The water-use of fruit tree orchards:

Project Update

Mark Gush – CSIR
Nicky Taylor – Univ. Pretoria
Sebinasi Dzikiti – CSIR
Teunis Vahrmeijer – CRI / UP
John Annandale – Univ. Pretoria
Gerhard Backeberg - WRC

WATER RESEARCH COMMISSION

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

100 1908 - 2008
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

cri citrus research international

CSIR
our future through science

The water-use of fruit tree orchards

Water-use of fruit tree orchards - WRC Project K5/1770

The challenge

- Agriculture uses ±60% of surface water in South Africa
- 90% of fruit production is dependent on irrigation
- Increasing water stress & competition: How to use less water without reducing fruit quality and yield?
- Traditional soil moisture methods are indirect & less accurate (percolation / evaporation)

The research and development

- Measurement of transpiration and total evaporation of fruit trees and orchards using new instrumentation and techniques
- Long-term monitoring across wide-ranging sites for priority fruit tree species
- Development of water-use models & crop factors for optimum irrigation scheduling in fruit tree orchards

WATER RESEARCH COMMISSION
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
agriculture, forestry & fisheries
citrus research international
CSIR
our future through science

The water-use of fruit tree orchards

The approach

- **Project** duration April 2007 to March 2014 (7 years)
- **Reviewed** international knowledge on the water use of fruit trees
- **Ranked** & selected the most important fruit tree species in SA
- **Selected** min of 4 fruit tree species incorporating sub-tropical & deciduous species in winter and summer rainfall areas (pome, stone, citrus and nut varieties) - TOR
- **Measured** unstressed water use & additional variables for up to 2-years in the field at each site
- **Testing** the most appropriate crop water use model(s) for the selected fruit tree species.
- **Deriving** monthly Crop Coefficients (K_{cb} & K_c) for each species
- **Disseminating** information to IAPs (ongoing)

