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Merlot noir responses to biostimulant application: grapevine performance and fruit quality

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Photo by Stefan Els

Outline

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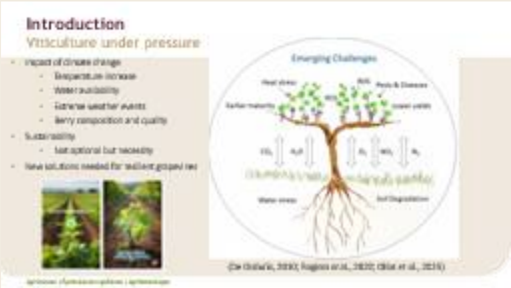
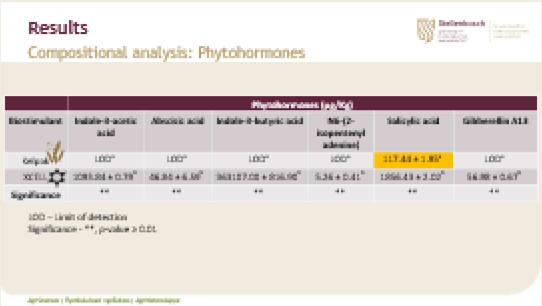
Introduction



Problem statement & research question. Aims & objectives

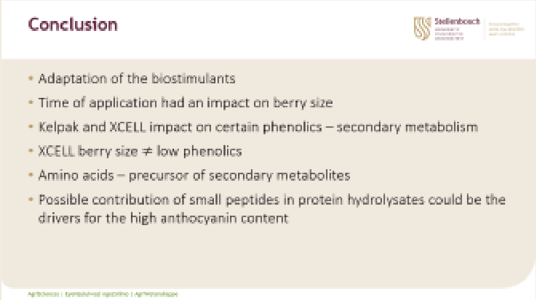
Materials & methods

Results



Limitations

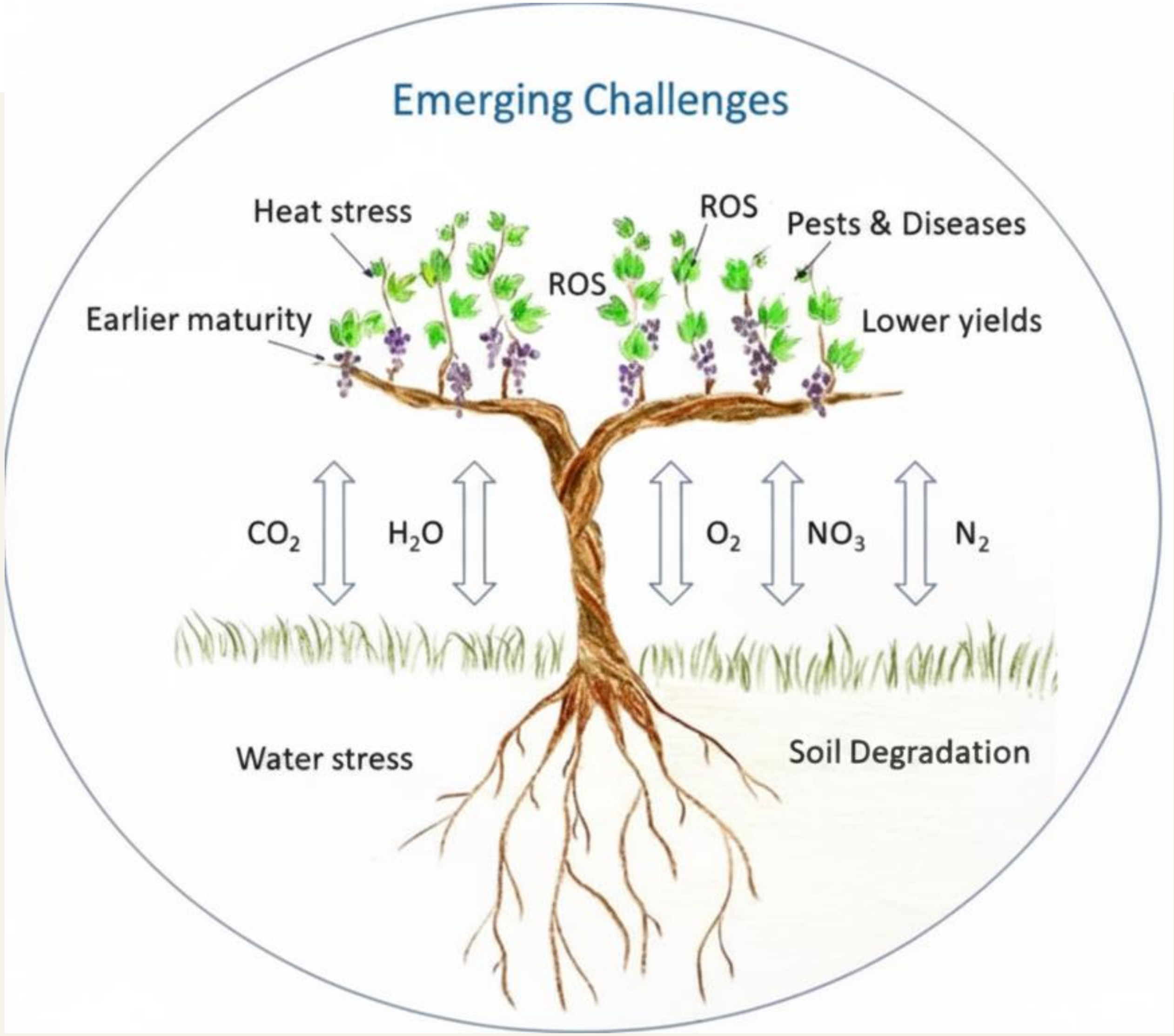
Conclusion & Questions



Introduction

Viticulture under pressure

- Impact of climate change
    - Temperature increase
    - Water availability
    - Extreme weather events
    - Berry composition and quality
- Sustainability
    - Not optional but necessity
- New solutions needed for resilient grapevines



(De Orduña, 2010; Rogiers *et al.*, 2022; Ollat *et al.*, 2025)

Introduction

A cornerstone variety (Merlot) at risk

- Why Merlot matters:
  - Global Reach (2nd)
  - Adaptability
  - Desirable berry and wine composition
- Merlot's vulnerability
  - Sensitive to stresses
- Relevance in South Africa
  - 4th cultivar (5.9%)

(OIV, 2023; SAWIS, 2023)

Biostimulants

Nature's allies for resilience

- Biostimulant categories
  - Non-microbial
    - Organic
      - Humic & Fulvic acid
      - Vermicompost leachate
      - Chitosan
      - Plant extracts
      - Seaweed extracts
      - Protein hydrolysates
    - Inorganic
      - Aluminium
      - Sodium
      - Selenium
      - Cobalt
      - Silicon
      - Phosphite
  - Microbial
    - Arbuscular mycorrhizal fungi
    - Plant-growth promoting rhizobacteria
    - *Trichoderma*

(Du Jardin., 2015; Gupta *et al*, 2021; Johnson *et al*, 2023; Jiang *et al*, 2024)

Introduction

Whey protein hydrolysates enhance grapevine resilience to abiotic and biotic stresses

Esteban Alfonso[1], Wilfried Andlauer[2], Wolfram Manuel Brück[2] and Markus Rienth[1*]

Effect of seaweed extract application on wine grape yield in Australia

Tony Arioli[1,2] · Scott W. Mattner[3,4] · Graham Hepworth[5] · David McClintock[6] · Rachael McClinock[6]

Protein hydrolysates effects on grapevine (*Vitis vinifera* L., cv. Corvina) performance and water stress tolerance

M. Boselli [a], M.A. Bahouaoui [a], N. Lachhab [a], S.M. Sanzani [b], G. Ferrara [b], A. Ippolito [b]

Effects of *Ecklonia maxima* seaweed extract on the fruit, wine—quality and microbiota in *Vitis vinifera* L. cv. Cabernet Sauvignon

Liam Jay Samuels, Alexia Elizabeth Papageorgiou, Mathabatha Evodia Setati, Erna Hailey Blancquaert

Problem statement and research question

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Problem statement:

- While research has been conducted on seaweed extracts impacts on different cultivars under field conditions, it is still unclear how Merlot noir will respond under different viticultural conditions to the foliar application of two biostimulant classes under South African conditions.

