Irrigation for Desert Crops

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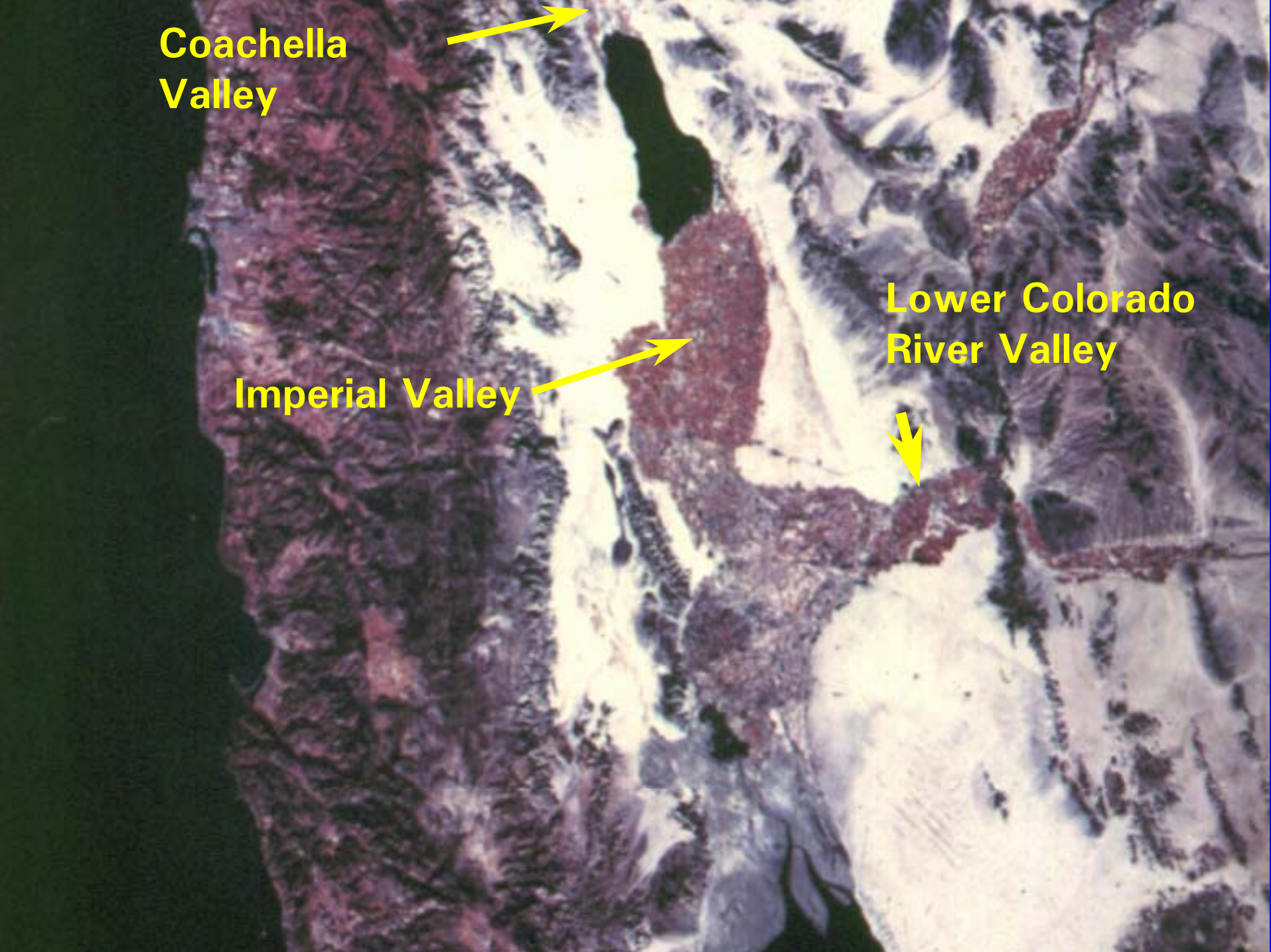
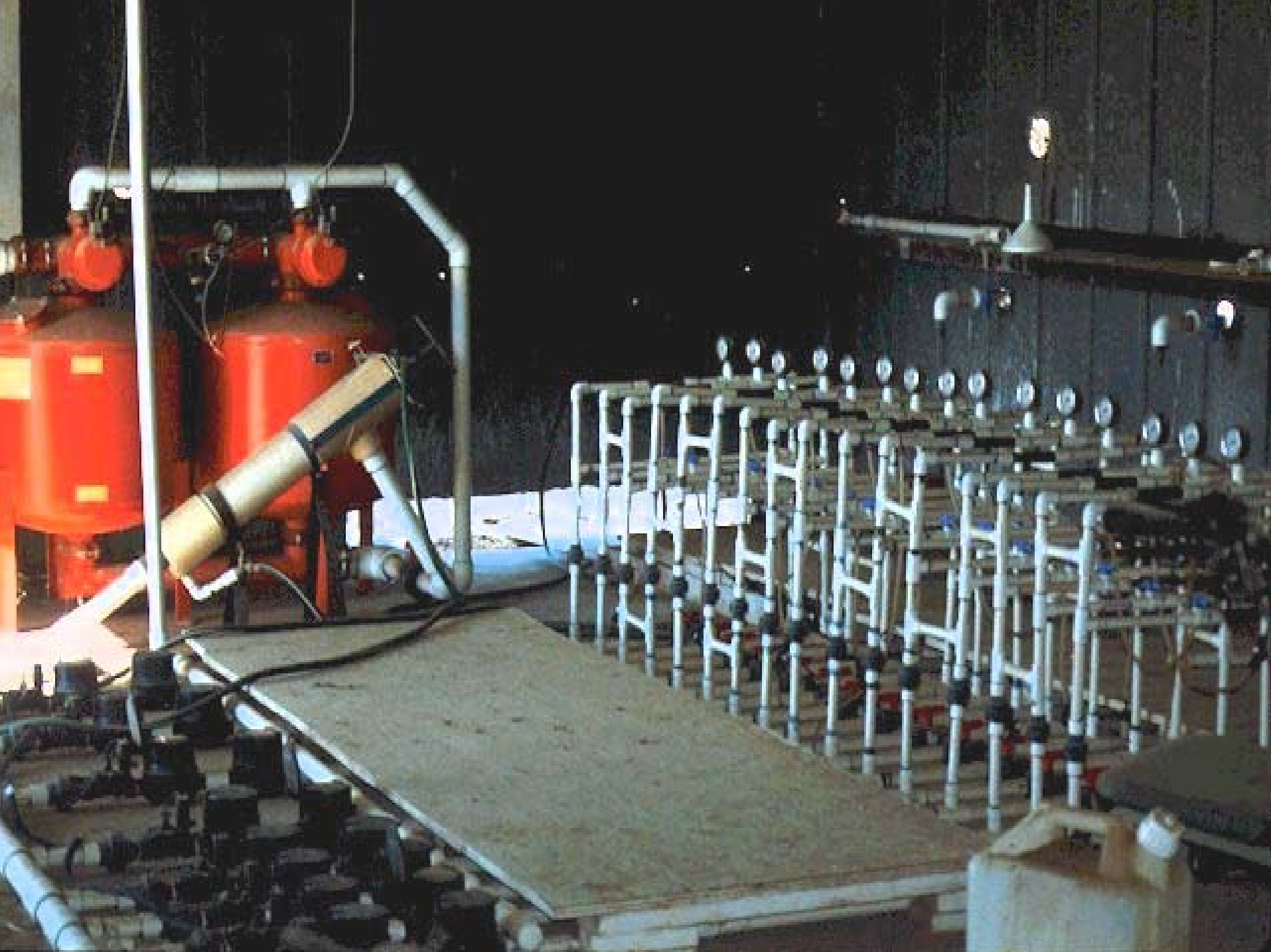

Coachella
Valley
Lower Colorado
River Valley
Imperial Valley



Relevant Questions.