WATER RESEARCH COMMISSION

100 1908 - 2008 UNIVERSITEIT VAN PRETORIA UNIVERSITY OF PRETORIA YUNIBESITHI YA PRETORIA

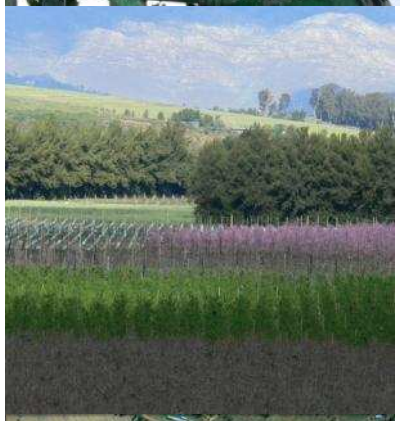
agriculture, forestry & fisheries

cri citrus research international

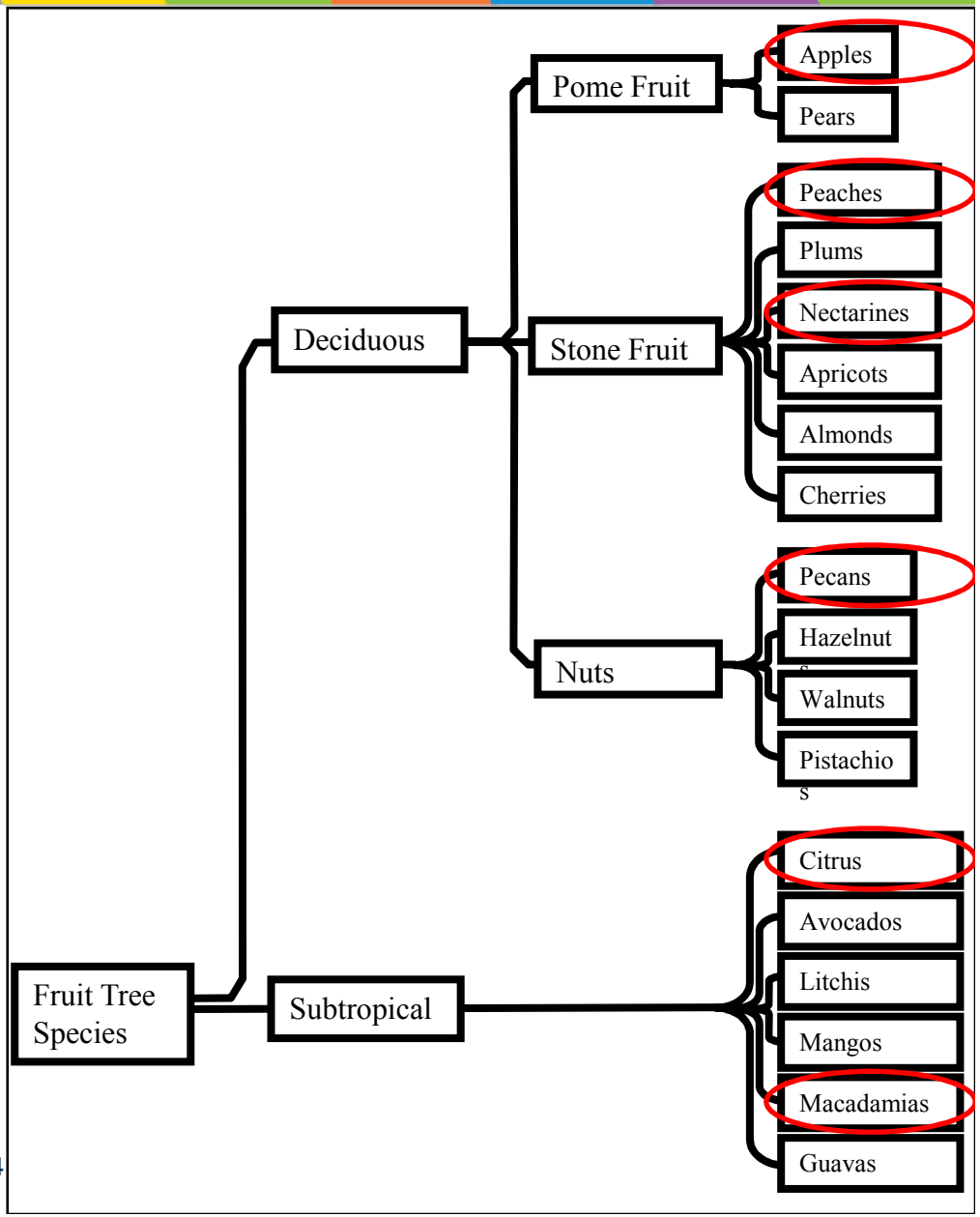
CSIR our future through science

The water-use of fruit tree orchards

Species selection



- Listed main fruit tree species grown in South Africa (excluding grapes and berries)
- Distinguished between sub-tropical and deciduous species
- Banana & papaya excluded by definition (not woody)

