Impact of overhead protection and irrigation level on table grape quality/ *Impak van oorhoofse beskerming en besproeiingspeil op tafeldruifgehalte*

E. Avenant[1,2] and J.H. Avenant[3,4]

[1]Stellenbosch University, SAGWRI; [2] South African Table Grape Industry (SATI)
[3]ARC Infruitec-Nietvoorbij, Division Viticulture (retired in October 2022); [4]Independant Researcher

- presented at the 10th International Table Grape Symposium, 28-11-2023, Somerset West, South Africa

Presenting results of two projects:

- **Impact of overhead netting on water use** of *Vitis vinifera* L. 'Sultanina H5' in a semi-arid summer rainfall region (2018/19 & 2019/20)

- **Impact of overhead protection and irrigation level on table grape quality** of *Vitis vinifera* L. 'Sultanina H5' in a semi-arid summer rainfall region of South Africa (2020/21 – 2022/23)

The impact of overhead netting on water use and the blue water footprint of *Vitis vinifera* L. 'Sultanina H5' in a semi-arid summer rainfall region

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Introduction
Main reasons for using overhead nets

- **Protection against:**
  - ➢ Hail damage
  - ➢ Wind damage
  - ➢ Bird damage

- **Microclimate modification**

- *Increased use of nets in all five SA table grape regions*

2018	2 000 ha
2022	**5 700 ha** (29% of total 19 800 ha) (SATI, 2023)

The impact of overhead netting on water use and the blue water footprint of *Vitis vinifera* L. 'Sultanina H5' in a semi-arid summer rainfall region

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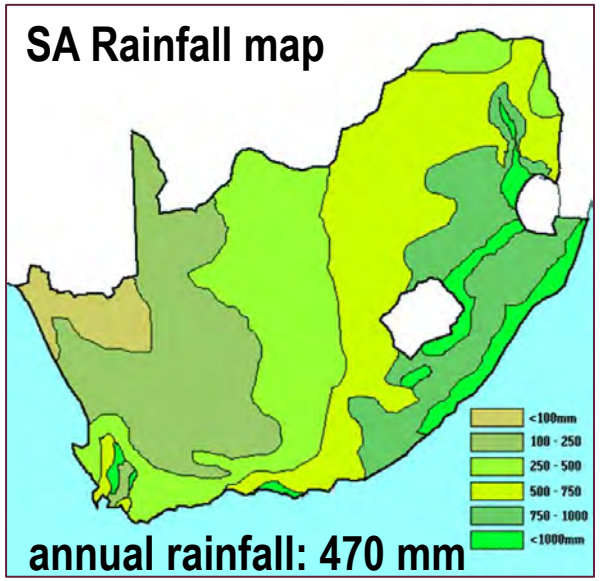
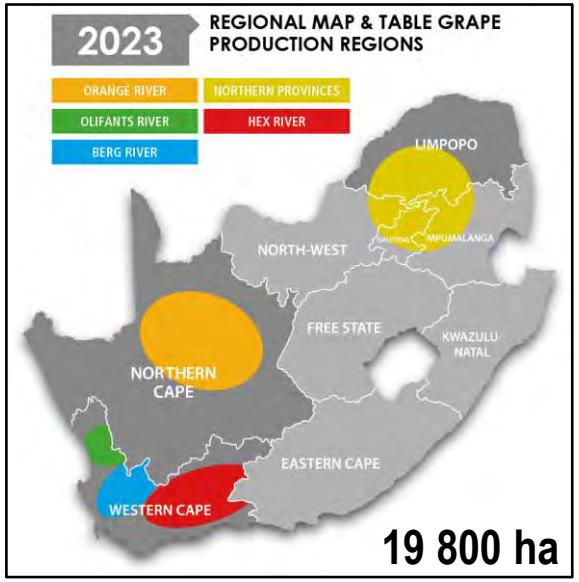
Introduction and Project Aim

- SA annual rainfall too low for table grape production without supplementary irrigation
- All commercial table grape production in SA under irrigation





Annual table grape irrigation requirement in SA

Region	Irrigation requirement	Reference
Berg River	256 mm (low frequency drip) 492 mm (daily pulse drip) 740 mm (micro sprinkler)	Myburgh & Howell (2012) Myburgh & Howell (2012) Avenant et al. (2017)
Hex River	411 mm (drip) 569 mm (micro sprinkler) 663 mm (micro sprinkler) 741 mm (micro sprinkler) 879 mm (micro sprinkler) 460 mm (drip) – 1 060 (micro sprinkler)	Saayman & Lambrechts (1995) Saayman & Lambrechts (1995) Myburgh (1996) Fourie (1989) Myburgh & Howell (2007) Avenant et al. (2017)
Northern Provinces	520 mm (drip) – 900 mm (micro sprinkler)	Avenant et al. (2017)
Olifants River	1 110 mm ("double" drip) 1 320 mm (micro sprinkler)	Avenant et al. (2017)
Orange River	655 – 1 348 mm (micro sprinkler) 1 200 – 1 840 mm (micro sprinkler)	Myburgh (2003) Avenant et al. (2017)

Irrigation water use varies between regions (climate), irrigation practices, canopy characteristics, vineyard vigour.

- Increase in cultivation of table grapes under netting in SA
- Limited research results available regarding vineyard water use under netting
- **Project aim: to determine the effect of overhead netting on water use of table grapes (semi-arid summer rainfall region)**

Material and Methods:
Experimental site

Open Netted

- Newgro farm, Kanoneiland, Lower Orange River region
- *Vitis vinifera* L. cv. Sultanina/Ramsey (10 ha), planted 2015
  - Augrabies soil form
  - 3.0 m x 2.5 m spacing
  - Pergola trellis system
  - Micro sprinkler irrigation
  - Rainfall at site during trial: 19 mm (2018/19); 80 mm (2019/20)
- 2 sub-plots of 5 ha each (Open and Netted)
  - Netted: covered overhead and on sides (**WHITE NET; 20% shade)**
  - in central row of each sub-plot:
    - AWS, 3 vines instrumented for sap flow measurements, SWC probes
  - in central 5 rows of each sub-plot:
    - 10 panels (2 data vines each)
      randomly selected for plant-based measurements
- macroclimate data obtained from Newgro AWS, 100 m from site

Material and Methods:
Water use measurements/ calculations

- **Water use:**
  - **Irrigation volume** (water meters in irrigation system)
    - standard irrigation practices applied by farm, aimed at optimal supply of water during each phenological stage
    - Irrigation volumes based on 100% of estimated evapotranspiration
  - **Transpiration (T)**: sap flow measurements (Heat Pulse Velocity method - Burgess et al., 2001)
  - **Estimated Evapotranspiration (ET):** AWS data , crop coefficients)

Sapflow monitoring (3 vines/sub-plot, probe depths 10, 15, 20, 25 mm)

Material and Methods:
Measurements: Midday Stem Water Potential (Ψs)