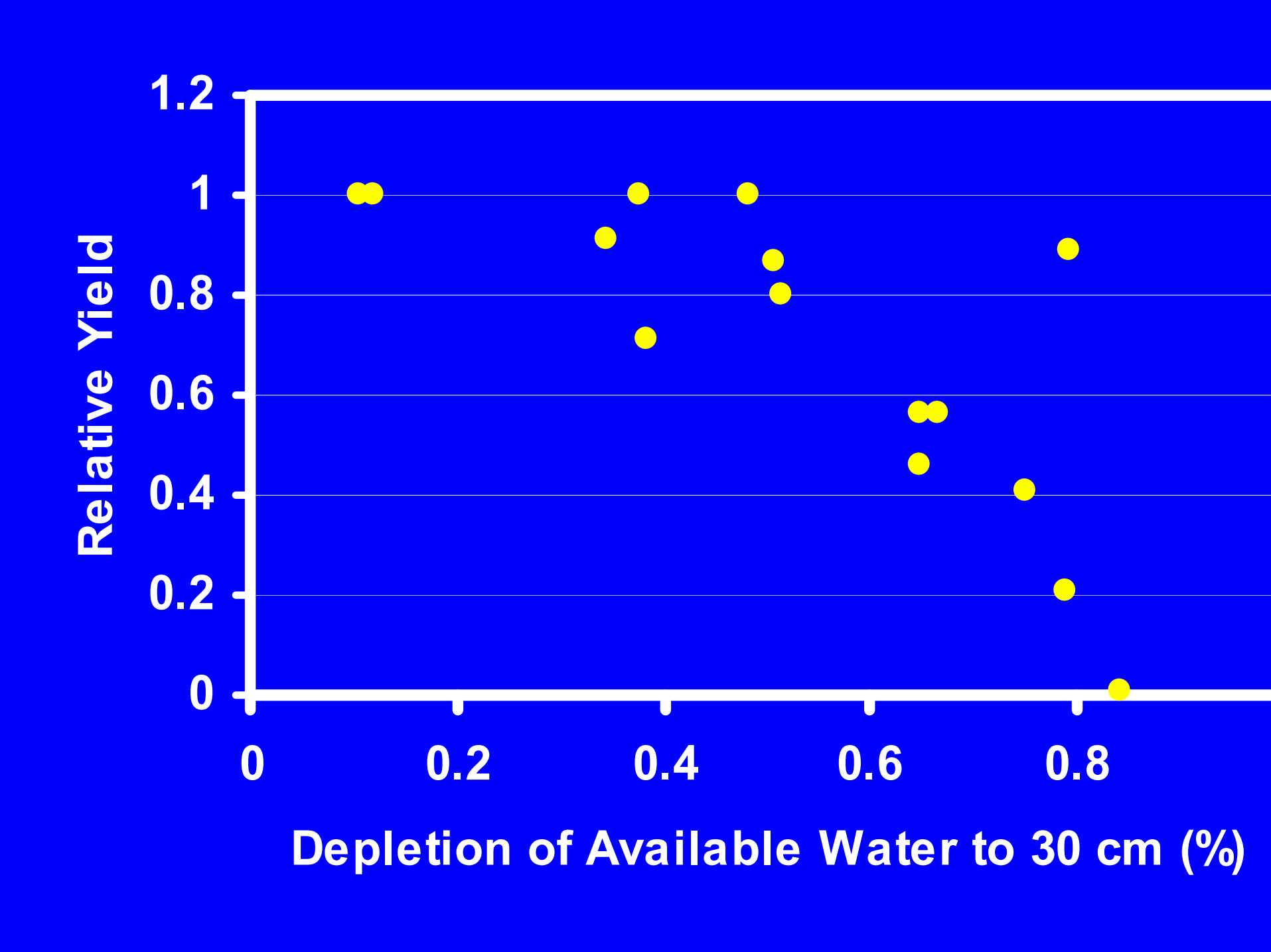
- When do I irrigate (Irrigation timing)?
- How much water do I apply (Required depth)?
- How do I (design and) operate my system?
  - Flow
  - Border length and width
  - Land slope
  - Cutoff (time or distance)