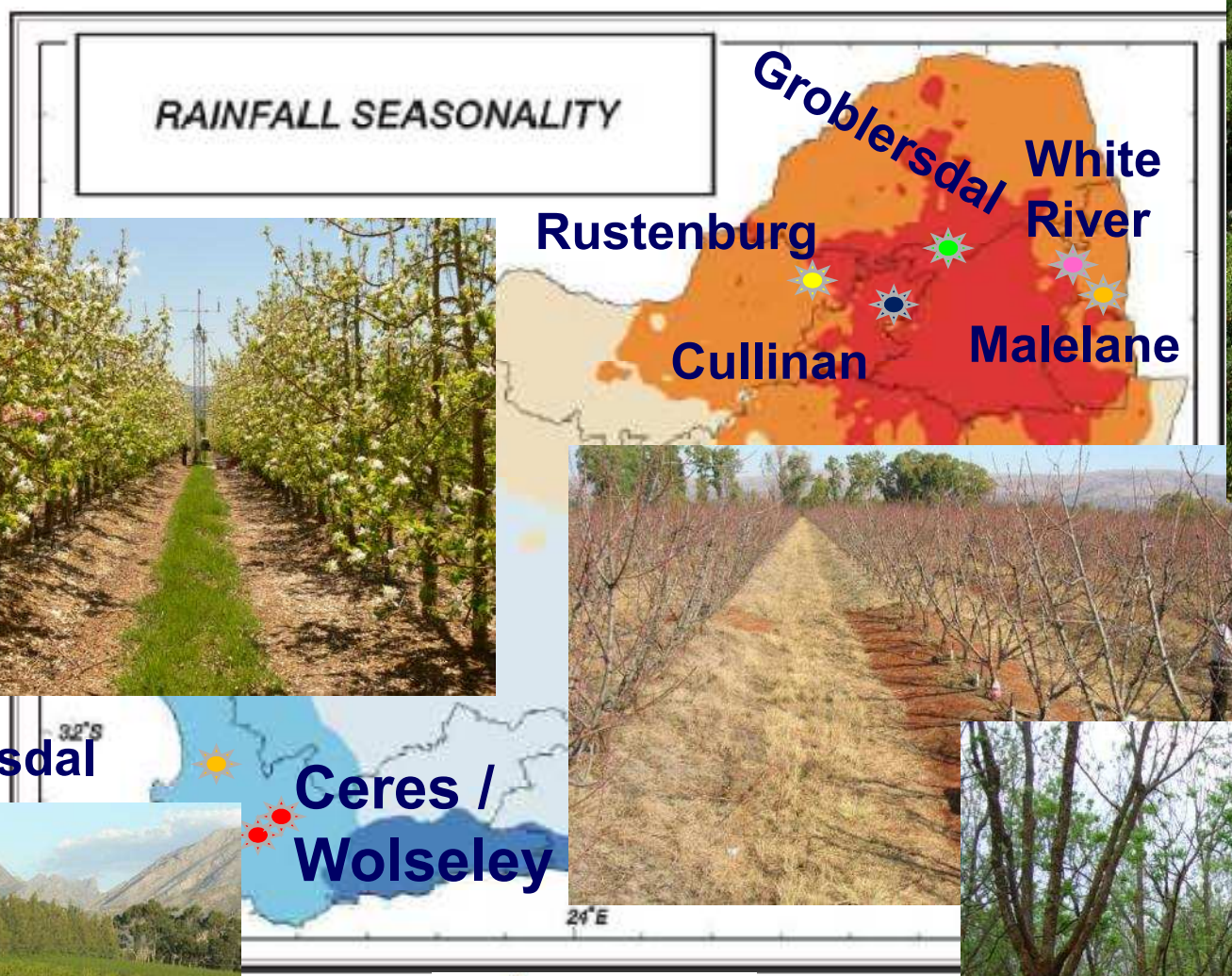


Ranking and selection

- Based on economic importance, production, hectarage & knowledge gaps
- Geographic distribution (rainfall seasonality) & species category (deciduous vs. sub-tropical) considered throughout - TOR
- Preference for farms with best management practice
- Selected widest possible range of priority fruit tree species within constraints of project – pome, stone, citrus and nut species

