

# Watergebruik en watergebruikseffektiwiteit van tafeldruiwe in Suid-Afrika

**E. Avenant<sup>1,2</sup> G.N. Kanguuehi<sup>2</sup> & J.H. Avenant<sup>3</sup>**

*<sup>1</sup>SATI, Posbus 2932, Paarl 7620, Suid-Afrika.*

*<sup>2</sup> Department Wingerd-en Wynkunde, Universiteit van Stellenbosch, Stellenbosch, Suid-Afrika.*

*<sup>3</sup>ARC Infruitec-Nietvoorbij, Afdeling Wingerdkunde, Privaatsak X5026, Stellenbosch, 7599, Suid-Afrika*



# Waterverbruik van tafeldruiwe: Inleiding

**Waterverbruik:** 2 prosesse:

*transpirasie* deur blare + *verdamping* vanaf grondopp

ET (evapotranspirasie) = transpirasie + verdamping

Blaaroppervlak per stok (totale loweropp) beïnvloed transpirasie

**Horisontale preeelstelsels vir tafeldruiwe**

byna vol oppervlak bedekking met lower

***transpirasie = groot bydra tot totale ET***



# Water use of table grapes: Introduction

*Water use varies* between: regions (climate), irrigation practices , canopy characteristics and vineyard vigour:

**Irrigation requirements of table and raisin grape vineyards on horizontal trellis systems under SA conditions (annual requirement):**

- 256 mm (with low frequency drip irrigation) to 492 mm (daily pulse drip irrigation of Dan-ben Hannah in Berg River Valley) (Myburgh & Howell, 2012),
- 411 mm for drip irrigation and 569 mm for micro irrigation of Barlinka in Hex River Valley (Saayman & Lambrechts, 1995)
- 663 mm (Myburgh, 1996) and 741 mm (Fourie, 1989) for Barlinka under micro irrigation in the Hex River Valley
- 879 mm for Sunred Seedless and Muscat Supreme under micro irrigation in Hex River Valley (Myburgh & Howell, 2007)
- 655 mm to 1348 mm for micro irrigated Sultanina in OR (Myburgh, 2003b)
- 8541 to 1343 mm for flood irrigated Sultanina in OR (Myburgh, 2003).

# Water use (Water foot print) of table grapes

- **Field trial: Hex River Valley** - Crimson Seedless  
(2013/14, 2014/15, 2015/16)
- **Water use case studies: in all 5 regions**  
(questionnaires, producer records, interviews)  
18 mature commercial Crimson Seedless blocks

# Water use: for irrigation of Crimson Seedless: summary of information obtained from producers via "Water foot print questionnaires".