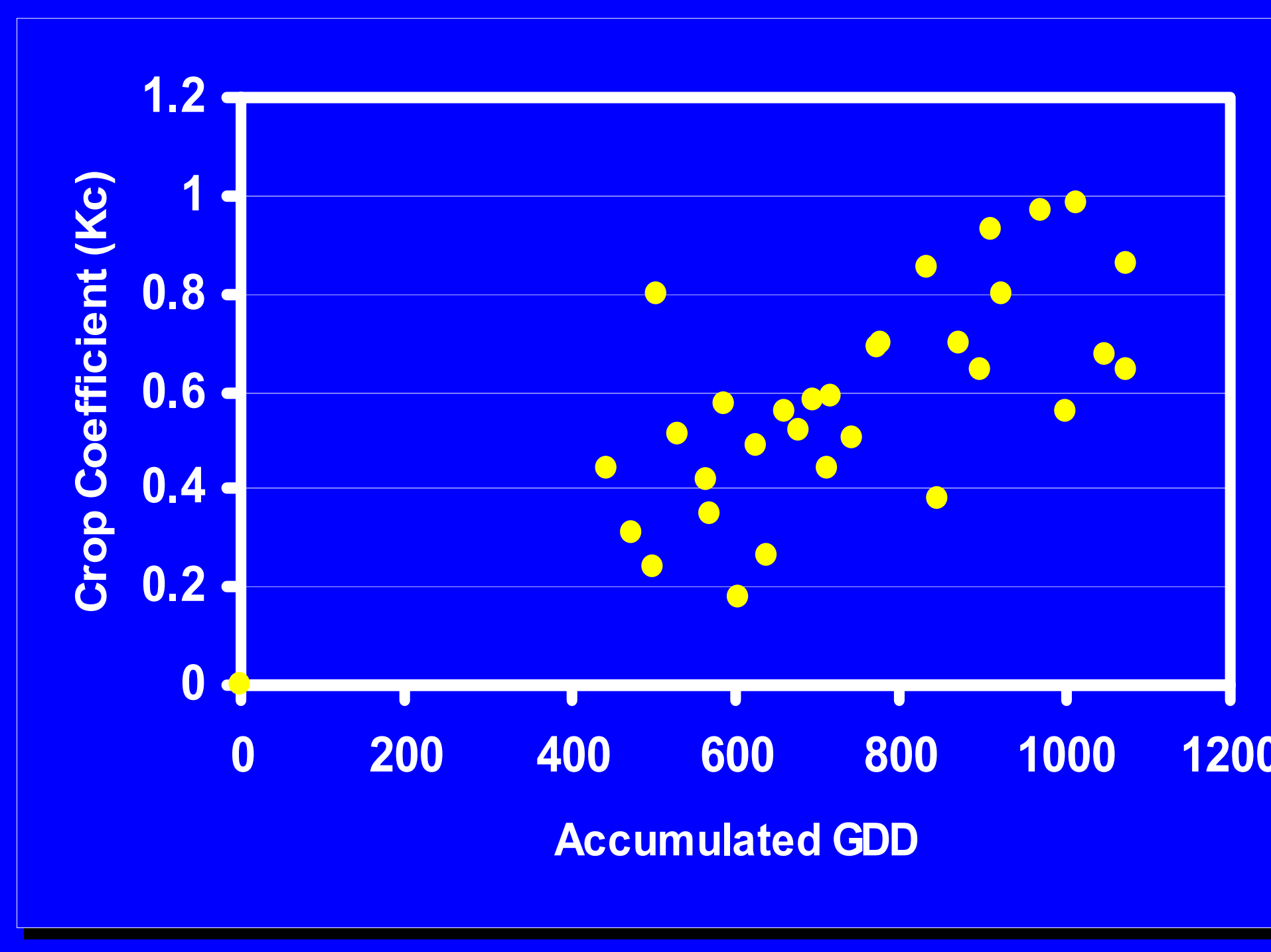
Elements of Efficient Irrigation

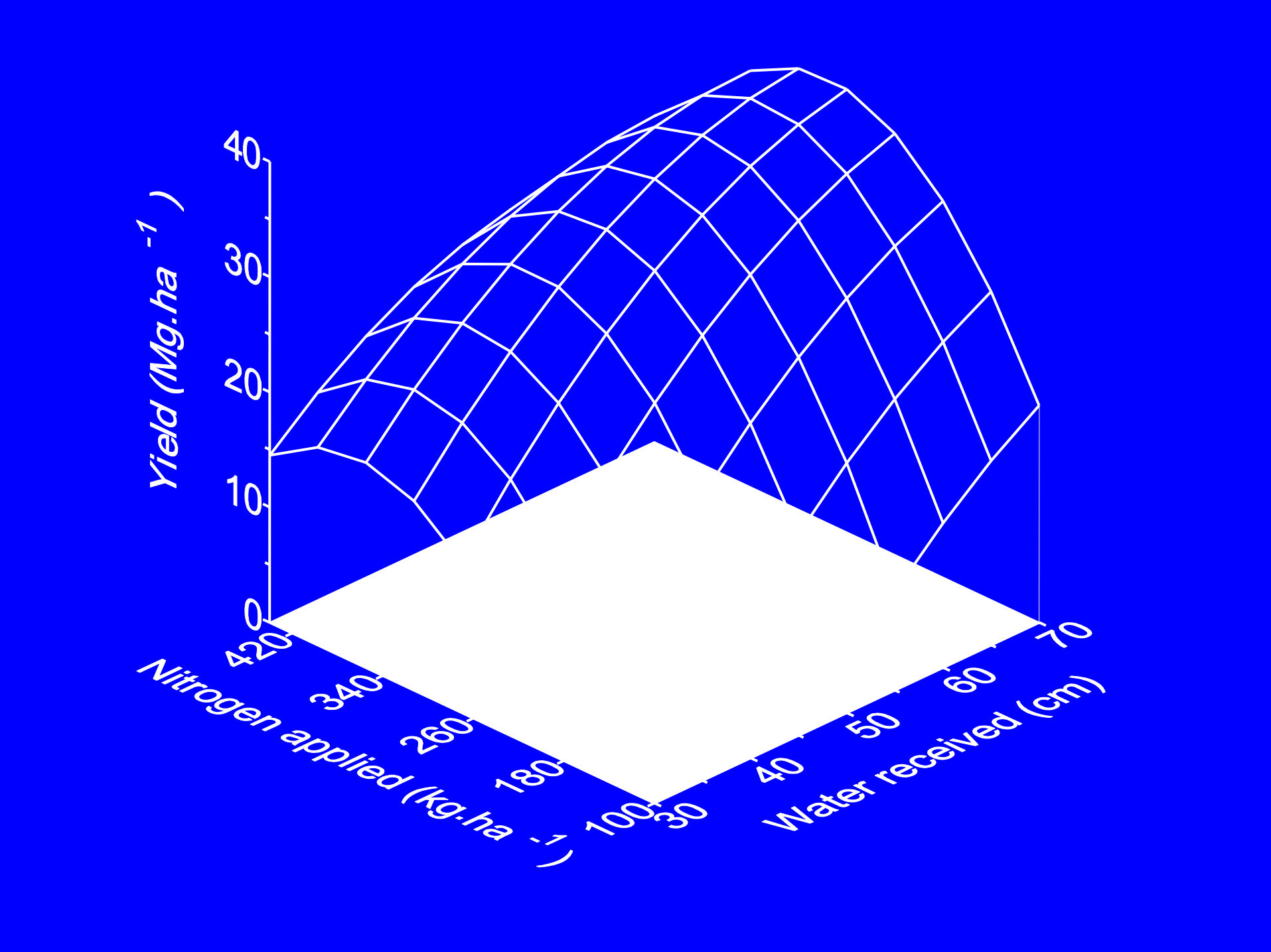
- Irrigation Scheduling (Timing and Required Depth).
- Adjustment of required depth for salt management (Leaching Requirement).
- Irrigation Design and Management (Efficient and Uniform application of Required Depth).

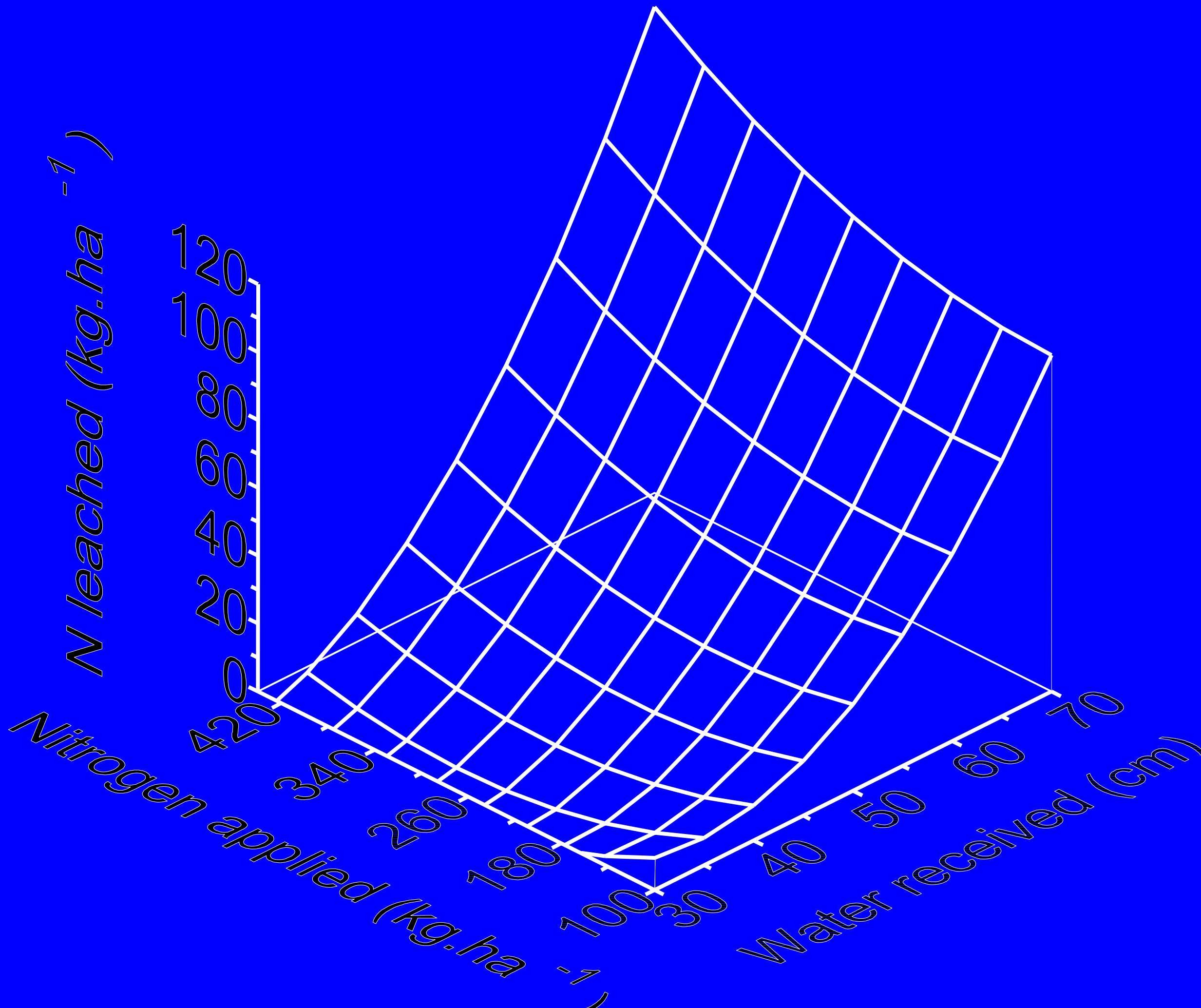
Irrigation Scheduling

- 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 ($ET=kcET^o$)

