Irrigation for Desert Crops

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Relevant Questions.

- When do I irrigate (Irrigation timing)?
- How much water do I apply (Required depth)?
- How do I (design and) operate my system?

- Flow
- Border length and width
- Land slope
- Cutoff (time or distance)
Elements of Efficient Irrigation

- Irrigation Scheduling (Timing and Required Depth).
- Adjustment of required depth for salt management (Leaching Requirement).
- Irrigation Design and Management (Efficient and Uniform application of Required Depth).
Irrigation Scheduling

• Irrigation is timed using a management allowable depletion (MAD), which is the acceptable depletion of soil water based on production or management constraints.

• The required depth is determined by the soil water (SWD) depletion since last irrigation adjusted for leaching requirement.

• Soil water depletion can be measured directly or estimated from weather data ($ET = kcET^0$)
Depletion of Available Water to 30 cm (%) vs. Relative Yield
Petiole Nitrate-N of Cauliflower to Irrigation

Midrib NO3-N (mg/kg)

DAP

50% ET
100% ET
150% ET
CL
Design and management

- Design and management
  - physical dimensions [design]
  - Bed slope [design]
  - inlet flow rate [design + management]
  - cutoff time (distance) [design + management]
Zero-Inertia Model
(Strelkoff and Katopodes (1977))

\[
\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} + \frac{\partial Z}{\partial t} = 0
\]

\[
\frac{\partial Y}{\partial x} = So - Sf
\]

\[
S_f = \frac{Q^2 \left( \frac{n}{C_u} \right)^2}{A^2 R^{4/3}}
\]
Inputs for Irrigation Simulation Model

- Design, management and operation variables
  - Length ($L$), Width ($W$), bottom slope ($So$)
  - Flow Rate ($Q$), Cuttoff

System Parameters

- Infiltration parameters (Kositiakov $k$, $a$, etc.)
- Resistance parameter (Manning $n$)
- Geometric parameters
Model Results

- Advance and recession curves
- Infiltrated water distribution
- Performance indices
MODKOST

- The type of infiltration function implemented is the modified Kostiakov-Lewis (parameters k, a, and fo).
- A modified version of a simple inverse solution technique known as the two point method (Elliott and Walker, 1982).
- Basic intake rate (fo) is calculated by change in surface storage at two times.
- Two equations are formed by applying principle of mass balance to two instants of time during advance phase.
Temporally and spatially averaged parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Fine</th>
<th>Mod. fine</th>
<th>Med.</th>
<th>Mod. coarse</th>
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<tr>
<td>K</td>
<td>mm/hr</td>
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<td>A</td>
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<td>fo</td>
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<td>Manning’s n</td>
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<td>Target Depth</td>
<td>mm</td>
<td>40</td>
<td>40</td>
<td>30</td>
<td>20</td>
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Comparison of model-predicted and field observed advance, silty-clay 1-02-99

![Graph showing the comparison of model-predicted and field observed advance. The x-axis represents distance (m) and the y-axis represents advance time (min). The graph includes a line labeled 'Calculated using SRFR' and data points labeled 'Field-observed'.]
Aggregate comparison of model-predicted and field-observed advance (excluding outliers)
Distribution Uniformity (fine-textured soil)
Performance indices as a function of bed slope, $Q_o = 0.08$ cfs/ft
Application efficiency expressed as a function of furrow length, $Z_r = 80$ mm
Application efficiency expressed as a function of furrow length, $Z_r = 40$ mm

Application efficiency (%) vs. Furrow length (m)

Different lines represent different flow rates:
- $Q_o = 50$ GPM
- $Q_o = 24.8$ GPM
- $Q_o = 11.9$ GPM
Thermal detector aerial image collected on Oct. 23, 2001
Soil Texture Variation in Lettuce Field
Volumetric Soil moisture before irrigation on Oct. 18 2001
GPS referenced lettuce yield in Imperial Valley
Irrigation scheduling criteria for lettuce have been developed and validated.

Field data were used to calibrate and validate hydrological models appropriate for irrigation in the low desert.

Simulations with the validated models evaluated alternative management scenarios and led to the development of a management package (guideline and tools) for surface irrigated citrus and vegetables.

Implementation of the proposed guidelines will result in substantial improvements in irrigation performance.
Future Research

• Coupled models for concurrent optimization of irrigation and fertigation

• Management of leaching fraction
Br⁻ profile retained in the crop root zone along three transects in an irrigation basin, two days after irrigation.
EM 38-DD Salinity Distribution Pattern: 0-30 cm depth

ECE(0-30 cm)
dS/m
- < 3
- 3 - 6
- 6 - 9
- > 9

Data Bounds
X: min & max
717569.92
717856.56

Y: min & max
3608549.68
3608926.59
Long Term

• Comprehensive irrigation decision support system