Research question

- Can biostimulants help Merlot noir sustain performance and fruit quality under stress?

Aim and objectives

Aim: To determine the effects of foliar application of biostimulant classes (seaweed extract and protein hydrolysates) on the vegetative and reproductive performance of irrigated and non-irrigated *Vitis vinifera* L. cv Merlot noir.

Objectives:

- To apply seaweed extracts and protein hydrolysates as a full canopy spray before flowering, at fruit set and at véraison.
- To monitor grapevine performance (stomatal conductance (gs), intrinsic water-use efficiency (iWUE), and chlorophyll content) and vegetative growth.
- To evaluate grape ripening dynamics and grape berry quality and yield.
- To determine the chemical parameters and wine phenolic content of the final wines.

Materials and Methods

Biostimulant classes that were used:

Kelpak® – Seaweed extracts

- Chemical composition – Auxins, cytokinins, brassinosteroids, gibberellins, and polyamines
- Enhance shoot growth
- Improve fruit quality
- Abiotic and biotic stress tolerance

XCELL® – Protein hydrolysates

- Chemical composition – essential amino acids and polyamines
- Improve fruit quality
- Increase yield
- Water stress tolerance
- Reduce stomatal conductance

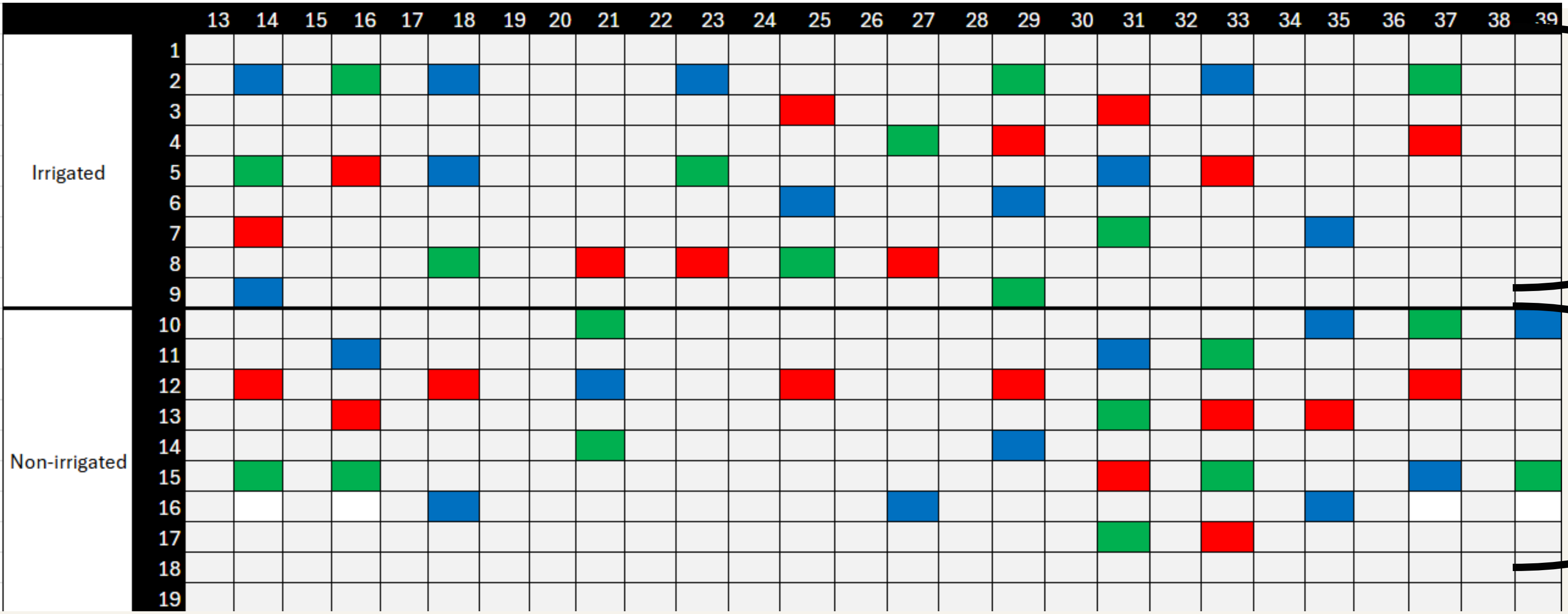
Pre-analysis of biostimulants

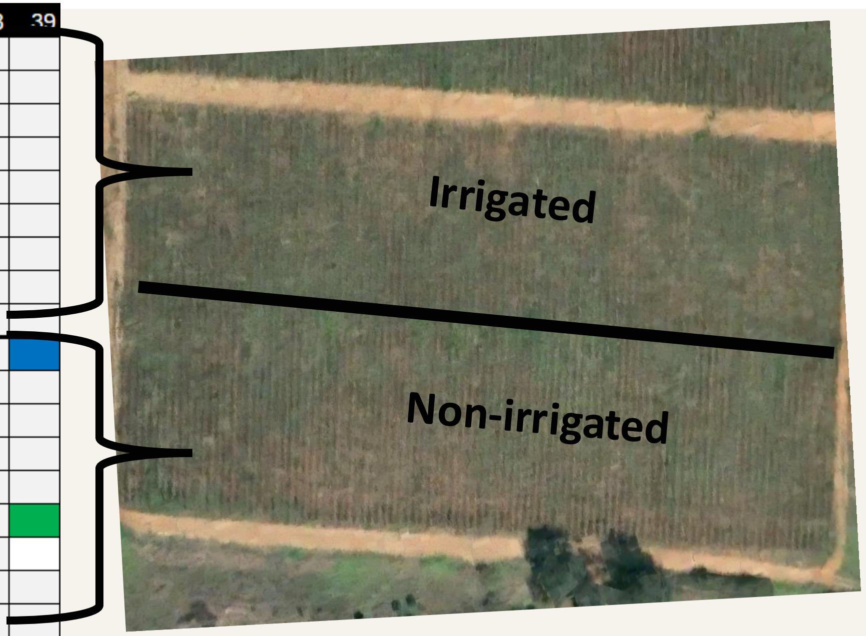
- 10 ml samples lyophilized for 5 days – Christ alpha 1-4LD Plus model freeze dryer
- Compositional analysis
    - Amino acids
    - Plant phytohormone content
    - Macro-and-micro elements status
- Central Analytics Facility (CAF)
- Gas Chromatography-Mass spectrometry (GC- MS)
- Inductively Coupled Plasma (ICP)

(Grobbelaar, 2014; Lötze & Hoffman, 2016; Simura et al., 2018)

