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Strategies for reducing water consumption in vineyard grapevines without affecting water status, yield and wine quality.

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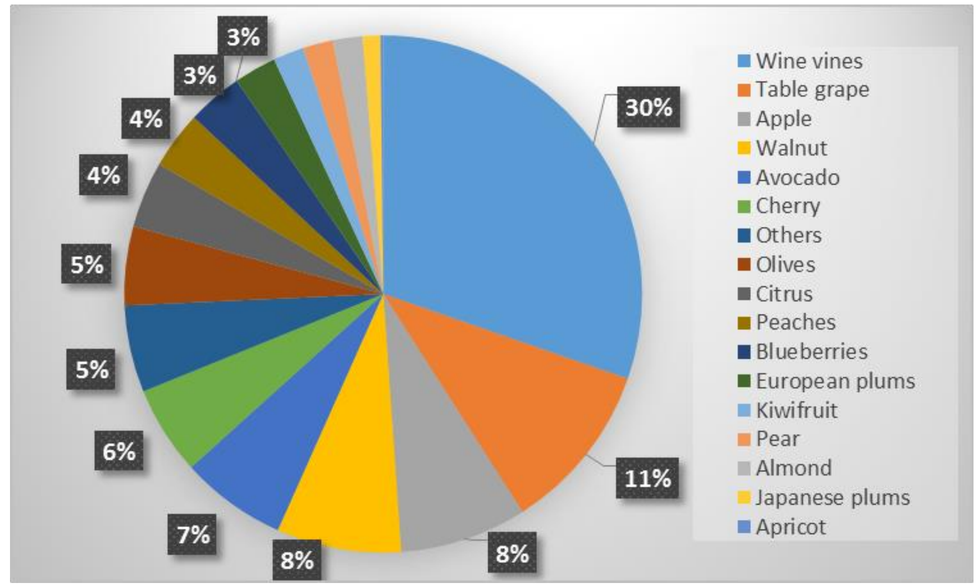
November 2018

Background

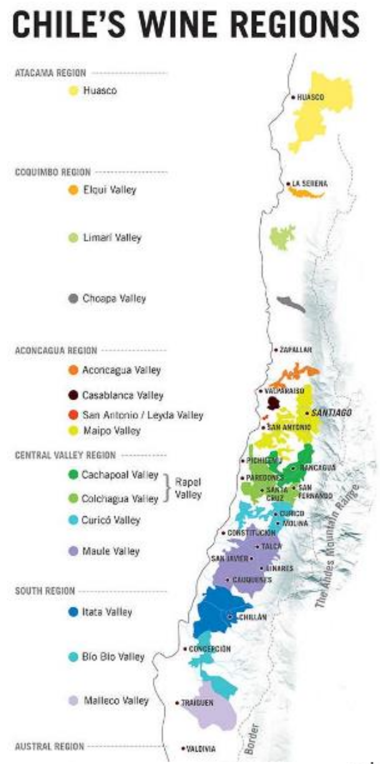
- Wine grape (*Vitis vinifera* L.) have high economic importance at Chile.
- 1,000-1,300 MM Liters per year. 80% exported to international markets.
- Chile is the 4th more important exporter of wine in the World.
- USD $1,800 MM income only in wine exportation.
- 100,000 direct employments.

