IMPACT OF CHANGING CLIMATIC FACTORS ON PHYSIOLOGICAL AND VEGETATIVE GROWTH PARAMETERS OF YOUNG GRAFTED GRAPEVINES

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Abstract:

Context and purpose of the study - scientific information on grapevine response to predicted levels of climate parameters is scarce and not sufficient to properly position the Wine Industry for the future. It is critical that the combined effects of increased temperature and CO_2 on grapevines should be examined, without omitting the important link to soil water conditions. The purpose of this study is to quantify the effects of envisioned changes in climatic parameters on the functioning and growth of young grafted grapevines under controlled conditions, simulating expected future climate changes. Scientific knowledge of precisely how the newly-planted grapevine will react morphologically, anatomically and physiologically (at leaf, root and whole plant level) to the expected changes in important climatic parameters will enable producers to make better-informed decisions regarding terroir, cultivar and rootstock choices as well as the adaptation of current cultivation practices.

Material and methods – four glass house compartments were set up with combinations of the two main environmental factors, namely ambient temperature and CO_2. Within each compartment, another treatment factor, water supply, was introduced. Young, grafted grapevines were established in pots in a randomized block design. Five growth cycles of 12 weeks each were monitored, with Shiraz as scion cultivar in three of them and Merlot in the other two. The rootstock used throughout was 101-14 Mgt. Vegetative and physiological growth parameters were measured throughout the growth cycles with critical sampling times at 4, 8 and 12 weeks after planting.

Results - a change in environmental growth conditions significantly affected physiological activity of the grapevine. Both increased CO_2 levels and adequate water supply increased photosynthetic activity for all treatment combinations. Newly planted vines were photosynthetically more active and reacted more strongly to treatments than slightly older vines. The higher temperature treatment seemed to impair photosynthesis under comparable CO_2 and H_2O conditions, especially with regards to very young vines.
The effect of temperature on vegetative growth was insignificant compared to the CO_2 and H_2O effects and only seemed to affect initial growth directly after planting. The availability of water was critical to root, shoot and leaf growth – higher CO_2 levels further enhanced vegetative growth.
The results indicate that the importance and impact of the climatic variables and the vine reaction change during the growth season. The strong interactions found between weeks after planting, available water, ambient temperature and CO_2 levels necessitate multi-variable research on the effect of changing climatic factors on the grapevine.

Keywords: Climate change; Grapevine, CO_2; Temperature; Water deficit; Growth; Physiology

1. Introduction

IMPACT OF CHANGING CLIMATIC FACTORS ON PHYSIOLOGICAL AND VEGETATIVE GROWTH PARAMETERS OF YOUNG GRAFTED GRAPEVINES

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Background and Motivation

The scientific reality of climate change was clearly stated by the IPCC - "warming of the climate system is unequivocal..." (*6*). This resulted in a significant increase in global research on mitigation and adaptation to a changing climatic system. Climate change entails a simultaneous shift in many interrelated climatic variables (*1*), but it is generally recognised that temperature increase and modification in rainfall patterns (and therefore water availability) are two of the most significant factors (*2,11*). World-wide, many wine producing regions are concerned about the likelihood of a shortage of water and the implications for irrigation (*10*).

Globally, wine production will be affected by climate change (*1*). Future vineyards might have to be established in different areas (*9*). Currently, there are still other options, such as revision of cultivar choice and wine style and the development or adaptation of production methods (*4,7*). Scientific knowledge of how the grapevine will react morphologically, anatomically and physiologically (at leaf, root and whole plant level) to the expected changes in climate will enhance decision-making regarding terroir, choice of cultivar and rootstock, and the alteration of cultivation practices to ensure product consistency and overall sustainability (*5*).

Physiological responses of the grapevine to single stress factors have been well-researched, but knowledge on the combined effect of multiple stress factors and their possible interaction is scarce (*8*). Interaction found between increased temperature and CO_2 level indicated that focussing on one factor at a time is insufficient to predict climate change impact on viticulture (*3*). The combined effects of increased temperature and CO_2 on grapevines should be further investigated, with inclusion of the important link to soil water conditions. "The reaction of the plant to increasing CO_2 concentrations, yet higher temperatures and drier conditions, presents an unavoidable research challenge" (*4*).

Rational and Purpose

The purpose of this study is to quantify the effects of envisioned changes in climatic parameters on the functioning and growth of young grafted grapevines, grown in pots under controlled conditions in glasshouse compartments. The study presents a unique opportunity to understand the reaction of the grapevine during early stages of growth. Young vine establishment and initial growth are critical stages that determine the longevity of the vine in terms of growth, vigour, yield and grape quality.

Materials and Methods

Potted vines directly after planting (2 compartments shown)

Four glass house compartments were set up with combinations of ambient temperature and CO_2. Within each compartment, another treatment factor, water supply, was introduced. Young, grafted grapevines were established in pots in a randomized block design. Five growth cycles of 12 weeks each were monitored, with Shiraz as scion cultivar in three and Merlot in two. Rootstock 101-14 Mgt was used. Vegetative and physiological growth parameters were measured at 4, 8 and 12 weeks after planting.