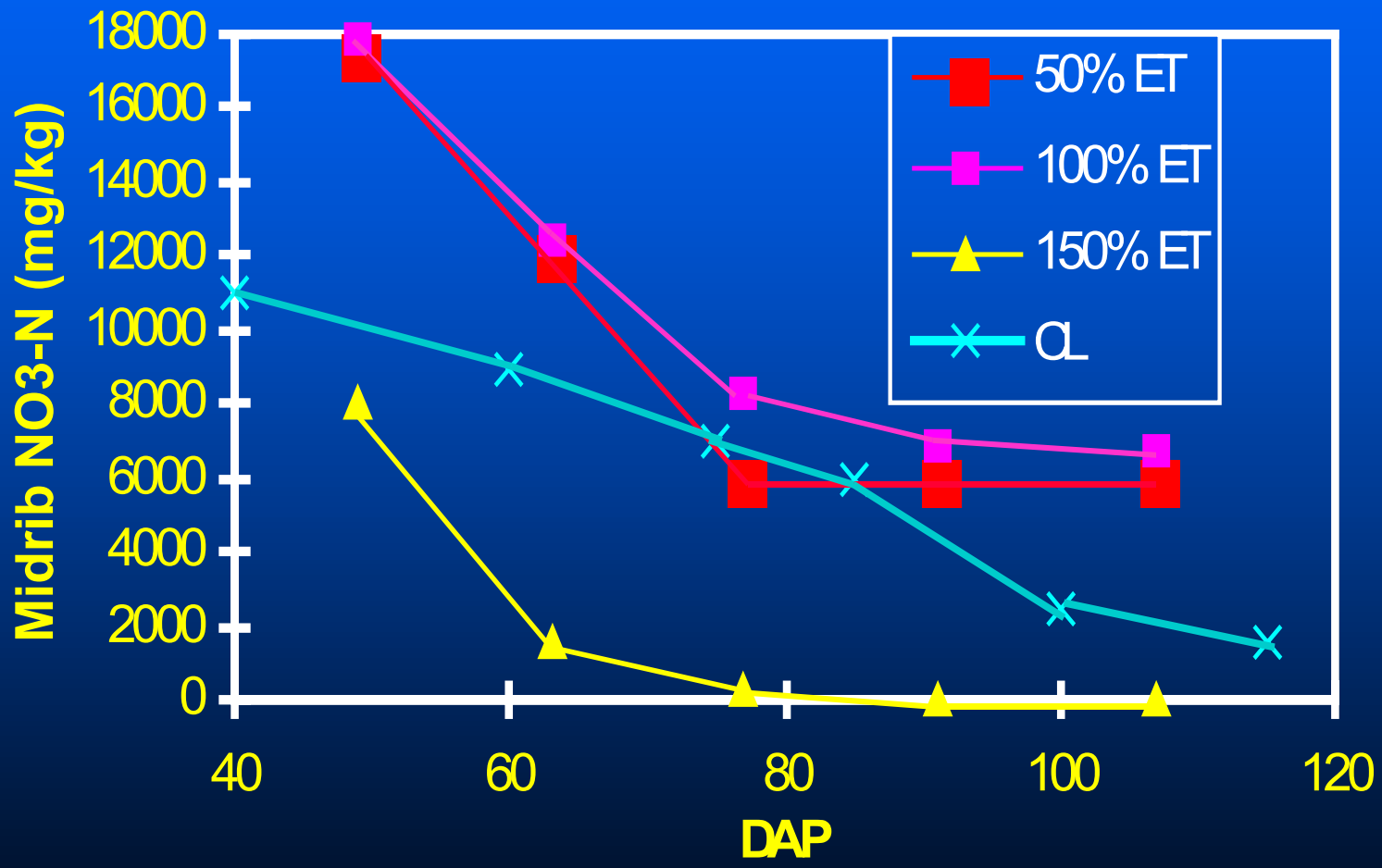

Relative Yield
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
Depletion of Available Water to 30 cm (%)


Crop Coefficient (Kc)
1.2
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
1200
Accumulated GDD


Yield (Mg.ha -1)
0
10
20
30
40
Nitrogen applied (kg.ha -1)
100
180
260
340
420
Water received (cm)
30
40
50
60
70


N leached (kg.ha -1)
120
100
80
60
40
20
0
Nitrogen applied (kg.ha -1)
420
340
260
180
100
Water received (cm)
30
40
50
60
70

Petiole Nitrate-N of Cauliflower to Irrigation



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))

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

$$\frac{\partial Y}{\partial x} = So - Sf$$

$$Sf = \frac{Q^2\left(\frac{n}{Cu}\right)^2}{A^2 R^{4/3}}$$

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

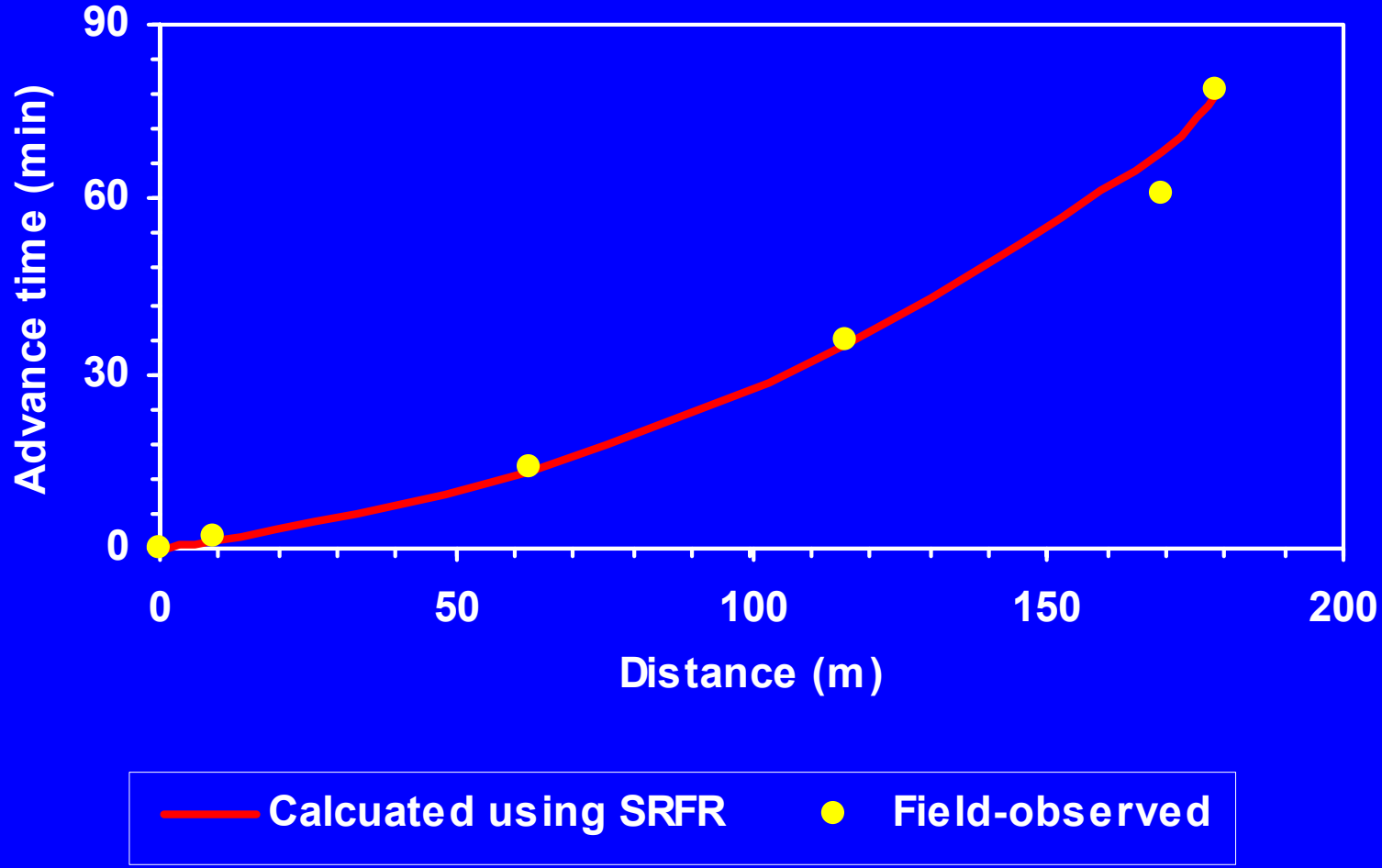
MODKOST

- 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.

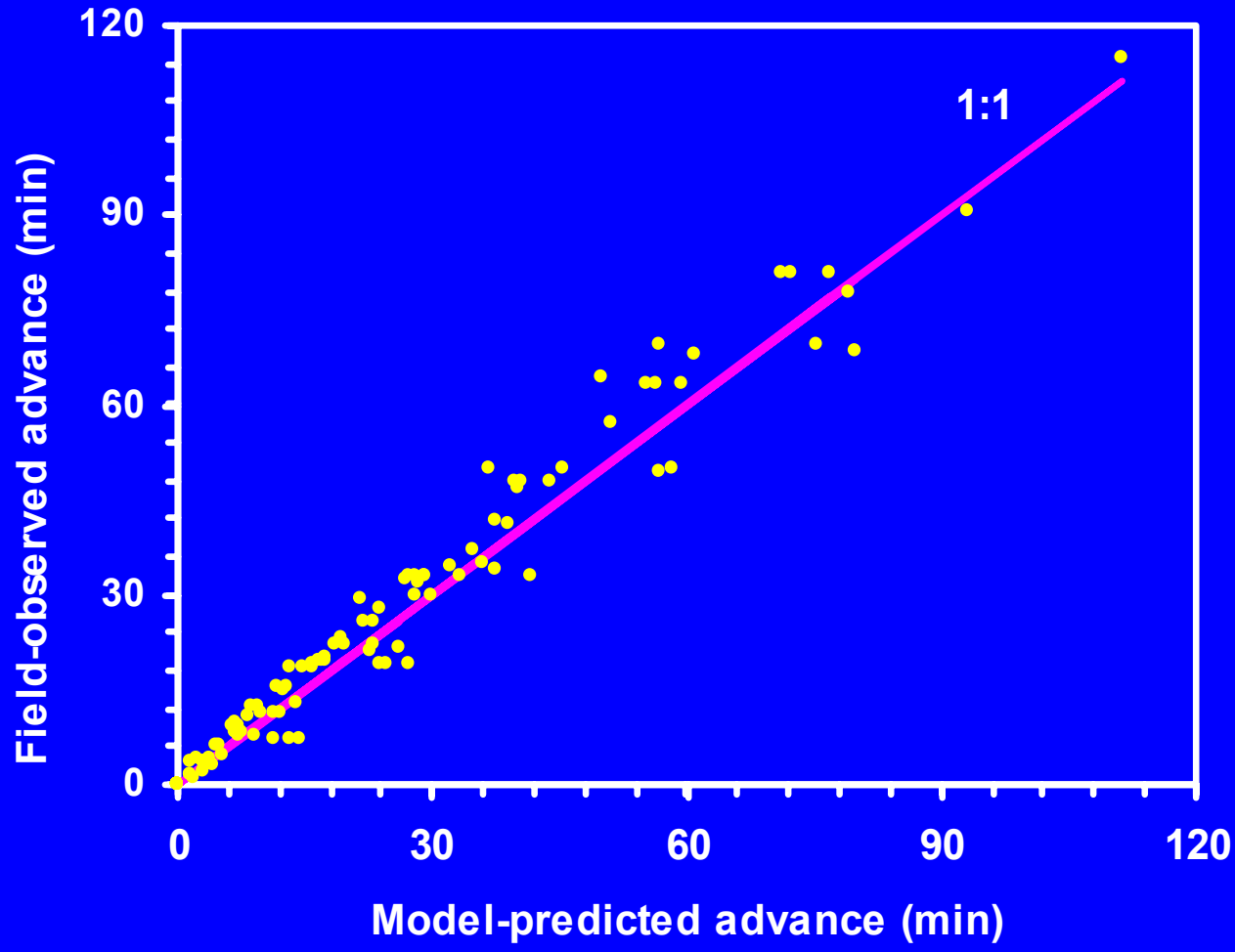
Temporally and spatially averaged parameters