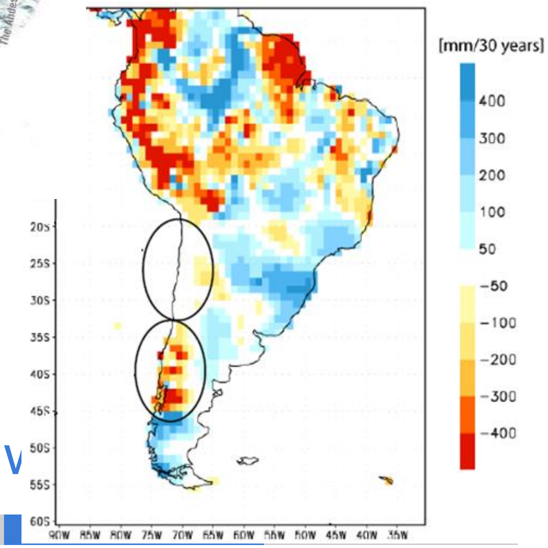


Vineyards in Chile: 137,375 ha.
(ODEPA, 2017)
3.2% less tan 2005

Background

- The central region of Chile has an optimal climate for producing high-quality wines.
- However rainfall has become increasingly scarcer, affecting surface and ground water availability.
- Drought has threatened the water security of the area making difficult to establish new vineyard, but also less water availability has affected vine vigor, fruit yield and quality when plant´s water demands have not been met.
- Thus, water is today the main limiting factor for the production of wine grapes.





Background

- Microirrigation in wine vines: 30% of the total wine vine surface (estimated).
- However water is very critical for yield and wine quality.
- Regulated deficit irrigation (RDI) in grapes has been commonly used in vineyards for enhancing wine quality, however water shortage can severely affect vineyard yield, general status and longevity.
- Other strategies are needed in order to save water.

Background

- The use of plastic covers, mulching, subsurface irrigation and nano-irrigation have demonstrated to reduce fruit trees and vegetables water consumption (Núñez-Elisea et al., 2005; Renquist, 2008; Lang, 2009; Netafim, 2018).

- Partial root drying (PRD) have been demonstrated to significantly improve water use efficiency in vines (Dry and Loveys 1998, 1999, 2000).

- In this work we present preliminar results from a research where we are evaluating the effects of irrigation water savings combined with different strategies for reducing water stress in 'Merlot', 'Carménère' and 'Cabernet Sauvignon' vines.

Hypothesis

"Restricted irrigation combined with water stress mitigation strategies would reduce water consumption without affecting yield and wine quality".

Objectives

General objectif.

To evaluate physiological response, yield, wine quality and blue water footprint in ‘Carménère’, ‘Merlot’, and ‘Cabernet Sauvignon’ vines subjected to restricted irrigation combined with water stress mitigation managements.

Specific objectives.

- To evaluate ‘Carménère’ vines in terms of physiological response, yield, wine quality and blue water footprint in response to Partial Root Drying.
- To evaluate ‘Merlot’ vines in terms of physiological response, yield, wine quality and blue water footprint in response to Partial Root Drying and Subsurface drip irrigation.
- To evaluate ‘Cabernet Sauvignon’ vines in terms of physiological response, yield, wine quality and blue water footprint in response to mulching and nano-irrigation.

Methodology

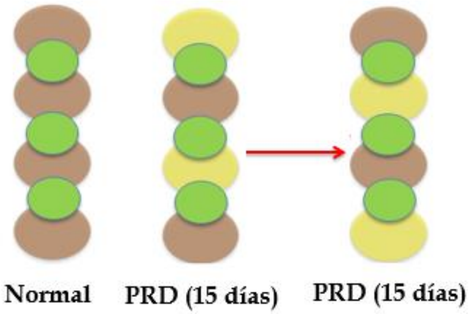
Experiment 1. .Carménère

Location

Vineyard from Santa Cruz, Colchagua, VIth región.

Treatments

- **T0:** Control, conventional irrigation regimes used by local growers (drip irrigation).
- **T1:** Water shortage: 50% of T0 during all season.
- **T2:** Partial Root Drying (PRD) irrigation resulting in a 50% reduction in irrigation volume compared to the control.
- Randomized complete blocks, 4 replications (16 plants each).



Methodology

Experiment 2. Merlot

Location

Vineyard from Marchigüe, Colchagua, VIth región.

Treatments

- **T0:** Control, grower´s drip irrigation.
- **T1:** Water shortage: 50% of T0 during all season.
- **T2:** T1+ PRD.
- **T3:** T1+ buried irrigation (susbsurface drip irrigation).
- Randomized complete blocks, 4 replications (16 plants each).