Ψs measurements with pressure chamber

- 5 mature, fully expanded sun-exposed leaves per data vine

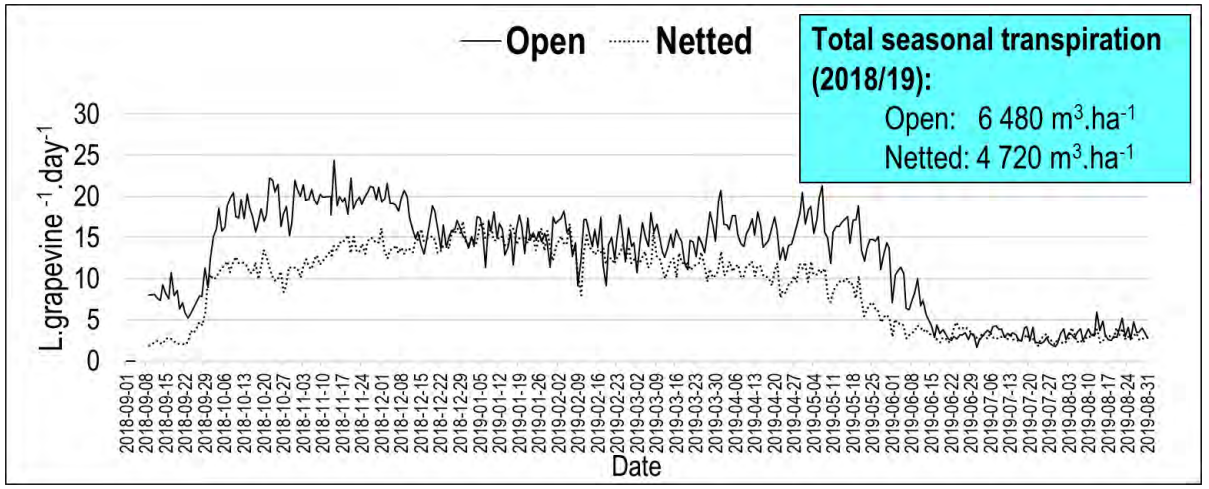
- **Compare:**

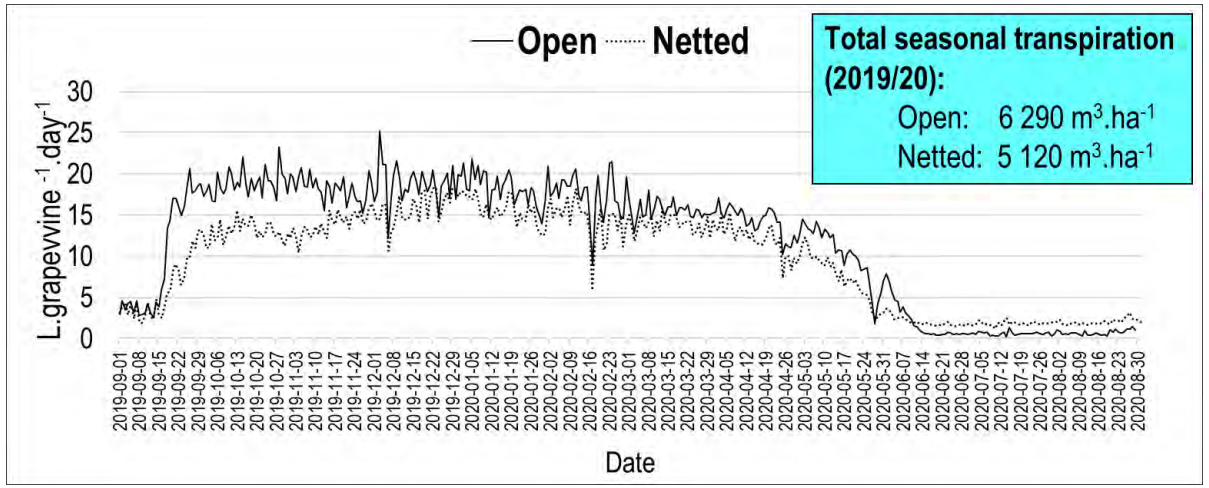
  sun-exposed leaves of data vines in OPEN (exposed to full sun)

  sun-exposed leaves under NET (exposed to sun, but under the 20% shade net)

- **Leaves enclosed in aluminum bags for at least 30 minutes before measurement**

Results: Water use
Sap flow/ Transpiration





Season	T (mm.month^{-1})												TOTAL	% dif-
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	(mm)	ference
Open 2018/19	34	86	87	76	72	64	70	70	67	22	0	0	648	
Netted 2018/19	12	57	61	67	68	56	56	45	35	15	0	0	472	-27%
Open 2019/20	46	87	80	87	80	70	69	60	44	6	0	0	629	
Netted 2019/20	29	60	62	72	71	62	62	51	31	9	0	9	518	-18%
Open ave	40	87	84	82	76	67	70	65	56	14	0	0	639	
Netted ave	21	59	62	70	70	59	59	48	33	12	0	5	495	-23%

Except for OPEN at harvest 2019/20

Midday Ψ_S indicated low to moderate water stress

18/19: Open -0.590 to -0.869 MPa; Netted -0.519 to -0.821 MPa

19/20: Open –1.062 to –1.200 MPa; Netted -0.918 to -1.056 Mpa

Results: Water use
Midday stem water potential

Treatment	2018/19					2019/20				
	Date	OPEN		NETTED		Date	OPEN		NETTED	
Phenological stage		ψ_s (MPa)	StDev	ψ_s (MPa)	StDev		ψ_s (MPa)	StDev	ψ_s (MPa)	StDev
1 month before harvest	2018-12-11	0.869	0.338	0.821	0.273	2019-12-12	1.062	0.134	0.918	0.107
Harvest (1st week of harvest)	2019-01-09	0.590	0.112	0.519	0.142	2020-01-15	1.200	0.159	1.035	0.123
1 month after end of harvest	2019-03-28	0.766	0.114	0.794	0.070	2020-03-05	1.079	0.154	1.056	0.090

StDev = standard deviation

Except for OPEN at harvest 2019/20

Midday Ψ_S indicated low to moderate water stress

18/19: Open -0.590 to -0.869 MPa; Netted -0.519 to -0.821 MPa

19/20: Open –1.062 to –1.200 MPa; Netted -0.918 to -1.056 MPa

Water constraint classification according to midday Ψ_s for table grape production (Myburgh & Howell (2022):

none (Ψ_s > -0.6 MPa), weak (-0.6 ≥ Ψ_s > -0.8 MPa), moderate (-0.8 ≥ Ψ_s > -1.0 MPa), strong (-1.0 ≥ Ψ_s > -1.2 MPa) and severe (Ψ_s ≤ -1.2 MPa).

Results: Water use
Irrigation applied

Results: Water use
Water used vs. water applied

Season	ET total (mm.year^{-1})	ET daily (mm.day^{-1})		T total (mm.year^{-1})			Irrigation total (mm.year^{-1})		
	OPEN	OPEN		OPEN	NET	% difference	OPEN	NET	% difference
		min	max						
2018/19	1606	1.1	7.7	648	472	-27%	1640	1445	-12%
2019/20	1567	1.1	7.6	629	512	-18%	1727	1659	-4%
Gem	1587	4.3		639	492	-23%	1684	1552	-8%

↓ Irrigation under NET

↓ Transpiration under NET

Irrigation applied ≥ ET

- OPEN – both seasons
- NET – 2019/20

Results: Fertility

Treatment	Bud break %			Fertility (Bunches per sprouted bud)			Fertility (Bunches per vine)		
	2019/20	2020/21	Mean	2019/20	2020/21	Mean	2019/20	2020/21	Mean
Open	93.2 a	70.0 a	81.6 a	0.76 a	0.59 a	0.67 a	112.6 a	57.5 a	85.0 a
Netted	94.6 a	74.6 a	84.6 a	0.71 a	0.46 a	0.59 a	59.8 b	42.3 b	51.0 b
Mean	93.9 y	72.3 x	83.1	0.74 y	0.52 x	0.63	86.2 y	49.9 x	68.0

↓ **Fertility under NET**

Results: Berry mass, TSS, TA, pH

Treatment	Berry mass (g)			Berry length (mm)			Berry diameter (mm)		
	2018/19	2019/20	Mean	2018/19	2019/20	Mean	2018/19	2019/20	Mean
Open	4.18	5.3	4.7 b	23.2 c	25.0 b	24.1	16.9	18.5	17.7 b
Netted	4.93	6.3	5.6 a	24.9 b	28.0 a	26.5	17.6	19.4	18.5 a
Mean	4.56 b	5.8 a	5.2	24.1	26.5	25.3	17.3 b	18.9 a	18.1

Trend:
↑ berry size under NET

Treatment	TSS (°B)			TA (g/L)			TSS:TA			pH		
	2018/19	2019/20	Mean	2018/19	2019/20	Mean	2018/19	2019/20	Mean	2018/19	2019/20	Mean
Open	15.2 a	16.2 a	15.7	11.5 a	9.4 b	10.4	13.3 b	17.3 a	15.3	3.32 b	3.42 a	3.37
Netted	14.0 b	14.2 b	14.1	12.1 a	11.5 a	10.4	11.8 b	12.5 b	12.1	3.24 c	3.18 c	3.21
Mean	14.6	15.2	14.9	11.8	10.4	11.1	12.6	12.6	13.7	3.28	3.30	3.29

Delayed ripening under NET

Conclusion and recommendations

- **Seasonal total T values** → vines under NET used 19 - 27% less water
- **Midday Ψ_S for OPEN and NET** → low to moderate levels of water stress (adequate water supply)
- **Seasonal volume of water used for transpiration**
  - indication of the minimum water requirement for table grape vines under micro irrigation under conditions of the study
  - 4 720 m^3 (NET) to 6 480 m^3 (OPEN)
- **Estimated ET of the OPEN subplot (1 567 to 1 606 mm)**
  - considered as a maximum threshold value for water allocation per hectare for uncovered table grape vines under micro irrigation in this region, irrigated at 100% of estimated ET
- **Peak daily estimated ET of 7.7 $mm.day^{-1}$**
  - could be used in irrigation system design for this region
  - to ensure that the delivery capacity of the system meets the peak demand

Conclusion and recommendations

- Irrigation water applied equaled or exceeded the estimated ET (indicating over-irrigation)

- Further research conducted: Establish to what extent irrigation applied can be decreased, without negatively impacting production and quality.

Acknowledgements

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  - SATI
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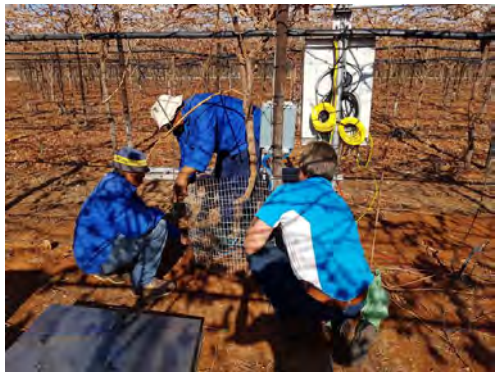
  - SU and UP Viticulture Table grape students
- **Other research team members**
  - Dr Nicolette Taylor (UP)
  - Dr Carlos Poblete (SU)
  - Post-graduate students (SU DVO & SAGWRI, UP)



The impact of overhead protection and irrigation level on table grape quality of *Vitis vinifera* L. 'Sultanina H5' in a semi-arid summer rainfall region of South Africa - at harvest and after post-harvest cold storage

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Aim

To establish the impact of

- overhead protection with nets and plastic covering,
- combined with three irrigation levels
  - on table grape quality at harvest and post-harvest



Material and methods

Experimental Vineyards	
Location	Newgro, Kanoneiland, Orange River region
Cultivar/Rootstock	Sultanina H5/Ramsey
Trellis system	Pergola
Spacing	3.0 m x 2.5 m
Viticultural treatments	
• **Thinning**	GA_3
• **Sizing**	GA_3 and Girdling

- Vineyard managed by the farm
  - Viticultural practices
  - Irrigation application
  - Plastic management

