The FAO Guidelines for Water Management of Fruit Trees and Vines

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IN THE YEAR OF BIODIVERSITY, IN AGRICULTURE THE MOST ENDANGERED SPECIES IS THE FARMER

SUSTAINABILITY MEANS MANY THINGS, BUT MUST INCLUDE ECONOMIC VIABILITY
EFFICIENCY OF WATER USE CONTINUES TO INCREASE

In the USA, 41% Thermoelectric cooling
37% Irrigation
(7% less than in 2000)

ENERGY IS THE BIGGEST WATER USER!!
(not the case in the Mediterranean Basin)

USGS Report, 27-10-2009
HOW TO REDUCE WATER USE IN IRRIGATION?
YIELD RESPONSE TO WATER USE

YIELD (%) vs. CONSUMPTIVE USE (%)

- MAIZE WATER PRODUCTION FUNCTION
- FAO I&D 33 1979
- 1:1
Background

- Revision of the 1979 FAO I & D Paper no.33, “Yield Response to Water”
- Separation between field-crops and trees: AquaCrop & Guidelines

WHAT ARE THE BASIS FOR THE GUIDELINES, AND HOW CAN THEY CONTRIBUTE TO IMPROVING WATER MANAGEMENT IN FRUIT TREES AND VINES
MAIZE WATER PRODUCTION FUNCTION

The basic Transpiration Efficiency has not changed

YIELD (%) vs. CONSUMPTIVE USE (%)

FAO I&D 33
1979

Payero et al.,
2009

1:1
The irrigation methods have improved

EFFECTS OF IMPROVING DISTRIBUTION UNIFORMITY

<table>
<thead>
<tr>
<th>Relative Yield</th>
<th>100%</th>
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<tbody>
<tr>
<td>95% CU</td>
<td></td>
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<tr>
<td>70% CU</td>
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Water saved?

LOSSES
PREDICTION OF ET₀ TO MEET CROP ET₀c
TECHNICAL IRRIGATION SCHEDULING:

OPTIMAL IRRIGATION TIMING AND AMOUNTS
AFTER IMPROVING SYSTEM UNIFORMITY AND IRRIGATION SCHEDULING; WHAT IS NEXT?

REDUCE CONSUMPTIVE USE, E AND T
Yield Response to Water:
Fruit Trees and Vines
Prepared and revised by about 20 authors from California, Italy, Spain, Australia, New Zealand, Israel, Chile, Turkey, Germany,..
CONTENT

GENERAL SECTION

SPECIFIC CROP CHAPTERS (Almond, Apple, Citrus, Olive, Peach, Pear, Pistachio, Wine and Table Grapes, and, Apricot, Avocado, Kiwi, Walnut)
Chapter outline

1. Introduction and Background
2. Stages of Development in relation to Yield Determination
3. Responses to Water Deficits
4. Water Requirements
5. Water Production Function
6. Suggested RDI Regimes
7. Additional Considerations
8. Bibliography
9. Tables & Figures
4. Water Requirements

5. Water Production Function

6. Suggested RDI Regimes
WATER REQUIREMENTS
ETc = ETo x Kc x Kf

Fereres et al., 1981
Water requirements: tree crops and vines

Evolution of Kc values determined for apple in a weighing lysimeter (from GIRONA et al., 2010)
MEASURING ETc in TREE CROPS AND VINES

ALMOND LYSIMETER
Ignacio Lorite, IFAPA, Cordoba, Spain, 2009
OTHER ET MEASURING TECHNIQUES: EDDY COVARIANCE

SEPARATION OF E AND T
E from models, CALIBRATED FOR THE SOIL
T from measurements (sap flow) and models based on the PM equation and canopy conductances (which are crop specific)

For olive: Orgaz et al., 2007; Villalobos et al., 2009; Testi et al., 2006, 2008, 2009.
WATER PRODUCTION FUNCTIONS
YIELD RESPONSE TO WATER USE

YIELD (%)

MAIZE WATER PRODUCTION FUNCTION

FAO I&D 33 1979

LINEAR RESPONSE

CONSUMPTIVE USE

ETc (%)
Water Production Functions: Fruit Trees and Vines

Fruit Yield (%) vs. ETc (%)

OLIVE
A= maximum yield region with increasing drainage losses after point 1. (The soil water level increases with the amount of irrigation)

B= region of excess water reducing yield

C=region of yield maintenance with Deficit Irrigation

D= region of yield loss with Deficit Irrigation

E= region of high risks of commercial losses due to severe water stress.
COMPLEXITIES RELATED TO PRODUCT QUALITY

