ISOHYDRIC AND ANISOHYDRIC BEHAVIOR OF 18 WINE GRAPE VARIETIES GROWN IN AN ARID CLIMATE

Authors:Joelle MARTINEZ*, Markus KELLER

Irrigated Agriculture Research and Extension Center, Washington State University, Prosser, WA, USA

*Corresponding author: *mkeller@wsu.edu*

Abstract:

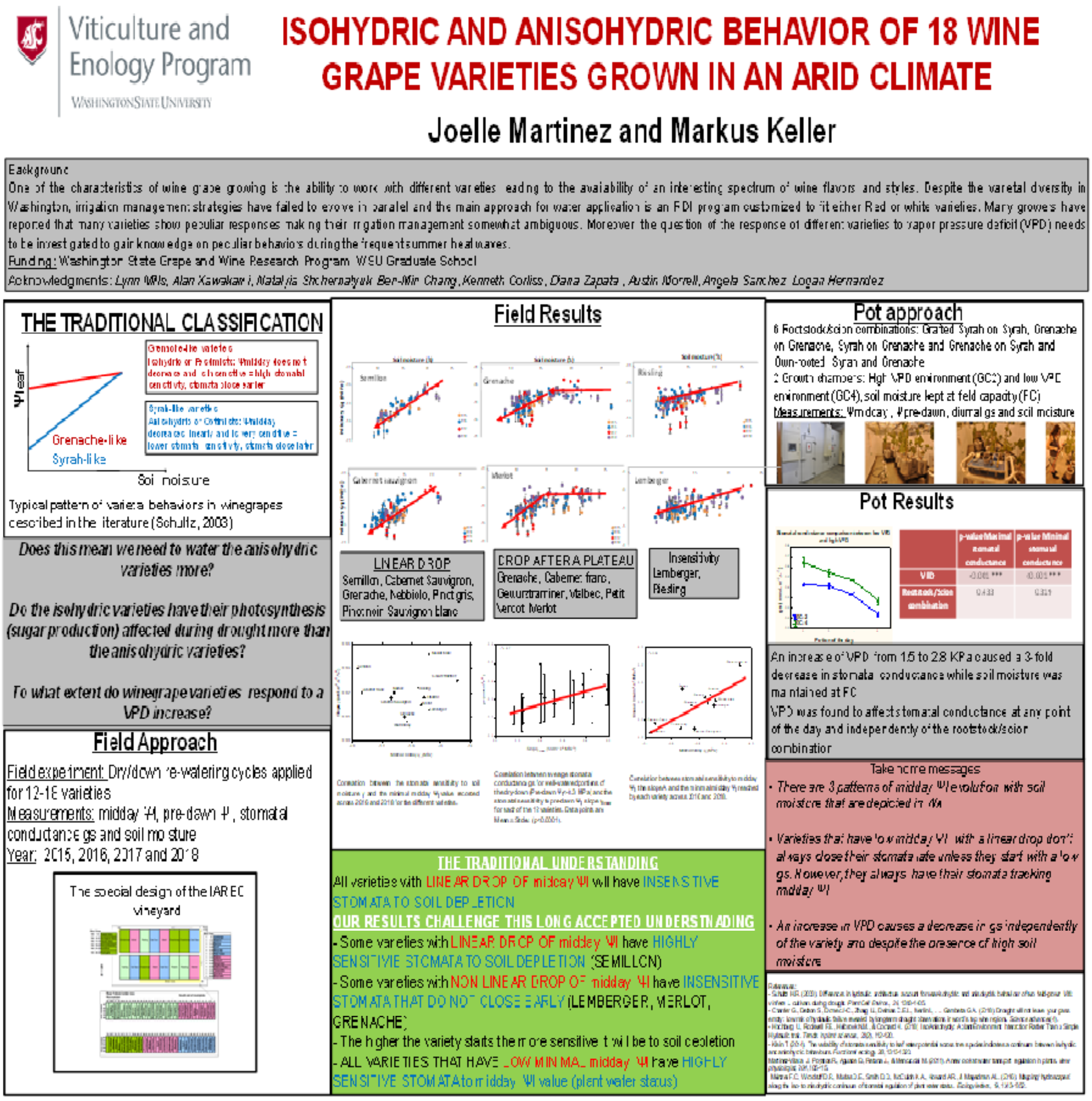
Context and purpose of the study - The interest in understanding the water balance of terrestrial plants under drought has led to the creation of the isohydric/anisohydric terminology. The classification was related to an implication-driven framework, where isohydric plants maintain a constant and high leaf water potential through an early and intense closure of their stomata, hence risking carbon starvation. In contrast, anisohydric plants drop their leaf water potential to low values as soil drought is establishing due to insensitive stomata and thus risk mortality through hydraulic failure, albeit maximizing carbon intake. When applied to grapevines, this framework has been elusive, yielding discrepancies in the classification of different wine grape varieties around the world. There is a need to assess different wine grape varieties under the same growing conditions to enable conclusions on the differences in their response to drought and facilitate variety-specific irrigation management.

Material and methods – The vineyard was located in the ROZA irrigation district in the Yakima valley, Washington. Varieties were grown side by side and replicated 8 times. Spacing was 1.8 m x 2.7 m in a North-South orientation. The vines were on their own-roots, double-trunked, trained to a bi-lateral cordon. 12-18 varieties of wine grape grown were studied for this experiment. Access tubes were installed for soil moisture measurements using a neutron probe, and irrigation was independently controlled for each row. Dry-down cycles were applied pre- and post-veraison from 2016 to 2018. On the same day, predawn (Ψ_{pd}) and midday leaf water potential (Ψ_{md}) were measured with a pressure chamber, stomatal conductance (g_s) was measured with a porometer at midday and on the same leaf in 2016 and 2017 and with an infrared gas analyzer in 2018. Soil moisture measurements were taken on the same day for each vine.