Three trials – each trial consisted of 13 rows in the center of a 5 ha block		
Without nets	With nets	With Nets plus plastic
Plastic installation		
Just before harvest (if rain is expected)	Veraison	Between bud break and before flowering
Removal of plastic – just after harvest		

Experimental Lay-out	
Design	Randomized block
Treatments	3
Replications	7

Material and methods

Irrigation treatments in each trial site

Treatments	Code	Microjet delivery rate (L/h)
Control	T100	50
20% ↓	T100-20	40
40% ↓	T100-40	30

50 L/h

40 L/h

30 L/h

Example of two irrigation plots (one replicate)

Row Number	Vine number															
13	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
12	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
11	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
9	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
8	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
7	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Centre row
6	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

middle 2 vines = data vines
2 buffer vines right around data vines

Material and Methods-
Vegetative and reproductive measurements:

- **Vegetative :**
  - Cane mass
- **Reproductive :**
  - Fertility assessment
  - Bunch mass
  - Berry mass
  - Total soluble solids (TSS)
  - The titratable acid (TA)
  - Berry cracking field
- Macro-climate data obtained from Newgro AWS, 100 m from trial site

Effect of storage and time of cold storage on grape quality after cold storage

Seasons (average of 3 seasons)

Cold storage: (2020/21 - 4 weeks at 0.5°C + 1 week at 7.5 °C) 7/2
(2021/22 - 4 weeks at 0.5°C + 1 week at 7.5 °C) 24/2
(2022/23 - 5 weeks at 0.5°C + 0 weeks at 7.5 °C) 14/3

Time in cold storage (2022/23) **Oesdatum:3/1/2023**

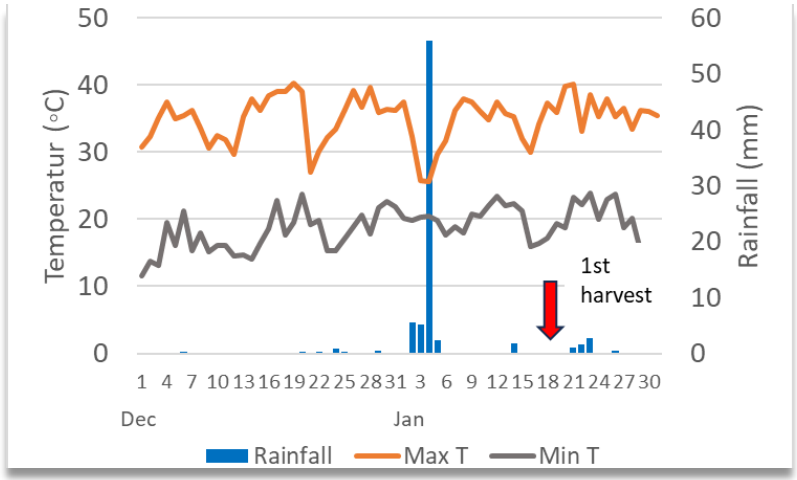
Cold storage: (5 weeks at 0.5°C + 0 weeks at 7.5 °C) 7/2
(8 weeks at 0.5°C + 0 weeks at 7.5 °C) 24/2
(11 weeks at 0.5°C + 0 weeks at 7.5 °C) 14/3

Packing material: 54x4 mm perforated LDPE liner
+ Uvasys® SO_2 generator sheet

Results

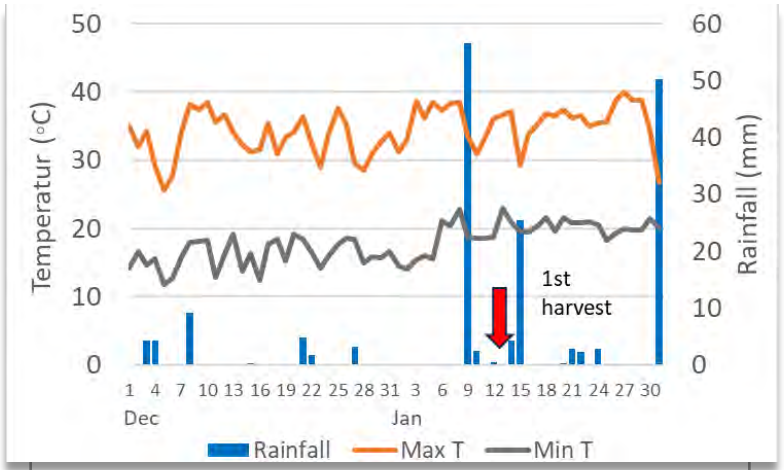
Average of 3 seasons

Climate conditions



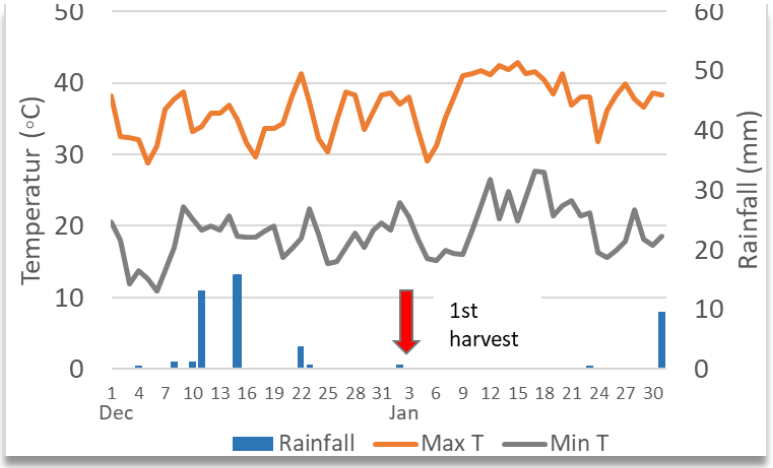
2020/21 season

Trial site Without Nets were not covered with plastic



2021/22 season

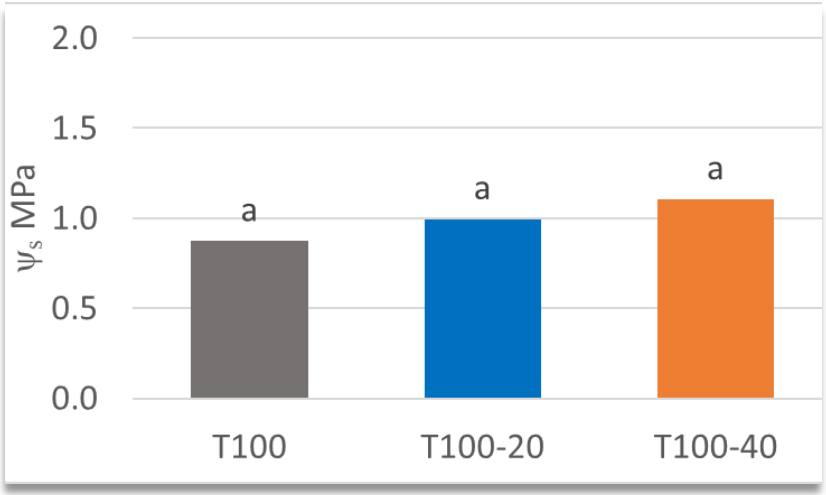
All trials were covered before harvest with plastic at different times



2022/23 season

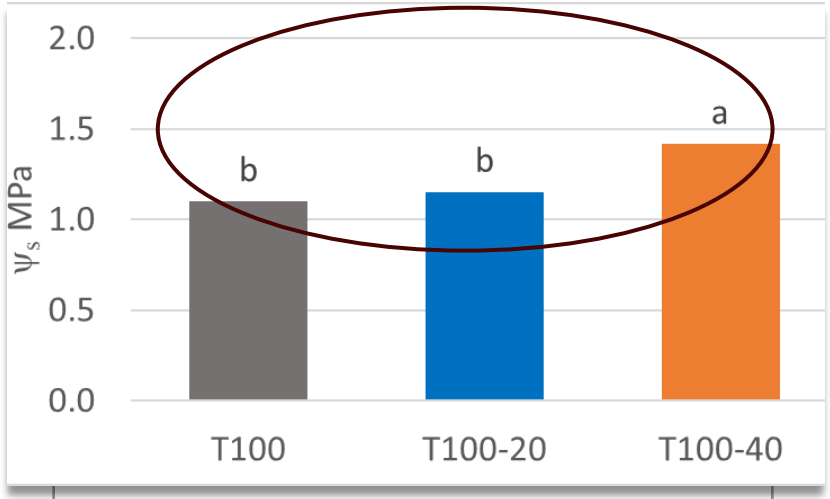
All trials were covered before harvest with plastic at different times

Midday stem water potential (- Ψ_S)



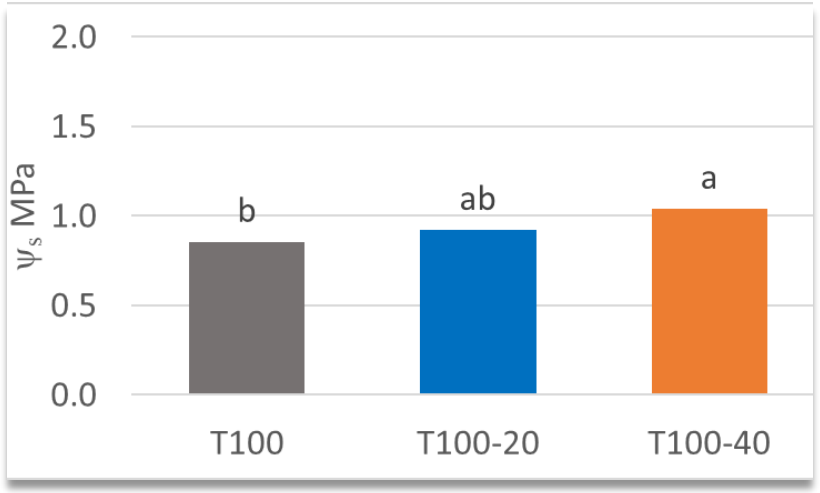
Without nets

Factors	P-value
Irrigation treatment (I)	0.162
Season (S)	0.010
I x S Interaction	0.379



