GROWING FRUIT WHERE WATER RESOURCES ARE LIMITED - A SOUTH AFRICAN PERSPECTIVE -

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INTRODUCTION

- Water resources are generally limited
- Due to Mediterranean climate, summer rainfall alone is too low

Table 1. Long term mean annual rainfall in selected fruit growing districts in the Western Cape.

Region	District	Rainfall (mm)		
		Autumn & winter	Spring & summer	Total
Elgin	Grabouw	645	366	1011
Coastal	Stellenbosch	490	254	744
	Piketberg	580	263	843
Breede River	Tulbagh*	392	182	574
	Robertson	164	116	280
Little Karoo	Montagu	176	149	325
	Barrydale	204	154	358

* Where most prunes are grown in South Africa.

INTRODUCTION…..

- Fruit production depend on boreholes, winter water stored in dams on farms or government irrigation schemes
- Water restrictions imposed during droughts that occur periodically
- If climate change result in warmer, drier summers, it will increase the dependency of fruit production on irrigation water
- Water Act enables CMA's to terminate water use licences if growers misuse their allocated water resources
- A general reduction in the water "footprint" of irrigated crops will improve the image of irrigation farmers
- Foregoing factors are encouraging growers to adopt practices which will contribute towards more efficient utilization of irrigation water

INTRODUCTION…..

- Water use efficiency of crops can be defined in more than way
- Relationship between yield and the amount of irrigation water applied will be expressed in terms of Irrigation Water Productivity (IWP)
- IWP is calculated by dividing the yield (kg) per hectare by the volume of irrigation water (m^3) applied per hectare
- However, ratio between fresh mass of fruit produced and a unit of irrigation water can be misleading
- Objective should either be to produce more fruit using the same volume of irrigation water, or……
  to produce the same yields using less water under a given set of climatic, soil and horticultural conditions

INTRODUCTION…..

- Transpiration and evaporation from the soil are the primary components of evapotranspiration (ET)
- Reduction in transpiration will result in lower fruit production and/or quality
- Evaporation losses from the soil (E_s) do not necessarily affect yields
- Consequently, reduction of E_s is the more logic way to improve IWP of permanent row crops

OBJECTIVE OF PRESENTATION

1. A brief introduction to evaporation losses from the soil (E_s)
2. Soil preparation
3. Irrigation system
4. Soil surface management
5. Quality of plant material
6. Irrigation strategies
7. Irrigation monitoring

} will be discussed with respect to the direct, or indirect, improvement of IWP

- Unfortunately, the relevant technologies were mostly developed in field experiments with grapevines or fruit crops other than prunes

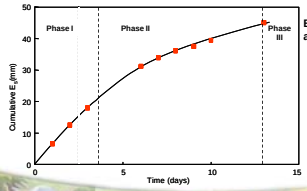
OBJECTIVE OF PRESENTATION…..

- However, basic principles concerning soil and water management will be applicable to most fruit crops, including prunes
- Furthermore, orchards and vineyards are situated next to each other in similar soils on many farms
- Basic soil and water management strategies are likely to have similar effects in orchards and vineyards

DISCUSSION

1. Evaporation from the soil surface

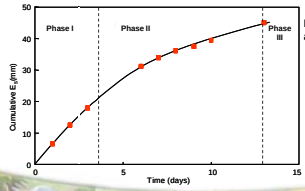
- After rain or irrigation, initial E_s from the wetted soil surface may be divided into three distinct phases
- During Phase I, the rate of E_s is mainly influenced by the prevailing atmospheric conditions
- The warmer and windier, the higher the rate of E_s
- E_s almost equates to evaporation from a free water surface



Example of cumulative E_s after irrigation and/or rain (Myburgh, 1998).

1. Evaporation from the soil surface…..

- Phase I persists normally up to three days depending on the soil type and atmospheric conditions
- During Phase II, the E_s rate is governed by the physical characteristics of the soil, *e.g.* hydraulic conductivity
- E_s in Phase II is therefore considerably lower compared to Phase I
- In Phase III, the soil is so dry that water flows in its vapour phase. E_s is small compared to the first two phases and does not contribute to ET



Example of cumulative E_s after irrigation and/or rain (Myburgh, 1998).

Factors affecting IWP

2. Soil preparation

- To create a favourable root environment, deep soil preparation prior to planting is essential to alleviate soil physical and chemical limitations
- It is generally accepted that 600 mm root depth is adequate if good quality irrigation water is available
- If root depths are extended to, *e.g.* 800 mm, the amount of water that can be retained will increase concomitantly

Table 2. Effect of root depth on the estimated seasonal ET of wine grapes in a sandy loam soil irrigated at 75% PAW depletion. Simulations were carried out using the VINET 1.1 model (Myburgh, 1998).

