HORTGRO
Growing Fruit IQ

Technical Symposium 2026

What have we learned from all our research on orchard water use?

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What have we learnt from our research on orchard water use?

Dr Sebinasi Dzikiti & Prof Stephanie Midgley

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Hortgro Technical Symposium – 2026

WRC
WATER RESEARCH COMMISSION

INTRODUCTION

- **Most fruit are grown under irrigation**
- **Water resources under threat**
  - Competition
  - Droughts
- **Water use affected by**
  - Crop type
  - Environmental conditions (soils & climate)
  - Irrigation system (drip vs micro)
  - Management (crop load, canopy size, orchard floor etc.)
- **Need to know the maximum water requirements**
  - Irrigation scheduling
  - Water use licensing
  - Irrigation system designing

Water Research Commission & Industry funded projects

RESEARCHERS	FUNDER/S	CROP TYPE	AREA	COMPLETED
Gush & Taylor	WRC	Apple & nectarines	W/ Cape	2014
Dzikiti et al	WRC & Hortgro	High yielding apples	W/ Cape	2018
Midgley et al	Hortgro	Apple rootstocks	W/ Cape	2023
Midgley et al	Hortgro & WRC	Apples under nets	W/ Cape	2023
Jovanovic et al	Hortgro & WRC	High yielding plums	W/ Cape	2025
Volschenk et al	WRC & NRF	Pomegranates	W/ Cape	2025
Dzikiti et al	Hortgro & WRC	High yielding pears	W/ Cape	2026
Tharaga et al	WRC	Apricots	W/ Cape	Ongoing
Munjonji et al	WRC	Nectarines	W/ Cape	Ongoing
Midgley et al	Hortgro	Various (water productivity)	SA/Global	Ongoing

AIMS & OBJECTIVES

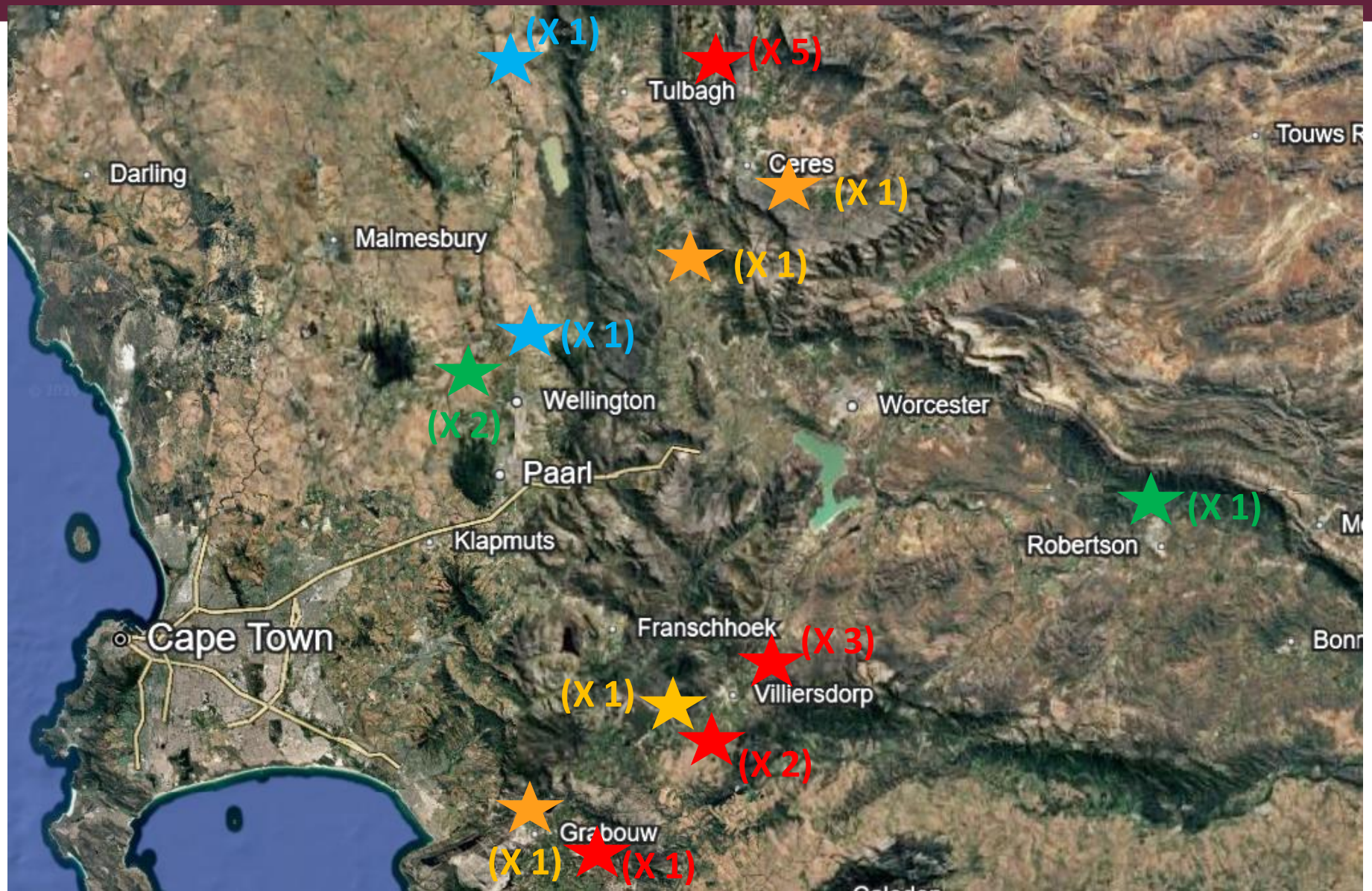
AIM

To quantify the maximum unstressed water use of orchards and how this relates to yield (quality & quantity)

FOCUS AREAS

- Crop type;
- Cultivars;
- Growing region (climate);
- Management (shade nets, crop load, canopy cover, orchard floor)

MATERIALS & METHODS : STUDY SITES & CULTIVARS



CULTIVARS

A. Apples

- *Cripps Pink*
- *Cripps Red*
- *Golden Delicious*

B. Pears

- *Forelle*
- *Packham's Triumph*

C. Pomegranates

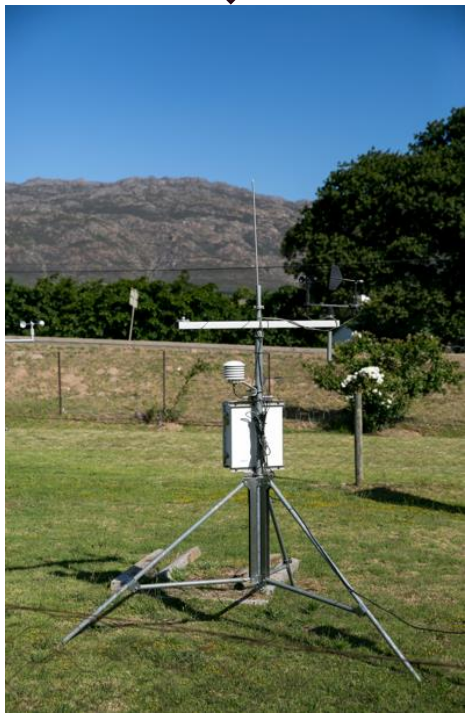
- *Wonderful*

D. Plums

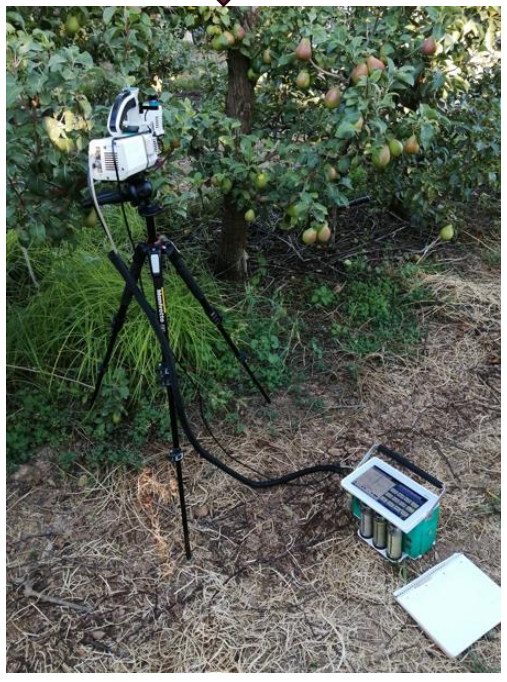
- *African Delight*
- *Ruby Sun*

DATA COLLECTION

Weather stations



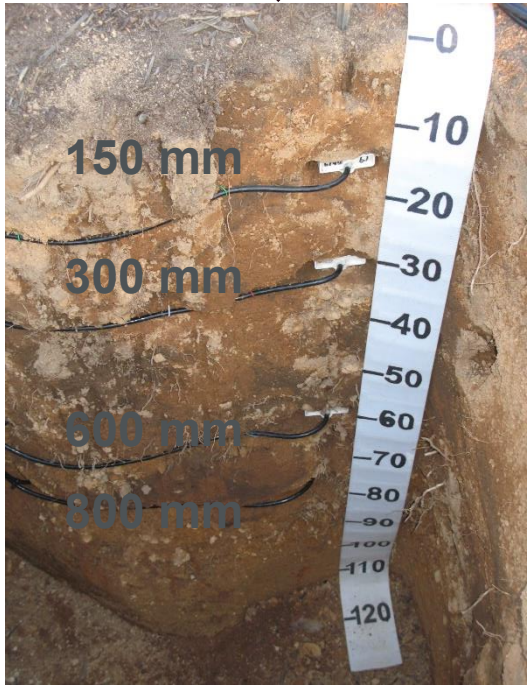
Leaf gas exchange & stem water potential