The water-use of fruit tree orchards

Study Sites



www.csir.co.za

The water-use of fruit tree orchards

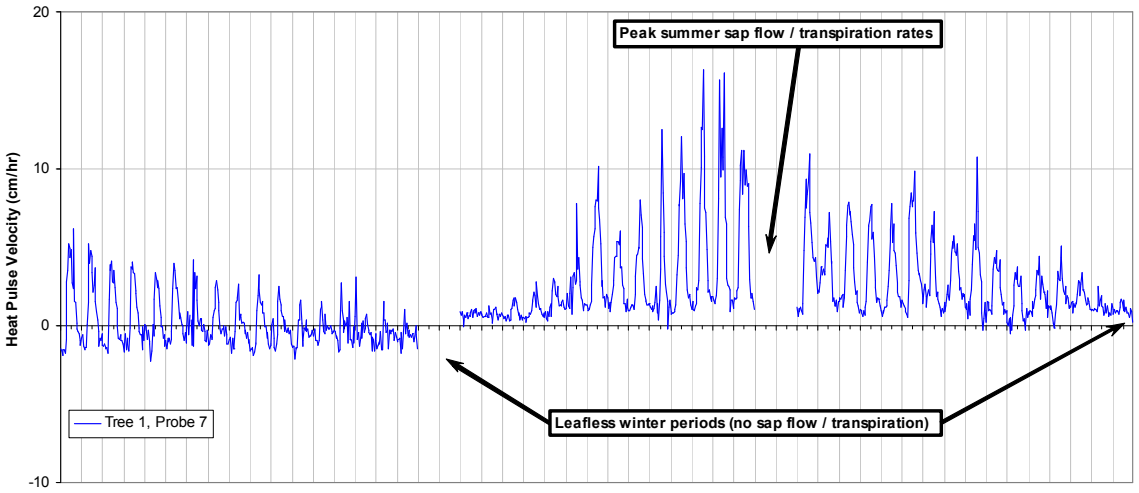
Methods

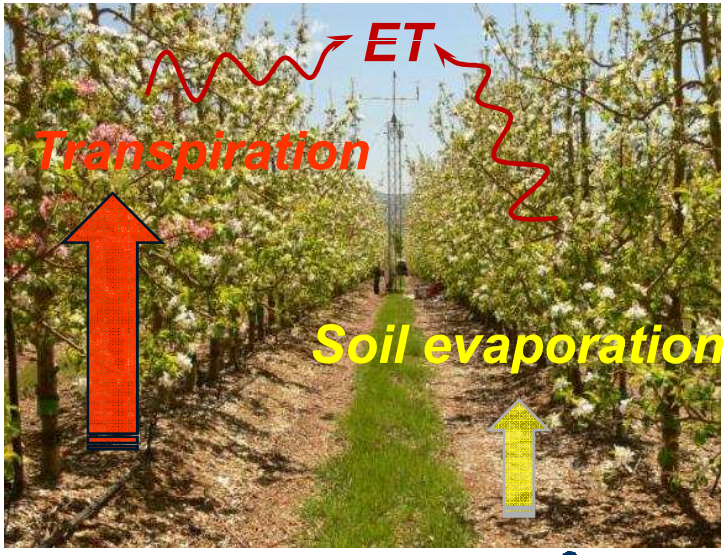
Measurements

- Full suite of climatic variables using Automatic Weather Stations (AWS) – Reference ET_o
- Sap flow / transpiration (Heat Pulse Velocity technique) – 2-yrs of continuous hourly measurements
- Total orchard evaporation (Eddy Covariance technique) – seasonal
- Irrigation applications (Timing and amounts) and soil water variation - continuous
- Structural (e.g. dimensions), physiological (e.g. xylem anatomy) and phenological (e.g. timing of bud-burst, flowering, fruiting and leaf area) characteristics and changes of the various fruit tree species over time
- Regular site visits to check systems, change batteries, download data, and record structural, physiological and phenological changes in the trees

Modelling

- Aim: to predict water use of orchards in South Africa using an existing model, or to develop a new robust model, with minimal and easily accessible input requirements
- Field measurements used to calibrate & verify simulations of annual T & ET (and E_s)
- Various models being tested(e.g. FAO56, SWB, Samani, Allen & Pereira, Dual-source transpiration & soil evaporation with Jarvis stomatal conductance sub-model)