Root depth (mm)	Number of irrigations	Seasonal ET (mm)
400	19	764
600	9	534
800	5	417
1000	3	345

Reduction in the number of high E_s peaks

2. Soil preparation…..

- Physical limitations (natural compactness, shallow weathered rock, cemented pans, layers alternating in texture)
- Chemical limitations (acidity and salinity)
- Crawler tractors, *i.e.* at least D8 Caterpillars or equivalent machines, are used
- Implements are adapted to suit specific soil types


2. Soil preparation…..

- Wheel tractors can work to 800 mm if limitations are not to severe
- Rear wheels cause re-compaction in the plough furrows
- Use ripper behind rear wheel


2. Soil preparation…..

- Waterlogged conditions during late winter and early spring occur in many soils
- Planting crops in ridged topsoil will allow efficient surface drainage during rainstorms, lift the roots above the water table and enhance aeration in the root environment compared to level land
- Ridging incr… …s warmer soil conditions c…
- Ridges dry c… …crease evaporation losses from …
- Only recomm… …are impractical or where irrigat…

2. Soil preparation…..

- When preparing land for flood irrigation, laser-controlled equipment should be used for surface levelling
- This will improve water distribution when irrigations are being applied

3. Irrigation systems

- Irrigation systems have inherent water application efficiencies due to water losses that occur while irrigations are being applied

Table 3. Irrigation system efficiencies as proposed by Ley (1994).

Irrigation system	Application efficiency (%)
Flood (border, rill)	45 to 60
Sprinklers - portable	60 to 70
Micro-sprinklers	75 to 85
Drip (trickle)	85 to 90
Subsurface drip	90 to 95

- It is evident that permanent systems such as micro-sprinklers or drip will be a more appropriate choice in situations where water resources are limited

3. Irrigation systems…..

- Pressure in irrigation systems should not be too high – fine mist will increase evaporation losses

- Irrigate during night at localities where strong winds prevail during the day - if the irrigation infrastructure allows it

3. Irrigation systems……

- Evaporation losses can be reduced considerably if the irrigation water is only applied to a fraction of the irrigated land


Table 4. The effect of irrigation system on irrigation volume, yield and IWP of (non-clone) Thompson Seedless near Upington. Data are means for three seasons (Myburgh, 2003).

Irrigation system	Irrigation applied (m^3)	Yield (t/ha)	IWP (kg/m^3)
Full surface flood	12718	24.5	1.9
Furrows	7932	26.6	3.3
Irrigation in alternating rows	7386	24.6	3.3

3. Irrigation systems……


Table 5. Effect of irrigation system on irrigation volume, yield and IWP of young Sapphire plum trees near Stellenbosch (Beukes, 1999).

Irrigation system	Irrigation applied (m^3)	Yield (t/ha)	IWP (kg/m^3)
Micro-sprinklers	230	5.3	2.3
Drippers	113	5.4	4.8

3. Irrigation systems……

- Subsurface drip did not seem to have any positive effects on IWP compared to furrows and above-ground drippers

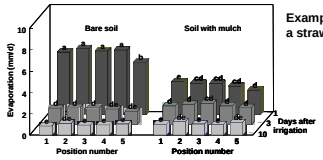
Table 6. The effect of irrigation system on irrigation volume, yield and IWP of Thompson Seedless (H5 clone) grown for dried grape production near Upington. Data are means for three seasons (Myburgh, 2007).

Irrigation system	Irrigation applied (m^3)	Yield (t/ha)	IWP (kg/m^3)
Furrows	6930	40.2	5.8
Above-ground drippers	7030	36.2	5.2
Subsurface drippers	6770	35.6	5.3

- High risk of clogging that will reduce the lifespan of the system

4. Soil surface management

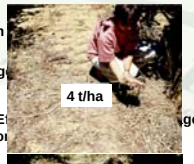
- Evaporation losses can be reduced by covering the soil surface using mulches consisting of tree bark, cereal straw or even plastic films
- It seems that mulches only reduce evaporation losses significantly during Phase I evaporation compared to bare soil
- The reduction in E_s obtained with mulching will be more pronounced in the case of high frequency irrigation

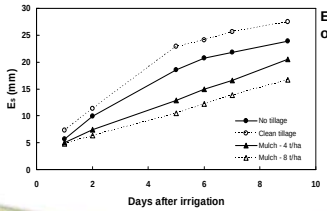


Example illustrating the effect of a straw mulch on E_s

4. Soil surface management…..

- Thicker mulches, *e.g.* 8 t/ha, will also reduce E_s more than thinner ones
- Loosening the soil surface increased E_s from
- Tillage is expensive, and will certainly damag surface layer – not recommended





4. Soil surface management…..

- Mulching will not be economically viable if the material has to be transported over long distances
- Evaporation losses from the soil surface will also be less where irrigations are applied at night time when atmospheric conditions are cooler and usually less windy than during the day

5. Plant material

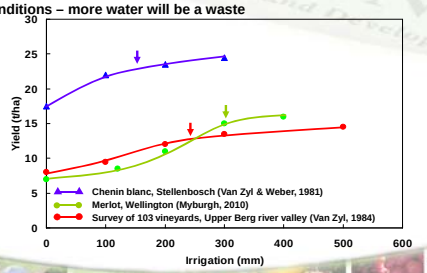
- Plant material can also determine the mass of fruit produced per unit volume irrigation water

Effect of plant material on IWP of furrow irrigated Thompson Seedless grapevines near Upington. Data are means for three seasons.