Experimental design

Randomized block design





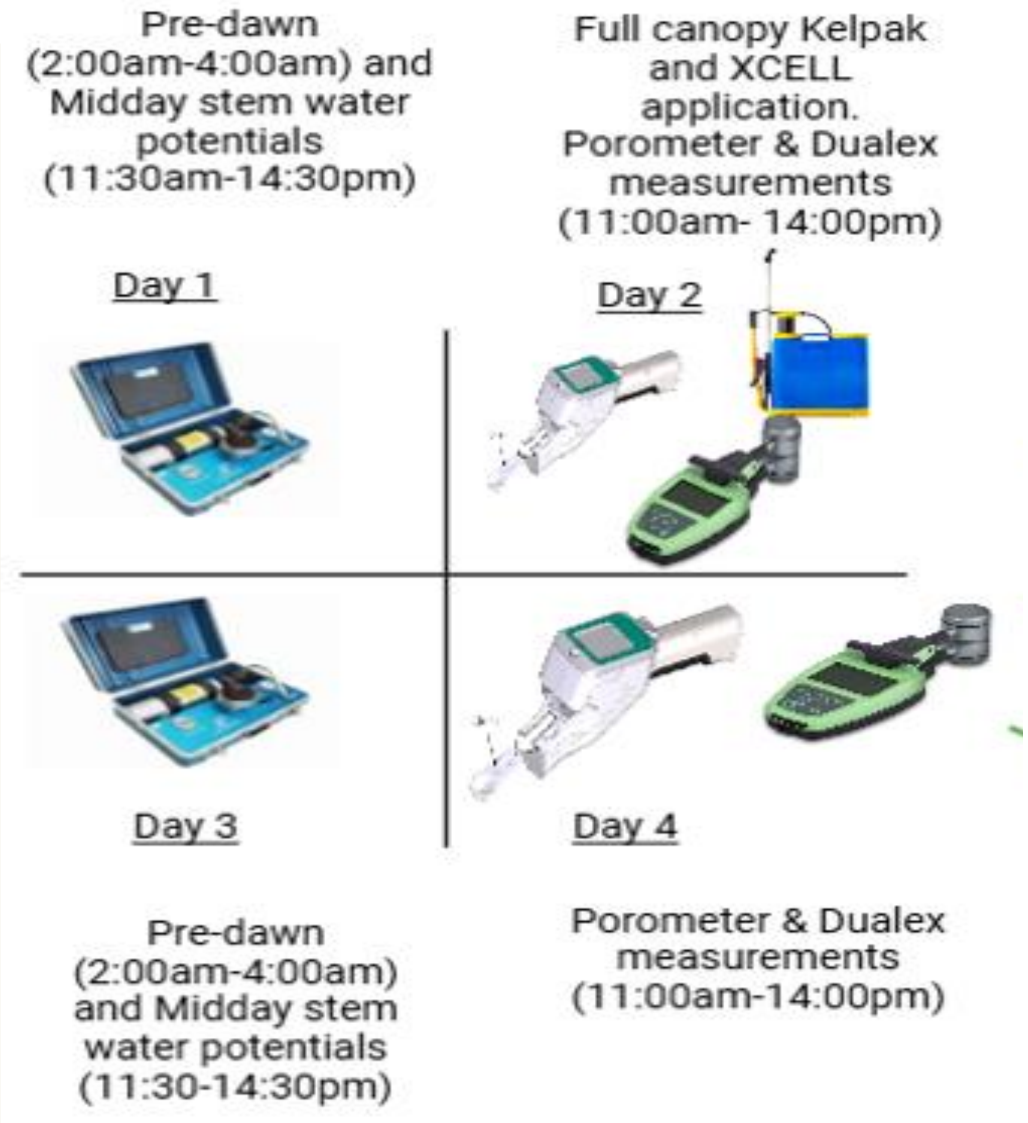
- Merlot block
  - 2002
  - Rootstock – Richter 110
  - Scion – MO348
- 7 wire hedge trellis
- Drip irrigation (Sometimes they do irrigate bottom part)

Legend	
Control	(blue)
Kelpak	(red)
XCELL	(green)

Application method

- Full canopy foliar application
    - Before flowering, fruit-set and véraison
    - Applied between 04:00 am to 06:00 am
- Kelpak – 1:500
- XCELL – 2:500

Vineyard measurements
Vine physiology



EL-18 (Before flowering)

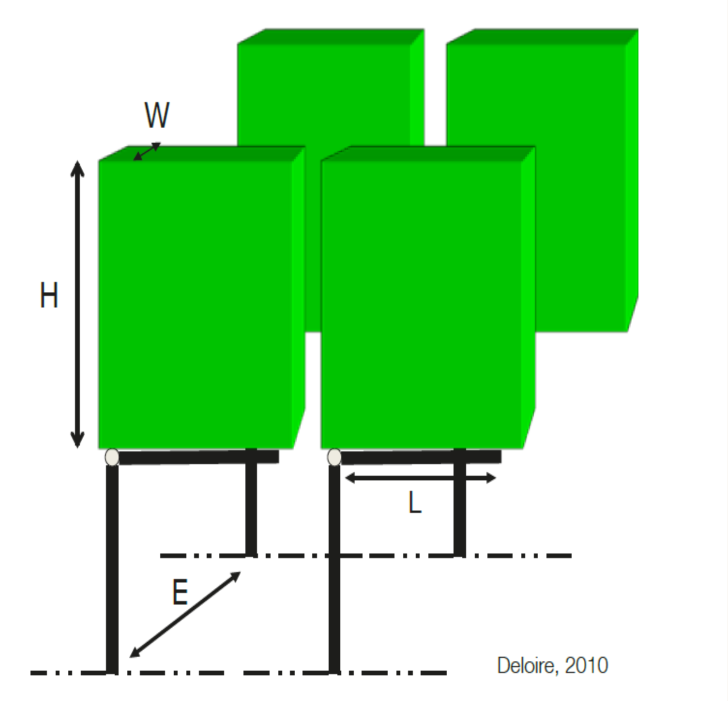
EL-27 (At fruit-set)

EL-35 (Véraison)

- Intrinsic water-use efficiency
- Stomatal conductance
- Chlorophyll content

Vineyard measurements
Vegetative characteristics

- **Leaf area index**
  - Tagged leaves
  - Véraison (E-L 35)
  - Mid-ripening (E-L 37)
  - Post-harvest (E-L 39)
  - ImageJ (Rasband, W.S., ImageJ, U. S. National Institutes of Health, Bethesda, Maryland, USA)
- **Canopy characteristics**
  - canopy length, width and height measurements
  - From bunch closure (E-L 32) to Harvest (E-L 38)



(Coombe, 1995;Glozer, 2008; Deloire, 2012)

Vineyard measurements

Ripening dynamics

Véraison (E-L 35) → Harvest (E-L 38)

- **Classical berry ripening analysis:**
  - 150 berries (3 x 50 replicates)
- **Total soluble solids (°Brix)**: (Atago, PR-32α Digital Palette refractometer)
- **Titratable acidity (TA) and pH**: (Metrohm automated titrator 785 DMP Titrino)
- **Carpological analysis:**
  - 150 berries (50 x 3 replicates) - (berry weight, berry length and berry diameter)

Vineyard measurements

Analysis of primary metabolites

Sugars, organic acids and amino acid content

- At véraison (E-L 35), mid-ripening (EL-37) and at harvest (E-L 38)
- 150 berries (3 x 50 replicates) – homogenous sampling
- Freeze at -20°C - for later analysis
- Sugars and organic acids
- Amino acids

(Eyéghe-Bickong *et al*., 2012; Du Plessis *et al*., 2017; Blancquaert, 2015)

Vineyard measurements

Secondary metabolites

Phenolic content of berries

- PhenoLab method
- At véraison (E-L 35), mid-ripening (EL-37) and at harvest (E-L 38)
- Sample of 150 berries per treatment (3 x 50 replicates)
- Freeze at -20°C - for later analysis
- Homogenization – Ultra-Turraz model T25 homogenizer
- Diluted -50x with HCL (1M)
- Dark-adapted for1 hr to enhance absorbance
  - 270nm, 290nm, 500nm, 540nm

(Aleixandre-Tudo *et al.*, 2017)