Parameter	Unit	Fine	Mod. fine	Med.	Mod. coarse
K	mm/hr	39.88	45.17	9.2	7.7
A	-	0.174	0.527	0.424	0.182
fo	mm/hr	6.3	6.9	3.1	6.3
Manning's n		0.04	0.04	0.04	0.04
Target Depth	mm	40	40	30	20

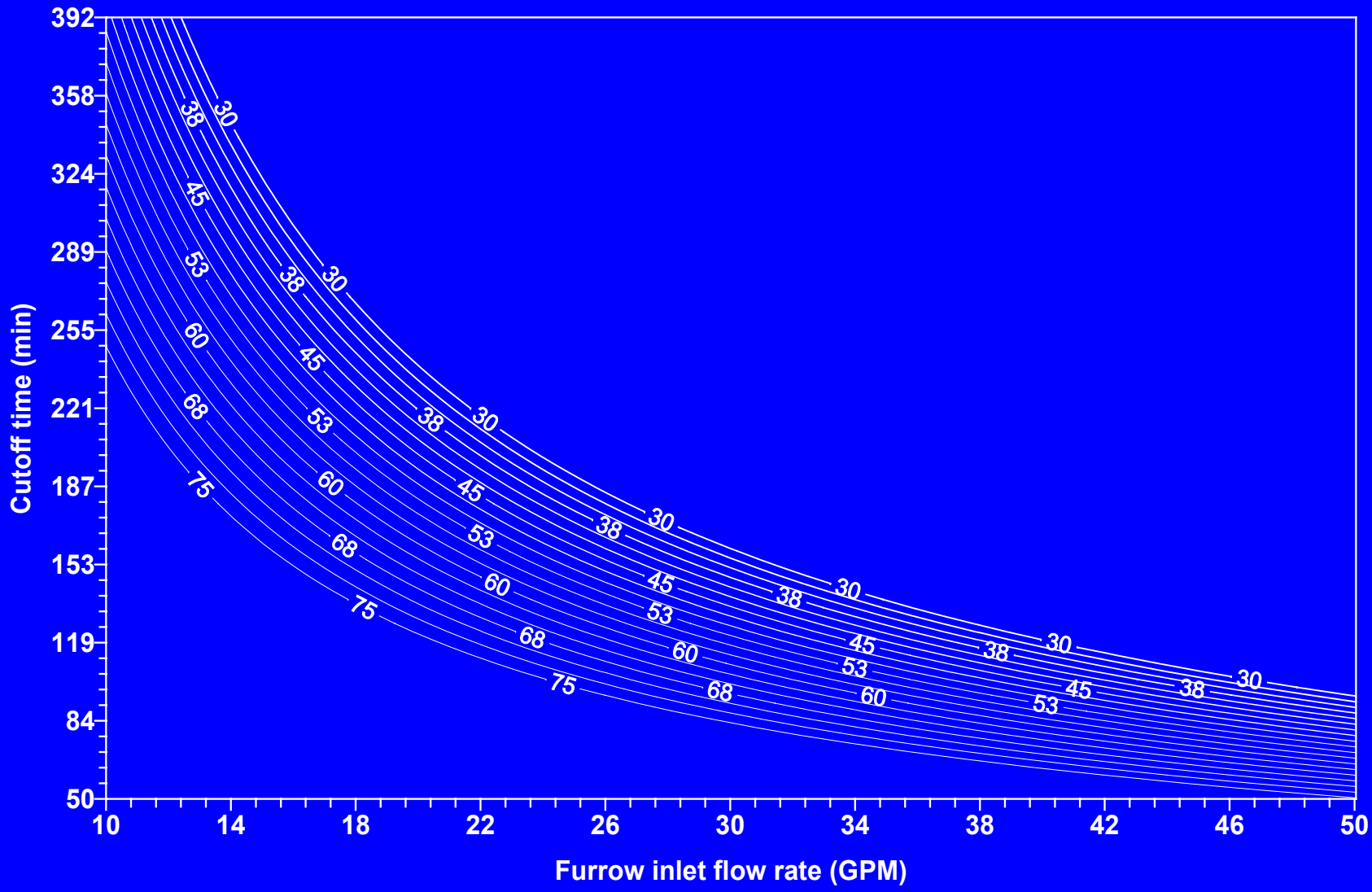
Comparison of model-predicted and field observed advance, silty-clay 1-02-99



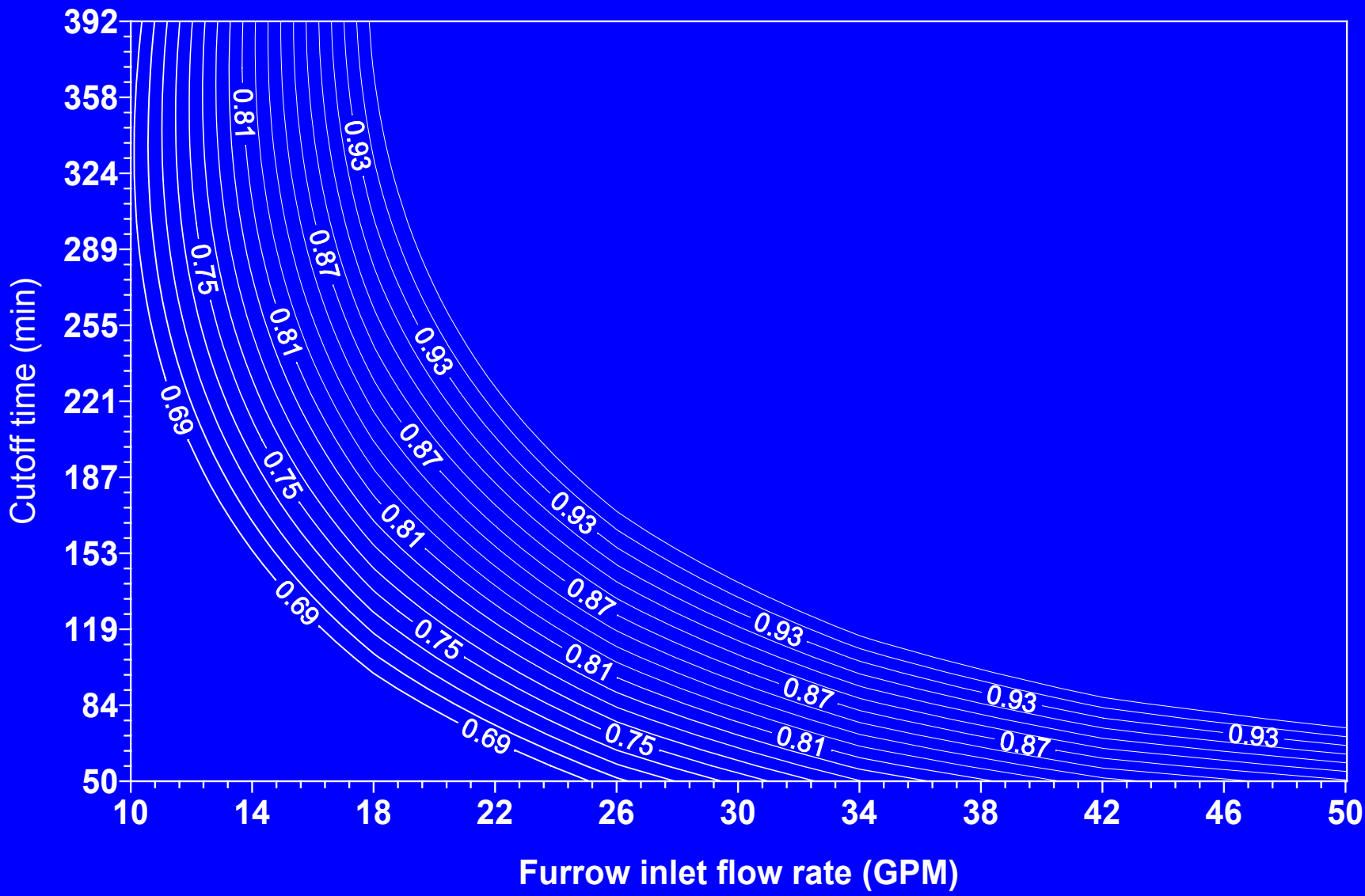
Aggregate comparison of model-predicted and field-observed advance (excluding outliers)

