The Abdus Salam International Centre for Theoretical Physics

United Nations Educational, Scientific and Cultural Organization

IAEA International Atomic Energy Agency

2444-12

College on Soil Physics - 30th Anniversary (1983-2013)

25 February - 1 March, 2013

Introduction to AquaCrop

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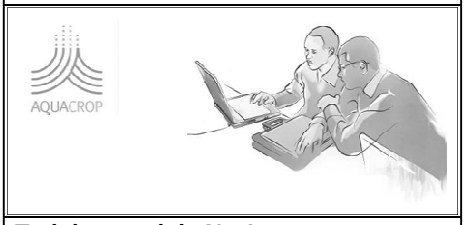
BELGIUM

Food and Agriculture Organization
Land and Water Division

Introduction to AquaCrop



Training module Nr. 1
October 2012, prepared by Dirk Raes

Structure of the presentation

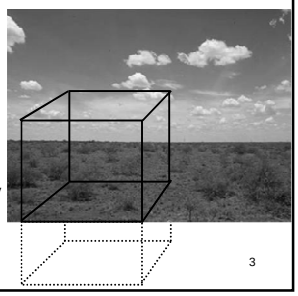
1. The AquaCrop model
2. Practical applications
3. Calculation scheme
4. Input data
5. Limitations
6. Under development

Simulation as a tool to formulate guidelines

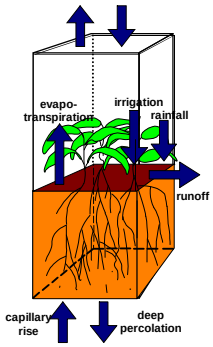
Simulation is performed by means of a ***mathematical model***

simplified representations of a particular system

part of the reality that the engineer wants to study



System: soil-plant-atmosphere continuum (SPAC)



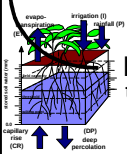
atmosphere
plant
soil

Field experiments

to asses yield response to water
before valid recommendations can be formulated the experiments should run for a number of years (different climatic conditions), by considering various planting dates, different environmental conditions, …

Calibrated/Validated model

- quickly obtain promising field management strategies
- test successful strategies in other regions/crops
- formulation of guidelines



Explanatory model (SPAC)

to asses yield response to water
Calibration/Validation

A model to assess crop yield response to water

A model is required which:

- **is based on accurate plant physiological and soil water budgeting processes**
- **is widely applicable with acceptable accuracy**
- **require only commonly available input (climatic, soil, crop and field data)**
- **allow easy verification (simple field observations ←→ simulation results)**
- **is simple to use**

AquaCrop **uses a relatively small number of parameters (explicit and mostly intuitive) and attempts to balance simplicity, accuracy and robustness.**

Structure of the presentation

1. The AquaCrop model
2. Practical applications

7

INPUT
environmental conditions

OUTPUT
biomass and crop yield for given environmental conditions

- various weather conditions
- selected crop
- selected soil
  - Soil profile
  - Groundwater table
- various management conditions
  - field management
  - irrigation management

understand crop responses to environmental changes

8

conditions	
rainfed	irrigation

The model is useful

- to understand crop responses to environmental changes (educational purposes);
- to design optimum management practices;
- to develop irrigation strategies under water deficit conditions
- to compare attainable against actual yields (benchmark tool);
- to study the effect of climate change on food production,
- to analyze scenarios for policy makers;
- to formulate guidelines for farmers;
- etc.

9

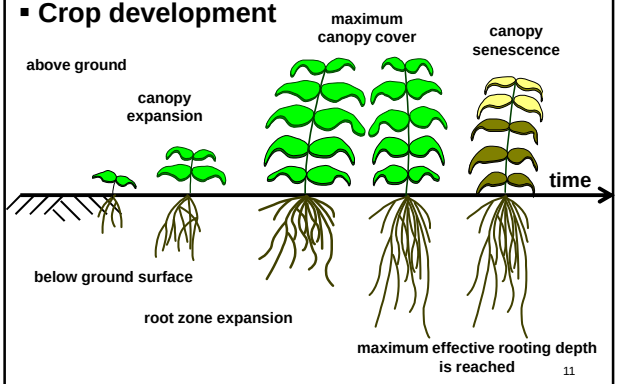
Structure of the presentation

1. The AquaCrop model
2. Practical applications
3. Calculation scheme
   - Crop development
   - Crop transpiration
   - Biomass production
   - Yield formation