Whole tree transpiration

Eddy covariance (evapotranspiration)

Soil water balance



Yield and fruit quality

KEY FINDINGS

A. HIGH PERFORMING APPLE ORCHARDS

Year	Region	Cultivar	Transpiration (mm)	ET (mm)	Canopy cover	Peak LAI	Yield (t ha^{-1})
2014/15	KBV	Golden Delicious	813	1086	High	3.6	74
	KBV	Cripps' Pink	589	974	High	2.6	110
	KBV	Golden Delicious R	199	481	Low	1.0	-
	KBV	Rosy Glow	271	562	Low	1.3	-
2015/16	EGVV	Golden Delicious	757	1110	High	3.3	100
	EGVV	Cripps' Pink	631	902	High	2.8	109
	EGVV	Golden Delicious	155	501	Low	0.7	-
	EGVV	Cripps' Red	133	500	Low	0.8	-
2016/17	KBV	Golden Delicious R	420	596	Medium	1.5	18
	KBV	Cripps' Pink	547	871	Medium	2.0	61
	EGVV	Golden Delicious R	249	534	Medium	1.3	35
	EGVV	Cripps' Pink	471	872	Medium	1.8	58

- Canopy cover, not crop load, had the greatest effect on tree water use
- The longer growing season for Cripps' Pink did not result in higher seasonal total water use
- No significant differences in transpiration per unit leaf area for Cripps' Pink & Golden Delicious cultivars
- Orchard floor evapotranspiration accounted for > 60% of orchard ET in young orchards

Irrigation requirements

- Mature Cripps' Pink
  ~ 6 550 - 6 930 m^3/ha
- Mature Golden Delicious
  ~ 8 050 – 8 630 m^3/ha
- Young non-bearing orchards
  ~ 2 000 – 2 810 m^3/ha

B. HIGH PERFORMING PEAR ORCHARDS

Region	Cultivar	LAI	ETo (mm)	Transpiration (mm)	ET (mm)	Irrigation (mm)	Rainfall (mm)	Yield (t/ha)
Ceres	Forelle	3.8	1164	804	945	730	335	60
Wolseley	P. Triumph	3.2	1162	634	809	-	-	57
Vyeboom	P. Triumph	2.8	1079	536	854	520	266	84
Elgin	Forelle	3.6	1103	645	875	-	-	56

- Canopy cover major driver of orchard water use
- Maximum crop water requirement ~ 9 450 m^3/ha (average over 3 years)
- Water use also varied by growing region
- Irrigation requirements

  ~ 5 880 – 6 950 m^3/ha

C. FIXED VS DRAPED NETS (ROSY GLOW APPLE ORCHARDS)

Variable		KBV: Fixed nets	KBV: Fixed nets	KBV: Black draped nets	EGVV: Black draped nets
		Rosy Glow	Rosy Glow	Golden Delicious R	Golden Delicious
		2018-19	2019-20	2019-20	2020-21
Transp	Open	5810	6430	6170	8120
(m^3/ha)	Nets	5330	5460	5970	6930
	Difference	-8	-15	-3	-15
ET	Open	-	9920	9820	7170
(m^3/ha)	Nets	-	9850	7990	8270
	Difference	-	-1	-19	15
Irrig	Open	-	9390	7570	6010
(m^3/ha)	Nets	-	10440	6800	6140
	Difference	-	11	-10	2

- Fixed nets reduced seasonal total transpiration by ~ 12 and draped nets by ~ 9%
- Insignificant differences in ET between open & fixed nets due to higher T by orchard floor vegetation

D. PLUMS / POMEGRANATES

D. PLUM ORCHARDS: Hydrus 2-D model (Jovanovic et al. 2025)

REGION		ET (mm/yr)	Irrig req (m3/ha/yr)
Wellington	African Delight	958-1170	7800
	Ruby Sun	1094-1149	7500
Robertson	African Delight	1076-1267	10000
	Fortune	1190-1285	10200

E. POMEGRANATE ORCHARDS (Volschenk et al., 2025)

	Transpiration (mm/season)		ET (mm/season)		Rainfall (mm/season)		Irrigation (m3/ha/season)	
	2022/23	2023/24	2022/23	2023/24	2022/23	2023/24	2022/23	2023/24
Young	169.9	219.5	596.7	465.9	513	329	840	1370
Mature	161.8	250	898.5	888.6	740	491	1580	3980

Conclusions

- Canopy cover, not crop load is the major driver of water use (all crop types)
- Water use influenced by growing region, but insignificant differences in water use between cultivars (apples)
- Need for drip or narrow range micro-sprinklers or mulching in young orchards
- Effective management of orchard floor vegetation essential to maximize water savings under fixed nets

What else have we learnt from our research on water use?

Brief Summary of research funded by Hortgro Science and others, ca. 2010-2025
- Focusing on using water as efficiently as possible, and managing water deficit risks

Climate Change: Changing water requirements into the future; drought-resilient production systems

Water Productivity: What in-field research in South Africa and globally tells us in the context of different fruit types and environments

Practices: The influence of canopy size, rootstock, shade netting and deficit irrigation on Water Productivity

Acknowledgements

Funders:

HORTGRO Growing Fruit IQ

WATER RESEARCH COMMISSION

SAMAC Macadamias South Africa NPC

SAAGA · SAAKV

WWF

agriculture, forestry & fisheries
Department: Agriculture, forestry & fisheries
REPUBLIC OF SOUTH AFRICA

SAPPA South African Pecan Nut Producers Association

cri citrus research international

INKOMATI-USUTHU CATCHMENT MANAGEMENT AGENCY

NRF National Research Foundation

Researchers:

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UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

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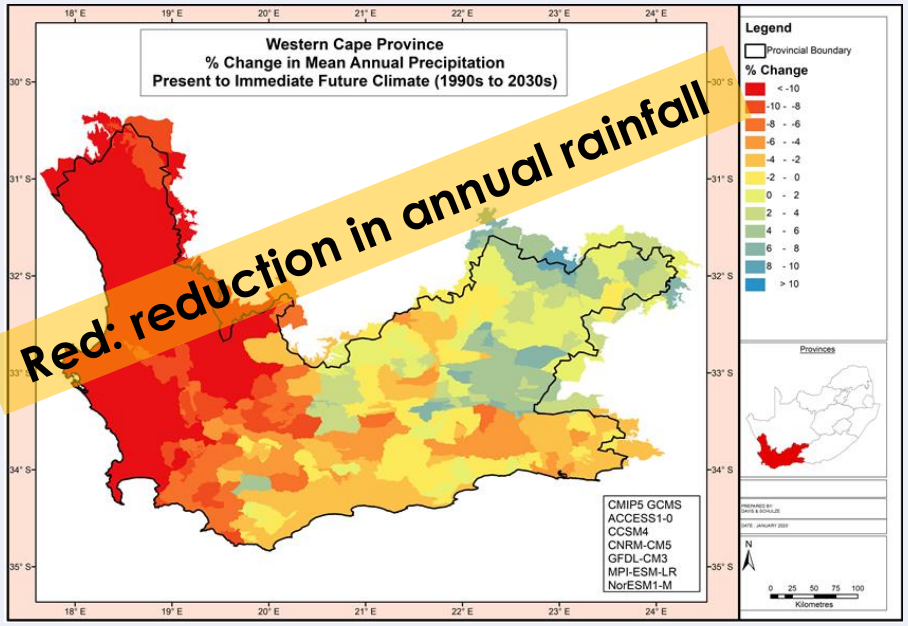
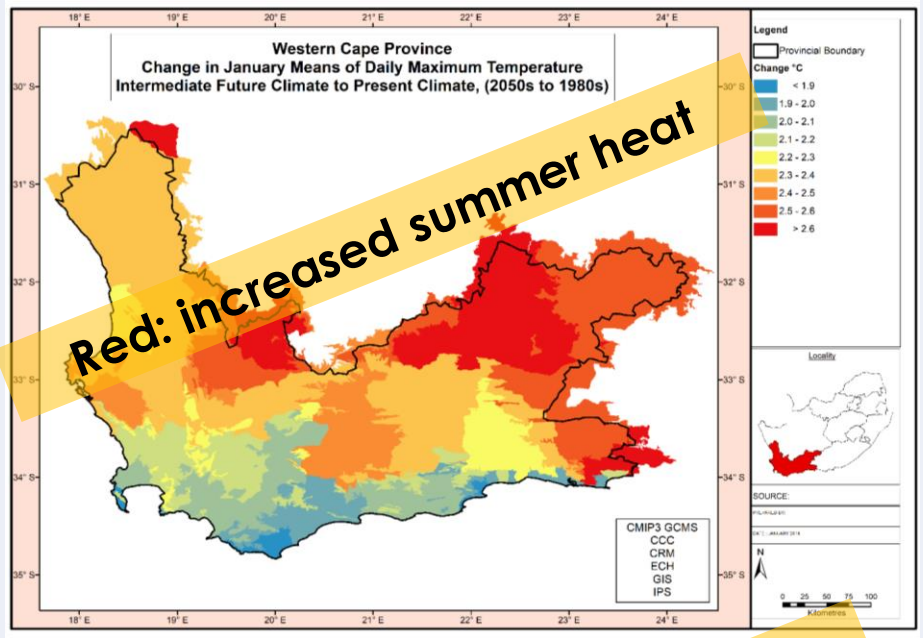
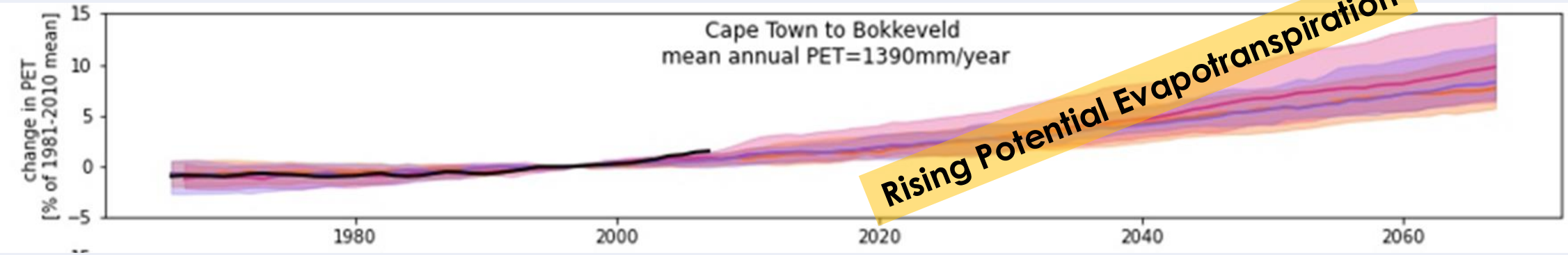
Isikhungusethu Environmental Services (Pty) Ltd