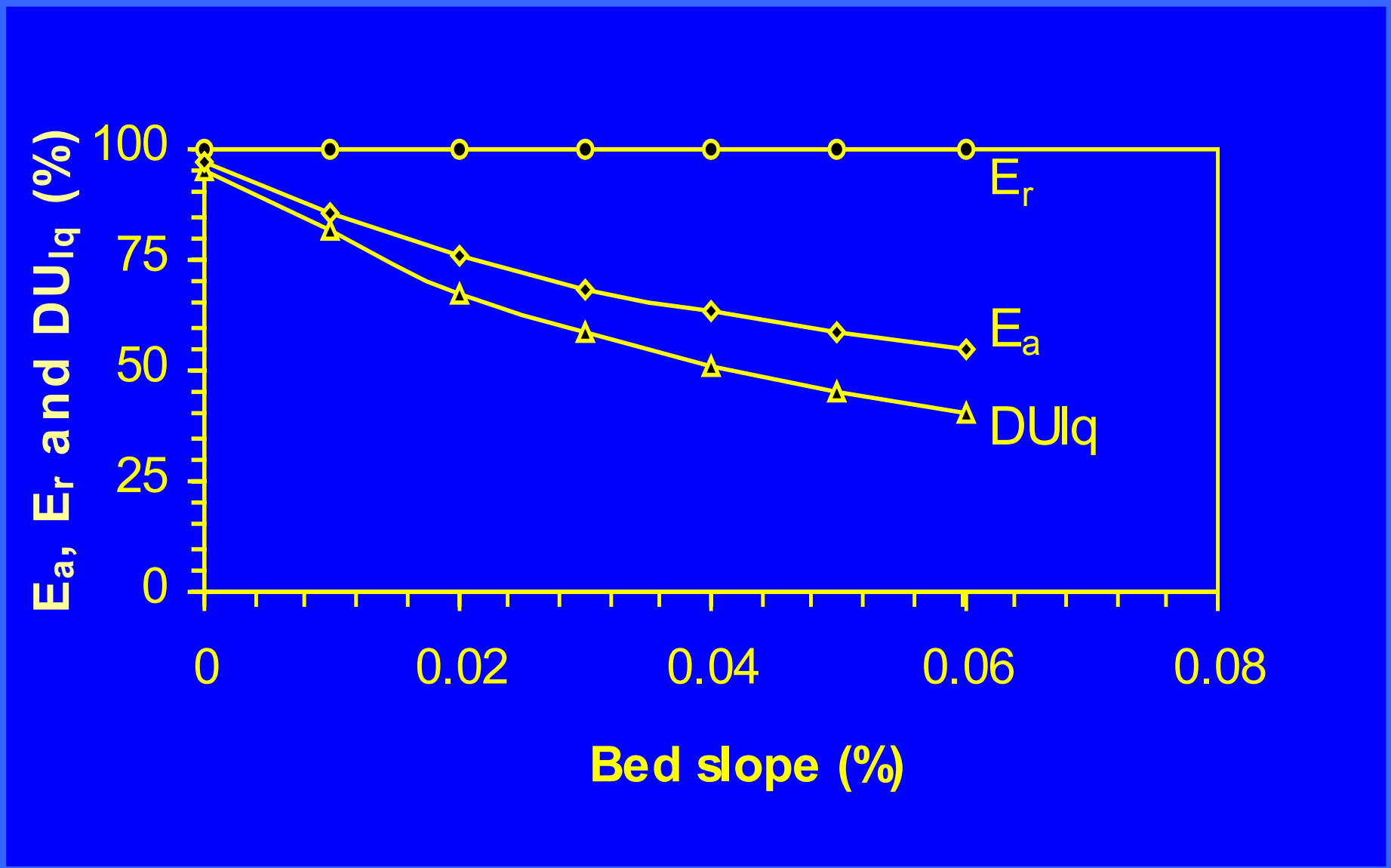


Application efficiency (fine-textured soil)

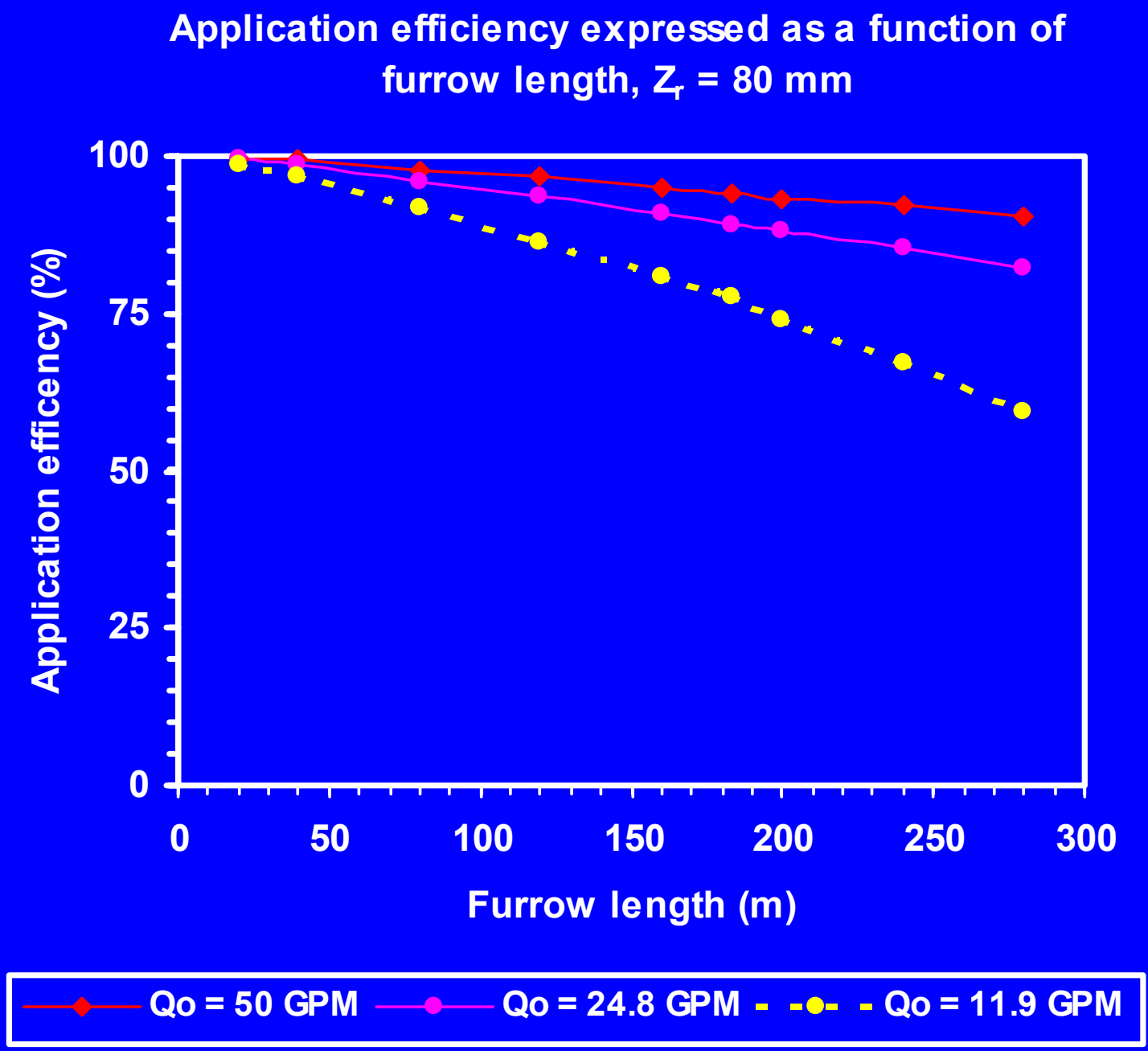


Distribution Uniformity (fine-textured soil)