Results

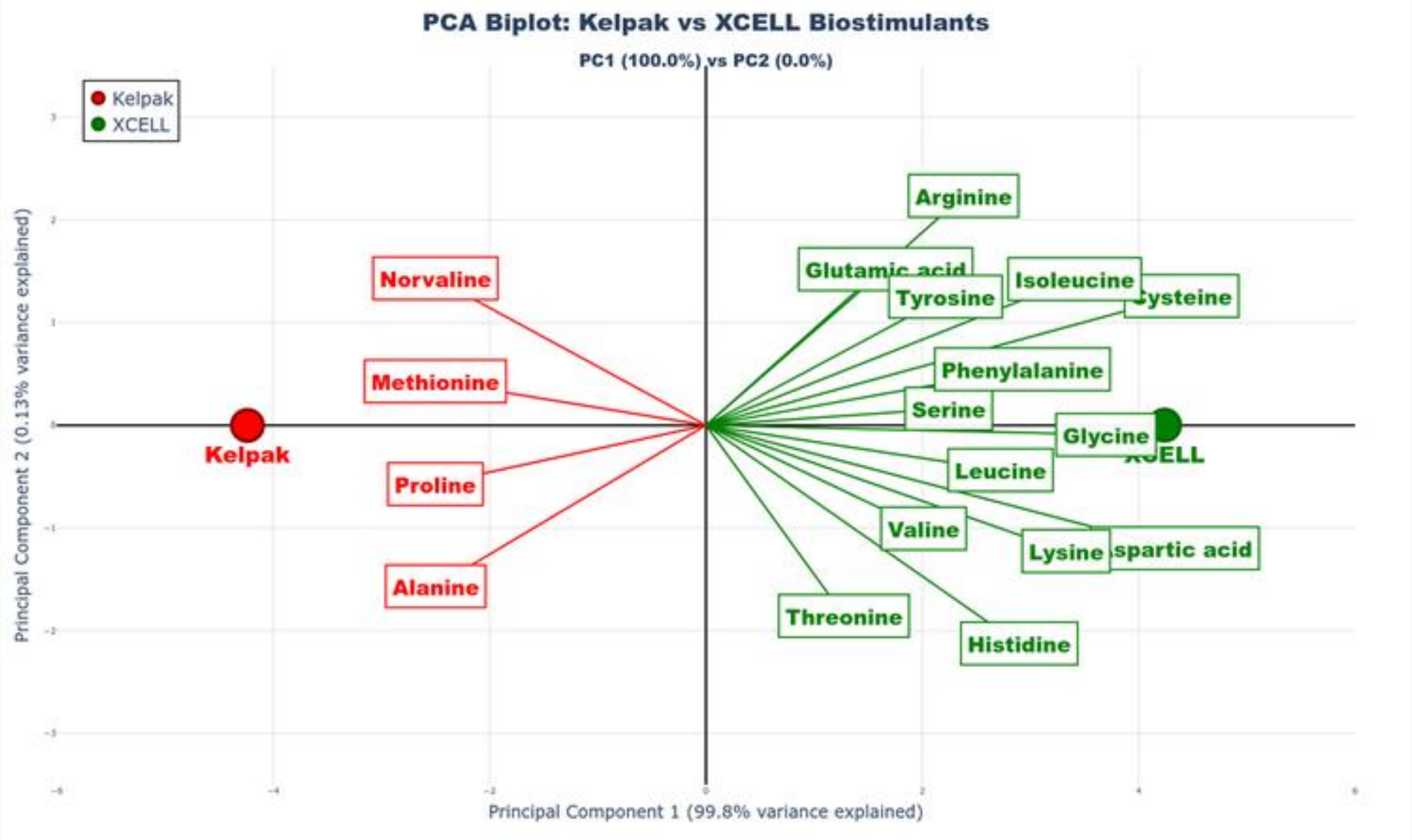
Compositional analysis: Phytohormones

	Phytohormones (µg/Kg)					
Biostimulant	**Indole-3-acetic acid**	**Abscisic acid**	**Indole-3-butyric acid**	**N6-(2-isopentenyl adenine)**	**Salicylic acid**	**Gibberellin A13**
Kelpak	LOD[a]	LOD[a]	LOD[a]	LOD[a]	117.44 ± 1.95[a]	LOD[a]
XCELL	1093.84 ± 0.79[b]	46.84 ± 6.59[b]	363107.00 ± 816.90[b]	5.26 ± 0.41[b]	1856.43 ± 2.02[b]	56.98 ± 0.67[b]
Significance	**	**	**	**	**	**

LOD – Limit of detection
Significance - **, *p*-value ≥ 0.01

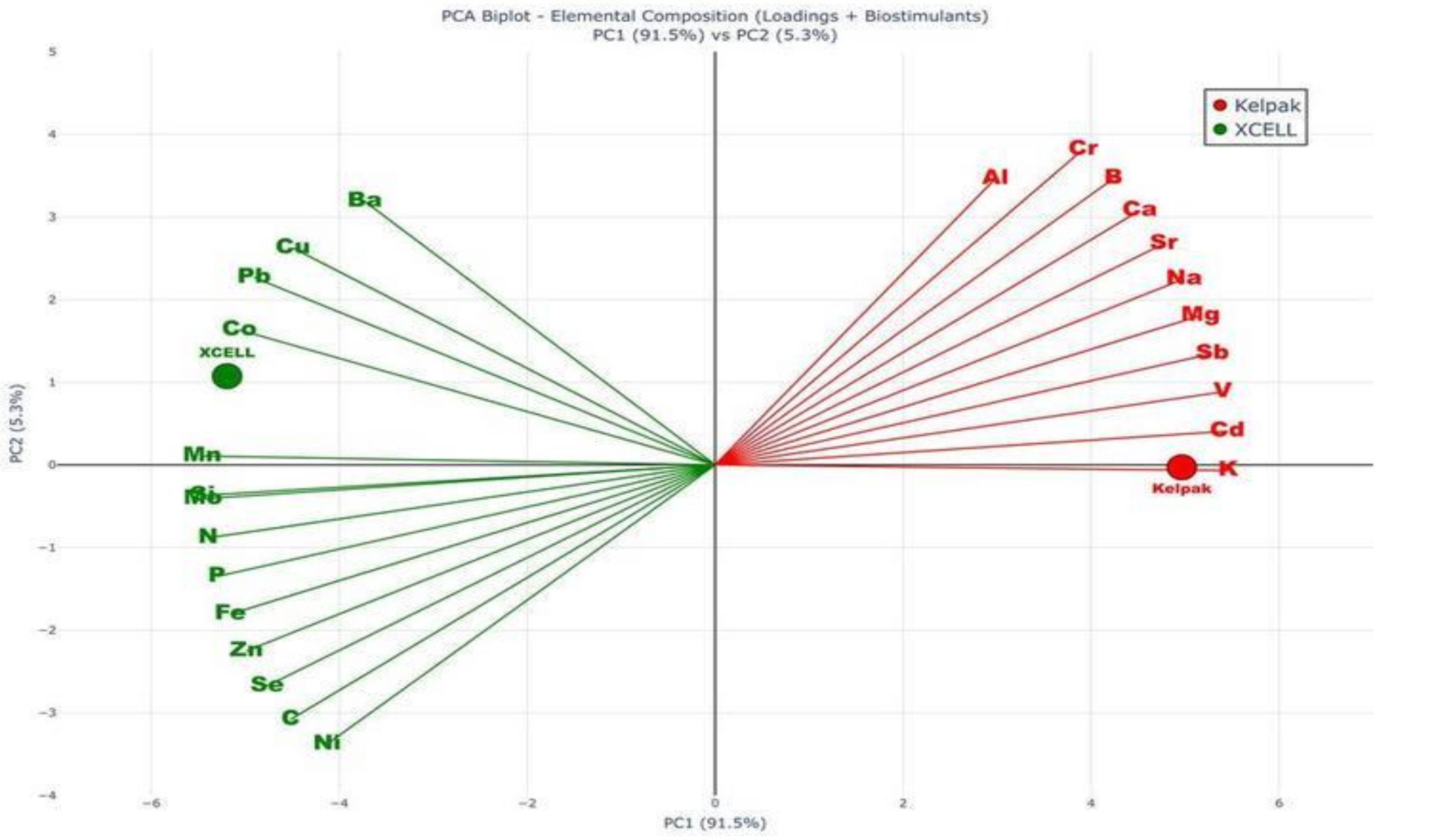
Results

Compositional analysis: Amino acids



Results

Compositional analysis: Micro- and macro- nutrients



Results

Grapevine performance

	Pre-dawn Leaf water potential (MPa)	Midday stem water potential (MPa)	Stomatal conductance (mol m^{-2} s^{-1})	Chlorophyll content
Treatment				
Control	-0.37 ± 0.15	-0.70 ± 0.17	0.14 ± 0.09	21.97 ± 2.25
Kelpak	-0.36 ± 0.14	-0.68 ± 0.14	0.14 ± 0.08	21.37 ± 2.86
XCELL	-0.36 ± 0.13	-0.68 ± 0.12	0.13 ± 0.08	21.46 ± 3.79
Water regime				
Irrigated	-0.38 ± 0.16^{a}	-0.68 ± 0.13^{a}	0.14 ± 0.08^{a}	21.60 ± 3.10^{a}
Non-irrigated	-0.35 ± 0.12^{b}	-0.69 ± 0.16^{a}	0.14 ± 0.09^{a}	21.60 ± 2.96^{a}
Significance				
Treatment	ns	ns	ns	ns
Water regime	**	ns	ns	ns
EL-stages	**	**	**	**