Plant material	Irrigation applied (m^3)	Yield (t/ha)	IWP (kg/m^3)
Non-clone	7932	26.6	3.3
H5 clone	6930	40.2	5.8

6. Irrigation strategy

- Yield of most permanent row crops will not increase indefinitely with the volume of irrigation water applied
- Identify the point where maximum yield for a specific species or cultivar can be obtained under a given set of climatic, soil and horticultural conditions – more water will be a waste



6. Irrigation strategy…..

- Irrigation can be reduced during periods when yield of fruit crops are less sensitive to water deficits

Table 7. Effect of water deficits during different growth stages on Neethling peaches as determined over two seasons in a field trial near Robertson (Beukes, 2002).

Stage		Sensitivity to water deficits
I	Cell growth	No effects due to mild atmospheric conditions and rainfall.
II	Slow fruit growth	Excessive vegetative growth limited, no effect on yield - *can apply deficit irrigation.*
III	Rapid fruit growth	Excessive vegetative growth limited, no effect on yield - *deficit irrigation not recommended.*
IV	Fruit ripening	Vegetative growth limited, fruit size and yield reduced - *deficit irrigation not recommended.*
V	Post harvest	No carry over effects occurred, *can apply deficit irrigation.*

6. Irrigation strategy…..

- Timing, duration and severity of the regulated water deficits that can be imposed will differ between species and cultivars
- Prevailing atmospheric conditions and plant available water in the soil will also determine the extent of the regulated deficit irrigation
- More research based information is required to determine the response of fruit crops to deficit irrigation in South Africa
- Information will also be of great value for sustainable horticulture if climate changes cause drier and/or warmer conditions

6. Irrigation strategy…..

- Irrigation applied according to open hydroponic principles (OHP) is also regarded as an irrigation strategy to improve IWP and fruit quality
- "Real time" water and nutrition requirements of crops are supplied by the application of nutrient enriched water in short pulses over the course of the day
- OHP strategy had no yield and quality advantages over conventionally fertigated apple trees near Grabouw (T. Volschenk)
- OHP strategy did not improve table grape yield and quality of table grapes to such an extent that it could justify the high cost of equipment and management inputs (P. Myburgh, unpublished data)

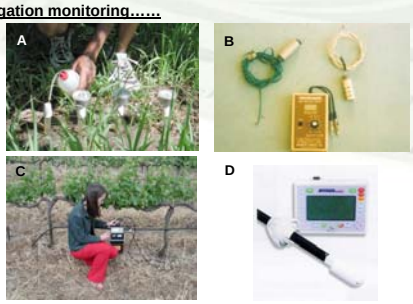
6. Irrigation strategy…..

- There are numerous claims that irrigation according to the partial root zone drying (PRD) strategy can improve IWP
- To obtain the PRD effect, one half of a plant's root system is kept well watered while the other half is allowed to dry out
- After approximately two weeks, the irrigation is switched to the dry half
- In South Africa two field trials showed that the PRD strategy had no positive effect on the IWP of wine grapes
- In most previous studies the PRD strategy was compared to over-irrigated controls (Sadras, 2009)

7. Irrigation monitoring

- Measuring the soil water status or estimating irrigation volumes forms the basis of accurate and reliable irrigation scheduling
- Since crop coefficients are usually applicable to the ideal situation, *i.e.* when adequate water is available, measuring soil water status is a more reliable option when water saving strategies need to be implemented

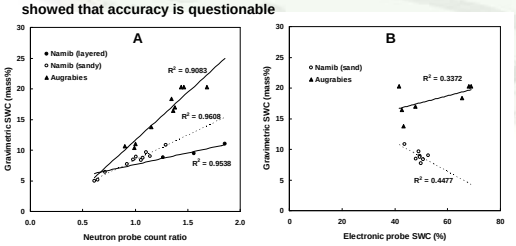
7. Irrigation monitoring……



Examples of tensiometers (A) and Watermark® (B) sensors used to measure soil matric potential as well as portable instruments, *e.g.* CPN® neutron probe (C) and Diviner 2000® (D) used to measure soil water content.

7. Irrigation monitoring…..

- Manufacturers claim "no calibration needed", but practical experience showed that accuracy is questionable



Calibration curves for (A) neutron probe and (B) locally manufactured electronic probes against gravimetric soil water content (SWC) (P.A. Myburgh, unpublished data).

SUMMARY

- Proper soil preparation is essential to ensure deep, well developed root systems and to reduce the number of irrigations
- Choose irrigation systems that will only wet a fraction of the soil surface
- Irrigate during the night where possible
- Apply a surface mulch if cheap material is available nearby
- Using frequent tillage to reduce E_s is not recommended

SUMMARY…..

- Only use high quality plant material
- Determine the optimum yield *vs* irrigation water curve for a given situation
- Do not reduce irrigation during periods when fruit growth/yield is sensitive to water deficits – more research needed
- Monitor soil water status using accurate equipment, particularly when water deficits are deliberately induced

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Thank you for your attention