10

2. Calculation scheme

- Crop development



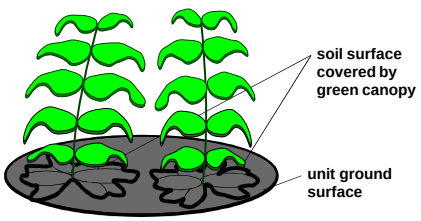
11

Instead of Leaf Area Index (LAI)
AquaCrop uses **green canopy cover (CC)**

$$CC = \frac{\text{soil surface covered by the green canopy}}{\text{unit ground surface area}}$$

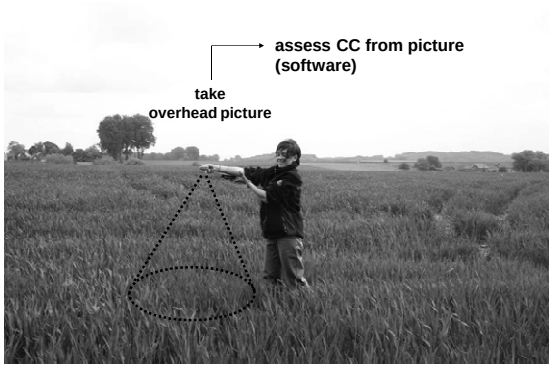
ranges from 0 (bare soil) to 1 (full canopy cover)

0 % → 100 %



12

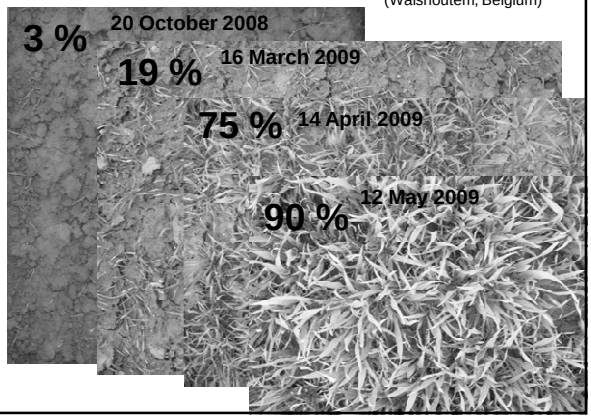
Canopy Cover ?



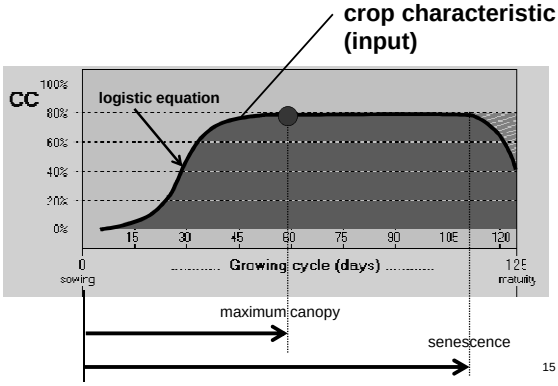
13

Green Canopy Cover (CC)

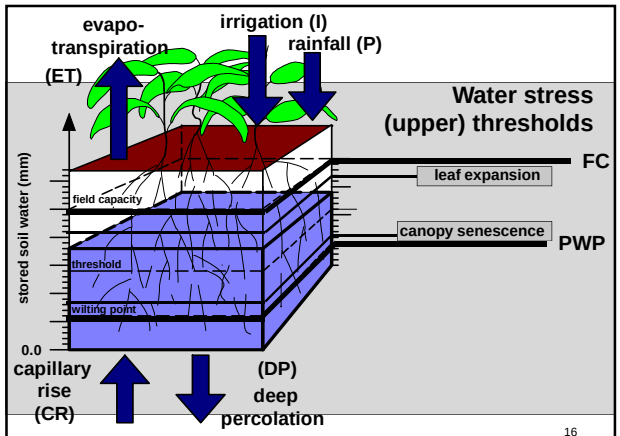
Winter wheat
(Walshoutem, Belgium)



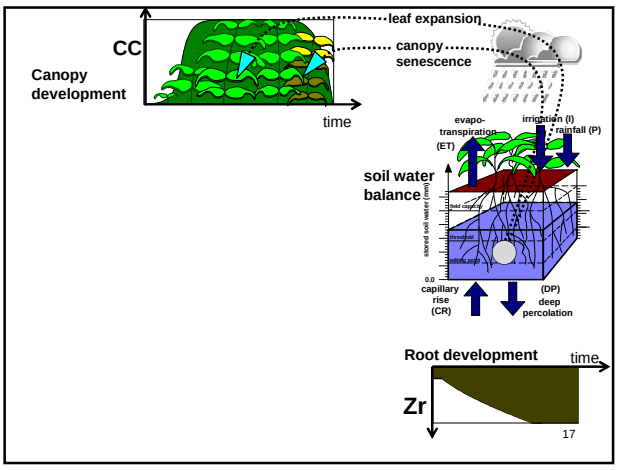
Canopy development (non-limiting conditions)



