CARBON ISOTOPE DISCRIMINATION IN BERRY JUICE SUGARS: CHANGES IN RESPONSE TO SOIL WATER DEFICITS ACROSS A RANGE OF *Vitis Vinifera* CULTIVARS

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Abstract:

Context and purpose of the study - In wine producing regions around the world, climate change has the potential to decrease the frequency and amount of precipitation and increase average and extreme temperatures. This will lower soil water availability and increase evaporative demand, thereby increasing the frequency and intensity of water deficit experienced in vineyards. Among other things, grapevines manage water deficit by regulating stomatal closure. The dynamics of this regulation, however, have not been well characterized across the range of *Vitis vinifera* cultivars. Providing a method to understand how different cultivars regulate their stomata, and hence water use in response to changes in soil water deficits will help growers manage vineyards and select plant material to better meet quality and yield objectives in a changing climate.

Material and methods – Berry samples were collected at maturity from 41 different *Vitis vinifera* cultivars at replicate locations within the VitAdapt common-garden vineyard at the *Institut des Sciences de la Vigne et du Vin* (ISVV) in Bordeaux, France. Carbon isotope ratios were measured in berry juice sugars from these samples to determine the level of carbon isotope discrimination ($\delta^{13}C$) existing when the sugars were accumulated. The level of $\delta^{13}C$ in berry juice sugar is considered an effective indicator of the level of stomatal closure during the sugar accumulation period. Then, using local meteorology and observed phenology, a water balance model was used to estimate the average soil water content during the berry ripening period for each cultivar in each year. Replicate measurements of $\delta^{13}C$ in each cultivar for 2012 through 2016 were then compared against modeled average soil water content for the associated berry ripening period, with results characterized and classified by cultivar.

Results - As soil water content during the berry ripening period decreased, the corresponding $\delta^{13}C$ measurements in berry juice sugars for all cultivars became less negative, indicating greater stomatal closure during this period. Using data from years 2012 through 2016 this trend was well demonstrated with a power function regression curve that gave similar shapes for all cultivars, although statistically significant differences in overall levels of $\delta^{13}C$ were observed between many cultivars. Also, the difference in $\delta^{13}C$ measurements between dry versus wet conditions for a given cultivar provides an indication of that cultivar's stomatal closure sensitivity in response to increasing soil water deficits. These results support the use of $\delta^{13}C$ measurements in berry juice sugars as a simple and effective way of assessing differences in stomatal behavior among cultivars in the field, perhaps across different rootstock, soil, and/or climate conditions. Next steps for continuing and improving the analysis are also presented

1. Introduction.

CARBON ISOTOPE DISCRIMINATION ($\delta^{13}C$) IN BERRY JUICE SUGARS: CHANGES IN RESPONSE TO SOIL WATER DEFICITS ACROSS A RANGE OF *Vitis Vinifera* CULTIVARS

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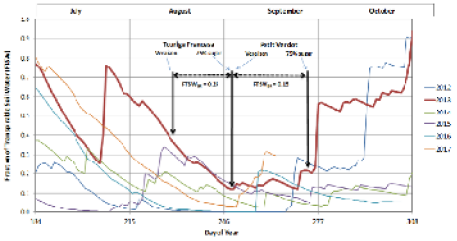
INTRODUCTION

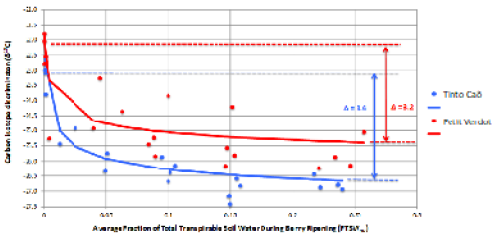
Carbon isotope discrimination measurements of certain plant tissues have been shown to provide effective characterization of stomatal closure (Gaudillère et al. 2002). Using replicated data from 41 *Vitis vinifera* cultivars in an experimental common-garden vineyard at the *Institut des Sciences de la Vigne et du Vin* (ISVV) near Bordeaux, the response of $\delta^{13}C$ measured in berry juice sugars was compared across cultivars against soil water deficits during the corresponding berry ripening period as estimated by a water balance model.