Key message 1: Climate Change is increasing water demand and risks of water supply constraints – industry must remain sustainable through better and adapted irrigation and management strategies







Midgley, S.J.E., Davis, N. & Schulze, R.E. (2021) Scientific and Practical Guide to Climate Change and Pome/Stone Fruit Production in South Africa. Project No. V-18-USH-CP25, Hortgro Science.

Key message 2: Efficiency of water use (Water Productivity) of pome fruit in SA is amongst the highest globally

- **Water Productivity of Actual Evapotranspiration (WP-ET_a):**
  Ratio between marketable yield produced by a crop and actual seasonal crop evapotranspiration (ET_a).

$$WP_{ETa} = \frac{Yield}{ET_a}$$

- **Transpiration Water Productivity (WP-T):**
  Ratio between marketable yield produced by a crop and seasonal crop transpiration (T) measured by sap flow techniques.

$$WP_T = \frac{Yield}{T}$$

- **Irrigation Water Productivity (WP-I):**
  Ratio between marketable yield produced by a crop and volume of irrigation water applied (IWU) over the season.

$$WP_I = \frac{Yield}{IWU}$$

- **Productivity of Total Water Use (WP-TWU):**
  Ratio between marketable yield produced by a crop and total amount of water used in crop production (TWU, sum of volume of irrigation water applied and seasonal rainfall).

$$WP_{TWU} = \frac{Yield}{TWU}$$

- **Economic Water Productivity (EWP-T or EWP-ET_a):**
  Ratio between gross or net crop value and T or ET_a. Local currency was converted to US Dollars (mid-November 2025).

$$EWP = \frac{Value}{T \text{ or } ET_a}$$

Database and Analysis: Global studies

Temperate deciduous fruit

39 Studies; 487 Observations

Factor variables:

- orchard-specific information
- climate information
- yield
- measured T and/or ET_a
- irrigation water volume, rainfall
- research treatments
- crop value

- Data extracted separately for each treatment and each study year

Köppen-Geiger climate zones represented:

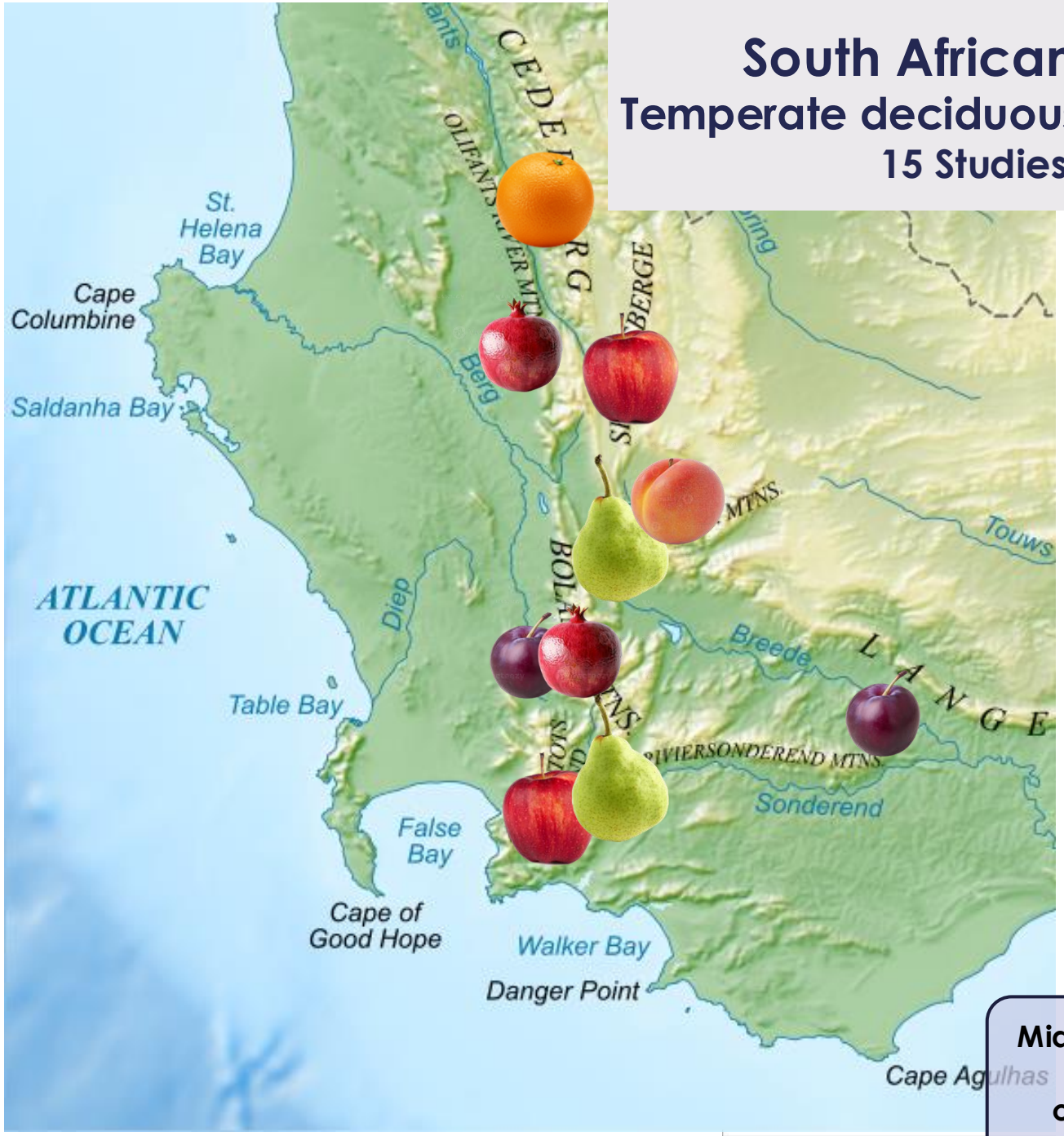
B (dry)	W (arid desert) S (semi-arid steppe)	h (hot) k (cold)
C (temperate)	w (dry winter) f (no dry season) s (dry summer)	a (hot summer) b (warm summer)