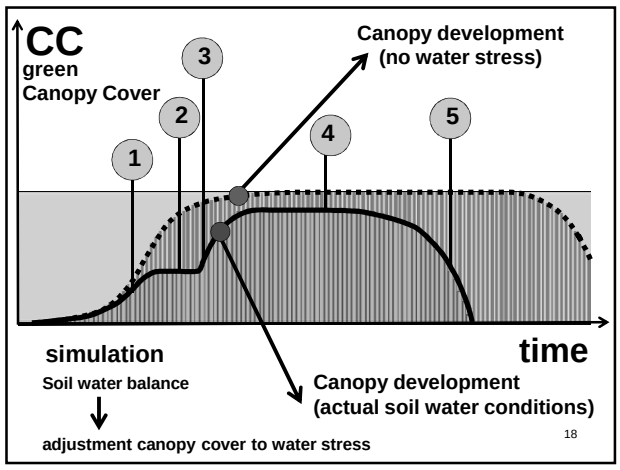
15



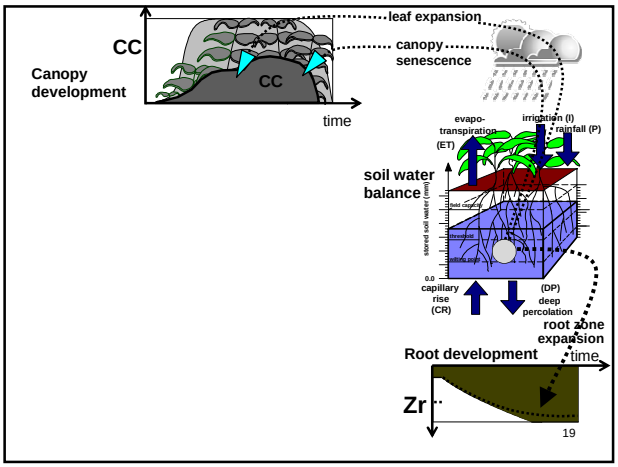
16



17



18



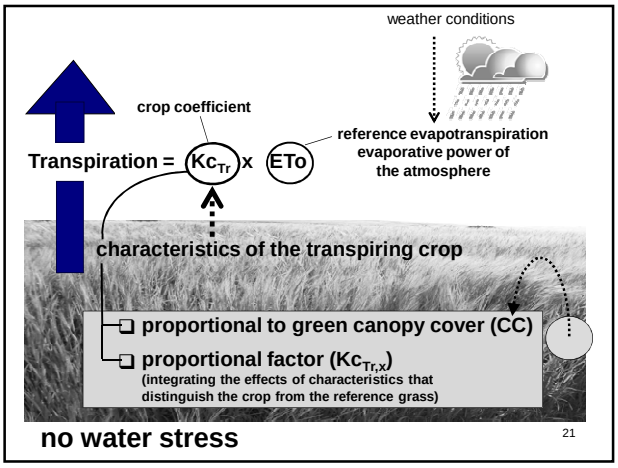
2. Calculation scheme

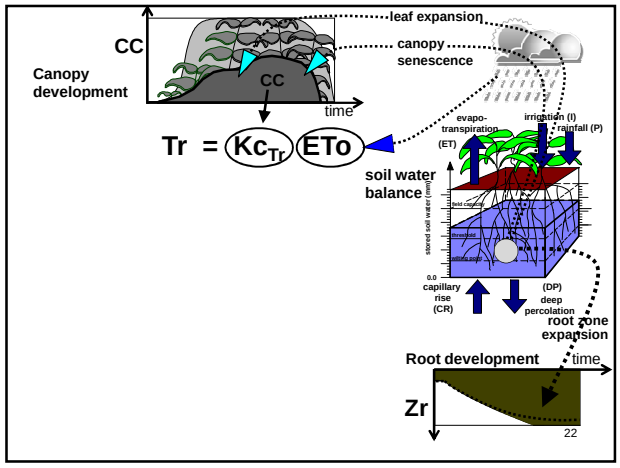
- Crop development
- Crop transpiration

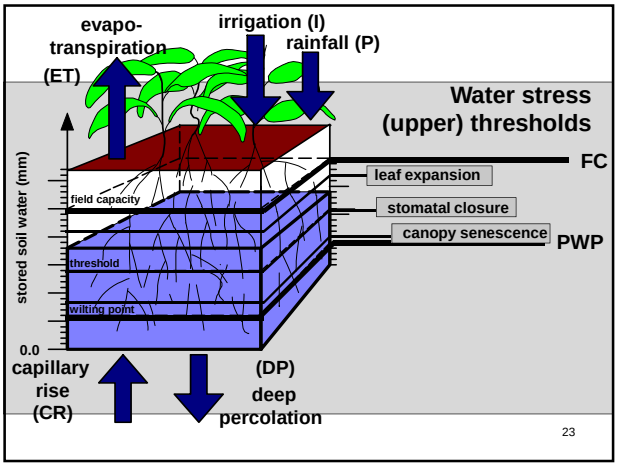
CC

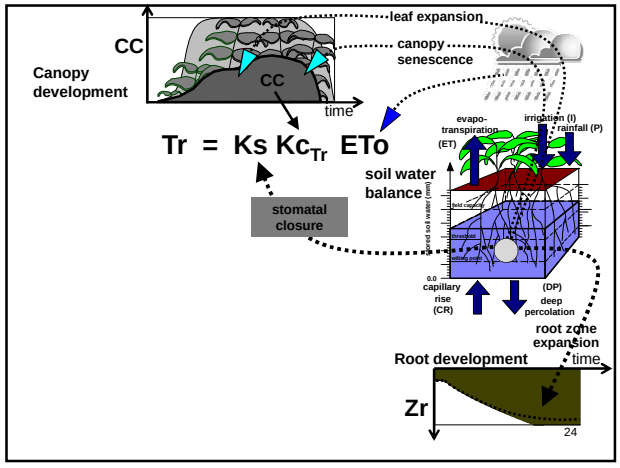
transpiration

20



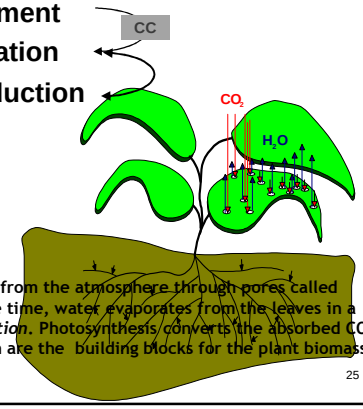






2. Calculation scheme

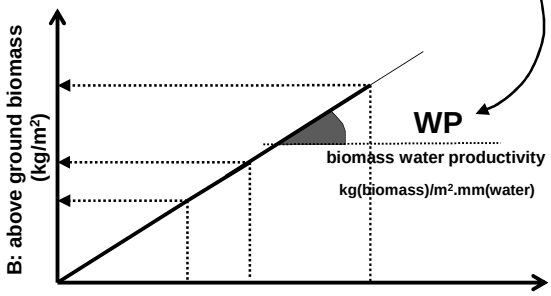
- Crop development