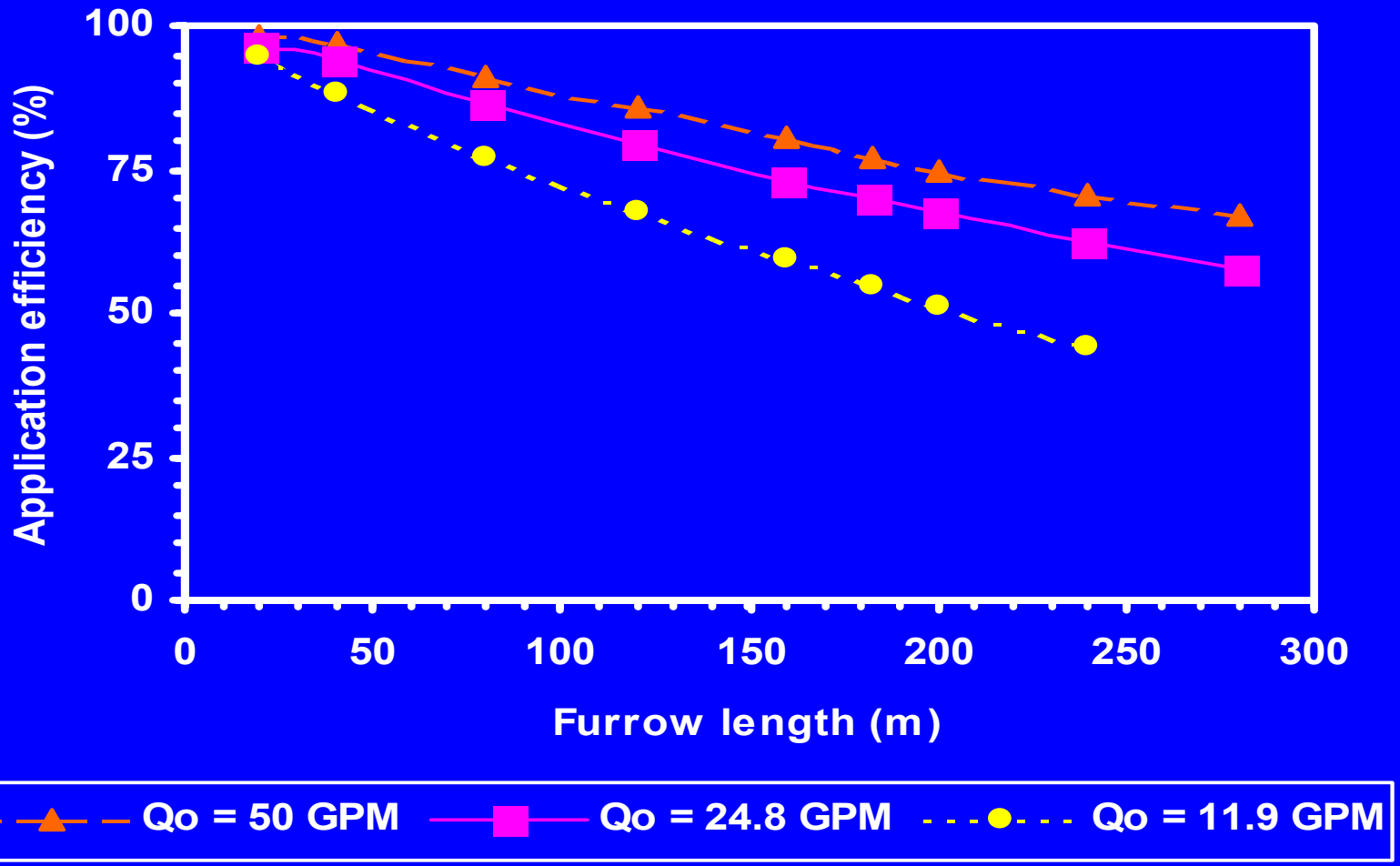




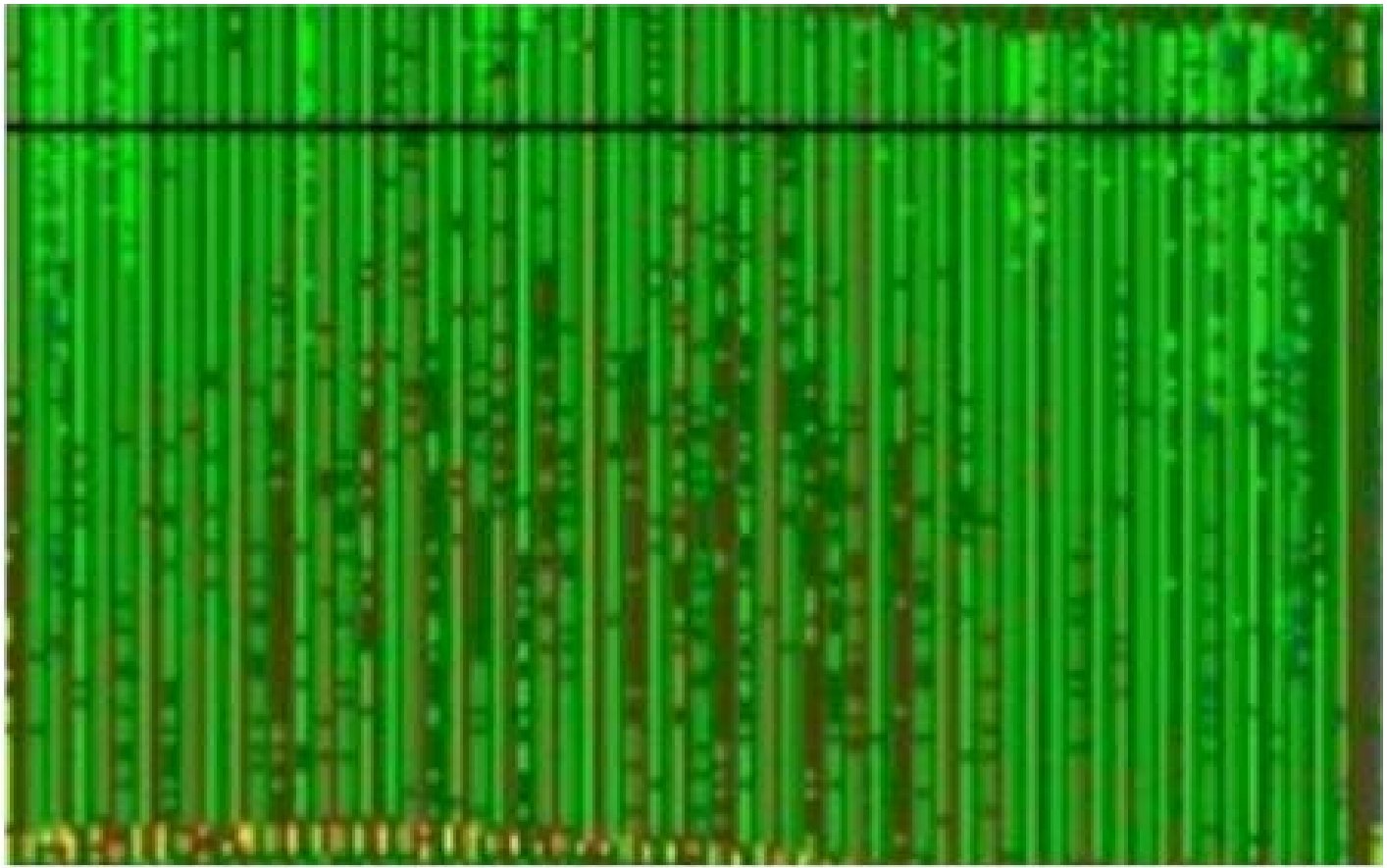
Performance indices as a function of bed slope, Q_o = 0.08 cfs/ft


Application efficiency expressed as a function of furrow length, Z_r = 80 mm
Application efficency (%)
100
75
50
25
0
0
50
100
150
200
250
300
Furrow length (m)
Qo = 50 GPM
Qo = 24.8 GPM
Qo = 11.9 GPM