Region	Subregion	Farm nr	Season	Irrigation season		Irr system	Irrigation applied												
				Start	End		AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	TOTAL
							m3	m3	m3	m3	m3	m3	m3	m3	m3	m3	m3	m3	m3
Western Cape	Hex River Valley	1	2013/14	1/10	9/5	Drip	0	0	88	198	792	770	1144	858	660	88	0	0	4598
			2014/15	22/9	8/5		0	0	484	528	1496	1694	1716	858	660	88	0	0	7524
			2015/16	21/9	27/5		0	0	484	528	1496	1694	1716	858	660	88	0	0	7524
Western Cape	Hex River Valley	2	2013/14	1/9	31/5	Micro	0	880	880	939	1467	1173	1173	939	880	235	0	0	8565
			2014/15	15/9	31/5		0	528	939	939	1467	1173	1173	1173	704	352	0	0	8448
			2015/16	7/9	13/5		0	704	939	1173	1760	1760	1760	1408	704	352	0	0	10560
Western Cape	Hex River Valley	3	2013/14	1/9	31/5	Micro	0	960	960	1024	1600	1280	1280	1024	960	256	0	0	9344
			2014/15	15/9	31/5		0	576	1024	1024	1600	1280	1280	1280	768	384	0	0	9216
			2015/16	7/9	13/5		0	768	1024	1024	1440	1152	1152	1440	864	384	0	0	9248
Western Cape	Hex River Valley	4	2013/14	1/10	23/5	Drip	0	0	220	770	1155	1540	1232	1001	418	165	0	0	6501
			2014/15	1/10	29/5		0	0	275	616	924	1540	1232	1001	418	165	0	0	6171
			2015/16	21/9	27/5		0	0	275	616	924	1540	1232	1001	418	165	0	0	6171
Western Cape	Berg River	6	2015/16	1/9	31/5	Micro													0
			2016/17	1/10	30/6		0	0	0	197	1067	2696	1123	983	674	618	0	0	7358
Western Cape	Berg River	7	2015/16	1/9	31/5	Micro													0
			2016/17	1/10	30/6		0	0	0	562	1180	2191	1123	1011	674	674	0	0	7414
Western Cape	Olifants River	11	2016/17	15/8	15/7	Drip	397	624	794	738	1986	1532	2354	964	567	397	397	397	11148
Western Cape	Olifants River	12	2015/16	1/9	31/5	Micro	0	821	1408	1877	1877	2347	1877	1613	704	704	0	0	13229
			2016/17	1/9	31/5	Micro	0	821	1232	1877	1877	2347	1877	1525	704	763	0	0	13024
Orange River	Kanoneiland	16	2013/14	1/8	31/7	Mikro	518	1,241	1,570	2,072	3,549	2,690	2,328	2,150	803	535	423	330	18209
			2014/15	1/8	31/7	Mikro	707	1,064	1,565	2,729	2,892	2,649	2,328	2,984	530	620	160	130	18358
			2015/16	1/8	31/7	Mikro	260	520	1,400	2,060	2,700	1,700	1,600	1,100	670	300	0	0	12310
Orange River	Kakamas	17	2013/14	1/8	31/7	Mikro	300	880	1,240	1,380	1,890	2,080	1,760	1,570	920	510	440	170	13140
			2014/15	1/8	31/7	Mikro	320	1,130	1,080	1,950	1,640	1,640	2,280	1,770	280	280	240	150	12760
			2015/16	1/8	31/7	Mikro	350	620	1,250	1,940	2,300	2,330	1,580	660	270	210	0	0	11510
Orange River	Kakamas	18	2013/14	1/8	31/7	Mikro	370	810	1,380	1,450	2,210	1,880	2,160	1,900	1,100	600	520	200	14580
			2014/15	1/8	31/7	Mikro	340	970	980	1,980	1,760	1,760	2,570	2,140	280	280	240	150	13450
			2015/16	1/8	31/7	Mikro	350	560	1,120	1,720	2,090	2,000	1,040	840	590	220	70	0	10600
Orange River	Kanoneiland	20	2013/14	1/8	31/7	Mikro	519	1,242	1,559	2,070	3,549	2,690	2,328	2,150	803	535	423	330	18198
			2014/15	1/8	31/7	Mikro	707	1,064	1,565	2,729	2,892	2,649	2,328	2,640	950	660	270	180	18634
			2015/16	1/8	31/7	Mikro	360	470	1,350	2,700	3,360	1,800	2,090	1,430	660	390	0	0	14610
Northern Prov	Groblersdal	21	2013/14 actual	1/8	31/7	Drip	507	507	828	1068	828	614	534	534	427	427	222	222	6719
Northern Prov	Groblersdal	21	2013/14&14/15	1/8	31/7	Drip	333	515	1345	1559	985	555	556	556	500	500	222	222	7848
Northern Prov	Groblersdal	22	2013/14&14/15	1/8	31/7	Drip	178	267	889	711	889	355	355	355	444	102	102	63	4710
Northern Prov	Groblersdal	23	2013/14&14/15	1/8	31/7	Drip	280	280	1400	1120	1400	1120	720	720	450	280	280	350	8402
Northern Prov	Marble Hall	24	2014/15	1/8	31/7	Drip	390	650	1110	1110	1410	1300	1040	780	480	250	200	250	8972