- Crop transpiration
- Biomass production



Plant leaves *absorb* CO_2 from the atmosphere through pores called stomata and, at the same time, water evaporates from the leaves in a process called *Transpiration*. Photosynthesis converts the absorbed CO_2 into carbohydrates which are the building blocks for the plant biomass.

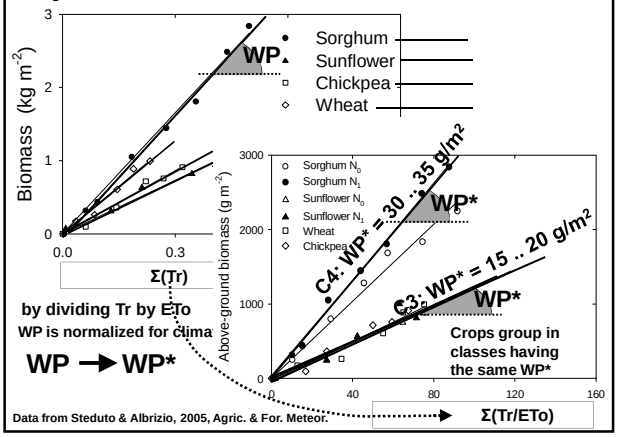
25

There exists a stable & conservative nature between ▪ Biomass (B) and
▪ Cumulative transpiration (Σ(Tr))