① Soil water availability during ripening



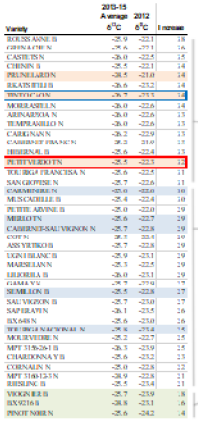
- A water balance mode estimated daily fraction of total transpirable soil water (FTSW) following method of Lebon et al. 2003
- Average soil water content during berry ripening ($FTSW_{RR}$) calculated between véraison and 75% sugar accumulation
- Model uses local meteorology and observed varietal phenology
- Difficulty estimating total transpirable soil water (TTSW)

Stomatal closure plasticity ($\delta^{13}C$ vs. soil water availability)

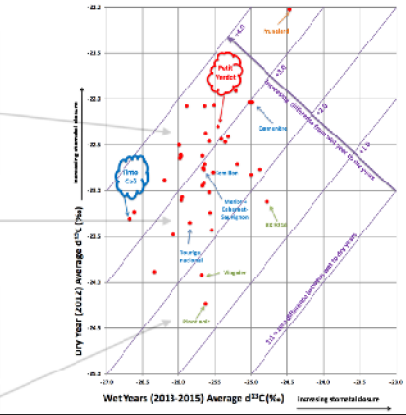


- $\delta^{13}C$ measured in berry juice sugar at maturity (5 years w/ 4-5 replicates)
- Data show increased $\delta^{13}C$ (indicating stomatal closure) in response to decreasing soil water availability during the berry ripening period
- Statistically significant differences in $\delta^{13}C$ measurements observed between some varieties - should improve as more data is collected
- $\delta^{13}C$ response for all varieties fit similar 'power function' regression

Relative Stomatal Sensitivity (Variability in stomatal closure plasticity across vintages)



Variety	2013-15 Average δ¹³C	2012 δ¹³C	Increase
ROUSSANNE B	-25.9	-22.1	3.8
GRENACHE N	-25.6	-21.1	4.5
CASTETS N	-26.0	-22.5	3.5
CHENIN B	-25.5	-22.1	3.4
PRUNELARD N	-26.5	-23.0	3.4
ILKAYSELI B	-26.6	-23.2	3.4
MOURVEDRE N	-25.7	-22.5	3.2
MORLAASES N	-26.0	-22.8	3.2
ARINARNOA N	-26.0	-22.8	3.2
TEMPRANILLO N	-26.0	-22.8	3.2
CARIGNAN N	-26.2	-22.9	3.3
CABERNET FRANC N	-26.3	-23.0	3.3
SERSENIAL B	-25.6	-22.4	3.2
PETIT VERDOT N	-25.5	-22.3	3.2
TOURIGA FRANCESA N	-25.6	-22.5	3.1
SAN GIOVESE N	-25.7	-22.6	3.1
CABERNET DORSA N	-25.8	-22.6	3.2
MUSCADELLE B	-25.4	-22.4	3.0
PETITE ARVINE B	-25.0	-22.0	2.9
MERLOT N	-25.6	-22.7	2.9
CABERNET SAUVIGNON N	-25.7	-22.8	2.9
COT N	-25.7	-22.8	2.9
ASSYRTICO B	-25.7	-22.8	2.9
UGNI BLANC B	-25.9	-23.1	2.9
MARSELLAN N	-25.3	-22.5	2.9
LEROMIA B	-26.0	-23.1	2.9
CLAIRETTE	-25.7	-22.9	2.8
SEMILLON B	-25.5	-22.8	2.7
SAUVIGNON B	-25.7	-23.0	2.7
SAPERAVIN	-26.1	-23.5	2.6
RKM48 N	-25.6	-23.0	2.6
TOURIGA NACIONAL N	-25.8	-23.2	2.6
MOURVEDRE N	-25.2	-22.7	2.5
MPT 51-9-26-1 B	-25.3	-23.0	2.3
CHARDONNAY B	-25.6	-23.2	2.3
CORNALIN N	-25.0	-22.8	2.2
MPT 51-10-13 N	-25.9	-23.8	2.1
RIESLING B	-25.5	-23.4	2.1
VIOGNIER B	-25.7	-23.9	1.8
RK9216 B	-25.8	-24.1	1.6
PINOT NOIR N	-25.6	-24.2	1.4



- $\delta^{13}C$ in berry sugars measured in 2012 (a dry year during ripening) vs. average of 2013 – 2015 (wet years during ripening) - 5 years w/ 4-5 replicates
- Difference in $\delta^{13}C$ observed in driest versus wettest years varies between varieties
- Suggests more/less plasticity of stomatal closure for different varieties in response to drier conditions experienced during berry ripening
- For further assessment:
  - Characterization of response curves
  - Consistency of $\delta^{13}C$ response across years
  - Soil water deficit calculation during ripening

Next Steps

Water Balance Modeling

- Individual water balance models for each variety in each year
- Weighted calculation of soil water availability during ripening
- Improvements in TTSW estimates
- Comparison against field measurements of transpiration

Carbon Isotope Discrimination

- At least four more years of data anticipated
- Measure kinetics of berry sugar $\delta^{13}C$ during ripening
- Measurement of leaf, or phloem sap $\delta^{13}C$
- Comparison of response against water potential measurements

References

- Gaudillère et al., 2002 J Exp Bot, 53 757–63
- Lebon et al., 2003 Funct Plant Biol, 30 699-710

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