# Case study results: Water use for Irrigation

- **Total water use for irrigation (per ha per season)**

- Northern Provinces (summer rain, high 700 mm/yr): 4 710 - 8402 m<sup>3</sup>
- Orange River region (OR) (summer rain, low 80-150 mm/yr): 12 301 - 18 634 m<sup>3</sup>
- Olifants River Valley (winter rain, low 200 mm/yr): 11 100 – 13 200 m<sup>3</sup>
- Berg River Valley (winter rain, 300-700 mm/yr): 7358 – 7 414 m<sup>3</sup>
- Hex River Valley (winter rain, low 300 mm/yr): 4 598 - 10 560 m<sup>3</sup>

- **Highest volumes used in OR – because of:**

- higher temperatures, lower RH
- long growing season, low rainfall, long irrigation season
- use micro sprinkler irrigation systems, not drip



# Case study results: Water use for Spray applications

“Spray application water use” per ha per season  
(Plant protection, PGRs, nutrition, weed control)

- highest volumes used in Northern Provinces – 30.1 m<sup>3</sup>
  - Long growing season and long summer rainfall period
    - more applications needed for plant protection
  - Uneven bud break, flowering and further development of phenological stages:
    - more applications of PGRs needed, e.g.:
      - Hydrogen cyanamide (Dormex) for rest breaking
      - Thinning and berry sizing applications



# Case study results: Water use in Pack store

- **“Pack store water use” per ha per season**
  - washing of crates and working surfaces
  - pre-cooling systems
  - measured values for only 2 blocks (water meter at pack store):
    - 11.3 en 11.8 m<sup>3</sup>
  - all other values: calculations/ estimates by producers
- **Large variation (< 1 tot 11.8 m<sup>3</sup>):**
  - pre-cooling vs no pre-cooling
  - closed vs. non-closed systems for pre-cooling
  - accuracy of calculations/ estimates?





# Watervoetspoor en Watergebruikseffektiviteit

## *Water footprint and Water use efficiency (WUE)*

- **Watervoetspoor** = water gebruik per kg druiwe geproduseer ( $\text{m}^3/\text{kg}$ )

**Water footprint (WF)** = *water used per kg grapes produced ( $\text{m}^3/\text{kg}$ )*

3 WF groups/categories: green, blue, green, grey water (Clothier, 2010; Mekonnen & Hoekstra, 2011)

**blue water** = surface and ground water available (IRRIGATION/BESPROEING)

**green water** = rainwater

**grey water** = freshwater needed for chemical and fertiliser dilution

- **Watergebruikseffektiviteit** = kg druiwe geproduseer per liter water gebruik ( $\text{kg}/\text{m}^3$ )

**WUE** = *kg of table grapes produced per liter of water used ( $\text{kg}/\text{m}^3$ )*



# Watervoetspoor en Watergebruikseffektiviteit Water foot print and Water use efficiency (WUE)

- Spray applications and pack store: *small contribution to total water use*

Bespuitings en Pakstoor: *klein bydrae tot totale watergebruik*

➤ Calculate blue WF and WUE based on irrigation water use

Bereken blou WF en WUE op grond v besproeiingswatergebruik



# Water use efficiency (kg/m<sup>3</sup>) of Crimson Seedless in South Africa (determined from seasonal irrigation volumes)

Region	Irrigation applied (m <sup>3</sup> /ha/season)	WUE <sub>y</sub> Irr (kg/m <sup>3</sup> )
Hex River	4 590 - 10560	2.28 - 4.96
Berg River	7 358 - 7 414	3.64 - 3.67
Olifants River	11 100 - 13 200	1.56 - 2.29
Orange River	12 301 - 18 634	0.44 - 1.23
Northern Provinces	4 710 - 8 402	2.09 - 3.55

**WUE and Blue WF assessments – in context:**  
water used vs prod and quality and income

WUE of Crimson Seedless in this study: 0.44 – 4.96 kg/m<sup>3</sup>

WUE of table or raisin grapes on horizontal trellis systems (other studies):

