0.780**	-0.177*	-0.012	0.221**
Total A.	-0.278**	-0.036	0.136	-0.370**	-0.532**	0.310**	-0.780**	1	0.435**	0.122	-0.408**
Malic A.	0.132	-0.321**	-0.141	0.070	0.150*	0.329**	-0.177*	0.435**	1	0.350**	-0.101
Prun. W.	0.139	-0.291**	-0.076	0.207**	0.064	0.150*	-0.012	0.122	0.350**	1	-0.426**
Ravaz I.	0.324**	-0.143*	0.111	0.749**	0.569**	-0.443**	0.221**	-0.408**	-0.101	-0.426**	1

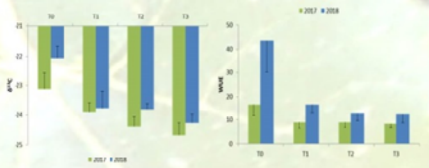

Figure 4. $\delta^{13}C$ and WUE mean values in 2017 and 2018.

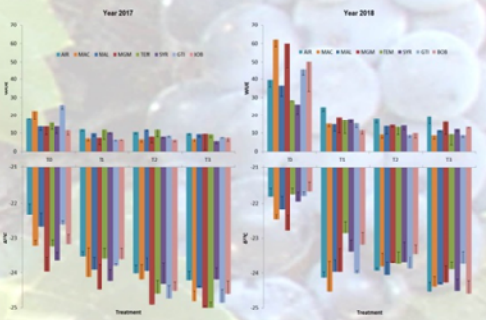

Figure 3. WUE and $\delta^{13}C$ mean values of varieties in all treatments, during two vintages.

Considering the data of two vintages together and treatment as a variable, the effect of irrigation regime in carbon isotope ratio was observed in all cases with significant differences ranging from -22.58 for T0 to -24.48 for T3, whereas in WUE only T0 (30.15 g/L) stood out from the rest (12.86 g/L, 10.84 g/L and 10.32 g/L for T1, T2 and T3 respectively). On the contrary, when grapevine variety was a variable, there were only significant differences in $\delta^{13}C$ when considering vintages independently. It was in 2017, with values ranging from -23.52 for Airén to -24.69 for Moscatel de Grano Menudo.

CONCLUSIONS

The results show that irrigation promoted a decrease of $\delta^{13}C$ in must sugar. It seems like both grapevine genotype and environmental conditions are factors contributing to variations in carbon isotope ratio. Differences between treatments were more marked in the drier year. In order to increase the reliability of findings, this work needs to be repeated for several more years.

REFERENCES

Gaudillere, J.P., Van Leeuwen, C. and Ollat, N. (2002). Carbon isotope composition of sugars in grapevine, an integrated indicator of vineyard water status. J. Exp. Bot. 53: 757-763.
De Souza, C.R., Maroco, J.P., Dos Santos, T.P., Rodrigues, M.L., Lopes C.M., Pereira, J.S. and Chaves, M.M. (2005). Impact of deficit irrigation on water use efficiency and carbon isotope composition ($\delta^{13}C$) of field-grown grapevines under Mediterranean climate. J. Exp. Bot. 56: 2163-2172.
Gómez-Alonso, S. and García-Romero, E. (2010). Effect of irrigation and variety on oxigen ($\delta^{18}O$) and carbon ($\delta^{13}C$) stable isotope composition of grapes cultivated in a warm climate. Aust. J. Grape Wine Res. 16 (2): 283-289.

21st International GiESCO Meeting, Thessaloniki (Greece), June 23rd – 28th, 2019