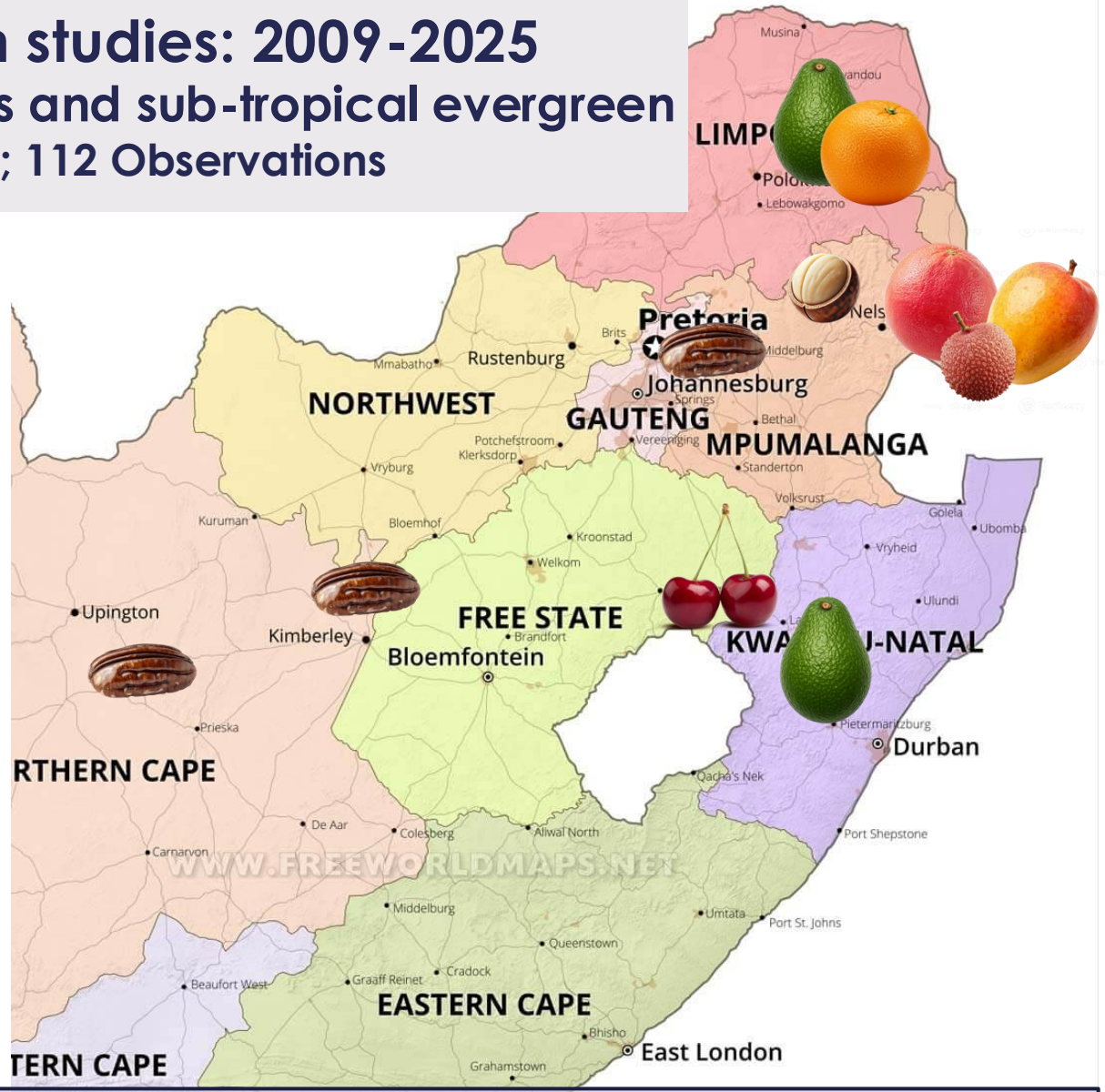
Midgley, S.J.E., Taylor, N.J., Dzikiti, S., Maphosa, B., (current) Practical guide to increasing crop water productivity in deciduous fruit orchards in South Africa. Project No. NP4-2024, Hortgro Science.

South African studies: 2009-2025

Temperate deciduous and sub-tropical evergreen

15 Studies; 112 Observations





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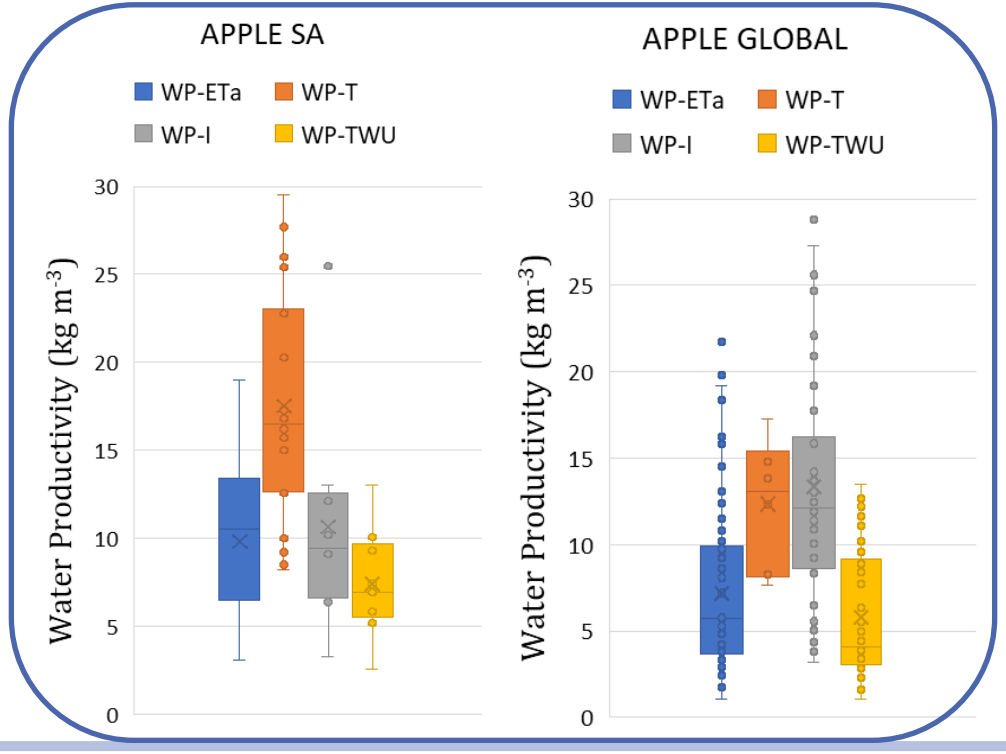
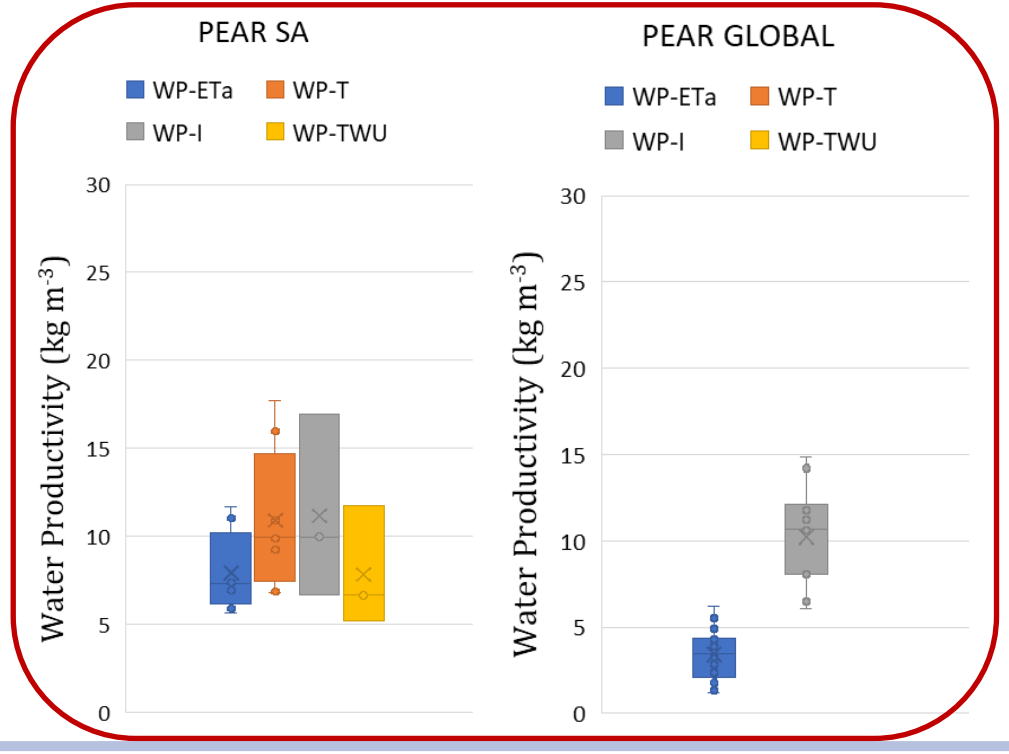
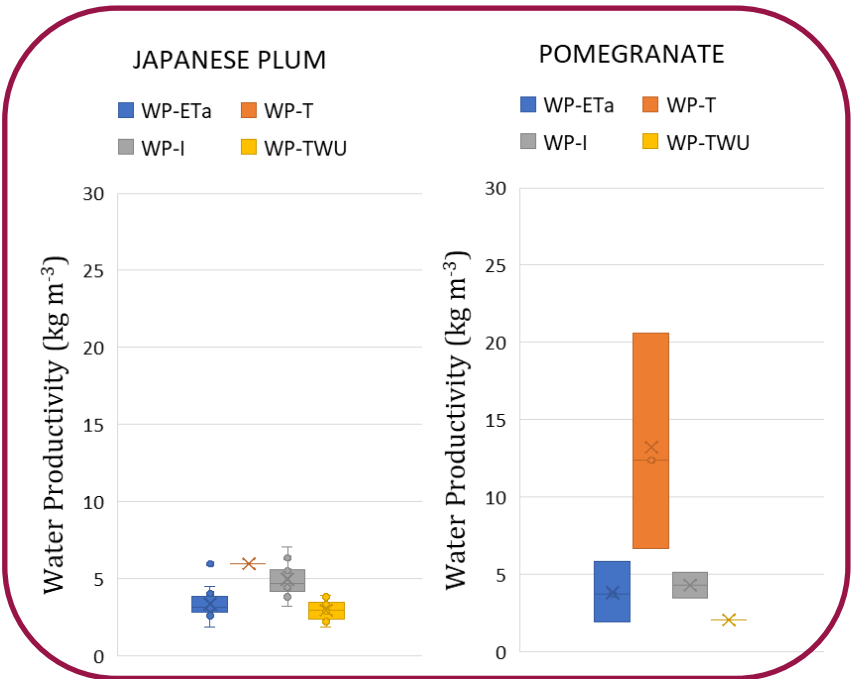
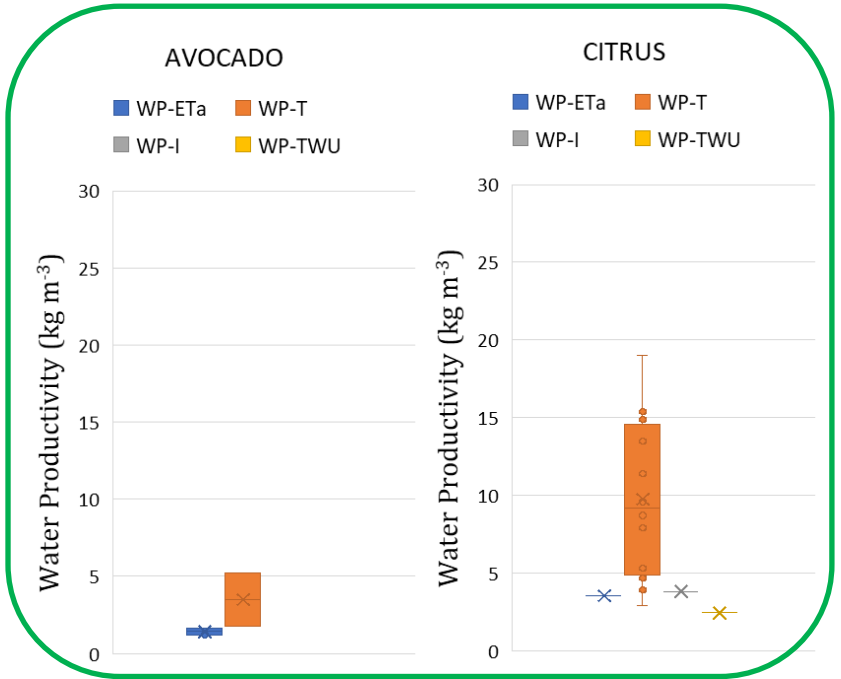