26

For given climatic conditions

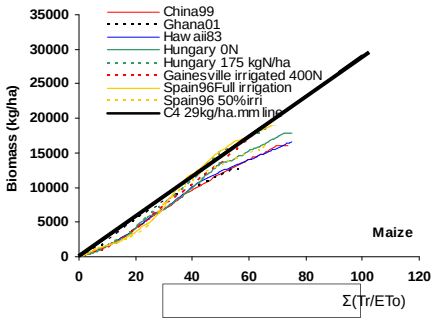


by dividing Tr by ETo
WP is normalized for clima

WP → WP*

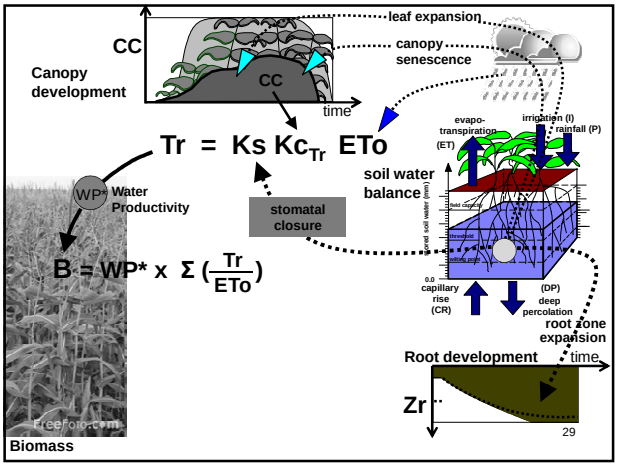
Data from Steduto & Albrizio, 2005, Agric. & For. Meteor.

WP* for maize



Data from ICASA, IAEA & UniMelb

28



29

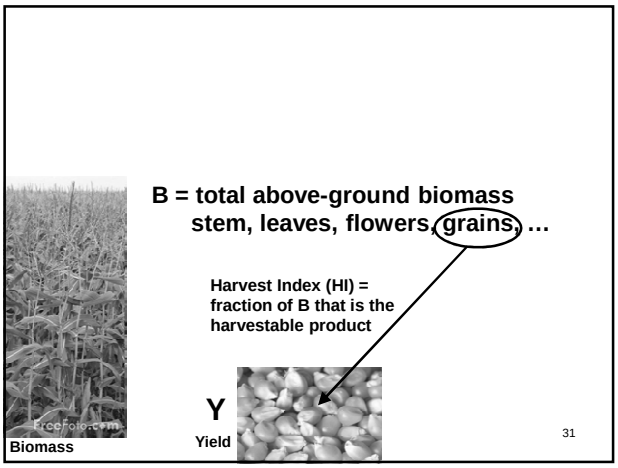
2. Calculation scheme

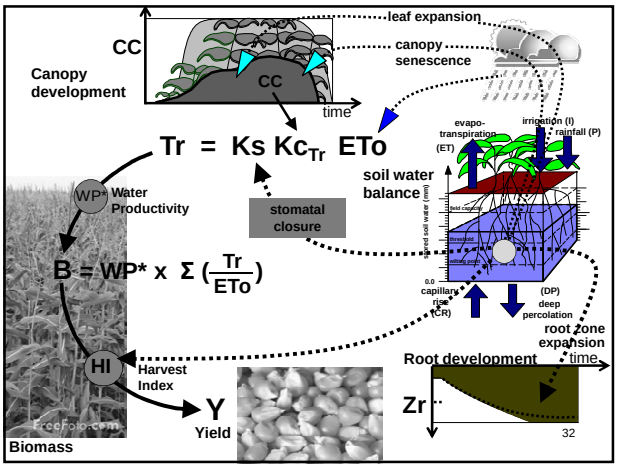
- Crop development
- Crop transpiration
- Biomass production
- Yield formation