Sultanina in Orange River region, SA (Myburgh, 2003): 1.9- 3.3 kg/m<sup>3</sup>  
 Sultanina in Australia (Yunusa et al., 1997): 4.05 kg/m<sup>3</sup>  
 Sultanina in California (Araujo et al., 1995): 5.5 kg/m<sup>3</sup>

# Water use, water footprint and water use efficiency of table grapes



- Field trial in Hex River Valley on Crimson Seedless (2013/14, 2014/15, 2015/16):
- different soil texture and irrigation system scenarios



Descriptor	Block A	Block B	Block C	Block D
Soil Type	Sandy Clay Loam 20.3% clay	Sandy Clay Loam (+ high stone fraction) 28.4% clay	Loamy Fine Sand 10.4% clay	Sandy Clay Loam (+ high stone fraction) 29.5% clay
Irrigation system	Drip	Micro sprinkler	Micro sprinkler	Drip

# Water use, water footprint and water use efficiency of table grapes



- Field trial in Hex River Valley on Crimson Seedless (2013/14, 2014/15, 2015/16):
- different soil texture and irrigation system scenarios

Block	Depth (cm)	Clay %	Silt %	Fine Sand	Medium Sand	Coarse Sand	Stone Volume (v/v)	WHC (mm/m)
Block A	0 - 30	15.76	13.60	50.03	11.59	9.04	12.10	116.90
Block A	30 - 60	21.36	9.60	54.56	9.17	5.32	15.98	115.60
Block A	60 - 90	23.60	13.20	44.42	11.36	7.51	14.40	106.94
Block B	0 - 30	26.80	12.00	46.88	7.90	6.43	15.32	109.52
Block B	30 - 60	29.20	11.60	48.50	5.79	4.92	25.16	98.52
Block B	60 - 90	29.20	10.00	50.60	6.45	3.77	42.26	78.12
Block C	0 - 30	10.00	10.40	38.82	28.42	12.37	3.42	97.70
Block C	30 - 60	10.40	8.80	41.82	28.45	10.56	5.00	98.60
Block C	60 - 90	10.80	7.60	40.86	27.84	12.93	4.22	97.60
Block D	0 - 30	24.00	10.80	45.26	9.62	10.32	18.26	102.46
Block D	30 - 60	29.60	14.00	38.62	7.04	10.76	18.78	98.58
Block D	60 - 90	34.80	12.80	37.02	5.89	9.51	21.64	93.10

# Blue WF m<sup>3</sup> /kg and Water use efficiency (kg/m<sup>3</sup>) of Crimson Seedless in Hex River Valley (field trial) (determined from seasonal irrigation volumes)

Farm nr	Soil type	Season	Irrigation season		Irr system	Irrigation applied m <sup>3</sup> /ha	Yield		Blue WF Irr m <sup>3</sup> /ton	WUE <sub>y Irr</sub> kg/m <sup>3</sup>
			Start	End			export cartons/ha	t/ha		
1 (A)	Sandy clay loam	2013/14	1/10	9/5	Drip	4598	4000	18.0	255	3.91
		2014/15	22/9	8/5	Drip	7524	4000	18.0	418	2.39
		2015/16	21/9	27/5	Drip	7600	4200	18.9	398	2.49
2 (B)	Sandy clay loam	2013/14	1/9	31/5	Micro	8565	4000	18.0	476	2.10
		2014/15	15/9	31/5	Micro	8448	4800	21.6	391	2.56
		2015/16	7/9	13/5	Micro	10560	5400	24.3	435	2.30
3 (C)	Loamy fine sand	2013/14	1/9	31/5	Micro	9344	5200	23.4	399	2.50
		2014/15	15/9	31/5	Micro	9216	5000	22.5	410	2.44
		2015/16	7/9	13/5	Micro	9248	4100	18.5	501	2.00
4 (D)	Sandy clay loam	2013/14	1/10	23/5	Drip	6501	5500	24.8	263	3.81
		2014/15	1/10	29/5	Drip	6171	6000	27.0	229	4.38
		2015/16	21/9	27/5	Drip	6200	6800	30.6	202	4.94