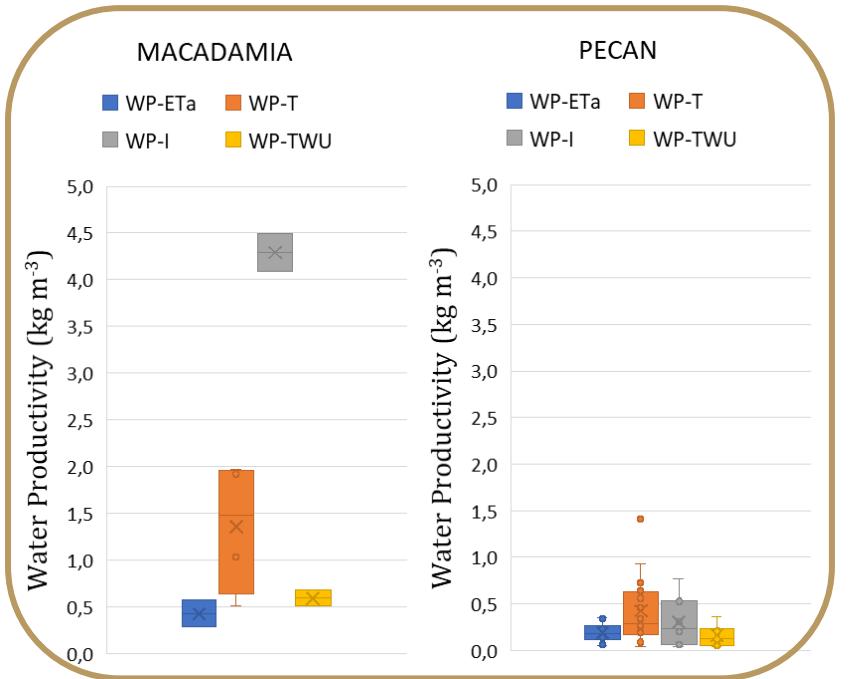


WP South Africa (kg/m^3 – 4 metrics)

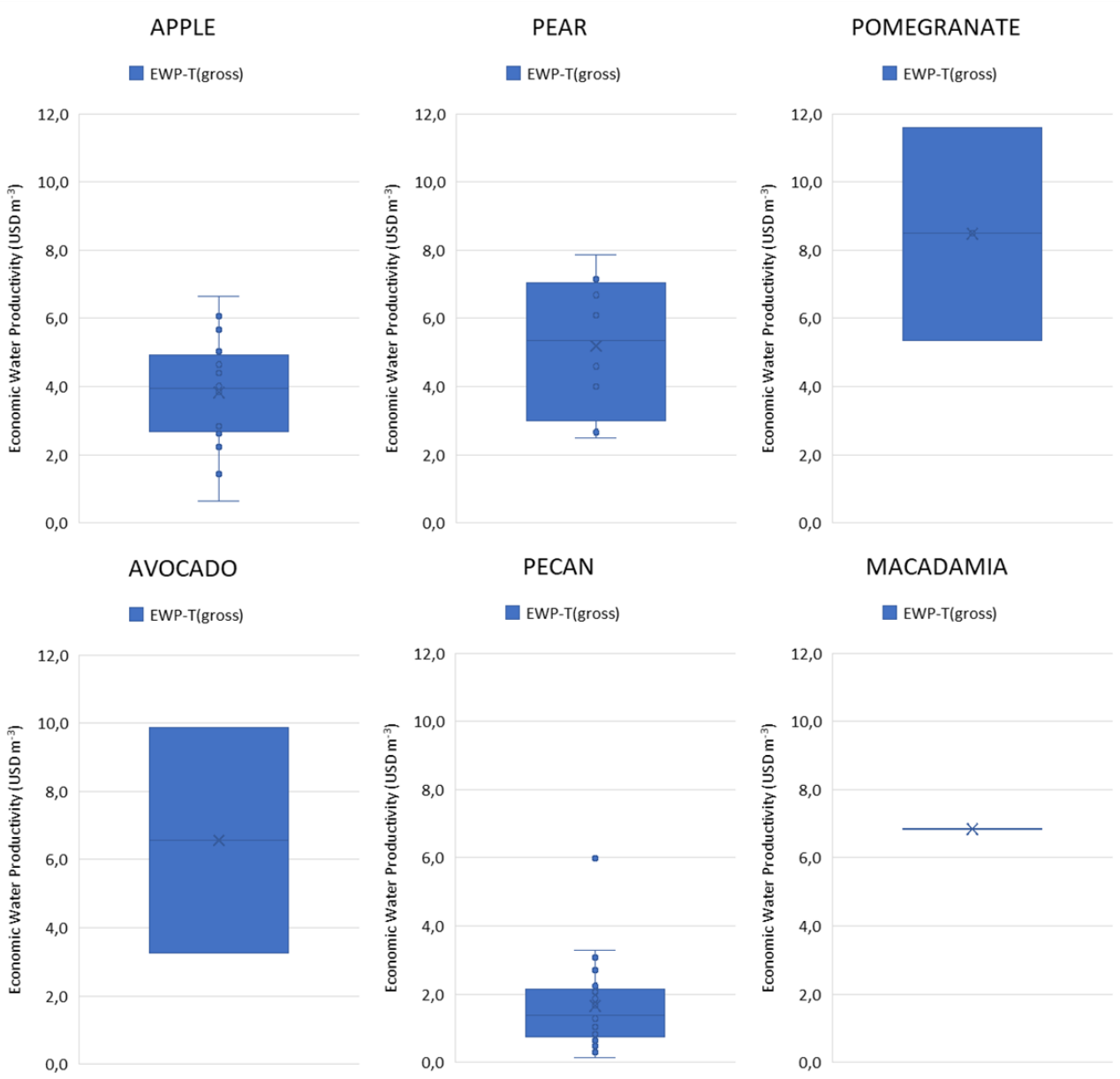
- Apple
- > Pear
- > Pomegranate
- ~ Citrus
- ~ Plum
- > Avocado
- > Macadamia
- > Pecan