CC

WP*

30

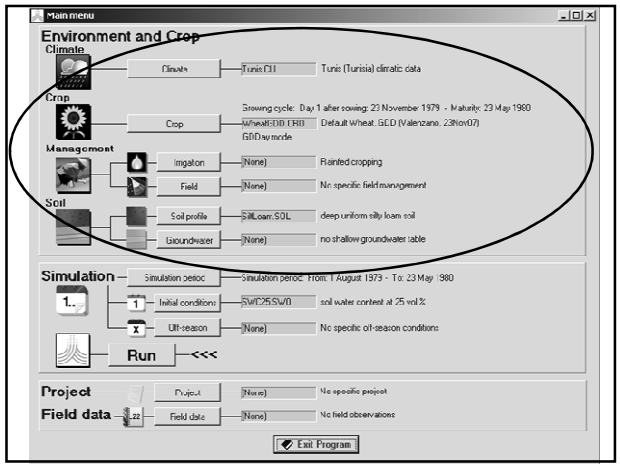


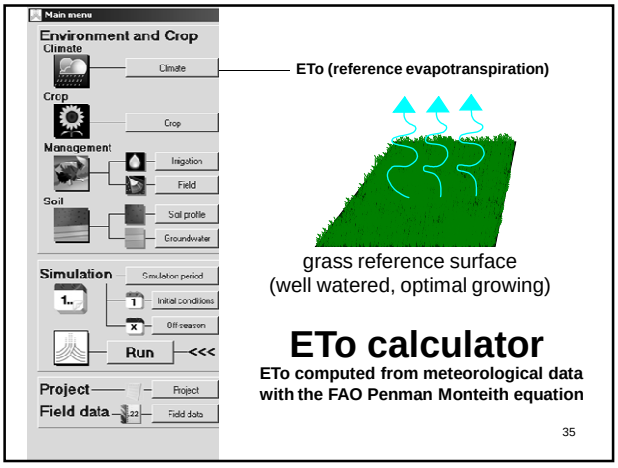


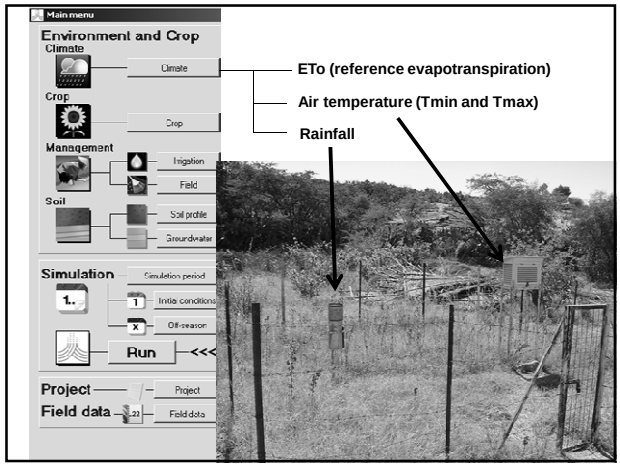
Structure of the presentation

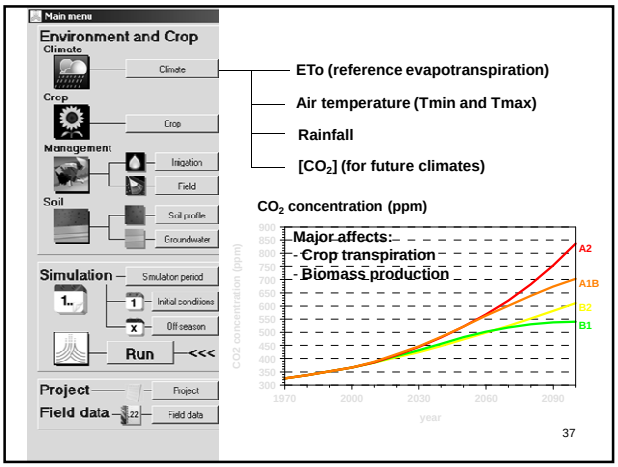
1. The AquaCrop model
2. Practical applications
3. Calculation scheme
4. Input data
   - Climate
   - Crop
   - Management
     - Field management
     - Irrigation management
   - Soil