**WUE of Crimson Seedless in this study: 2.00 – 4.96 kg/m<sup>3</sup>**

WUE of table or raisin grapes on horizontal trellis systems (other studies):

Sultanina in Orange River region, SA (Myburgh, 2003): 1.9- 3.3 kg/m<sup>3</sup>

Sultanina in Australia (Yunusa et al., 1997): 4.05 kg/m<sup>3</sup>

Sultanina in California (Araujo et al., 1995): 5.5 kg/m<sup>3</sup>

**WUE and Blue WF assessments – in context:  
water used vs prod and quality and income**

# Werklike watergebruik van die tafeldruifstok? Actual water use of the table grapevine?

## Horisontale preelestelsels vir tafeldruif

byna vol oppervlak bedekking met lower

**transpirasie = lewer groot bydra tot totale ET**

## *Horizontal trellis systems for table grapes*

*nearly full area coverage by canopy*

*transpiration = large contribution to total ET*



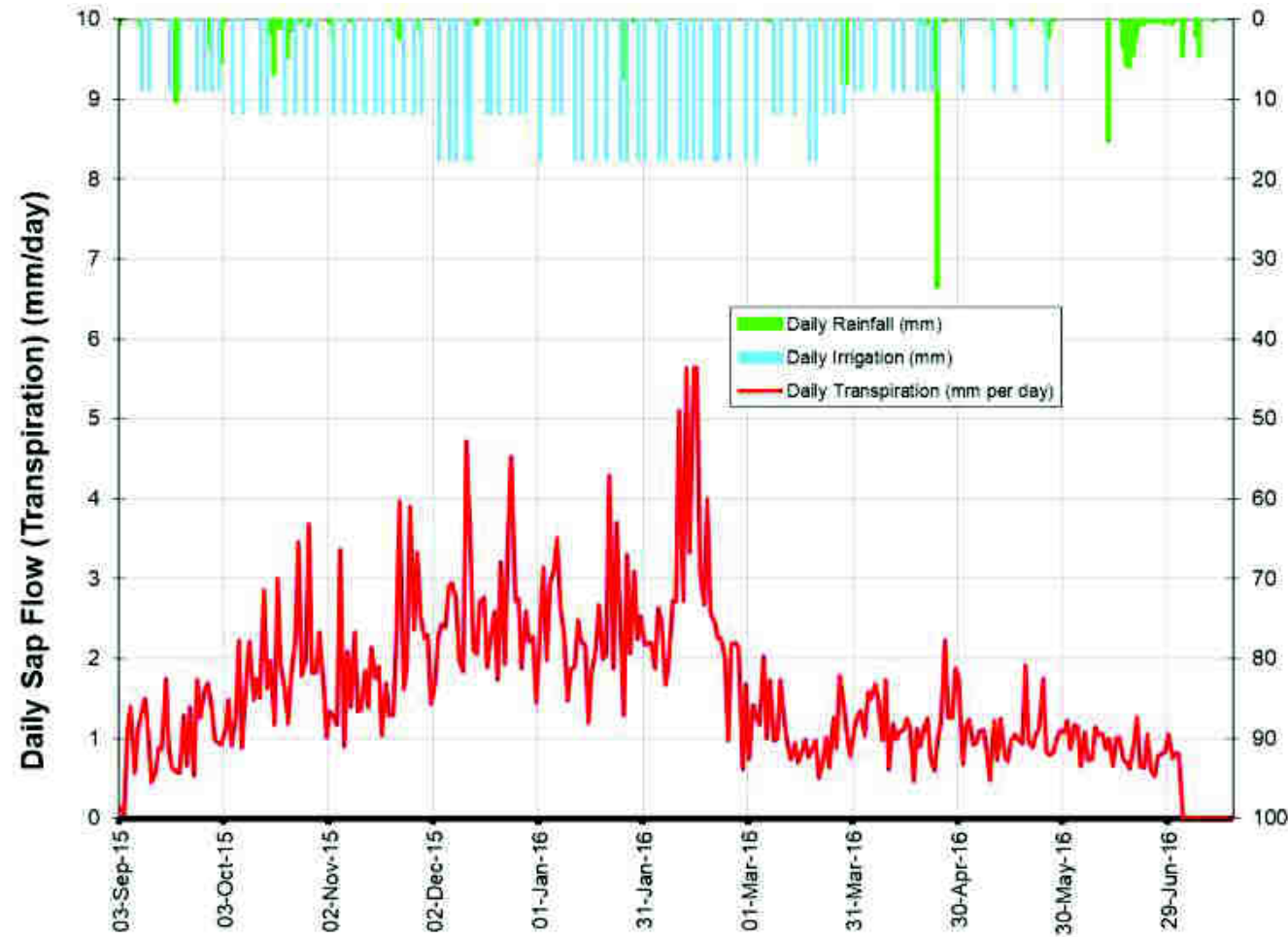




# Blue WF m<sup>3</sup> /kg and Water use efficiency (kg/m<sup>3</sup>)

of Crimson Seedless in Hex River Valley

determined from transpiration (Block 2 - micro on sandy clay loam, 2015/16)



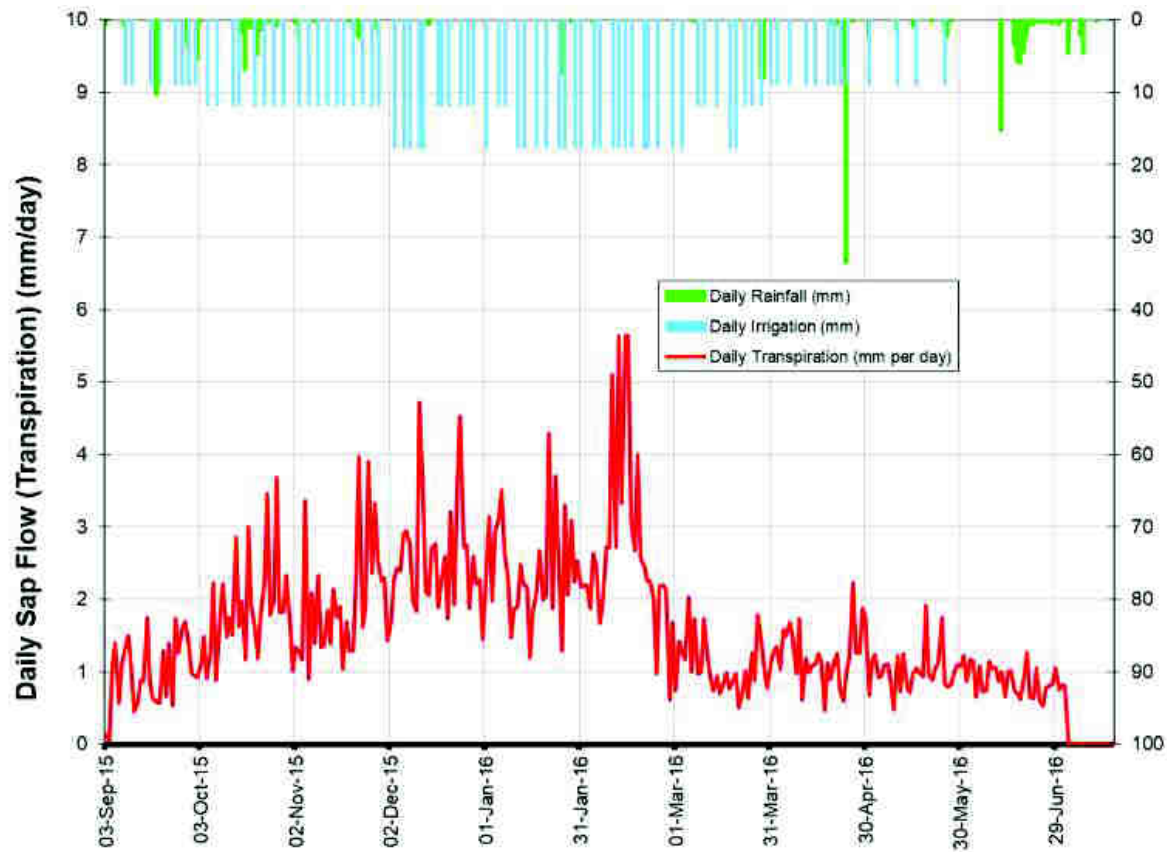
Daily Rainfall (mm/day) & Irrigation (mm/day)