With nets

Factors	P-value
Irrigation treatment (I)	0.002
Season (S)	0.073
I x S Interaction	0.660



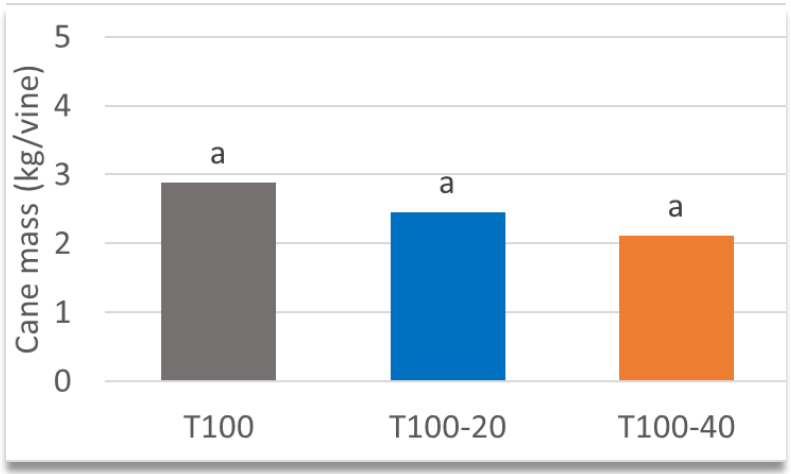
With nets plus plastic

Factors	P-value
Irrigation treatment (I)	0.058
Season (S)	0.533
I x S Interaction	0.355

Water constraint classification according to midday Ψ_s for table grape production (Myburgh & Howell (2022):

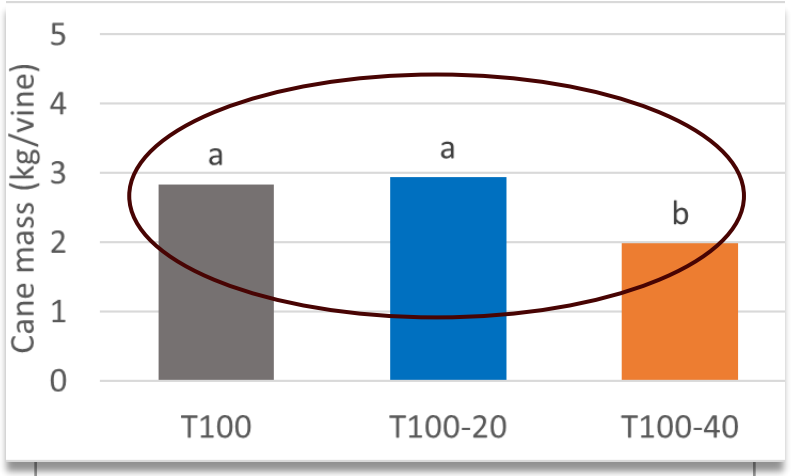
none (Ψ_s > -0.6 MPa), weak (-0.6 ≥ Ψ_s > -0.8 MPa), moderate (-0.8 ≥ Ψ_s > -1.0 MPa), strong (-1.0 ≥ Ψ_s > -1.2 MPa) and severe (Ψ_s ≤ -1.2 MPa).

Cane mass



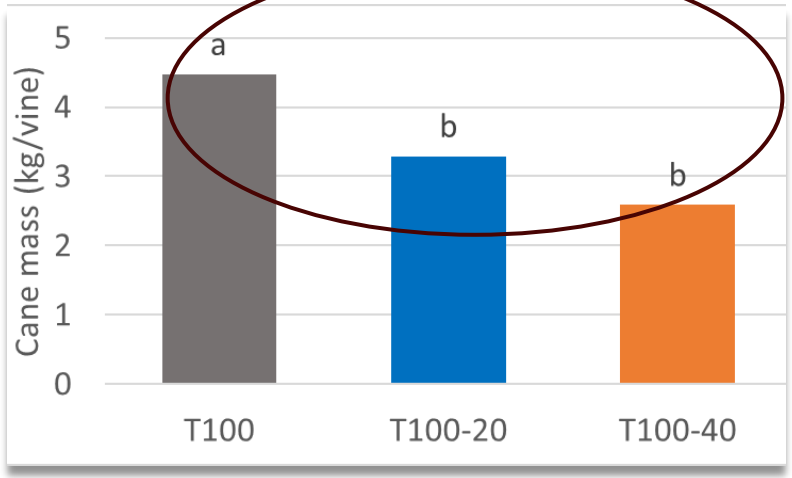
Without nets

Factors	P-value
Irrigation treatment (I)	0.215
Season (S)	0.001
I x S Interaction	0.120



With nets

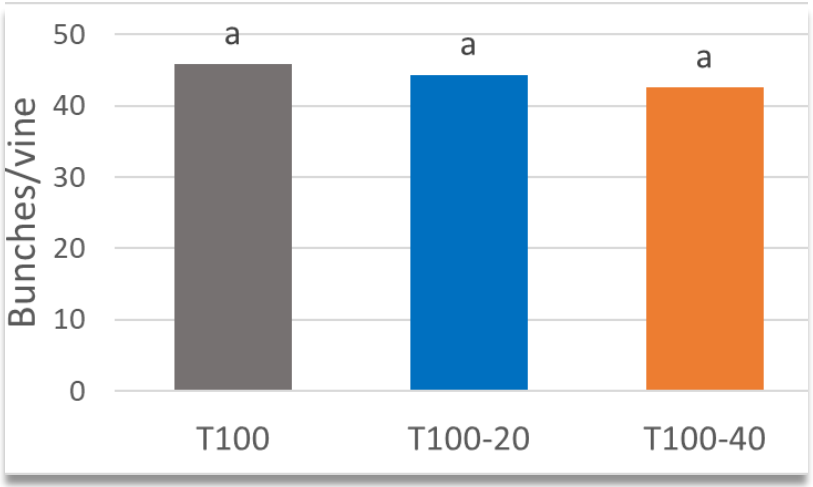
Factors	P-value
Irrigation treatment (I)	0.016
Season (S)	<0.001
I x S Interaction	0.627



With nets plus plastic

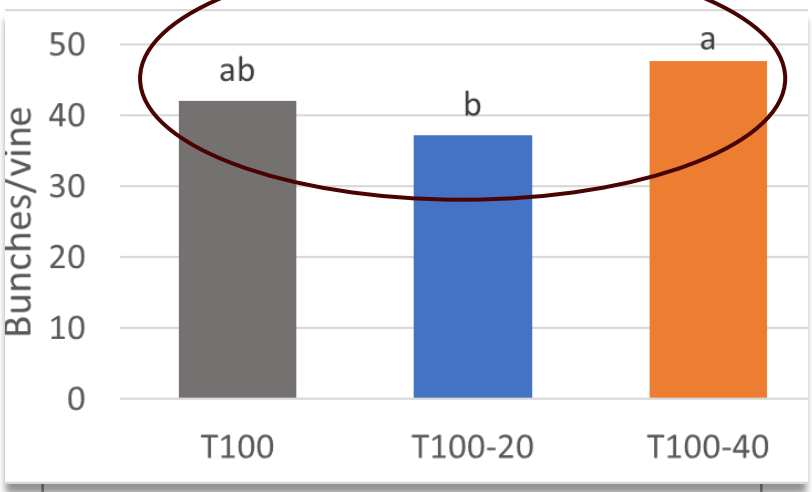
Factors	P-value
Irrigation treatment (I)	0.004
Season (S)	0.002
I x S Interaction	0.062

Fertility



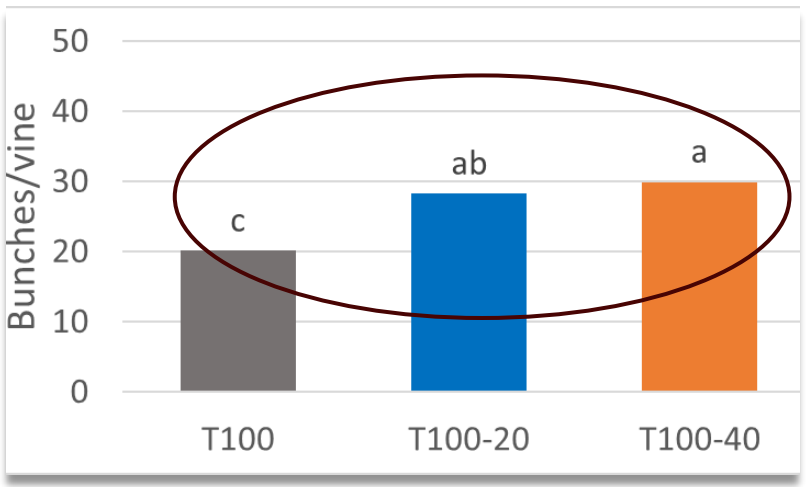
Without nets

Factors	P-value
Irrigation treatment (I)	0.619
Season (S)	<0.001
I x S Interaction	0.229