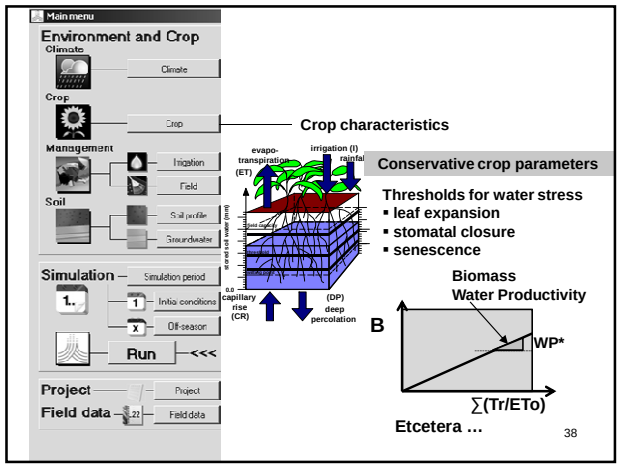
33

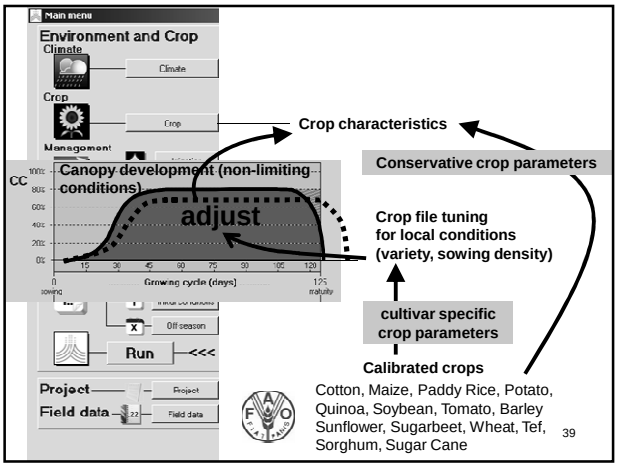


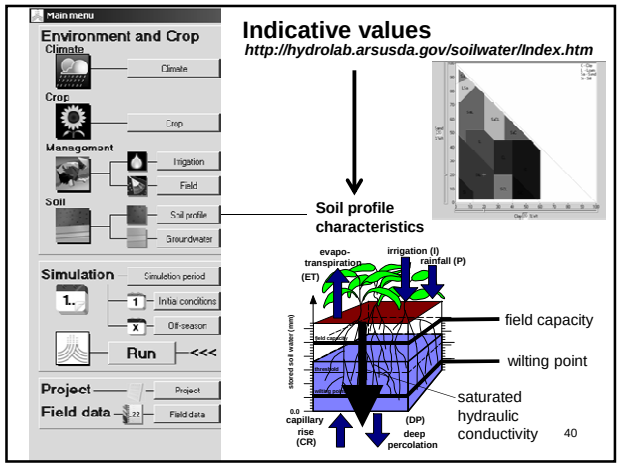


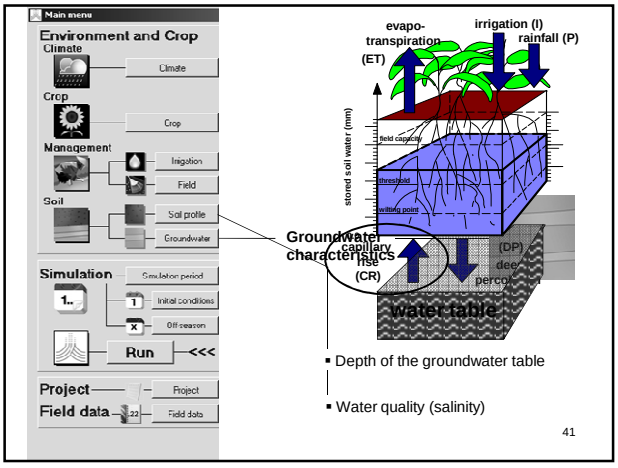


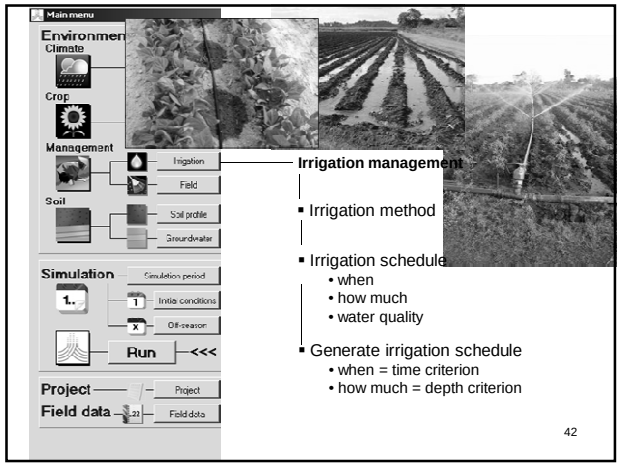

Main menu
Environment and Crop
Climate
Crop
Management
Soil
Simulation
Project
Field data
ETo (reference evapotranspiration)
Air temperature (Tmin and Tmax)
Rainfall
[CO2] (for future climates)
CO2 concentration (ppm)
Major affects:
- Crop transpiration
- Biomass production
A2
A1B
B2
B1
year
37

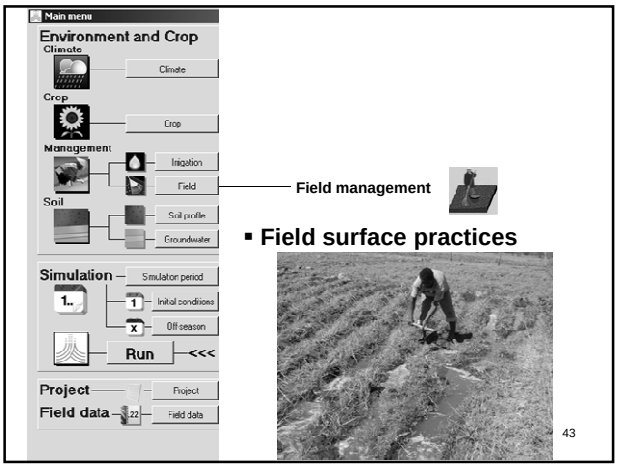

Main menu
Environment and Crop
Crop characteristics
Conservative crop parameters
Thresholds for water stress
▪ leaf expansion
▪ stomatal closure
▪ senescence
Biomass
Water Productivity
B
WP*
∑(Tr/ETo)
Etcetera …
38