ns – not significant, ** *p*-value ≥ 0.01

Results

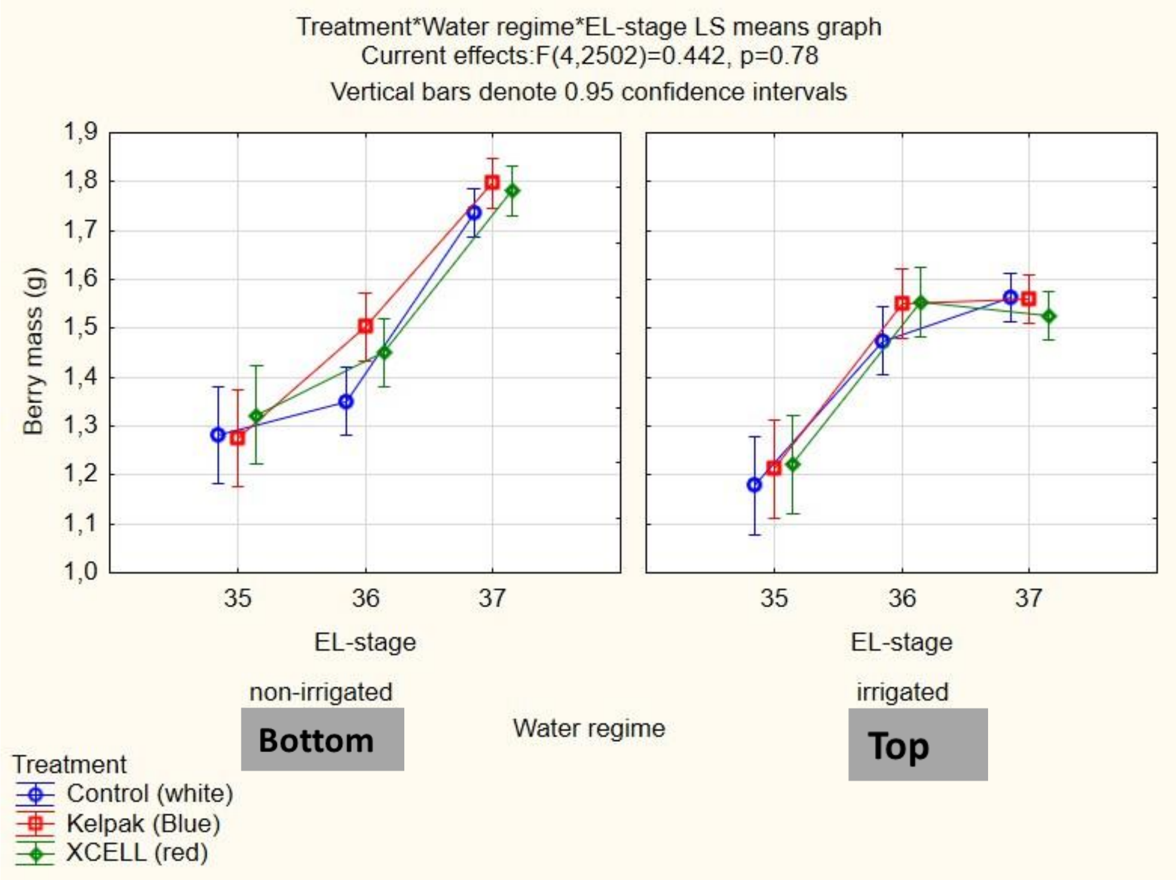
Grapevine performance: Canopy area & Leaf area

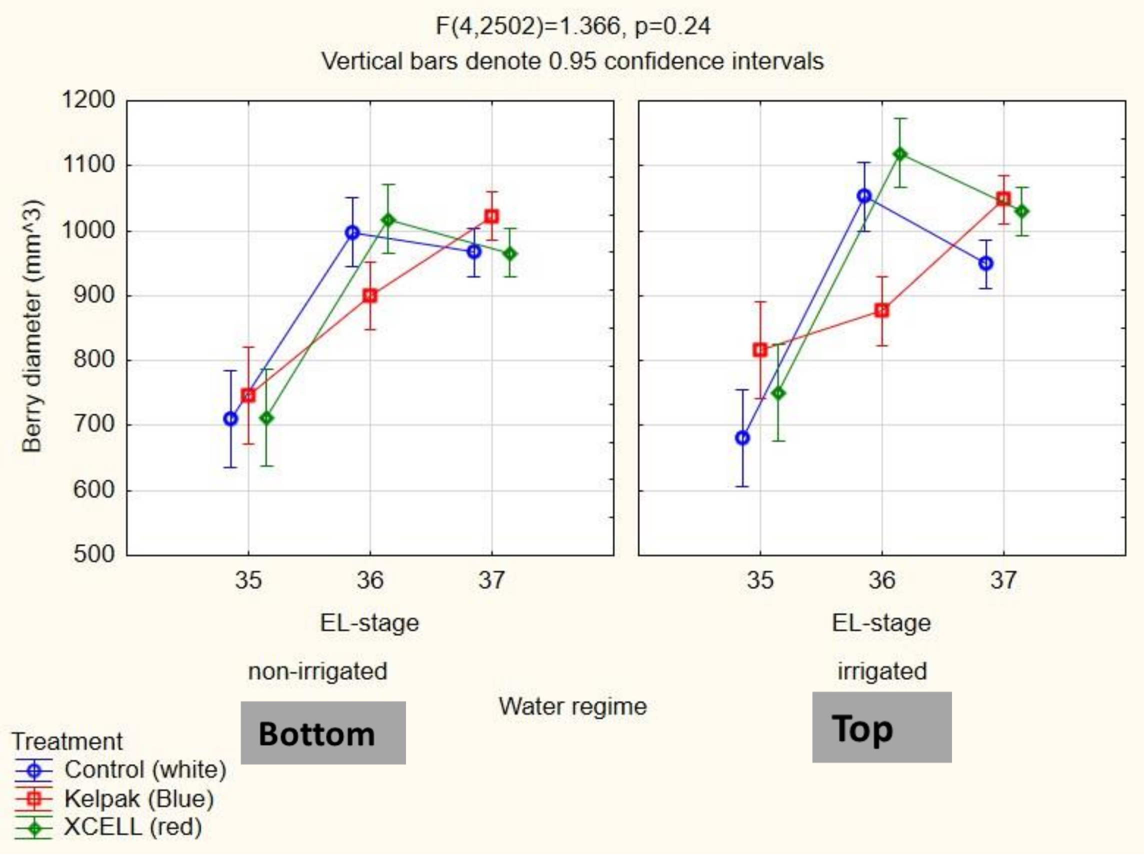
Treatment	Canopy area (^5 cm^3)	Leaf area (cm^2)
Control	6.49 ± 2.27	120.08 ± 25.01
Kelpak	6.95 ± 2.50	130.43 ± 20.53
XCELL	6.31 ±2.29	126.39 ± 26.47
Water regime		
Irrigated	6.32 ± 2.41[a]	115.79 ± 19.31[a]
Non-irrigated	6.84 ± 2.41[a]	135.76 ± 24.83[b]
Significance		
Treatments	ns	ns
Water regime	ns	**
Treatment* Water regime	ns	ns

(Gomez-del-Campo *et al.*, 2002; Bindi *et al.*, 2005; Scholasch & Rienth., 2019; Levin *et al.*, 2020)