With nets

Factors	P-value
Irrigation treatment (I)	0.044
Season (S)	<0.001
I x S Interaction	0.776



With nets plus plastic

Factors	P-value
Irrigation treatment (I)	0.048
Season (S)	<0.001
I x S Interaction	0.005

Irrigation treatments ↓

Fertility

T100

T100-20

T100-40

Trials →







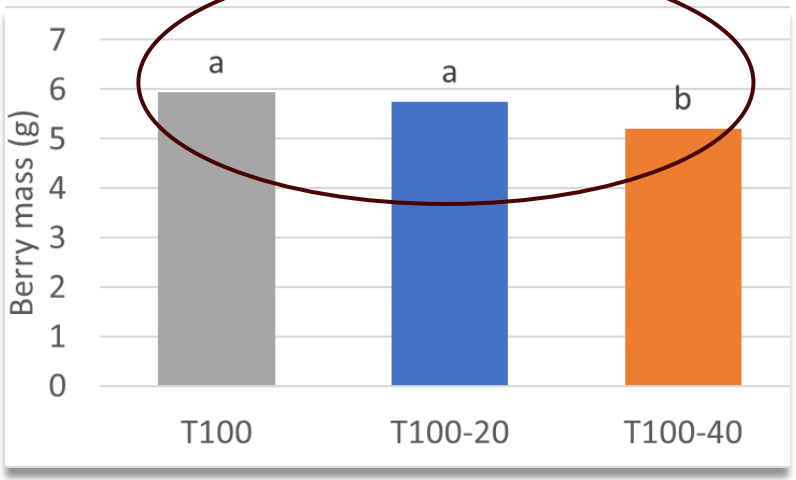


Without nets

With nets

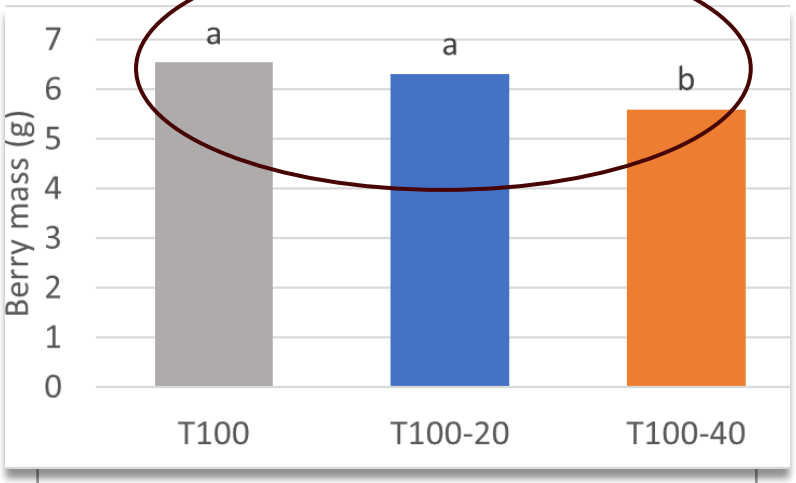
With nets plus plastic

Berry mass



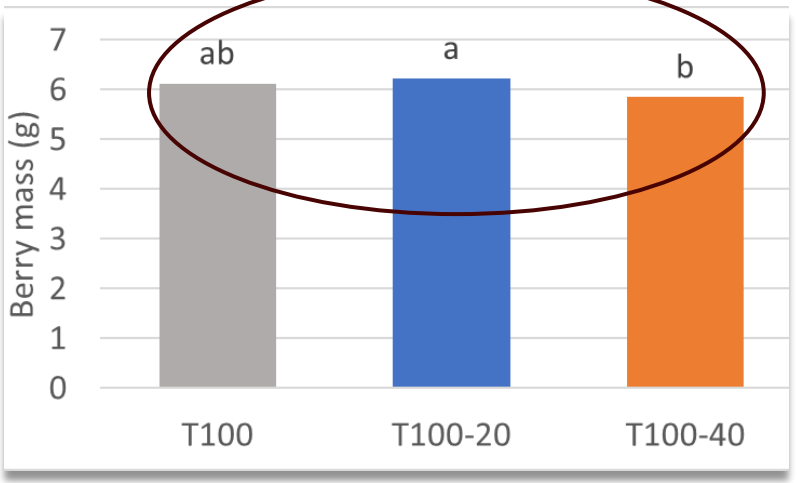
Without nets

Factors	P-value
Irrigation treatment (I)	0.001
Season (S)	<0.001
I x S Interaction	0.018



With nets

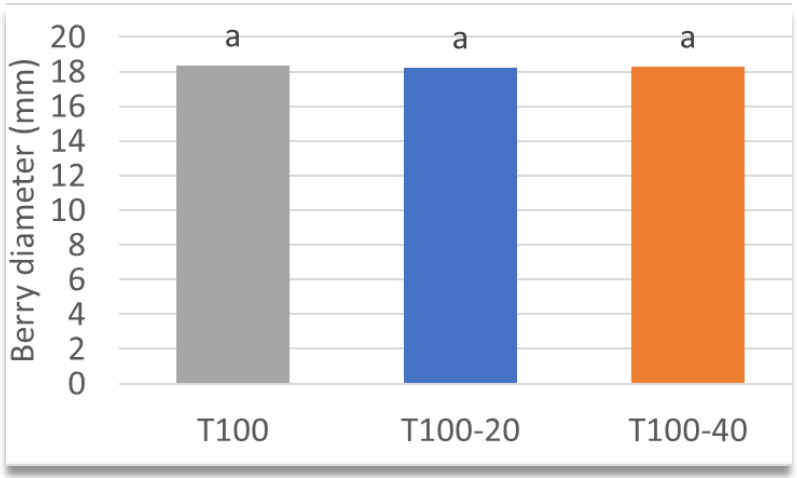
Factors	P-value
Irrigation treatment (I)	0.002
Season (S)	<0.001
I x S Interaction	0.009



With nets plus plastic

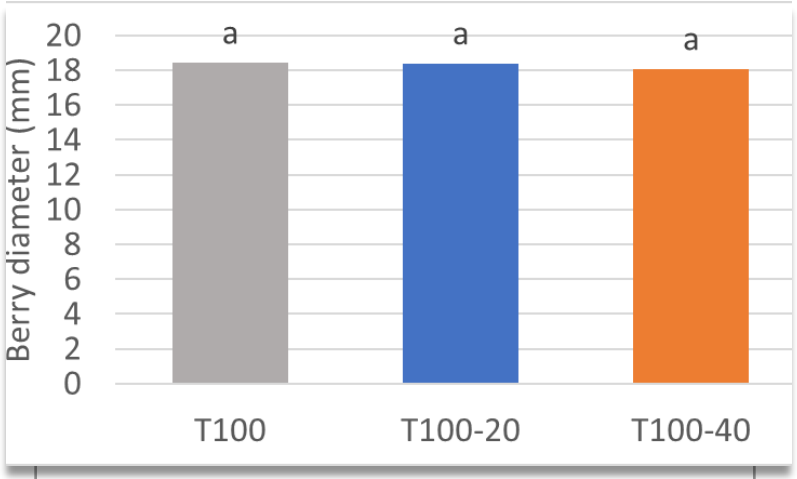
Factors	P-value
Irrigation treatment (I)	0.086
Season (S)	<0.001
I x S Interaction	0.619

Berry diameter



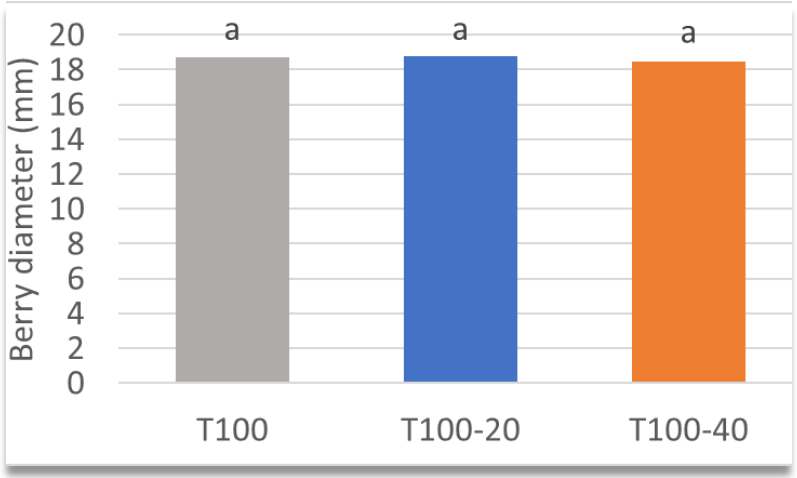
Without Nets

Factors	P-value
Irrigation treatment (I)	0.872
Season (S)	<0.001
I x S Interaction	0.018



With nets

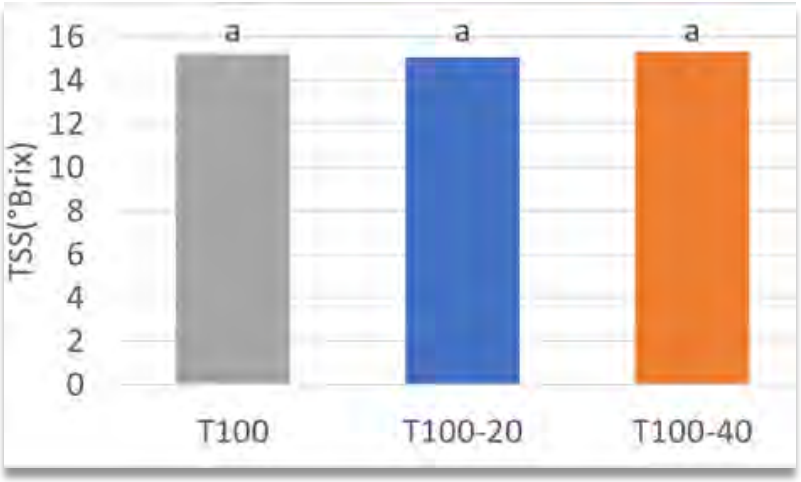
Factors	P-value
Irrigation treatment (I)	0.586
Season (S)	0.082
I x S Interaction	0.353