**Total annual transpiration = 5036 m<sup>3</sup>.ha<sup>-1</sup>**  
(1852 vines per ha)

**Production.ha<sup>-1</sup> = 24.1 t**

**m<sup>3</sup> water used (transpiration) per ton produced**  
**= 209 m<sup>3</sup>.t<sup>-1</sup>**

**WUE (based on transpiration) = 4.78 kg.m<sup>-3</sup>**



**Crimson Seedless, Hex River Valley transpiration (Block 2, 2015/16)**

**Total annual transpiration = 5036 m<sup>3</sup>.ha<sup>-1</sup> (1852 vines per ha)**

**Production.ha<sup>-1</sup> = 24.1 t**

**m<sup>3</sup> water used (transpiration) per ton produced = 209 m<sup>3</sup>.t<sup>-1</sup>**

**WUE (based on transpiration) = 4.78 kg.m<sup>-3</sup>**

Daily Rainfall (mm/day) & Irrigation (mm/day)

Phenological stage	Bud break-flowering/fruit set	Fruit set-Veraison	Veraison-Harvest	Begin harvest - end harvest	End harvest - leaf fall complete	Dormancy - Before bud break	TOTAL
Period	7/9-28/10	28/10-27/12	27/12-11/2	11/2-7/4	7/4-30/6	30/6-31/8	
Transpiration (m <sup>3</sup> /ha)	823	1346	1153	880	834	0	5036
Transpiration (% of total)	16	27	23	17	17	0	100

# Transpiration (m<sup>3</sup>/ha), Evapotranspiration (m<sup>3</sup>/ha) and Irrigation applied (m<sup>3</sup>/ha) of Crimson Seedless in Hex River Valley (Block 2, 2015/16 – Micro on sandy clay loam with high stone fraction)

Phenological stage	Bud break-flowering/fruit	Fruit set-Veraison	Veraison-Harvest	Begin harvest - end harvest	End harvest - leaf fall complete	Dormancy - Before bud break	TOTAL
Period	7/9-28/10	28/10-27/12	27/12-11/2	11/2-7/4	7/4-30/6	30/6-31/8	
Transpiration (m <sup>3</sup> /ha)	823	1346	1153	880	834	270	5306
Transpiration (% of total)	16	25	22	17	16	5	
Evapotranspiration (m <sup>3</sup> /ha)	1460	2180	1863	1878	1100	264	8744
Evapotranspiration (% of total)	17	25	21	21	13	3	
Irrigation (m <sup>3</sup> /ha)	1643	2933	2200	2728	1056	0	10560
Irrigation (% of total)	16	28	21	26	10	0	

ET: FruitLook Actual evapotranspiration (ET) [www.fruitlook.co.za](http://www.fruitlook.co.za), was used for the period that FruitLook data was available (October to April). For the period May to September, Evapotranspiration (ET) was estimated as the product of the reference crop evapotranspiration (ET<sub>o</sub>) and published crop coefficient values (Muburgh, 2003).  
Total rainfall (2015/16): 232 mm (2320 m<sup>3</sup>/ha)

ET (Evapotranspirasie) = *transpirasie* deur blare van wingerdstok + *verdamping* vanaf grondopp

**Transpirasie waarde = aanduiding van minimum waterbehoefte van wingerdstok**

### Aanbeveling: Verminder besproeiing

- neem SWP (Blaarsteel WP waardes) in ag
- "hervullyn" by -0.8 Mpa (Myburgh, 2018)