Results

Berry quality: Berry mass & diameter

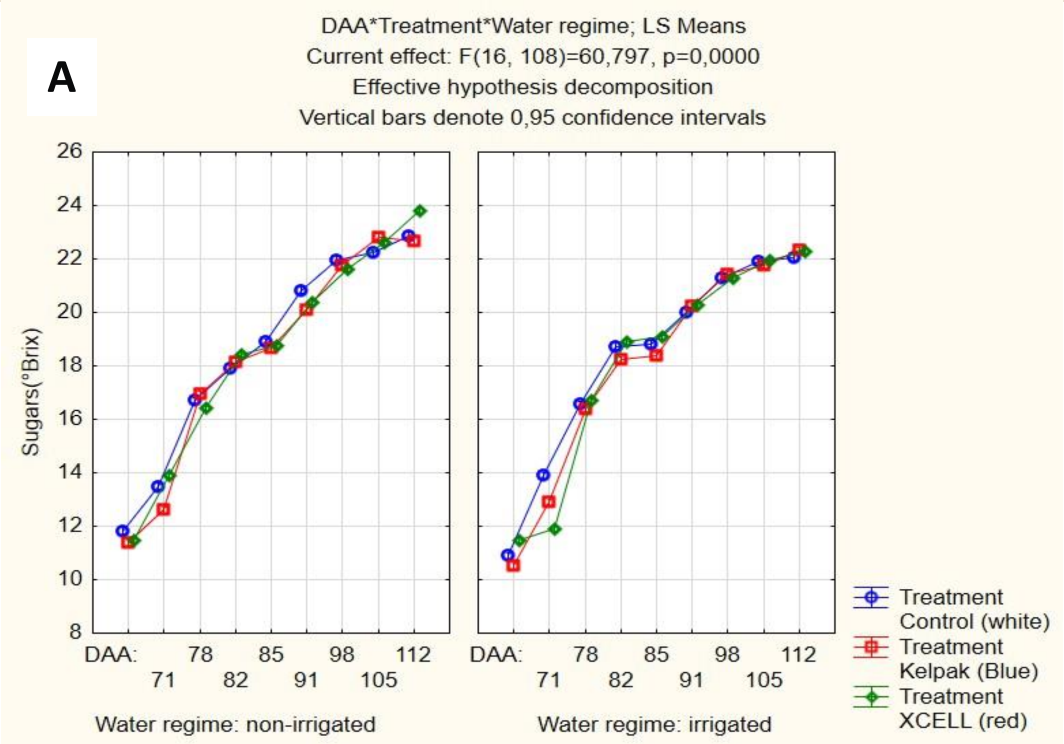


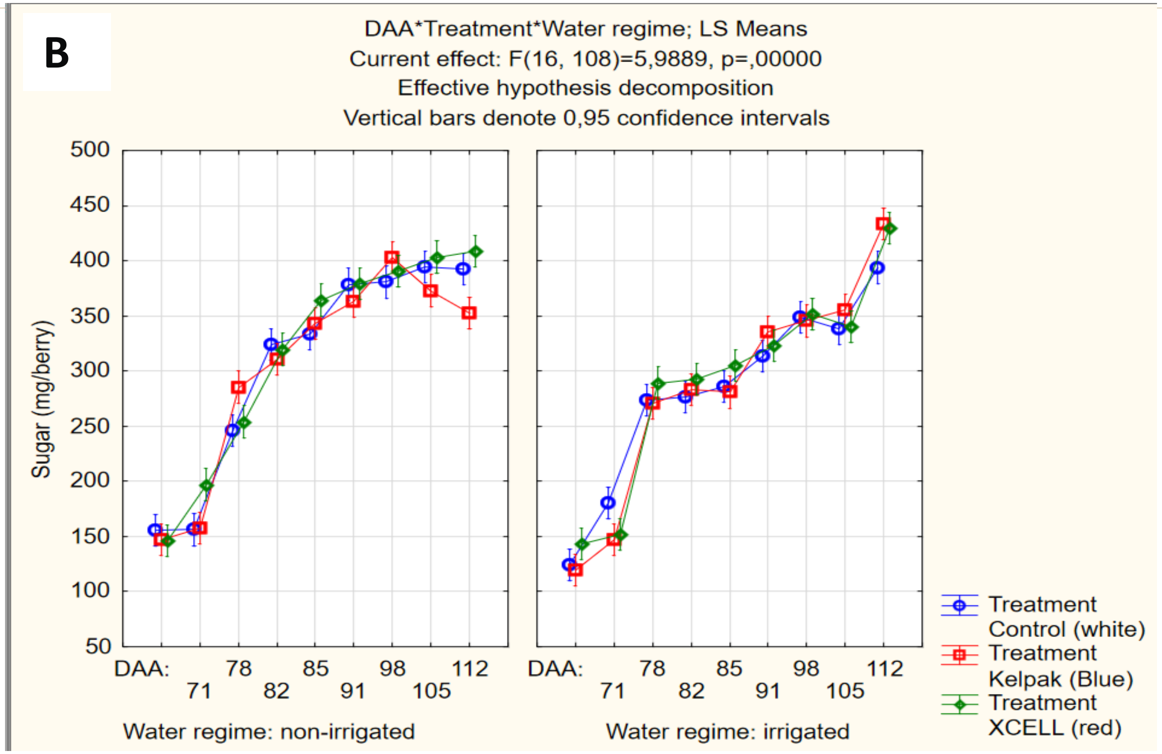


(Ojeda *et al.*, 2001; Koundrouras *et al.*, 2006)

Results

Berry quality: Sugar accumulation & °Brix





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(Boselli *et al*., 2019; Samuels *et al*., 2024)

Results

Berry quality: Anthocyanins, tannins, colour density, and total phenolic index

	Anthocyanins (mg/L)	Tannins (mg/L)	Colour density	Total phenolic index
Treatment				
Control	67.10 ± 0.22	1391.73 ± 1.66	6.71 ± 0.23	17.16 ± 0.21
Kelpak	62.97 ± 0.22	1358.03 ± 1.66	6.68 ± 0.23	16.81 ± 0.21
XCELL	71.55 ± 0.22	1527.12 ± 1.66	7.06 ± 0.23	17.16 ± 0.21
Water regime				
Irrigated	66.21 ± 0.18^{a}	1412.47 ± 1.36^{a}	6.74 ± 0.19^{a}	16.69 ± 0.17^{a}
Non-irrigated	68.21 ± 0.18^{b}	1438.79 ± 1.36^{b}	6.90 ± 0.19^{a}	17.40 ± 0.17^{b}
Significance				
Treatment	***	***	ns	ns
Water regime	***	***	ns	**
Treatment*Water regime	***	***	ns	ns

(Boselli *et al.*, 2019; Gutiérrez-Gamboa et al., 2019; Samuels *et al.*, 2024)

Limitations

Site

Commercial farm

Weather conditions

Conclusion

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- Adaptation of the biostimulants
- Time of application had an impact on berry size
- Kelpak and XCELL impact on certain phenolics – secondary metabolism
- XCELL berry size ≠ low phenolics
- Amino acids – precursor of secondary metabolites
- Possible contribution of small peptides in protein hydrolysates could be the drivers for the high anthocyanin content

Acknowledgments

- My supervisor Dr Erna Blancquaert
- My co-supervisors Dr Etienne Terblanche & Prof Markus Rienth
- My lab mates and friends who helped me collect the data.
- CA-lab and CAF
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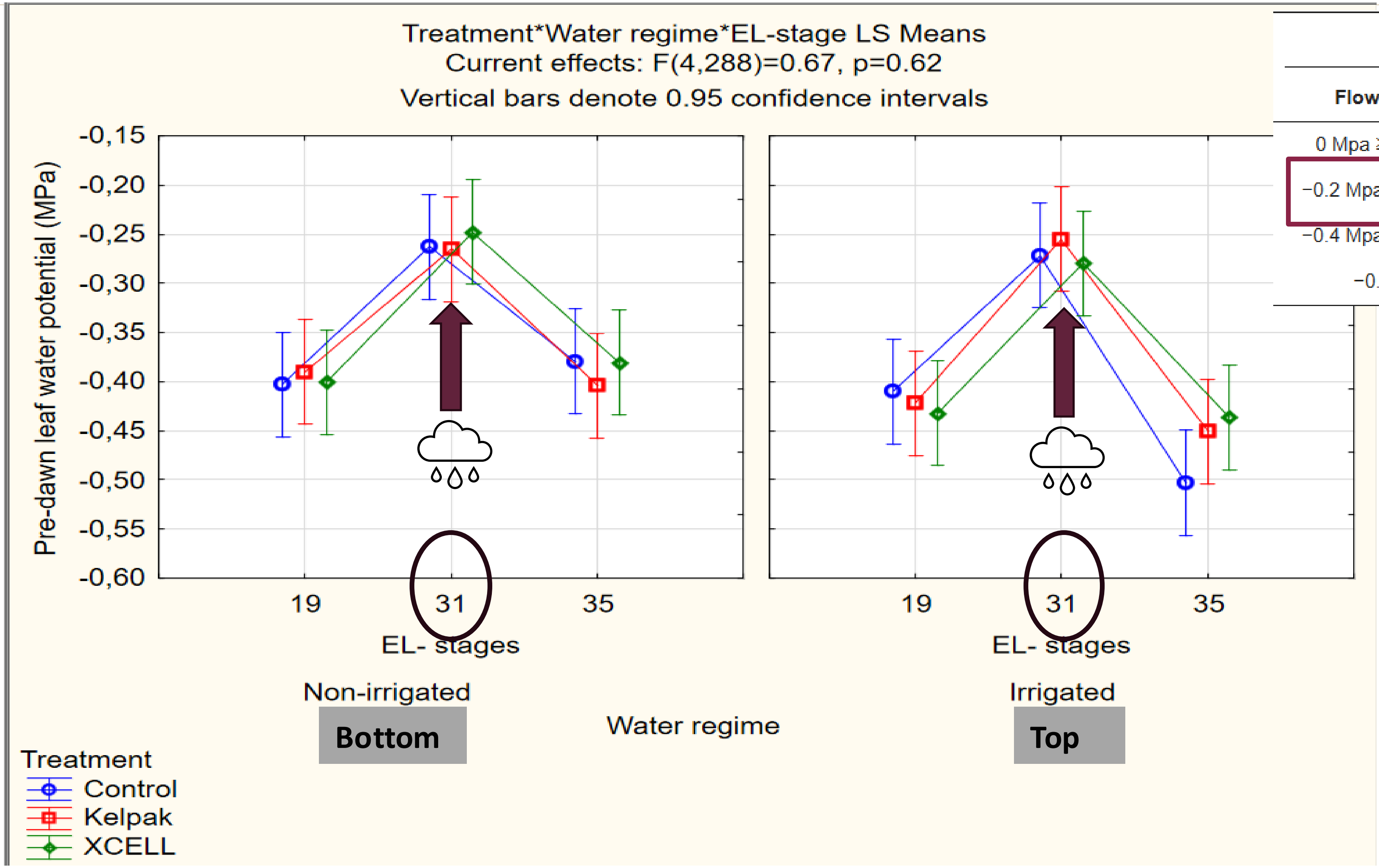
Thank you
Any questions