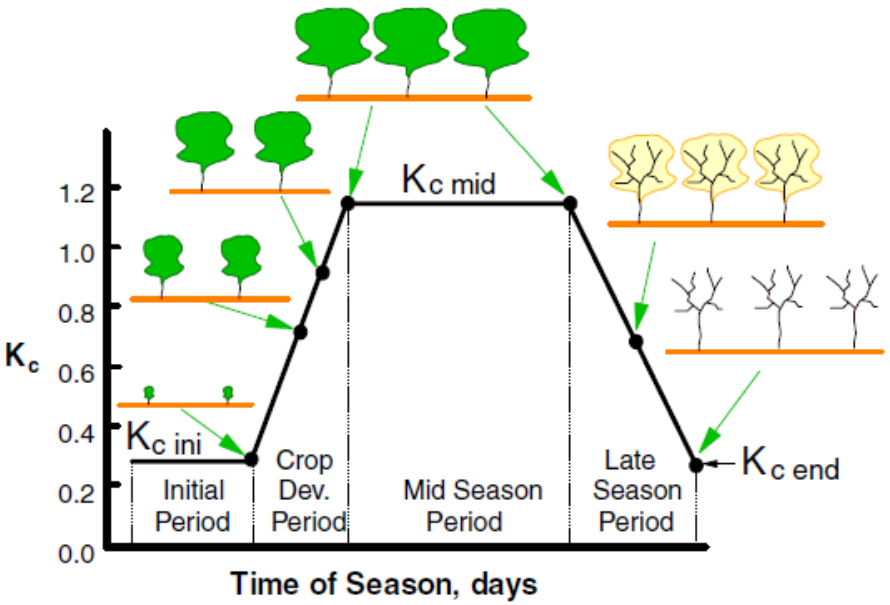


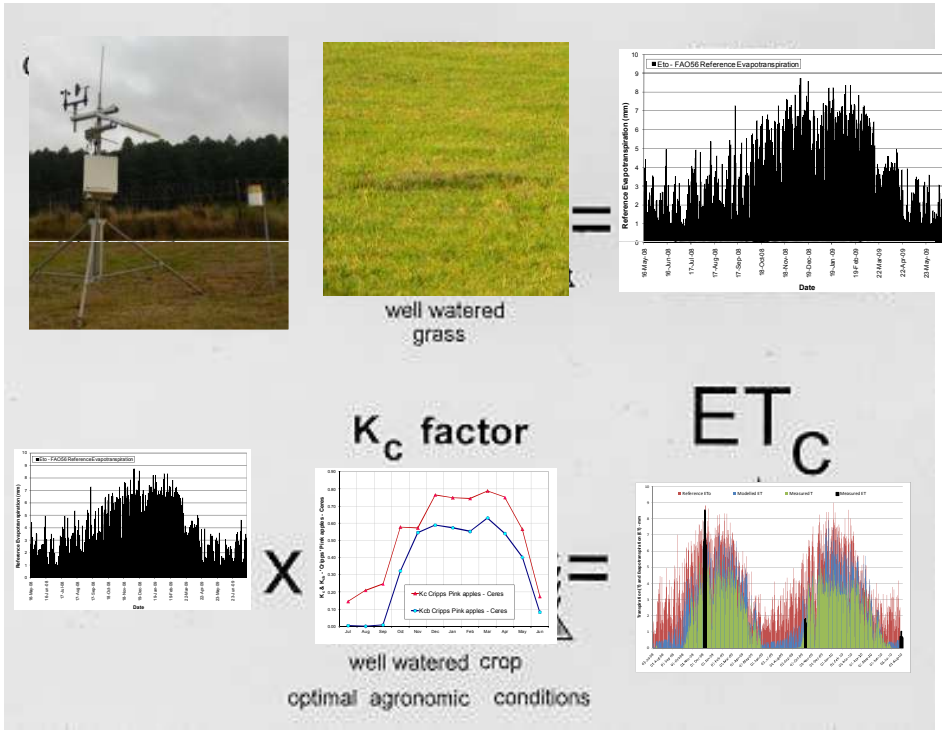


The water-use of fruit tree orchards

Modelling

- Daily values of T and ET from measurements and modelling
- Used to derive basal (K_{cb}) and full (K_c) crop coefficients for FAO56 type application