Results - The results show that there may be three distinctive major patterns of midday leaf water potential response to soil water availability: Linear drop across the entire soil moisture range such as for Cabernet franc and Semillon, linear drop below a threshold of soil moisture such as for Gewurztraminer and Grenache, and an insensitive to soil moisture such as for Lemberger and Riesling. Meanwhile, the stomatal sensitivity did not always mirror the Ψ_{md} behavior; for example some varieties like Cabernet franc show a linear drop of Ψmid while having a tight stomatal control during soil drought (r=0.76) while other varieties like Riesling have an insensitive response of Ψmid (r=0.33) without necessarily having sensitive stomata (r=0.56). Finally, the slope of the linear Ψmd:Ψpd, studied as an the indicator of the internal regulation of water status, varied between 0.4 for Grenache and 1 for Semillon. This shows that for our vineyard, transpiration sensitivity was always higher than hydraulic sensitivity. Since intense yellowing of leaves has been recorded in varieties like Cabernet franc, Muscat blanc and Malbec, these results direct us to inspect if the sensitivity of gs in those varieties is leading to carbon starvation during drought. These results may eventually be used by growers to devise variety-specific irrigation management strategies.

Keywords: Wine grape, Isohydric, Anisohydric, Stomatal regulation, Water potential, Hydraulic regulation.

1. Introduction.



Viticulture and Enology Program
Washington State University
ISOHYDRIC AND ANISOHYDRIC BEHAVIOR OF 18 WINE GRAPE VARIETIES GROWN IN AN ARID CLIMATE
Joelle Martinez and Markus Keller
Background
One of the characteristics of wine grape growing is the ability to work with different varieties leading to the availability of an interesting spectrum of wine flavors and styles. Despite the varietal diversity in Washington, irrigation management strategies have failed to evolve in parallel and the main approach for water application is an RDI program customized to fit either Red or white varieties. Many growers have reported that many varieties show peculiar responses making their irrigation management somewhat ambiguous. Moreover the question of the response of different varieties to vapor pressure deficit (VPD) needs to be investigated to gain knowledge on peculiar behaviors during the frequent summer heat waves.
Funding: Washington State Grape and Wine Research Program, WSU Graduate School
Acknowledgments: Lynn Mills, Alan Kawakami, Natalyia Shcherbatyuk, Ber-Min Chang, Kenneth Corliss, Diana Zapata, Austin Morrell, Angela Sanchez, Logan Hernandez
THE TRADITIONAL CLASSIFICATION
Ψleaf
Grenache-like
Syrah-like
Soil moisture
Typical pattern of varietal behaviors in winegrapes described in the literature (Schultz, 2003)
Does this mean we need to water the anisohydric varieties more?
Do the isohydric varieties have their photosynthesis (sugar production) affected during drought more than the anisohydric varieties?
To what extent do winegrape varieties respond to a VPD increase?
Field Approach
Field experiment: Dry-down re-watering cycles applied for 12-18 varieties
Measurements: midday Ψl, pre-dawn Ψ, stomatal conductance gs and soil moisture
Year: 2015, 2016, 2017 and 2018
The special design of the IAREC vineyard
Field Results
Semillon
Grenache
Riesling
Cabernet sauvignon
Merlot
Lemberger
LINEAR DROP
Semillon, Cabernet Sauvignon, Grenache, Nebbiolo, Pinot gris, Pinot noir, Sauvignon blanc
DROP AFTER A PLATEAU
Grenache, Cabernet franc, Gewurztraminer, Malbec, Petit Verdot, Merlot
Insensitivity
Lemberger, Riesling
THE TRADITIONAL UNDERSTANDING
All varieties with LINEAR DROP OF midday Ψl will have INSENSITIVE STOMATA TO SOIL DEPLETION
OUR RESULTS CHALLENGE THIS LONG ACCEPTED UNDERSTNADING
- Some varieties with LINEAR DROP OF midday Ψl have HIGHLY SENSITIVIE STOMATA TO SOIL DEPLETION (SEMILLON)
- Some varieties with NON LINEAR DROP OF midday Ψl have INSENSITIVE STOMATA THAT DO NOT CLOSE EARLY (LEMBERGER, MERLOT, GRENACHE)
- The higher the variety starts the more sensitive it will be to soil depletion
- ALL VARIETIES THAT HAVE LOW MINIMAL midday Ψl have HIGHLY SENSITIVE STOMATA to midday Ψl value (plant water status)
Pot approach
6 Rootstock/scion combinations: Grafted Syrah on Syrah, Grenache on Grenache, Syrah on Grenache and Grenache on Syrah and Own-rooted Syrah and Grenache
2 Growth chambers: High VPD environment (GC2) and low VPD environment (GC4), soil moisture kept at field capacity (FC)
Measurements: Ψmidday, Ψpre-dawn, diurnal gs and soil moisture
Pot Results
An increase of VPD from 1.5 to 2.8 KPa caused a 3-fold decrease in stomatal conductance while soil moisture was maintained at FC
VPD was found to affect stomatal conductance at any point of the day and independently of the rootstock/scion combination
Take home messages
There are 3 patterns of midday Ψl evolution with soil moisture that are depicted in Ψa
Varieties that have low midday Ψl with a linear drop don't always close their stomata late unless they start with a low gs. However, they always have their stomata tracking midday Ψl
An increase in VPD causes a decrease in gs independently of the variety and despite the presence of high soil moisture