Results

Grapevine performance: pre-dawn leaf water potential



Period		Water Status of the Vine
Flowering-Veraison	Veraison-Maturity	Type of Stress
0 Mpa ≥ Ψ_{PD} ≥ −0.2 Mpa	Ψ_{PD} ≥ −0.2 Mpa	None—Light
−0.2 Mpa > Ψ_{PD} ≥ −0.4 Mpa	Ψ_{PD} ≥ −0.4 Mpa	Light—Moderate
−0.4 Mpa > Ψ_{PD} ≥ −0.6 Mpa	Ψ_{PD} ≥ −0.6 Mpa	Moderate—Intense
−0.6 Mpa > Ψ_{PD}	Ψ_{PD} ≥ −0.8 Mpa	Intense

(Williams & Araujo., 2002; Deloire *et al.*, 2004; Deloire & Heyns 2011)

Results

Grapevine performance: midday stem water potential

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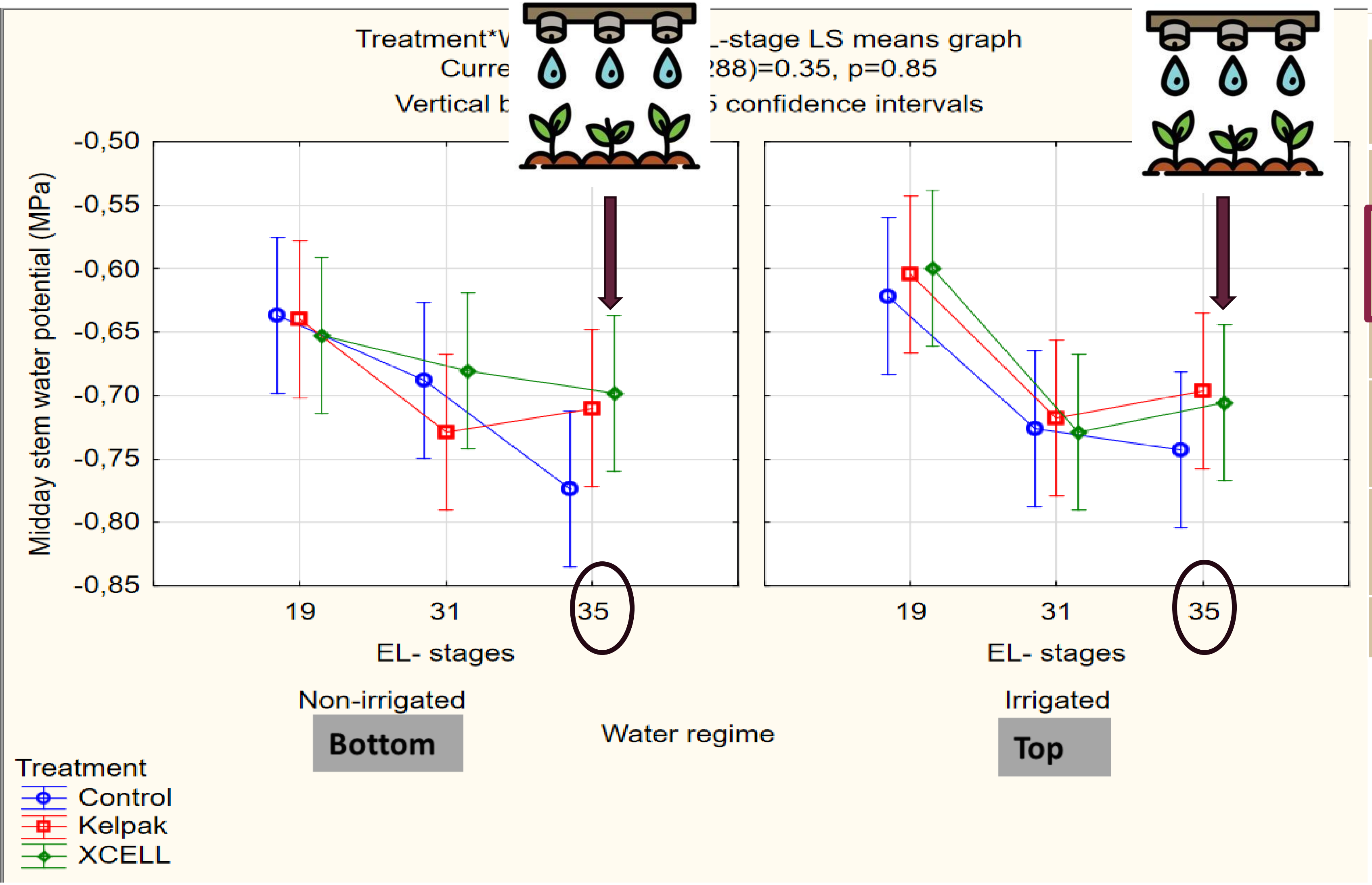
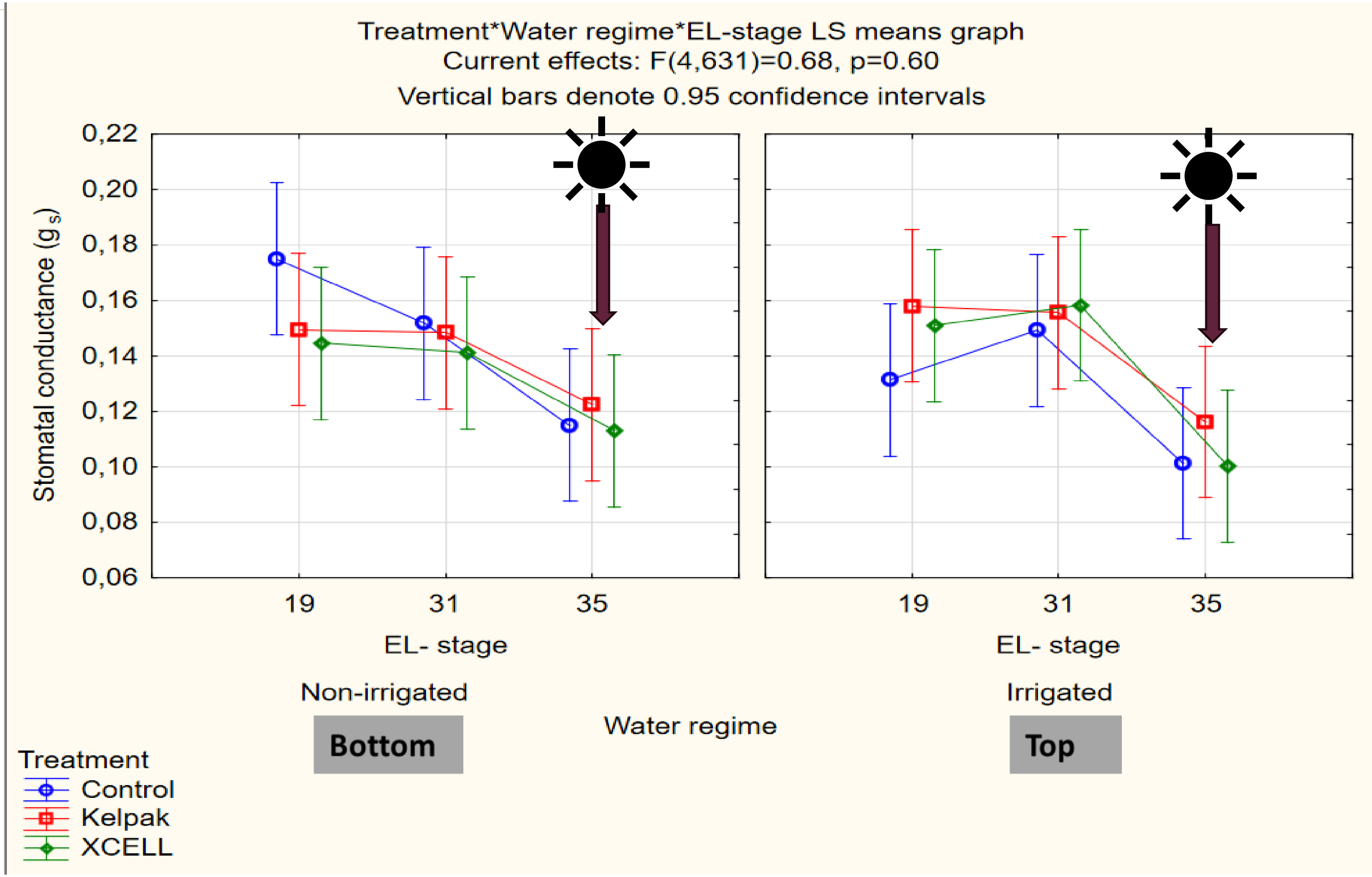