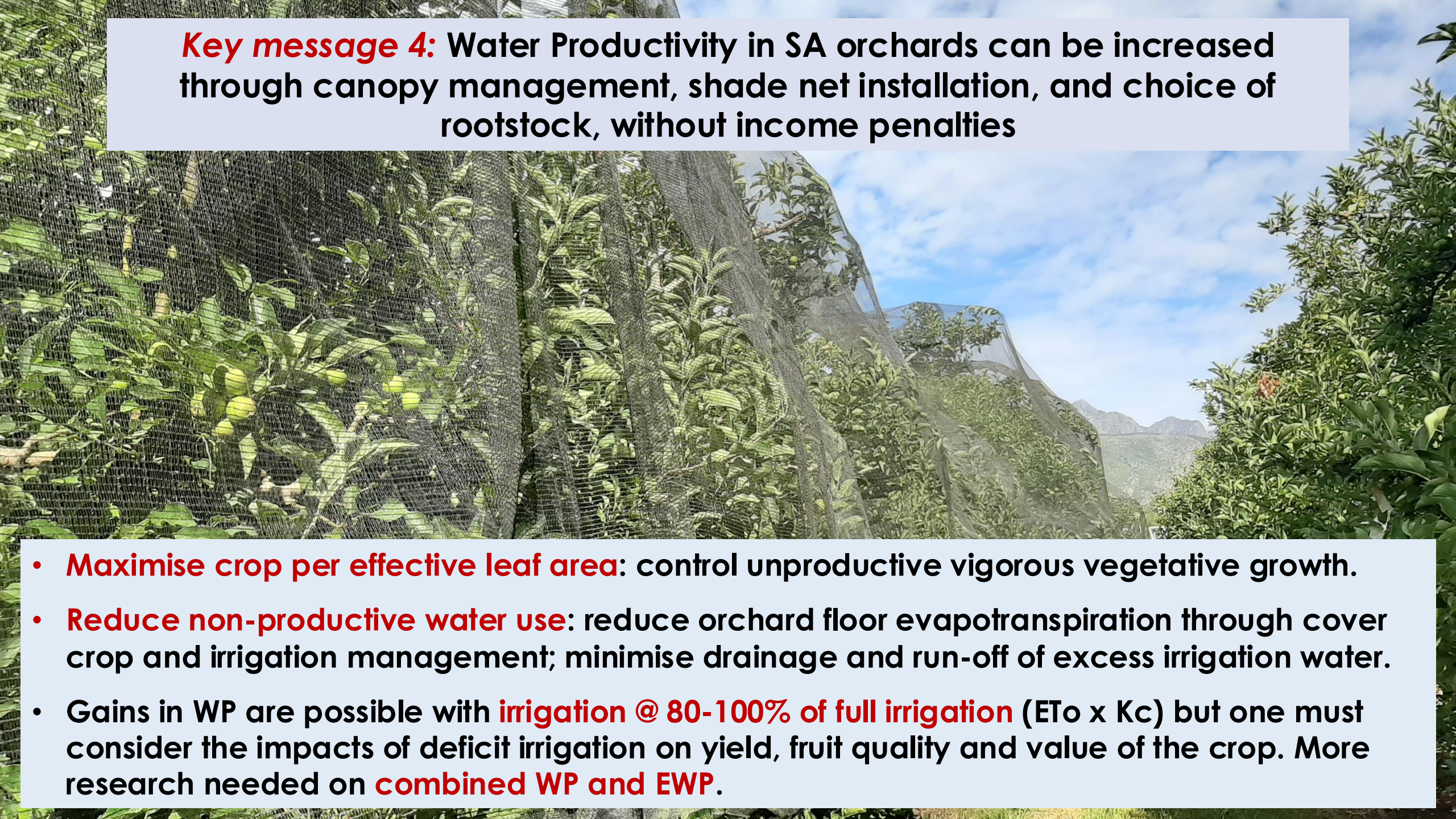
Key message 3: Economic Water Productivity for SA apple & pear is ~ R70-85/m³ with high values (R100-140/m³) in some high-yielding orchards



EWP can be high in pomegranate, avocado and nuts (dry yield), but variability is high due to alternate bearing and other yield/quality issues.

Need more data on EWP and modelling of the optimization between yield, fruit quality, crop value and water use for species and regions.

Midgley, S.J.E., Taylor, N.J., Dzikiti, S., Maphosa, B., (current) Practical guide to increasing crop water productivity in deciduous fruit orchards in South Africa. Project No. NP4-2024, Hortgro Science.

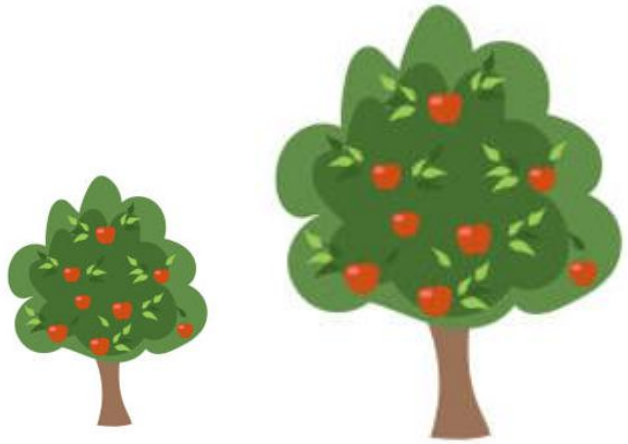


Key message 4: **Water Productivity in SA orchards can be increased through canopy management, shade net installation, and choice of rootstock, without income penalties**

- **Maximise crop per effective leaf area**: control unproductive vigorous vegetative growth.
- **Reduce non-productive water use**: reduce orchard floor evapotranspiration through cover crop and irrigation management; minimise drainage and run-off of excess irrigation water.
- Gains in WP are possible with **irrigation @ 80-100% of full irrigation** (ETo x Kc) but one must consider the impacts of deficit irrigation on yield, fruit quality and value of the crop. More research needed on **combined WP and EWP**.

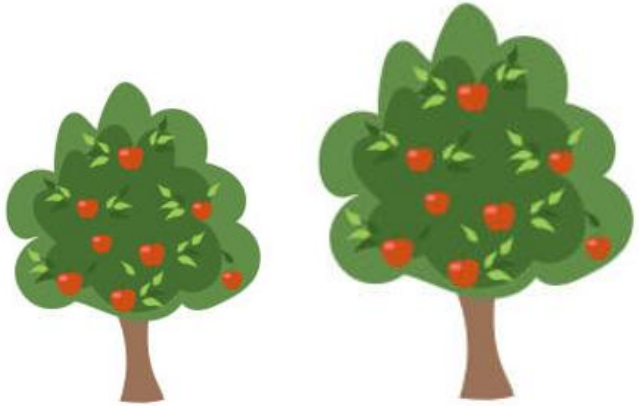
Apple water productivity – influence of canopy size / yield and cultivar

Dzikiti, S., Volschenk, T., Midgley, S., Gush, M., Taylor, N., Lötze, E., Zirebwa, S., Ntshidi, Z., Mobe, N., Schmeisser, M. and Doko, Q. (2018) Quantifying water use and water productivity of high performing apple orchards of different canopy sizes in winter rainfall areas of South Africa. WRC Report TT 751-2018. WRC and Hortgro Science.



'Golden Delicious'

Canopy size	WP-T ($kg\ m^{-3}$)	EWP-T ($R\ m^{-3}$)	Yield ($t\ ha^{-1}$)
Small-Med (LAI=1.3-1.5)	4.3 – 4.4	R21 – R49	11 – 16
Large (LAI-3.3-3.6)	10.8 – 18.0	R47 – R49	85 – 138



'Rosy Glow'

Canopy size	WP-T ($kg\ m^{-3}$)	EWP-T ($R\ m^{-3}$)	Yield ($t\ ha^{-1}$)
Medium (LAI=1.8-2.0)	10.4 – 11.3	R54 – R66	53 – 71
Large (LAI=2.6-2.8)	14.2 – 21.5	R73 – R93	88 – 141

Pear water productivity – influence of yield and cultivar

Dzikiti, S., Pienaar, J.C., Sidzumo, A., Midgley, S.J.E., Crouch, E., Dangare, P., Visser, J.-M., Giuliani, N. (2026) Quantifying water use and water productivity of high performing pear orchards in the winter rainfall areas of South Africa. WRC Project No. 2022-2023 - 00986.

'Packham's Triumph'

Region	WP-T ($kg\ m^{-3}$)	EWP-T ($R\ m^{-3}$)	Yield ($t\ ha^{-1}$)
Wolseley	9.9 – 10.0	R45 – R46	55 – 59
Vyeboom	16.0 – 17.7	R69 – R105	80 – 88

'Forelle'

Region	WP-T ($kg\ m^{-3}$)	EWP-T ($R\ m^{-3}$)	Yield ($t\ ha^{-1}$)
Ceres	6.8 – 10.9	R79 – R136	53 – 67
Elgin	6.9	R123	48