Methodology

Experiment 3. Cabernet Sauvignon

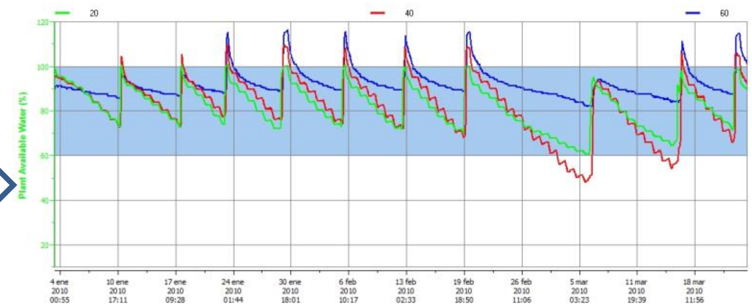
Location

Vineyard from Peralillo, Colchagua, VIth región.

Treatments

- **T0:** Control, drip irrigation used by local growers.
- **T1:** Water shortage: irrigation of 75% of T0 during all season (moderate restriction).
- **T2:** T1 + Mulching.
- **T3:** T1 + nano-irrigation drippers.
- Randomized complete blocks, 4 replications (16 plants each)

Measurements



Results

Carménère

Treatments and dates	Chlorophyll fluorescence	Relative Water Content (%)	Stomatal Conductance (mmol m^{-2} s^{-1})	Stem Water Potential (MPa)
16-nov				
T0: Control	0.70 ns	43.61 ns	567.27 ns	-0.59 ns
T1: 50% Control	0.69 ns	44.00 ns	535.85 ns	-0.57 ns
T2:T1 +PRD	0.66 ns	43.65 ns	577.32 ns	-0.55 ns
12-dec				
T0: Control	-	80.42 ns	781.73 ns	-0.76 ns
T1: 50% Control	-	86.67 ns	774.65 ns	-0.83 ns
T2:T1 +PRD	-	81.28 ns	784.27 ns	-0.81 ns
10-jan				
T0: Control	0.78 ns	79.32 b	588.28 ns	-0.83 ns
T1: 50% Control	0.76 ns	90.43 a	584.13 ns	-0.85 ns
T2:T1 +PRD	0.75 ns	85.66 ab	593.48 ns	-0.91 ns
20-feb				
T0: Control	0.72 ns	51.68 ns	780.75 a	-0.59 a
T1: 50% Control	0.68 ns	55.70 ns	682.28 b	-0.99 b
T2:T1 +PRD	0.68 ns	54.03 ns	794.23 a	-0.77 a
15-mar				
T0: Control	0.81 a	72.68 ns	528.25 ns	-0.59 a
T1: 50% Control	0.71 b	79.90 ns	414.75 ns	-0.64 ab
T2:T1 +PRD	0.77 a	83.70 ns	523 ns	-0.68 b

Anova, Tukey test, alpha≤0.05

Results

Carménère

	° Brix	pH	Total acidity (g/l)	Berry average weight (g)	Average yield per plant (Kg)	Blue waterfootprint (L/Kg)
T0: Control	21.8 ns	3.4 ns	3.7 ns	1.76 b	4.23 ns	204.25 b
T1: 50% Control	22.1 ns	3.5 ns	3.6 ns	1.94 ab	4.20 ns	102.86 a
T2:T1 +PRD	21.9 ns	3.5 ns	3.6 ns	2.06 a	4.00 ns	108.00 a

	Alcohol degree (°GL)	pH	Total Acidity (g/l)	Antocianas totales mg/L	Total tannins (mg/L)	Color intensity	Wine nuance
T0: Control	12.7 ns	3.7 ns	3.4 ns	653.9 ns	982.5 ns	8.5 b	0.4 b
T1: 50% Control	13.0 ns	3.8 ns	3.3 ns	642.4 ns	949.7 ns	8.7 b	0.4 b
T2:T1 +PRD	12.8 ns	3.8 ns	3.4 ns	646.4 ns	727.9 ns	13.9 a	0.6 a