The water-use of fruit tree orchards

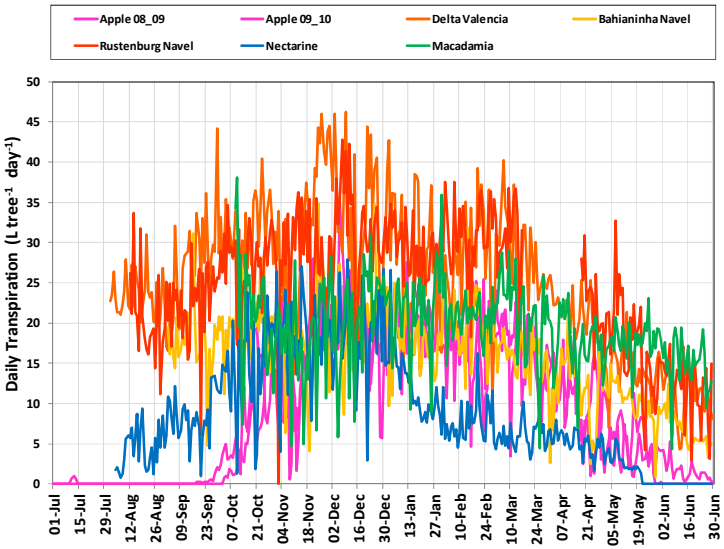
Results

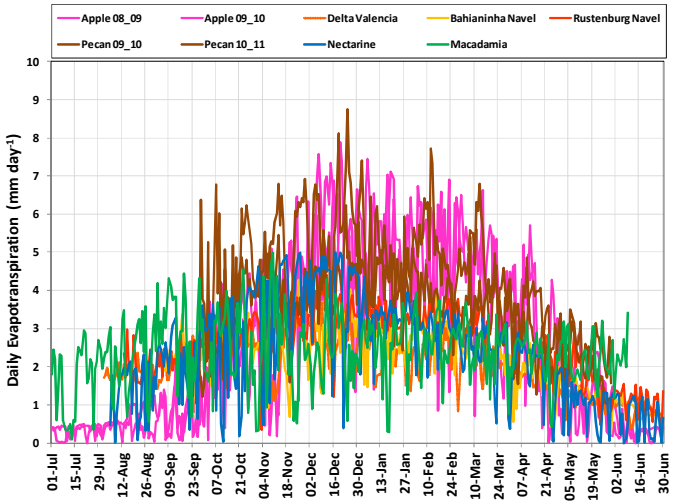
Species-specific volumes of water-use

- Daily, monthly, seasonal and annual totals(L/tree & mm)

Species-specific seasonal variation in water-use

- Links between phenology and water-use





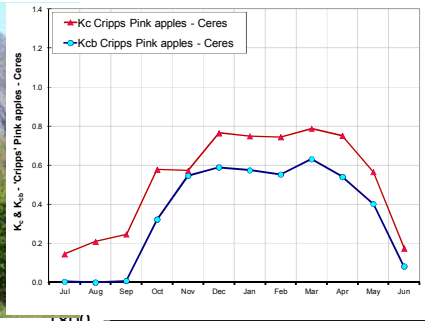
WATER RESEARCH COMMISSION

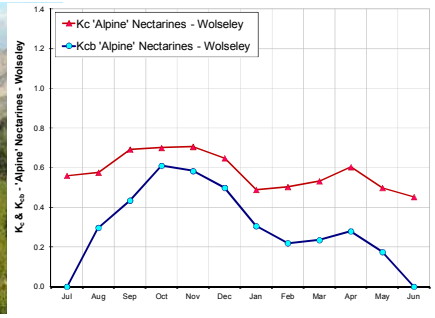
agriculture, forestry & fisheries

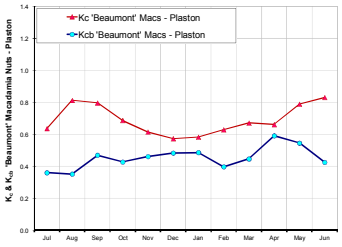
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