With nets plus Plastic

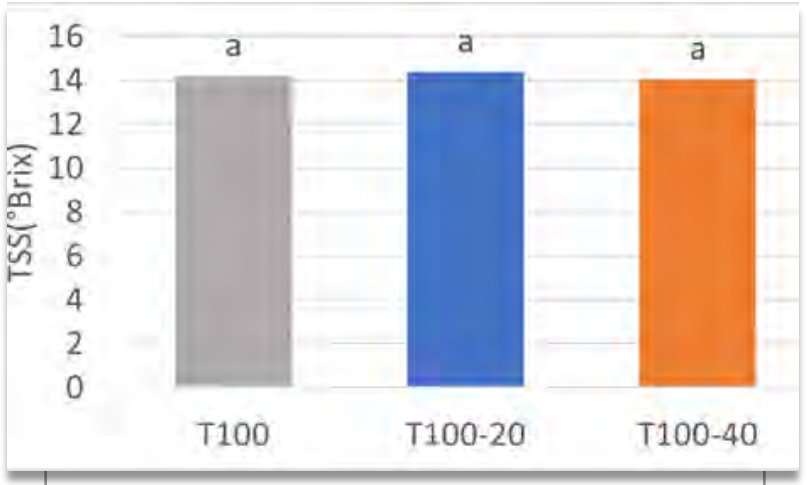
Factors	P-value
Irrigation treatment (I)	0.212
Season (S)	0.011
I x S Interaction	0.114

TSS



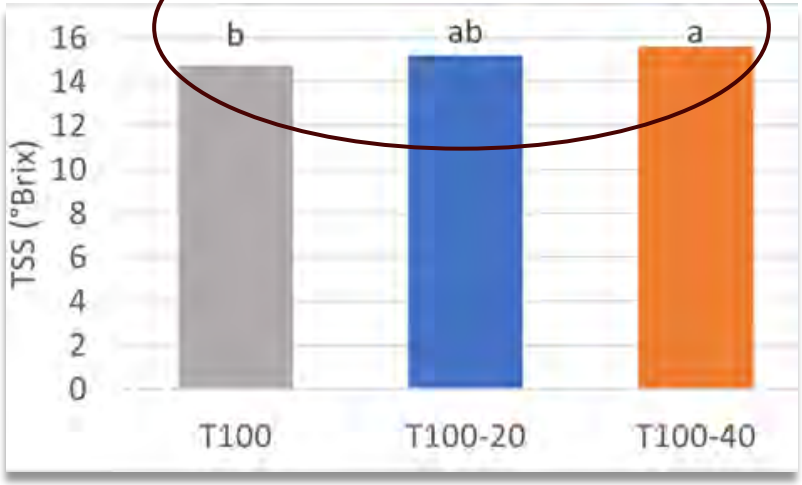
Without nets

Factors	P-value
Irrigation treatment (I)	0.810
Season (S)	0.003
I x S Interaction	0.636



With nets

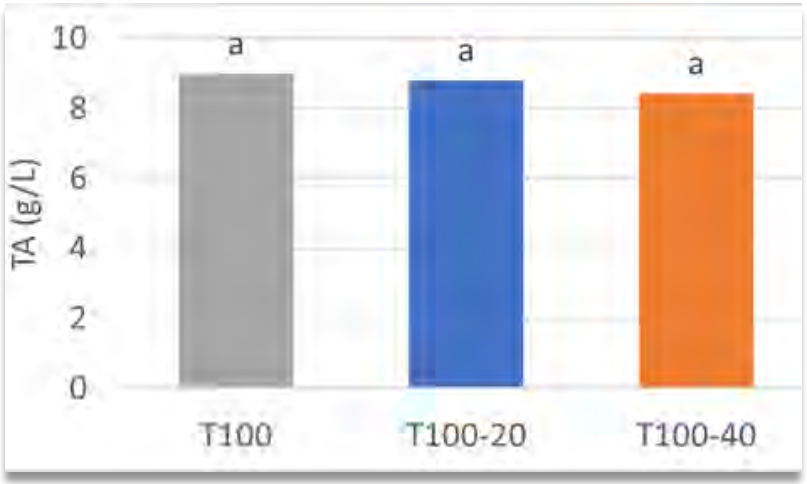
Factors	P-value
Irrigation treatment (I)	0.586
Season (S)	<0.001
I x S Interaction	0.173



With nets plus plastic

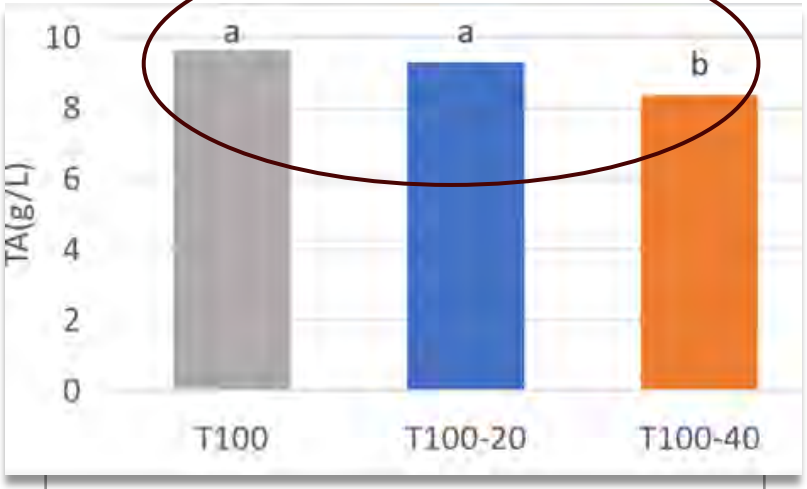
Factors	P-value
Irrigation treatment (I)	0.057
Season (S)	<0.001
I x S Interaction	0.197

TA



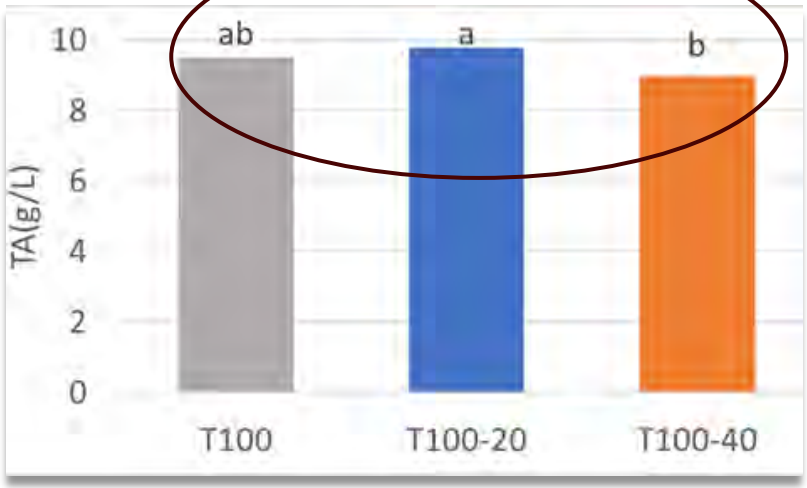
Without Nets

Factors	P-value
Irrigation treatment (I)	0.172
Season (S)	<0.001
I x S Interaction	0.738



With nets

Factors	P-value
Irrigation treatment (I)	<0.001
Season (S)	<0.001
I x S Interaction	0.860



With nets plus Plastic

Factors	P-value
Irrigation treatment (I)	0.080
Season (S)	<0.001
I x S Interaction	<0.001