SWP (ψswp, MPa)	Level of vine water deficit
>- -0.6	Zero water deficit
-0.7 to -0.9	Mild to moderate water deficit
-1.0 to -1.2	Moderate water deficit
-1.2 to -1.4	Moderate to important water deficit
-1.4 to -1.6	Strong to severe water deficit
< -1.6	Severe water deficit

(Van Leeuwen *et al*., 2009; Chaves et *al*., 2010; Deloire & Heyns, 2011; Van Leeuwen *et al*., 2019; Grossiord *et al*., 2020)

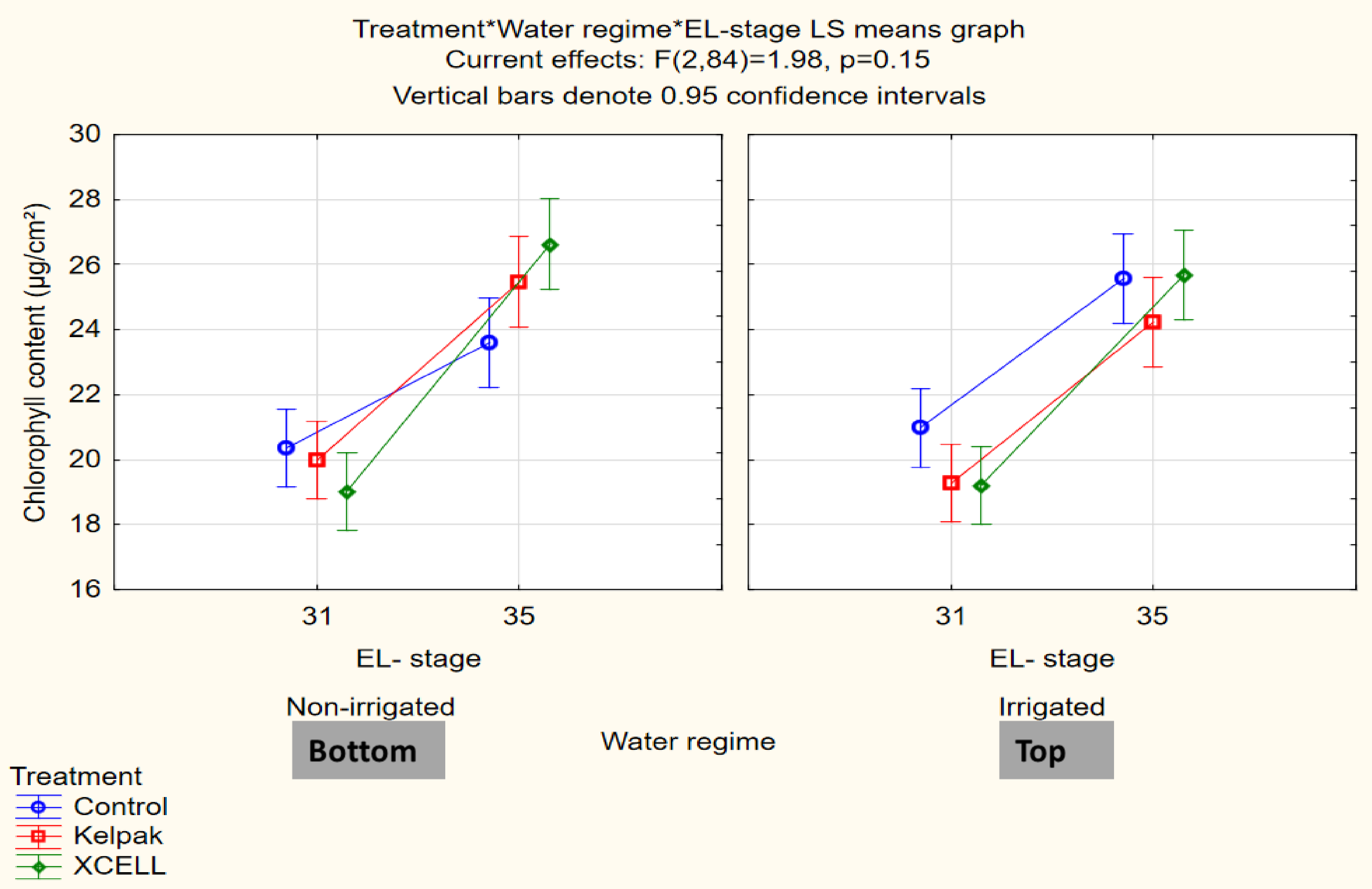
Results

Grapevine performance: Stomatal conductance



(Hochberg *et al.*, 2017; Vuerich *et al.*, 2021)

Results
Grapevine performance: Chlorophyll content



(Poni *et al.*, 1994)

Results

Berry quality: Neutral amino acids

	Glycine	Isoleucine	Leucine	Asparagine	Glutamine	Threonine	Tyrosine	Alanine	Tryptophan	Phenylalanine
Treatment										
Control	5.44	5.33	9.31	2.58	30.64	24.48	10.77	37.89	1.09	1.96
Kelpak	5.03	5.01	8.77	1.94	27.96	23.01	7.55	34.94	0.76	1.72
XCELL	5.40	4.71	8.16	1.80	23.21	23.14	7.80	33.66	1.53	1.37
Water regime										
Irrigated	5.64^{a}	5.46^{a}	9.10^{a}	2.42^{a}	25.10^{a}	23.58^{a}	9.26^{a}	36.06^{a}	0.52^{a}	1.68^{a}
Non-irrigated	4.94^{b}	4.58^{b}	8.39^{b}	1.79^{b}	29.44^{b}	23.50^{a}	8.15^{b}	34.93^{b}	1.73^{b}	1.69^{a}
Significance										
Treatment	ns	ns	*	***	***	***	***	***	ns	ns
Water regime	***	***	***	***	***	ns	***	***	*	ns
EL-stage	***	***	***	***	***	***	***	ns	***	***

Results

Berry quality: Non-polar amino acids

	Aspartic acid	Glutamic acid	Serine	Histidine	Arginine	GABA	Ornithine	Lysine	Proline
Treatment									
Control	14.58	44.36	33.42	17.27	121.71	51.96	7.45	3.47	468.04
Kelpak	14.88	40.00	31.86	14.19	109.71	52.43	7.02	3.48	438.99
XCELL	12.60	40.89	31.14	13.53	117.02	52.87	4.84	3.20	446.34
Water regime									
Irrigated	12.11[a]	37.71[a]	32.66[a]	14.60[a]	122.38[a]	53.03[a]	7.75[a]	3.46[a]	439.30[a]
Non-irrigated	15.93[b]	45.79[b]	31.61[b]	15.39[b]	109.91[b]	51.82[b]	5.11[b]	3.31[a]	462.95[b]
Significance									
Treatment	***	***	***	***	***	ns	*	*	***
Water regime	***	***	***	***	***	***	***	ns	***
EL-stage	***	***	***	***	***	***	***	**	***