# Summary and Conclusions

## Water use case study (Irrigation water use per ha per season):

- Practical records obtained from producers in all 5 regions (25 blocks)
  - All blocks: 4598 – 18 634 m<sup>3</sup>
  - Hex River Valley: 4 598 - 10 560 m<sup>3</sup>

## Field trail Hex River Valley:

- Data of 4 commercial blocks
- Water applied vs. water used
  - transpiration AND evapotranspiration
- **Transpiration value = indication of minimum water requirement by grapevine**



# Summary and Conclusions

**WUE and Blue WF assessments – in context:** water used vs prod and quality and income

- Field trial in Hex River Valley: **Block 4 (Drip irrigation/sandy clay loam soil+ high stone%)**
  - best irrigation WUE over three seasons
  - produced grapes of the best quality

Farm nr	Soil type	Season	Irrigation season		Irr system	Irrigation applied m <sup>3</sup> /ha	Yield		Blue WF Irr m <sup>3</sup> /ton	WUE <sub>Irr</sub> kg/m <sup>3</sup>
			Start	End			export cartons/ha	t/ha		
1 (A)	Sandy clay loam	2013/14	1/10	9/5	Drip	4598	4000	18.0	255	3.91
		2014/15	22/9	8/5	Drip	7524	4000	18.0	418	2.39
		2015/16	21/9	27/5	Drip	7600	4200	18.9	398	2.49
2 (B)	Sandy clay loam	2013/14	1/9	31/5	Micro	8565	4000	18.0	476	2.10
		2014/15	15/9	31/5	Micro	8448	4800	21.6	391	2.56
		2015/16	7/9	13/5	Micro	10560	5400	24.3	435	2.30
3 (C)	Loamy fine sand	2013/14	1/9	31/5	Micro	9344	5200	23.4	399	2.50
		2014/15	15/9	31/5	Micro	9216	5000	22.5	410	2.44
		2015/16	7/9	13/5	Micro	9248	4100	18.5	501	2.00
4 (D)	Sandy clay loam	2013/14	1/10	23/5	Drip	6501	5500	24.8	263	3.81
		2014/15	1/10	29/5	Drip	6171	6000	27.0	229	4.38
		2015/16	21/9	27/5	Drip	6200	6800	30.6	202	4.94

Using a drip irrigation system and irrigation applications as applied for Block 4 and under similar conditions to that in this study, could reduce the volume of irrigation water used and contribute to improve WUE.

# Summary and Conclusions

## Contribution of the study:

- Measurements of actual plant water use (transpiration) – as basis to establish minimum seasonal water requirement under similar conditions
- Field study: Plant based measurements to link water use and WUE to phenological stages, plant physiology, vegetative and reproductive performance (Detail presented in PhD thesis of Ms GN Kanguuehi)
- Contribute to limited available WF and WUE data for SA table grape industry



# Aknowledgements

## Project funding: SATI

## Technical support:

- Producers and their staff of farms where field trial was conducted:
  - Pieter Kriel (Nil Desperandum)
  - Christiaan de Villiers (Wolwehok)
- Producers and their staff for supplying data for the survey (all 5 regions)
- ARC Infruitec-Nietvoorbij Viticulture staff
- Stellenbosch University Table grape Intern students



# New project: Table grape water use overhead protection

New project funded by Dept of Agriculture Northern Cape and SATI:

“Determining the effect of netting on water use of table grapes  
in the Lower Orange River region”

## Main objectives:

- *Accurate scientific quantification of table grape water use under nets, for:*
  - improving irrigation scheduling and water use efficiency; and
  - formulating strategies for negotiations with policy makers regarding water allocation.
  
- *Scientifically verify whether netting do decrease water use and increase WUE.*
  
- *Human capacity building*
  - MSc student (Mukhetwa Sadikge)
  - Several 4th year BSc Agric students





# New project: Table grape water use under overhead protection

*funded by Dept of Agriculture Northern Cape and SATI*