Diagram showing relationships between:
- Applied Irrigation Water
- Relative ET
- Relative Yield
- Relative Revenue
- Relative Price

Graph indicates:
- MAX RELATIVE YIELD at 40% Relative ET
- MAX RELATIVE REVENUE at 90% Relative ET
- MAX RELATIVE PRICE at 90% Relative ET

Relative ET ranges from 0 to 100%.
HIGH-RISK SITUATIONS

APPLIED IRRIGATION WATER

RELATIVE ETo

RELATIVE YIELD

RELATIVE PRICE

RELATIVE REVENUE
Water Production Function of Pistachio

Consumptive Use (ETc) Relative to Fully Irrigated Trees

Yield of Split Nuts Relative to Fully Irrigated Trees

Kettleman City, CA, Atlantica
Madera, CA, PG1
Parlier, CA, Atlantica
Parlier, CA, PG1
Lost Hills, CA, Atlantica
Madera, CA, Atlantica
Turkey, Uzun
Spain, Terebinthus

D A Goldhamer et al., FAO in preparation
Water Production Function for Almonds

DA Goldhamer et al., FAO, in preparation

variation in the response; why?

DIFFERENT IRRIGATION REGIMES
SUGGESTED RDI REGIMES (stress management)
MANAGING WATER DEFICITS IN IRRIGATION OF APRICOTS

THE VALUE OF MANAGING DI

WATER DEFICITS APPLIED AT CRITICAL PERIODS

Derived from Torrecillas et al., (2000)
APPROACHES TO DEFICIT IRRIGATION

CONTINUOUS OR SUSTAINED DI: a constant fraction of ETc is applied → INCREASING DEFICITS OCCUR AS THE SEASON PROGRESSES (SDI);

REGULATED DI CONCENTRATES THE WATER DEFICITS AT CERTAIN PERIODS (RDI) (THOSE WHERE YIELD IS LEAST SENSITIVE TO WATER STRESS) (Chalmers et al., (1981); Mitchell et al. (1984))
Yield per unit applied irrigation water in controls (IWP, g/l)

Yield per unit applied irrigation water under DI or PRD (IWP, g/l)

DI THROUGH PARTIAL ROOT DRYING (PRD)
(Wetting alternate sides of rows)

From Sadras, (2009)
Why does PRD work in some situations (root-limited), but not in most field conditions?

Under what conditions will it work?
WHICH ONE IS THE BEST STRATEGY?

A COMPARISON BETWEEN TWO DEFICIT IRRIGATION STRATEGIES IN PEACH: **SDI vs. RDI**; BOTH USING THE SAME AMOUNT OF WATER (2/3 of Control)
DO NOT IGNORE THE QUALITY CONSIDERATIONS
Five year Results: RDI and Control had the same yields; SDI yielded 7% less than RDI and C, on the average.
Relative Crop Value

Peach 2003

Cumulative Relative Value vs Diameter (mm)
FREQUENCY DISTRIBUTION OF FRUIT SIZE: SDI vs. RDI and CONTROLS

Peach, Cordoba, 2005

Diameter (mm)

Frecuency
In 2005, Crop Value of SDI was reduced ca. 50 percent relative to Control, even though yield decreased by only 12 percent.
RDI generally improve fruit quality

Post-harvest behavior
4th week after harvest

Fruits of poor commercial quality
(12 sept 2005) (%)

RDI 29
SDI 46
RF 25
RM 33
\[ y = 0.0423x + 95.958 \]
\[ R^2 = 0.0237 \]

\[ y = 0.3945x + 60.877 \]
\[ R^2 = 0.725 \]
What is the best strategy in terms of yield response to deficit irrigation?

THE VALUE OF RDI?
IRRIGATION RESPONSE OF A FIELD
(The management unit)

APPLIED IRRIGATION WATER

ETc (%)
0
100
50
20
0

Deficit Irrigation Region

Root Zone Depletion (%)
(Averaged for the field)

SOIL WATER CONTENT

Drainage
Risks of Deficit Irrigation: The Need for More Precise Monitoring of Water Stress

The Use of New Plant and Soil Sensors
SCALING UP: Satellite imagery?

LIMITATIONS: Every 14 days; pixel size, problems with thermal sensors

Goal: monitoring irrigation management and providing advice (close to real time)
MAPS OF THE CROP WATER STRESS INDEX, CWSI

Fig. 9. CWSI map obtained from the UAV high resolution thermal imagery at 13:30 GMT on 23 August 2007.

(From Berni et al., 2009, RSE)
IMPROVING MONITORING AND MANAGEMENT

THANK YOU!