Anova, Tukey test, alpha≤0.05

Results

Merlot

Treatments and dates	Chlorophyll fluorescence	Relative Water Content (%)	Stomatal Conductance (mmol m^{-2} s^{-1})	Stem Water Potential (MPa)
11-ene				
T0: Control	0.76 ns	75.81 ns	470.50 ns	-1.14 ns
T1: 50% Control	0.75 ns	74.88 ns	431.80 ns	-1.22 ns
T2: T1 + PRD	0.77 ns	77.92 ns	496.11 ns	-1.04 ns
T3: T1 + buried irrigation	0.75 ns	73.09 ns	441.13 ns	-1.07 ns
22-feb				
T0: Control	0.75 ab	82.53 ns	277.92 a	-1.11 a
T1: 50% Control	0.69 b	83.93 ns	115.68 b	-1.58 b
T2: T1 + PRD	0.72 ab	70.90 ns	196.93 ab	-1.51 b
T3: T1 + buried irrigation	0.76 a	79.63 ns	237.06 a	-1.32 ab

Anova, Tukey test, alpha≤0.05

Results

Merlot

	° Brix	pH	Total acidity (g/l)	Berry average weight (g)	Average yield per plant (Kg)	Blue waterfootprint (L/Kg)
T0: Control	26.23 ns	3.7 ns	3.51 ns	1 ab	1.71 ab	238.60 c
T1: 50% Control	26.83 ns	3.55 ns	3.72 ns	0.84 b	1.32 b	154.55 cb
T2: T1+ PRD	26.27 ns	3.53 ns	2.89 ns	1.19 a	2.41 a	84.65 a
T3: T1+ buried irrigation	26.67 ns	3.45 ns	2.96 ns	0.97 ab	1.97 ab	103.55 ab

	Alcohol degree (°GL)	pH	Total Acidity (g/l)	Antocianas totales mg/L	Total tannins (mg/L)	Color intensity	Wine nuance
T0: Control	15.83 ns	3.8 ns	3.18 ns	548.41 ns	830.60 b	12.54 b	0.60 ns
T1: 50% Control	17.20 ns	3.6 ns	3.76 ns	412.61 ns	1,339.89 a	12.85 ab	0.59 ns
T2:T1 +PRD	16.17 ns	3.8 ns	3.41 ns	549.56 ns	1,128.96 ab	12.08 b	0.56 ns
T3: T1+ buried irrigation	16.23 ns	3.5 ns	3.83 ns	588.78 ns	1,165.03 ab	16.96 a	0.51 ns

Anova, Tukey test, alpha$\leq$0.05

Results

Cabernet Sauvignon

Treatments and dates	Chlorophyll fluorescence	Relative Water Content (%)	Stomatal Conductance (mmol m^{-2} s^{-1})	Stem Water Potential (MPa)
23-feb				
T0: Control	0.82 b	79.13 ns	341.7 c	-0.58 a
T1: 75% Control	0.80 a	75.33 ns	244.13 a	-1.0 b
T2: T1+ Nano- irrigation	0.82 b	83.10 ns	282.95 ab	-0.67 a
T3: T1+ mulch	0.82 b	81.55 ns	305.78 bc	-0.61 a
05-abr				
T0: Control	0.82 a	62.8 ns	573.75 a	-0.62 a
T1: 50% Control	0.77 b	66.43 ns	305.25 b	-1.1 b
T2: T1+ Nano- irrigation	0.80 ab	72.9 ns	393.75 b	-7,90 a
T3: T1+ mulch	0.80 ab	68.4 ns	430.25b	-6,75 a
27-abr				
T0: Control	0.78 a	50.00 ns	518.25 ab	-0.56 a
T1: 50% Control	0.71 b	57.53 ns	376.50 b	-0.75 b
T2: T1+ Nano- irrigation	0.75 a	57.03 ns	469.75 ab	-0.57 a
T3: T1+ mulch	0.76 a	57.38 ns	523.25 a	-0.56 a