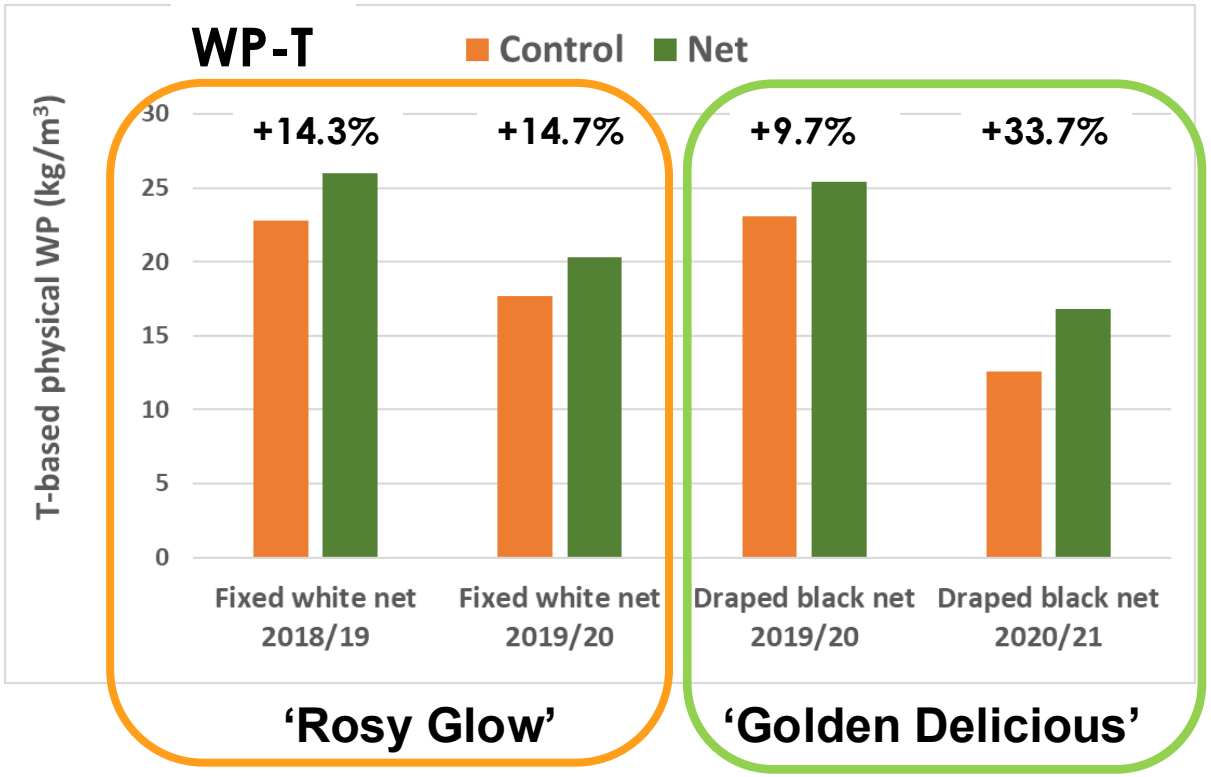
Apple water productivity – influence of fixed and draped net

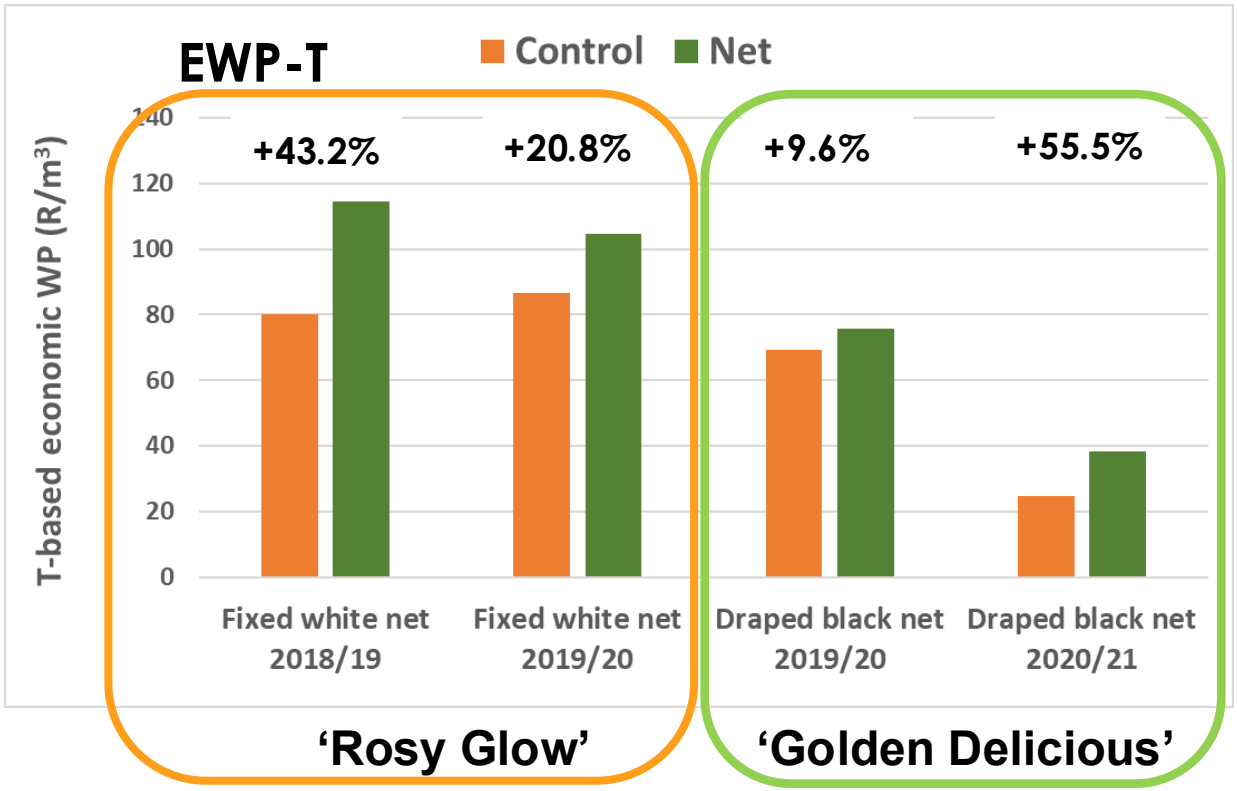
‘Rosy Glow’ white fixed net:

Higher WP-T under net mainly due to lower transpiration; **Higher EWP-T under net** due to both higher gross income and lower transpiration.

‘Golden Delicious’ black draped net:

Higher WP-T under net due to higher yield and lower transpiration; **Higher EWP-T** under net due to significantly higher gross income but also lower transpiration.



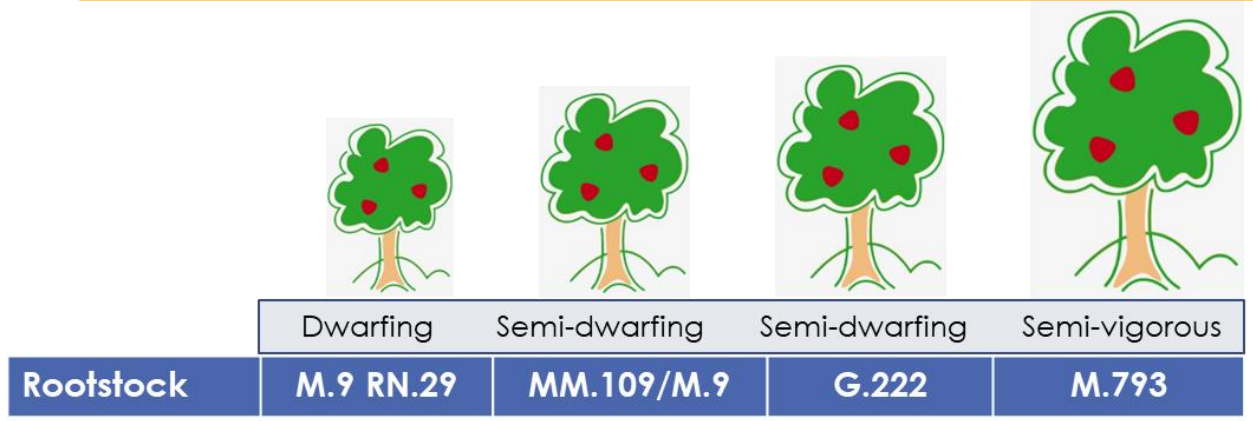


Midgley, S.J.E., Lulane, E.B., Volschenk, T., Dzikiti, S., Ntshidi, Z., Jordaan, S.C., Lötze, E., Mobe, N.T., Wagner, N.J. (2023). Investigating the potential of fixed and draped netting technology for increasing water productivity and water savings in full bearing apple orchards under micro-irrigation. WRC Report No. 2815/1/23. WRC and Hortgro Science.