Main menu
Environment and Crop
Crop characteristics
Canopy development (non-limiting conditions)
CC
adjust
Growing cycle (days)
Conservative crop parameters
Crop file tuning
for local conditions
(variety, sowing density)
cultivar specific
crop parameters
Calibrated crops
Cotton, Maize, Paddy Rice, Potato, Quinoa, Soybean, Tomato, Barley Sunflower, Sugarbeet, Wheat, Tef, Sorghum, Sugar Cane
39

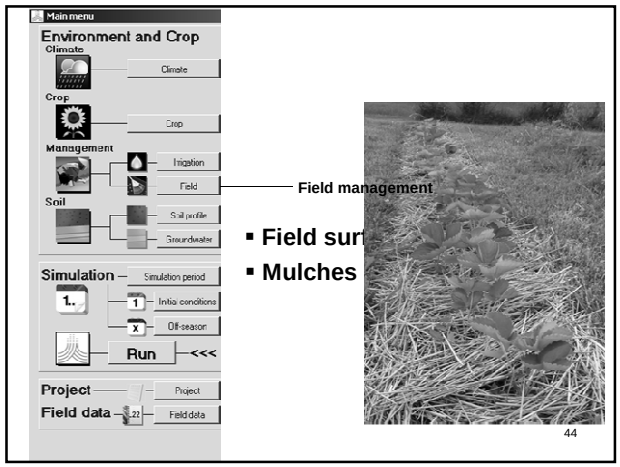

Main menu
Environment and Crop
Indicative values
http://hydrolab.arsusda.gov/soilwater/Index.htm
Soil profile
characteristics
evapo-transpiration (ET)
irrigation (I)
rainfall (P)
field capacity
wilting point
saturated hydraulic conductivity
capillary rise (CR)
(DP) deep percolation
40


Main menu
Environment and Crop
evapo-transpiration (ET)
irrigation (I)
rainfall (P)
stored soil water (mm)
Groundwater characteristics
capillary rise (CR)
(DP) deep percolation
water table
▪ Depth of the groundwater table
▪ Water quality (salinity)
41

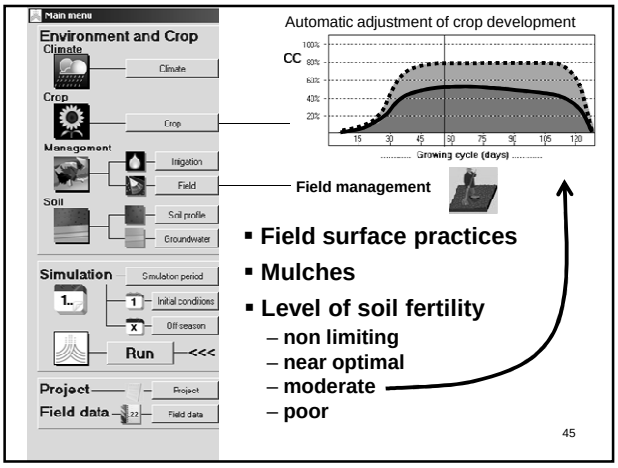

Main menu
Environment and Crop
Irrigation management
▪ Irrigation method
▪ Irrigation schedule
• when
• how much
• water quality
▪ Generate irrigation schedule
• when = time criterion
• how much = depth criterion
42



43



44



45

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1. The AquaCrop model
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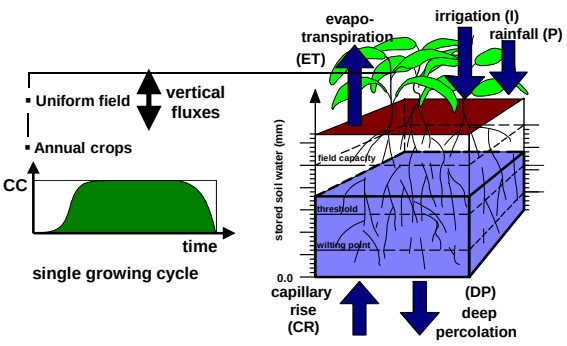
4. Input data
5. Limitations

46

5. Limitations



47

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http://www.fao.org/nr/water/aquacrop.html

- Version 3.0 – January 2009
- Version 3.1 – January 2010
- Version 3.1+ – January 2011
- Version 4.0 – August 2012
- Version 4.1 …….

48

Under development

- **Further calibration and validation of agricultural crops**
- **Forage crops (with several harvests during the season)**
- **Extra field management strategies (weed infestation, multiple crops, pests and diseases ..)**

49