Non differences from November 2017 to April 2018

Anova, Tukey test, alpha≤0.05

Results

Cabernet Sauvignon

	° Brix		pH		Total acidity (g/l)		Berry average weight (g)		Average yield per plant (Kg)		Blue waterfootprint (L/Kg)	
T0: Control	22.60	ns	3.5	ns	6.49	ns	1.26	ns	15.27	ns	89.06	ns
T1: 75% Control	22.47	ns	3.8	ns	6.59	ns	1.28	ns	13.29	ns	71.63	ns
T2: T1+ mulch	22.37	ns	3.7	ns	5.81	ns	1.23	ns	13.98	ns	68.10	ns
T3: T1+ Nano- irrigation	21.50	ns	3.8	ns	5.83	ns	1.3	ns	15.61	ns	60.99	ns

	WUE (Kg/m3)		Arginines (mg/g)		Pruning weight (Kg)		B (mg/Kg)	
T0: Control	11.2	c	4.7	b	2.16	a	38	a
T1: 50% Control	13.96	b	7.9	a	1.42	b	28	c
T2: T1+ Nano- irrigation	14.68	ab	8.7	a	1.78	ab	35	ab
T3: T1+ mulch	16.39	a	3.7	b	1.73	ab	30.33	bc

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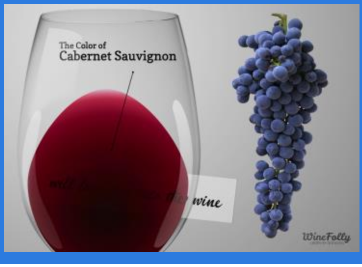
Anova, Tukey test, alpha≤0.05

Results

Cabernet Sauvignon



	Alcohol degree (°GL)	pH	Total Acidity (g/l)	Antocianas totales mg/L	Total tannins (mg/L)	Color intensity	Wine nuance
T0: Control	12.4 ns	3.93 ns	3.50 ns	491.32 ns	751.91 ns	8.72 ns	0.68 ns
T1: 50% Control	12.1 ns	4.04 ns	3.26 ns	534.57 ns	678.69 ns	8.54 ns	0.67 ns
T2: T1+ Nano- irrigation	12.0 ns	4.02 ns	3.17 ns	464.51 ns	518.03 ns	6.23 ns	0.69 ns
T3: T1+ mulch	12.5 ns	3.94 ns	3.42 ns	481.23 ns	702.73 ns	7.45 ns	0.67 ns

Anova, Tukey test, alpha≤0.05

Conclusions

- Sustained restricted irrigation in wine vines cv. Carménère, Merlot and Cabernet Sauvignon, can significantly affect plants water status.

- Moderate restricted irrigation combined with water stress mitigation strategies, such as mulching and nano-irrigation can importantly reduce water consumption without affecting plant water status, yield and wine quality.

- Restricted irrigation (50%) combined with water stress mitigation strategies, such as PRD, nano-irrigation and buried irrigation can importantly reduce water consumption, without affecting yield but causing an improvement of wine quality in cultivars Carménère and Merlot.

- Restricted irrigation regimes significantly improved Blue Water footprint.

- More evaluations have to be done in order to establish if restricted irrigation combined with mitigation strategies affect other parameters such as reserves and thus vine longevity.

Acknowledgements

- Founding: Fondo para la Innovación y la Competitividad (FIC), Gobierno Regional de O´Higgins, project “Transfer + R + D + innovation for sustainable and innocuous vineyards“
- Residents
- Winery staff: Polkura, Superfuit, Laura Hartwig

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More information?