Irrigation treatments ↓

T100

T100-20

T100-40

Trials →

Grape quality







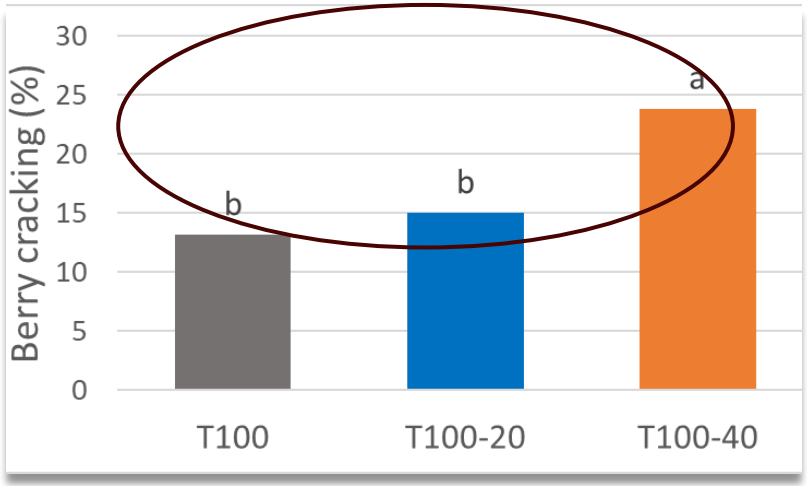


Without nets

With nets

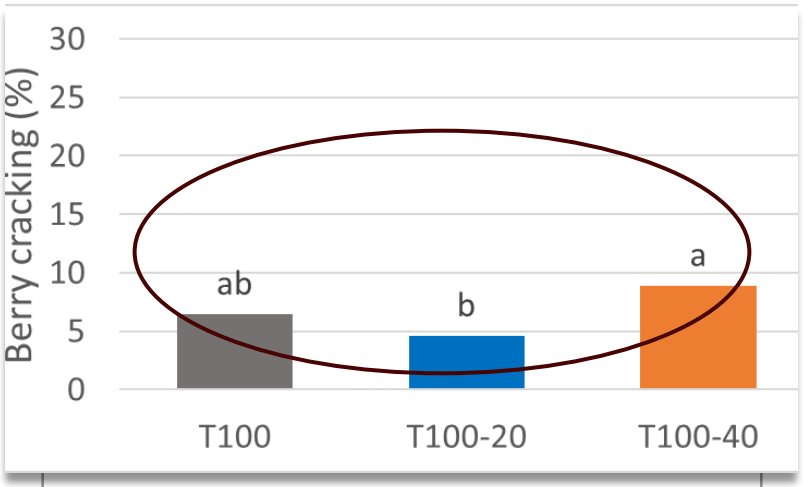
With nets plus plastic

Field berry cracking: Irrigation treatments (average of 2 seasons)



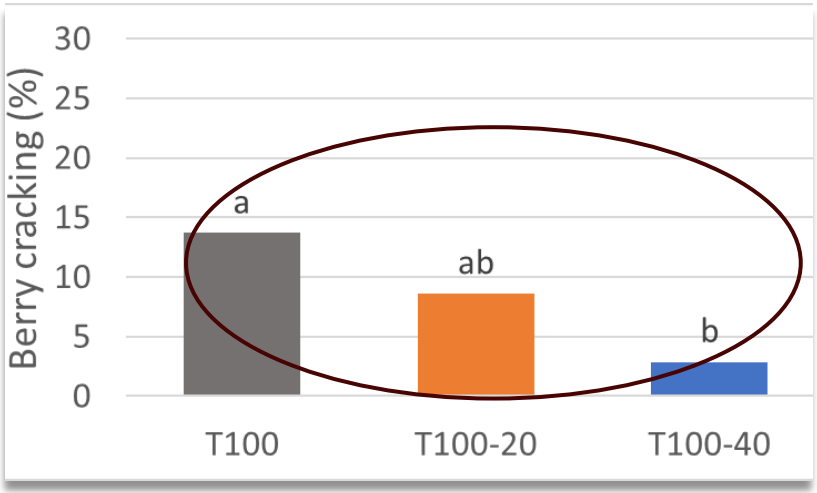
Without nets

Factors	P-value
Irrigation treatment (I)	0.001
Season (S)	<.001
I x S Interaction	0.001



With nets

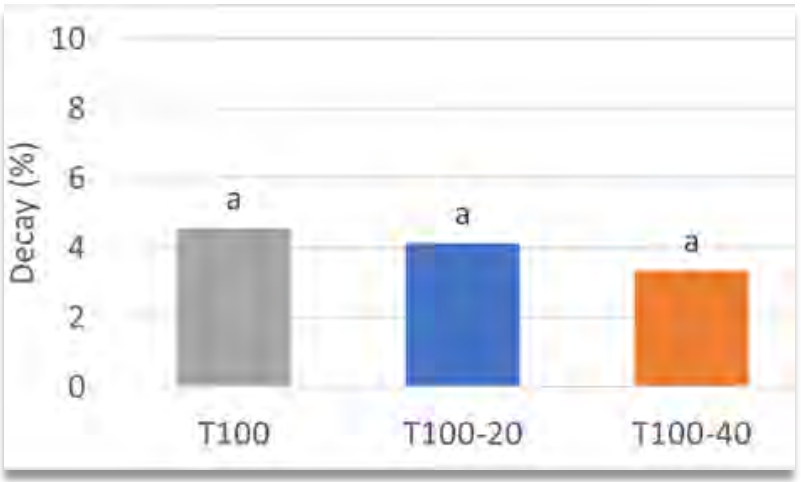
Factors	P-value
Irrigation treatment (I)	0.035
Season (S)	<0.001
I x S Interaction	0.013



With nets plus plastic

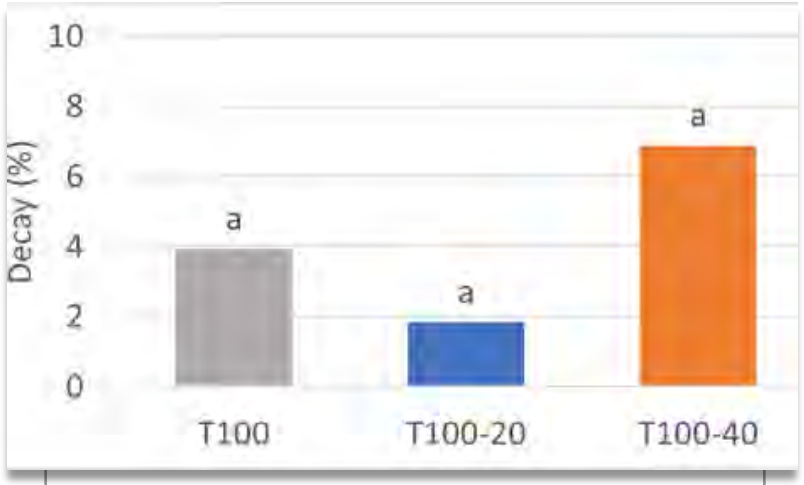
Factors	P-value
Irrigation treatment (I)	0.016
Season (S)	<0.001
I x S Interaction	<0.001

Quality after post-harvest cold storage
Decay



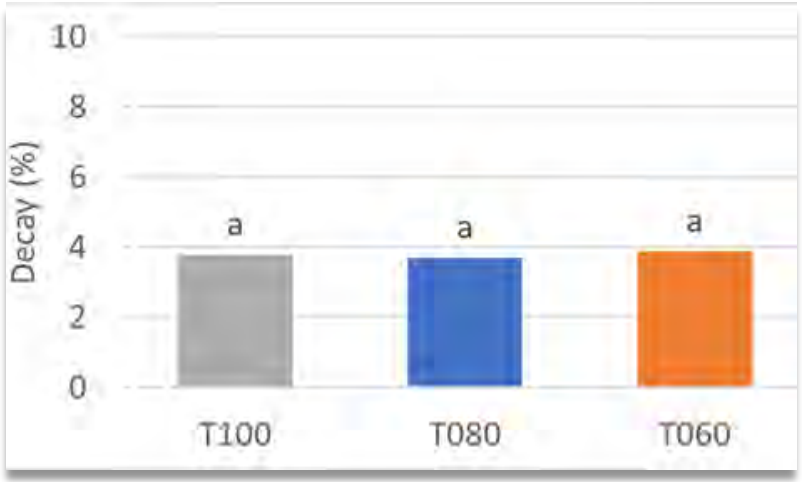
Without nets

Factors	**P-value**
Irrigation treatment (I)	0.531
Season (S)	<0.001
I x S Interaction	0.386



With nets

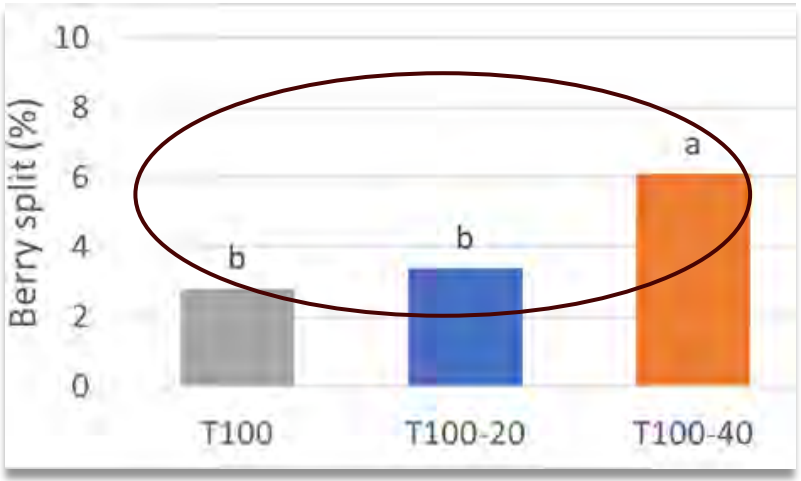
Factors	**P-value**
Irrigation treatment (I)	0.024
Season (S)	<0.001
I x S Interaction	0.235



With nets plus Plastic

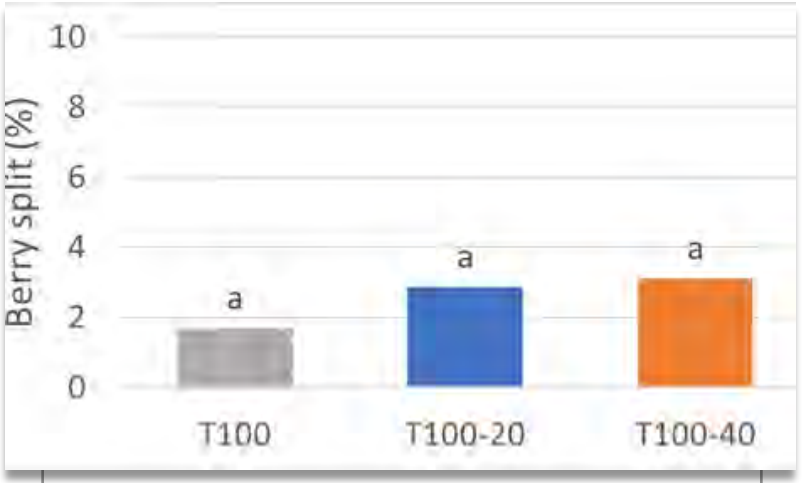
Factors	**P-value**
Irrigation treatment (I)	0.996
Season (S)	<0.001
I x S Interaction	0.765