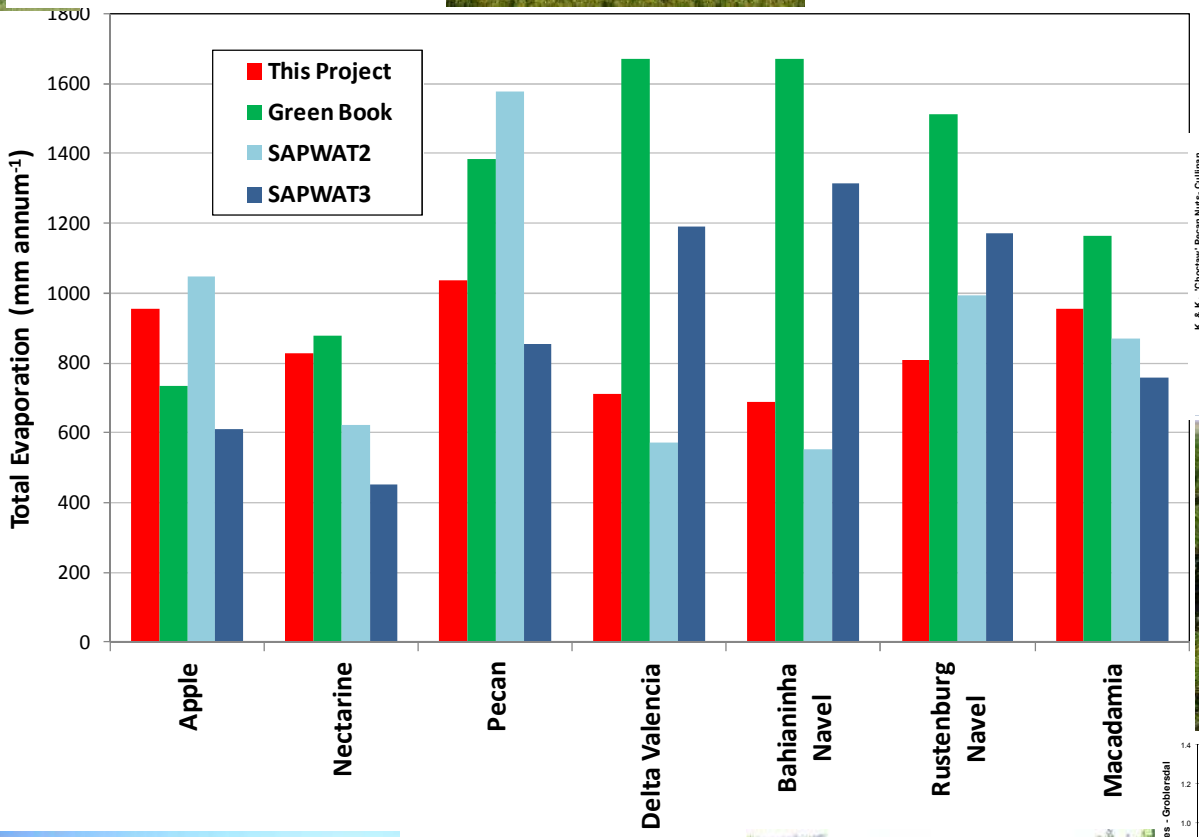
citrus research international

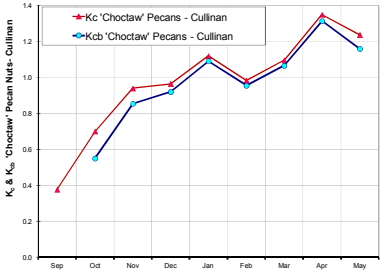
CSIR
our future through science

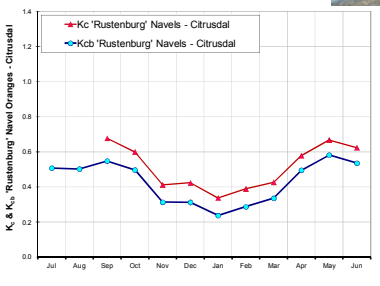

Kc Cripps Pink apples - Ceres
Kcb Cripps Pink apples - Ceres
Kc & Kcb - 'Cripps' Pink apples - Ceres
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun


Kc 'Alpine' Nectarines - Wolseley
Kcb 'Alpine' Nectarines - Wolseley
Kc & Kcb - 'Alpine' Nectarines - Wolseley
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun

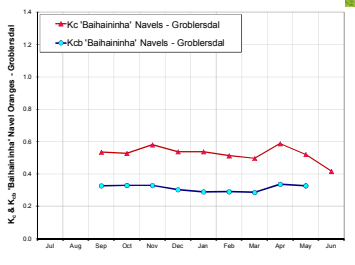

Kc 'Beaumont' Macs - Plaston
Kcb 'Beaumont' Macs - Plaston
Kc & Kcb 'Beaumont' Macadamia Nuts - Plaston
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun

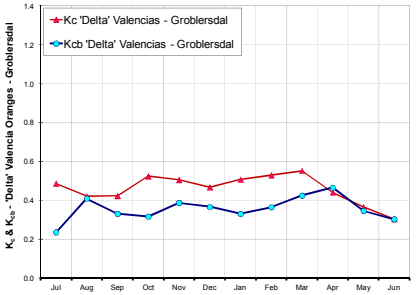

This Project
Green Book
SAPWAT2
SAPWAT3
Total Evaporation (mm annum-1)
0
200
400
600
800
1000
1200
1400
1600
1800
Apple
Nectarine
Pecan
Delta Valencia
Bahianinha Navel
Rustenburg Navel
Macadamia


Kc 'Choctaw' Pecans - Cullinan
Kcb 'Choctaw' Pecans - Cullinan
Kc & Kcb 'Choctaw' Pecan Nuts- Cullinan
Sep Oct Nov Dec Jan Feb Mar Apr May


Kc 'Rustenburg' Navels - Citrusdal
Kcb 'Rustenburg' Navels - Citrusdal
Kc & Kcb 'Rustenburg' Navel Oranges - Citrusdal
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun

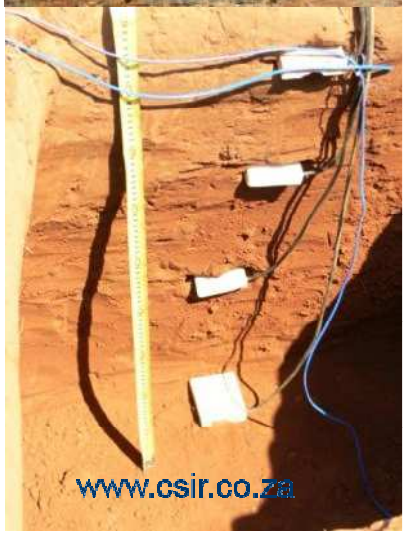

© CSIR


Kc 'Baihaininha' Navels - Groblersdal
Kcb 'Baihaininha' Navels - Groblersdal
Kc & Kcb - 'Baihaininha' Navel Oranges - Groblersdal
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun


Kc 'Delta' Valencias - Groblersdal
Kcb 'Delta' Valencias - Groblersdal
Kc & Kcb - 'Delta' Valencia Oranges - Groblersdal
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun

The water-use of fruit tree orchards

Conclusions



Outcomes

- Improved fruit tree water-use knowledge, crop factors & models
- Transpiration (mm) ≠ Irrigation (mm) due to <100% IE

Uptake

- Workshops, farmer info days & publications

Potential Impact

- Improved on-farm water management and irrigation scheduling
- Increased water-use efficiency through distinction between beneficial (T) & non-beneficial (ET-T) water-use
- Informed water allocation calculations (m^3/ha)
- Water footprint / Virtual water / Sustainable farming assessments

Way Forward

- Requirement for comprehensive AWS network (for Et_o)
- Ongoing liaison with DAFF, DWA, Irrig. Boards, Grower Assoc.'s
- Explore possibility to broaden measurements to extra species

Acknowledgements

- Funding - Water Research Commission & Dept. Agric. Forestry & Fisheries
- Project Team and students:
  - Seb Dzikiti & Vivek Naiken (CSIR)
  - Nicky Taylor, John Annandale & Teunis Vahrmeijer (Univ. Pta / CRI)
  - Alistair Clulow, Caren Jarmain, Michael Mengistu, Colin Everson
  - Nadia Ibraimo, Walter Mahohoma, Solomon Gezehei, Eunice Avenant, Hestia Pienaar
- Farmers & Farm Managers:
  - Louis Reynolds, Arno Marais, Danie du Plessis, Leon de Kock, Albert Baumeester, Jaco Burger, Hendrik Schoeman, Deon de Kok, Corli

Thank you!

WATER RESEARCH COMMISSION

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

100 1908 - 2008
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

cri citrus research international

CSIR
our future through science