Apple water productivity – influence of rootstock

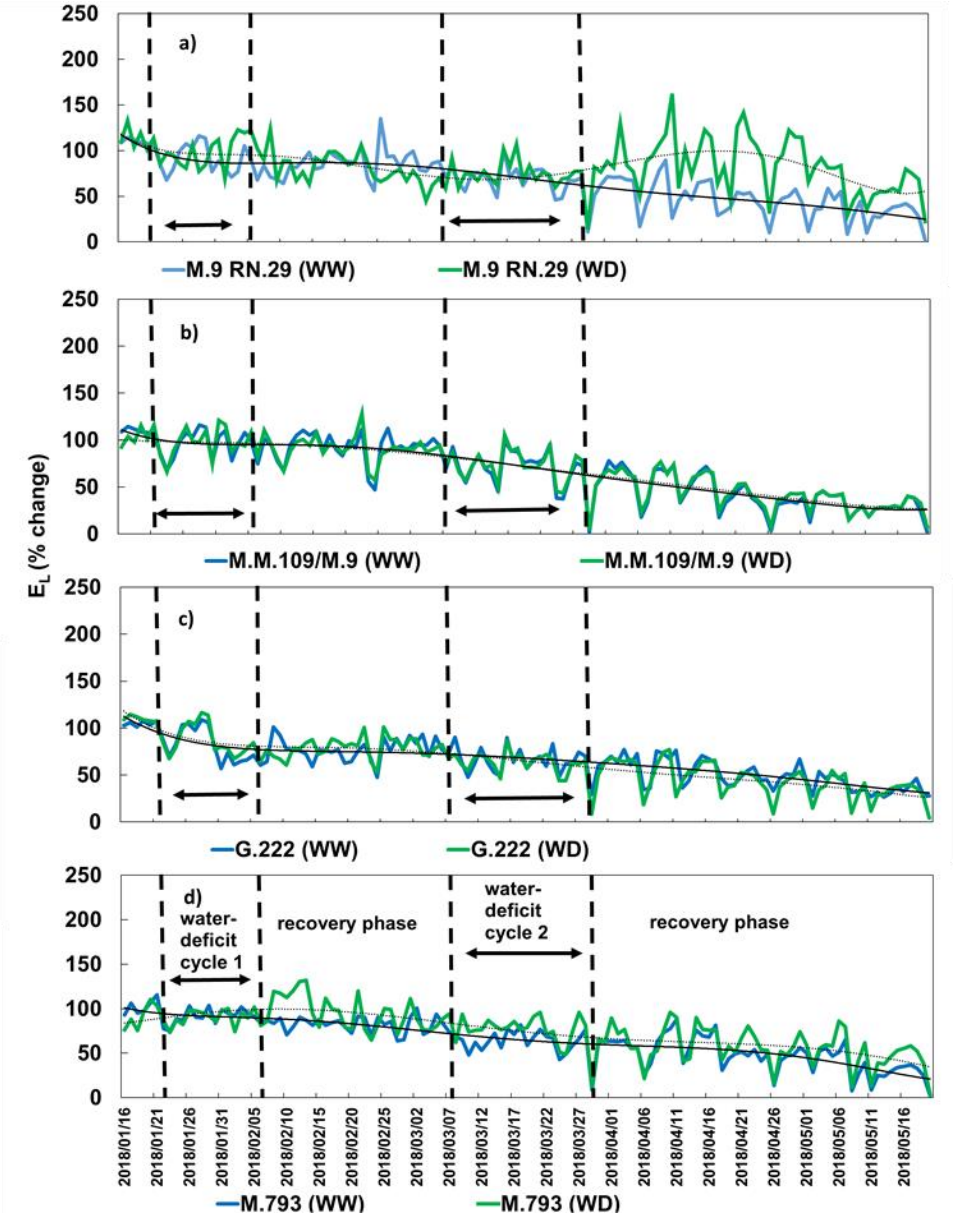
'Rosy Glow'

	Water use (L tree^{-1})	Water use (m^3 ha^{-1})	Yield (t ha^{-1})	WP-T (kg m^{-3})
M.9 RN.29	2052	4690	73.5	15.7
MM.109/M.9	3917	8950	132.0	14.8
G.222	3171	7250	102.5	14.1
M.793	3105	7260	85.6	11.8



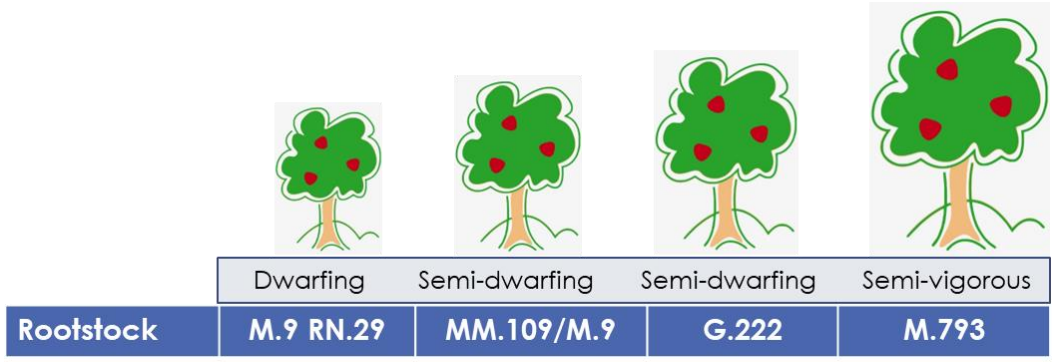
Midgley, S.J.E., Muchena, L., Dzikiti, S., Lötze, E. (2023) Sensitivity of various apple rootstocks to water stress. Project No. A-17-USH-CP01, Hortgro Science.

Key message 5: More dwarfing rootstocks are not more sensitive to drought stress in the field



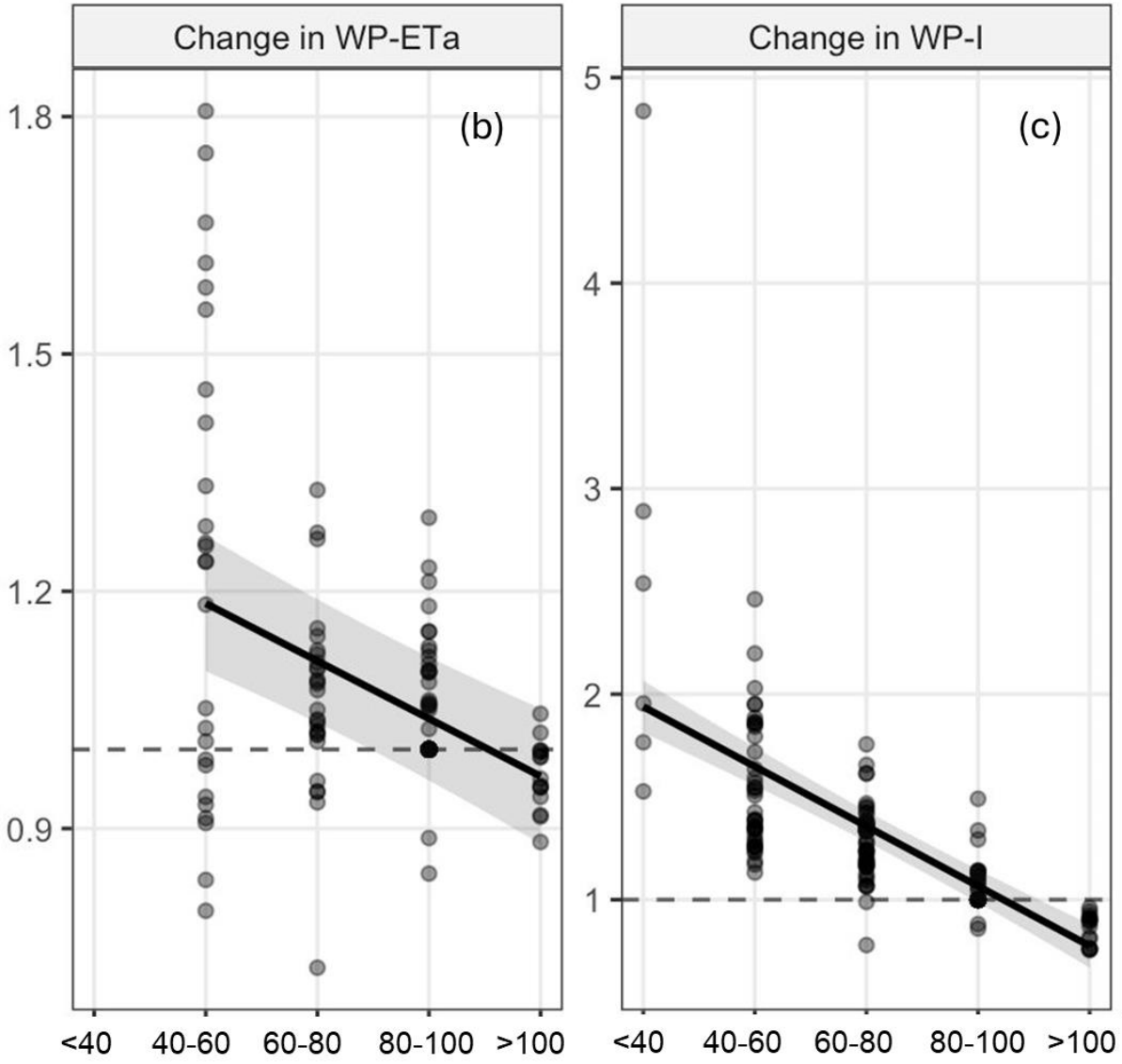
'Rosy Glow'

- Four apple rootstocks. Two drought cycles in mid- to end-summer.
- Transpiration of field-grown trees was not reduced by water deficit.
- The use of M.9 RN.29 in high-density plantings could result in a significant saving in irrigation water and a high water productivity.



Midgley, S.J.E., Muchena, L., Dzikiti, S., Lötze, E. (2023) **Sensitivity of various apple rootstocks to water stress.** Project No. A-17-USH-CP01, Hortgro Science.

Key message 6: Water Productivity in worldwide temperate deciduous orchards is increased through application of deficit irrigation



Irrig. Category (% full irrig.)	WP-ET_a change (%)	WP-I change (%)
<40	-	+94
40-60	+18	+65
60-80	+11	+36
80-100	+4	+7
>100	-3	-22

Midgley, S.J.E., Taylor, N.J., Dzikiti, S., Maphosa, B., (current) Practical guide to increasing crop water productivity in deciduous fruit orchards in South Africa. Project No. NP4-2024, Hortgro Science.

Key message 7: Applying the learnings to orchard- and farm-level realities

- Easy to measure variables (yield, value, irrigation volume, rainfall) are recommended for **monitoring of orchard- and farm-level WP-TWU and EWP-TWU** and systematic analysis of progress in raising WP against local benchmarks.
- **The Paradox of Irrigation Efficiency**: Higher efficiency rarely reduces water consumption and does not necessarily confer greater drought resilience.
- **Irrigator decisions** are based on on-farm trade-offs, the relative scarcity and cost of water compared to land and other inputs, and incentives.




thank you | enkosi | dankie