Quality after post-harvest cold storage: **Berry cracking**



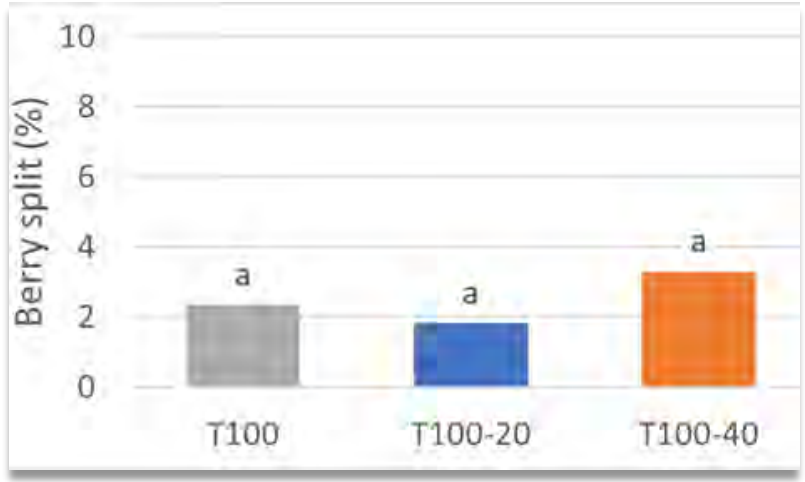
Without nets

Factors	P-value
Irrigation treatment (I)	0.024
Season (S)	<0.001
I x S Interaction	0.235



With nets

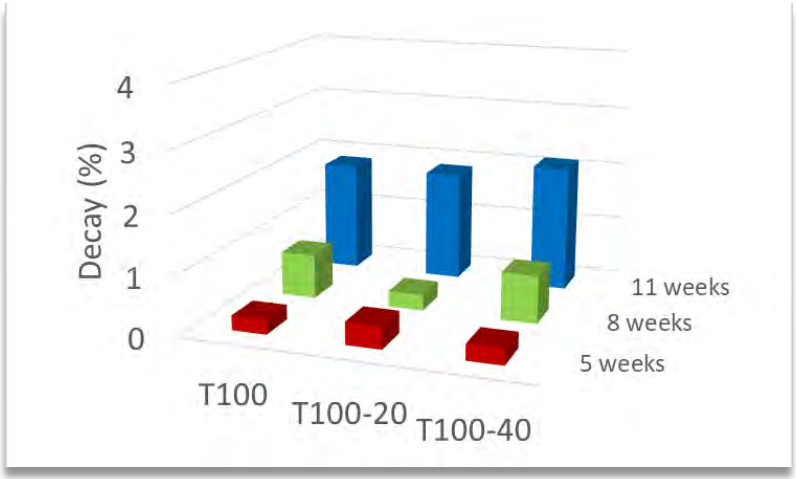
Factors	P-value
Irrigation treatment (I)	0.352
Season (S)	<0.001
I x S Interaction	0.126



With nets plus Plastic

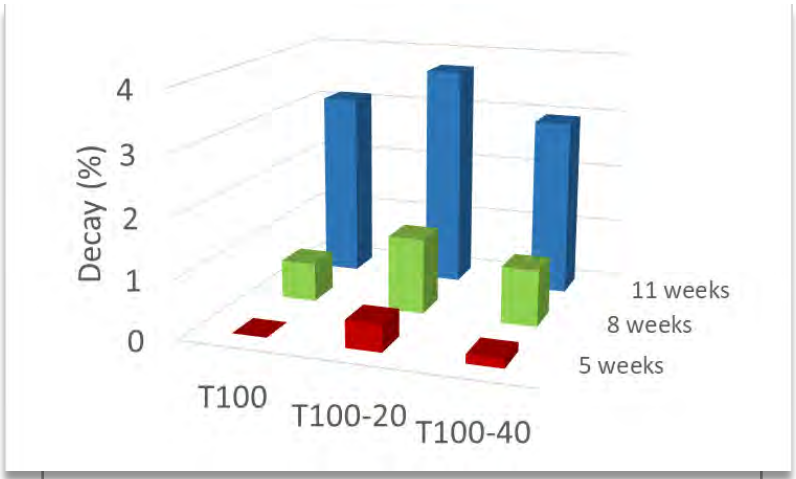
Factors	P-value
Irrigation treatment (I)	0.395
Season (S)	0.061
I x S Interaction	0.698

Quality after post-harvest cold storage: **Decay**



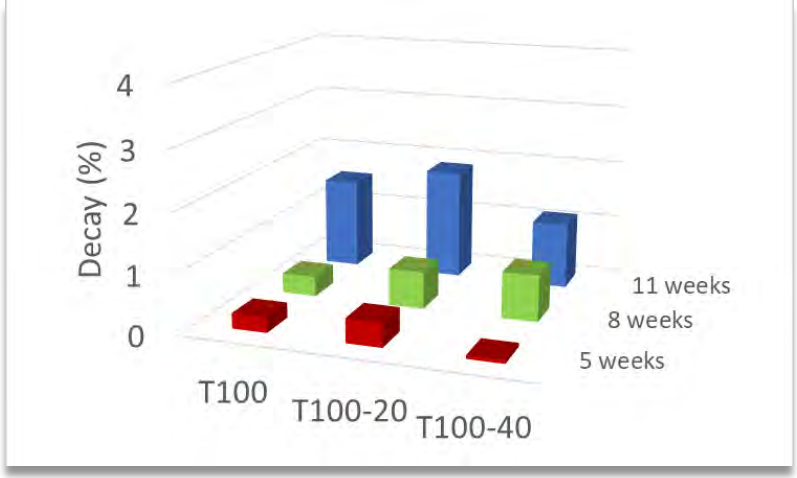
Without nets

Factors	P-value
Irrigation treatment (I)	0.821
Week (W)	<0.001
I x W Interaction	0.885



With nets

Factors	P-value
Irrigation treatment (I)	0.507
Week (W)	<0.001
I x W Interaction	0.999



With nets plus plastic

Factors	P-value
Irrigation treatment (I)	0.690
Week (W)	0.002
I x W Interaction	0.812

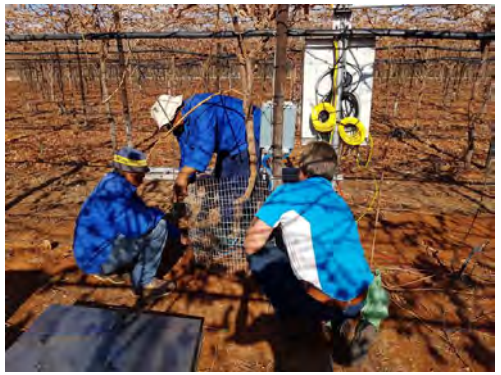
Summary and Conclusion

Irrigation Treatment	Without Nets	Nets	Nets+Plastic
Control (T100)			↓ fertility
T100-20	no negative impact on berry size & quality	no negative impact on berry size & quality	no negative impact on berry size & quality
T100-40	SWP > 1 MPa ↓ cane mass ↓ berry mass ↑ berry cracking too severe	SWP > 1 MPa ↓ cane mass ↓ berry mass ↑ berry cracking too severe	SWP > -1 Mpa ↓ cane mass ↓ berry mass ↑ TSS too severe

- **T100-20 (20% less irrigation) could be applied** without negatively impacting production, berry mass and quality (at harvest & after cold storage)
- **T100-20 should be evaluated further on a semi-commercial scale.**

Acknowledgements

- **Project funding**
  - Dept of Agriculture, Land Reform and Rural Development, Northern Cape
- **Technical support**
  - Karsten Boerdery
    - Newgro team (Cobus Kies, Brandon Plaatjies)
  - ARC Infruitec-Nietvoorbij Viticulture (Upington team)
  - SU DVO Viticulture Table grape students



Previous SA research: Nets

Microclimate

(Avenant, J.H., 1994)

- ↓ PPFD (black net 20% shade)
- Trend ↓ Air temperature
- ↑ Relative humidity
- ↓ Leaf temperature
- ↓ Leaf water potential
- ↓ Bunch max temp & ΔT

Vegetative & Reproductive parameters

(Avenant, J.H., 1994)

- ↑ Vegetative growth
- ↑ Leaf-N
- ↓ Fertility (1.7 vs 1.6 bunches/shoot)
- trend ↑ Berry size
- Delayed ripening (2-3 days)
- ↓ Berry anthocyanin (still met export requirements)

Physiological parameters & Water use

(Avenant, J.H., 1994; Avenant & Avenant, 2002, 2020)

- trend ↓ Transpiration rate
- trend ↑ Photosynthesis rate
- ↓ evaporation from soil
- ↓ water use

Previous SA research: Plastic

Plastic

Advance ripening
(10-30 days) (Avenant, 1997, 2018)

Protection (Avenant, 2018)

Delay
(21-42 days)
(Loubser, Avenant & Wolf, 1995)