Growing vines 7 weeks after planting (1 compartment shown)

Treatment combinations randomly allocated in four glasshouse compartments for five consecutive growth cycles

PARAMETERS	TREATMENTS											
	C0T0			C1T0			C0T1			C1T1		
Vine age	4 weeks	8 weeks	12 weeks	4 weeks	8 weeks	12 weeks	4 weeks	8 weeks	12 weeks	4 weeks	8 weeks	12 weeks
CO_2 levels	400 ppm	400 ppm	400 ppm	800 ppm	800 ppm	800 ppm	400 ppm	400 ppm	400 ppm	800 ppm	800 ppm	800 ppm
Temperature	15/27°C	15.5/29°C	16/31°C	15/27°C	15.5/29°C	16/31°C	18/30°C	18.5/32°C	19/34°C	18/30°C	18.5/32°C	19/34°C
Water treatments	Wet: FWC	Wet: FWC	Wet: FWC	Wet: FWC	Wet: FWC	Wet: FWC	Wet: FWC	Wet: FWC	Wet: FWC	Wet: FWC	Wet: FWC	Wet: FWC
	Dry: ½FWC	Dry: ½FWC	Dry: ½FWC	Dry: ½FWC	Dry: ½FWC	Dry: ½FWC	Dry: ½FWC	Dry: ½FWC	Dry: ½FWC	Dry: ½FWC	Dry: ½FWC	Dry: ½FWC

C0: Lower CO_2; C1: Higher CO_2; T0: Lower temperature; T1: Higher Temperature; FWC: Field Water Capacity

Results

PARAMETERS	TREATMENTS							
	C0T0		C1T0		C0T1		C1T1	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Photosynthesis	4.63c	2.96e	7.85a	4.81c	3.72d	2.20f	6.25b	4.88c
Transpiration	2.16b	1.30d	2.72a	1.19d	1.85c	1.10d	2.15b	1.26d
New root mass	7.41c	5.25e	10.05a	7.03c	8.20b	5.06e	10.09a	6.16d
Shoot mass	7.69b	5.21d	8.85a	6.31c	7.54b	4.89d	8.97a	6.04c
Leaf mass	9.43b	7.24d	10.55a	8.12c	9.23b	6.71e	10.20a	7.66cd

Values in rows followed by the same letter do not differ significantly ($p \leq 0.05$)

Conclusions

- Sufficiently available water and increased CO_2 levels enhanced photosynthetic activity. Lower temperature conditions seemed more favourable to physiological activity than the higher temperature treatment.
- Water supply and increased CO_2 positively affected root, shoot and leaf growth – the availability of water being the stronger factor. The temperature effect on vegetative growth was not significant.
- The importance and impact of the climatic variables and the vine reaction changed during the 12 week growth cycle (data not shown).
- Strong interactions found between weeks after planting, available water, ambient temperature and CO_2 levels necessitate multi-variable research on the effect of changing climatic factors on the grapevine.

* This is part of an ongoing PhD study of H. Theron at the University of Stellenbosch

Literature Cited

1. Confronting Climate Change: A South African Fruit & Wine Initiative, 2009. South African Fruit and Wine Climate Change Program, February 2009. http://www.namc.co.za/upload/all%20reports/Component1.Summary%20doc.With.Logo.Feb.09%285%al%29.pdf
2. Dequin, S., Escudier, J.L., Bely, M., Noble, J., Albertin, W., Masneuf-Pomarède, I., Marullo, P., Salmon, M.J., Sablayrolles, J.M. & Ollat, N. 2017. How to adapt winemaking practices to modified grape composition under climate change conditions. *Journal International des Sciences de la Vigne et du Vin*, 51(2): 205–214.
3. Edwards, E.J., Unwin, D., Kilmister, R., Treeby, M. & Ollat, N. 2017. Multi-seasonal effects of warming and elevated CO_2 on the physiology, growth and production of mature, field grown, Shiraz grapevines. *Journal International des Sciences de la Vigne et du Vin*, 51(2): 127–132.
4. Hunter, J.J., Archer, E., Volschenk, C.G., 2010. Vineyard management for environment valorisation. Proceedings of the VIII International Terroir Congress. Soave, Italy: 7.3-7.15.
5. Hunter, J.J., Volschenk, C.G. & Booyse, M. 2017. Vineyard row orientation and grape ripeness level effects on vegetative and reproductive growth characteristics of Vitis vinifera L. cv. Shiraz/101-14 Mgt. *European Journal of Agronomy*, 84: 47–57. http://dx.doi.org/10.1016/j.eja.2016.12.004.
6. IPCC, 2007. Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor, H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.ipcc.ch.
7. Jones, G. V. 2007. Climate Change: observations, projections and general implications for viticulture and wine production. *Climate and Viticulture Congress*, Zaragoza, Spain: 55–66. http://medcontent.metapress.com/index/A65RM03P4874243N.pdf.
8. Li, K., Bardaji, I. & Ollat, N. 2017. Adapting the wine industry in China to climate change: Challenges and opportunities. *Journal International des Sciences de la Vigne et du Vin*, 51(2): 71–89.
9. Leibar, U., Aizpurua, A., Unamunzaga, O., Pascual, I. & Morales, F. 2015. How will climate change influence grapevine cv. Tempranillo photosynthesis under different soil textures? *Photosynthesis Research*, 124:199–215.
10. Schultz, H.R., 2000. Climate change and viticulture: A European perspective on climatology, carbon dioxide and UV-B effects. *Australian Journal of Grape and Wine Research* 6:2-12. http://onlinelibrary.wiley.com/doi/10.1111/j.1755-0238.2000.tb00156.x/pdf.
11. Van Leeuwen, C., Destrac-Irvine, A. & Ollat, N. 2017. Modified grape composition under climate change conditions requires adaptations in the vineyard. *Journal International des Sciences de la Vigne et du Vin*, 51(2): 147–154.

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