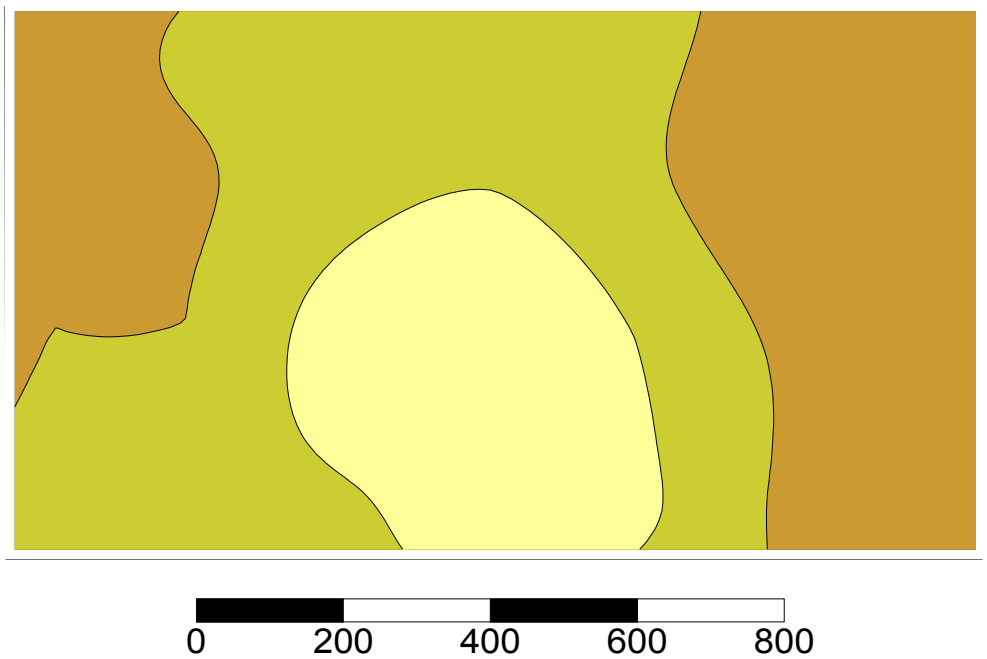
Application efficiency expressed as a function of furrow length, Z_r = 40 mm



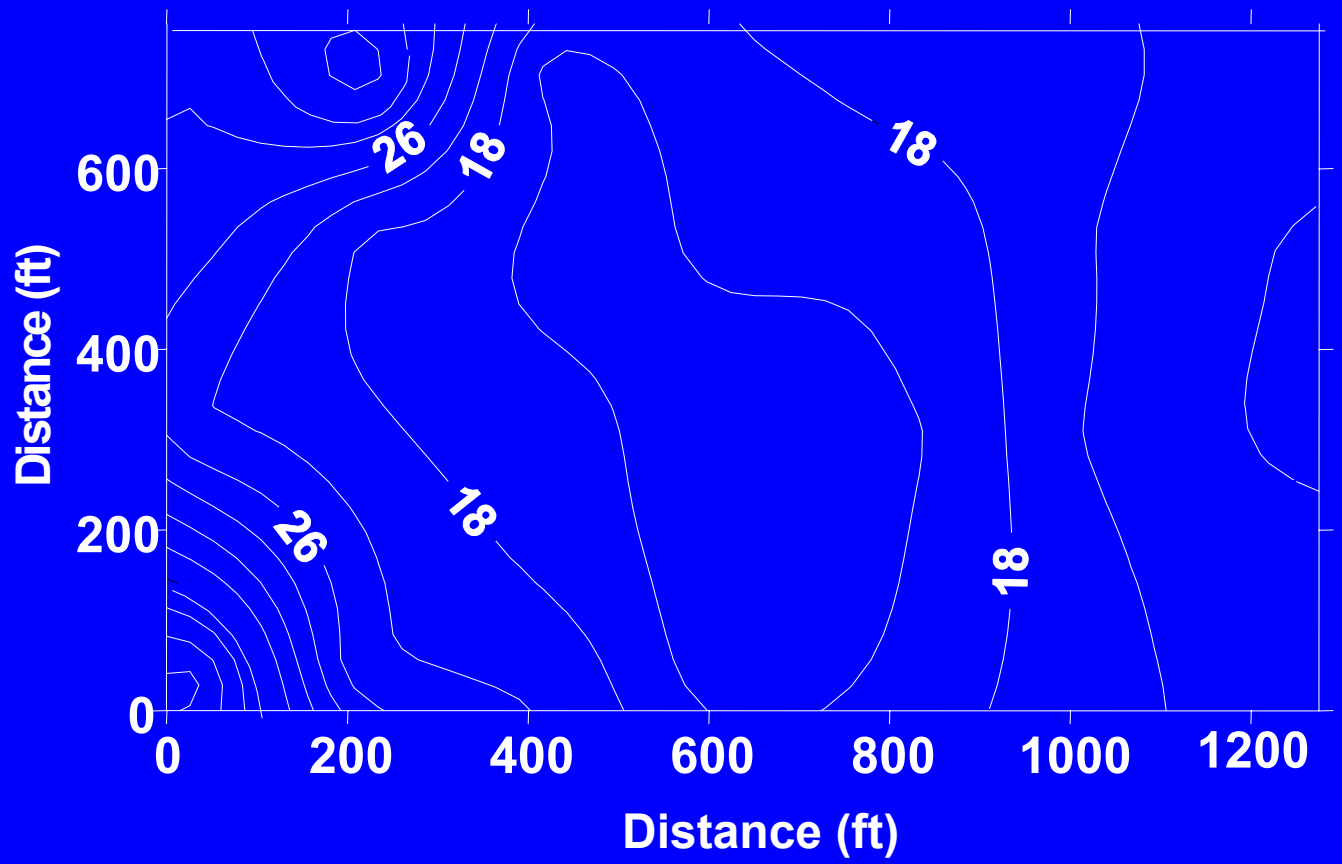
Thermal detector aerial image collected on Oct. 23, 2001



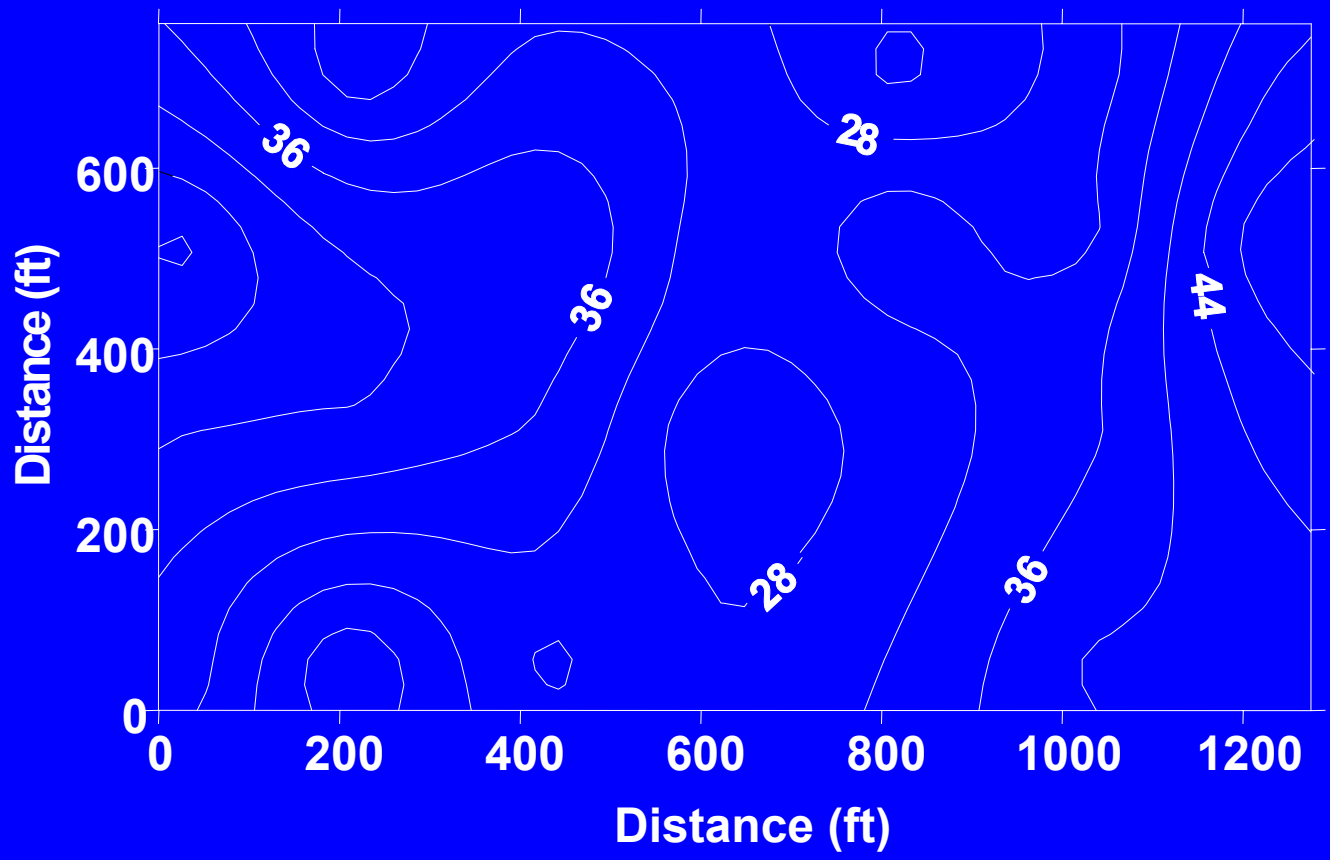
Soil Texture Variation in Lettuce Field



Volumetric Soil moisture before irrigation on Oct. 18 2001



GPS referenced lettuce yield in Imperial Valley

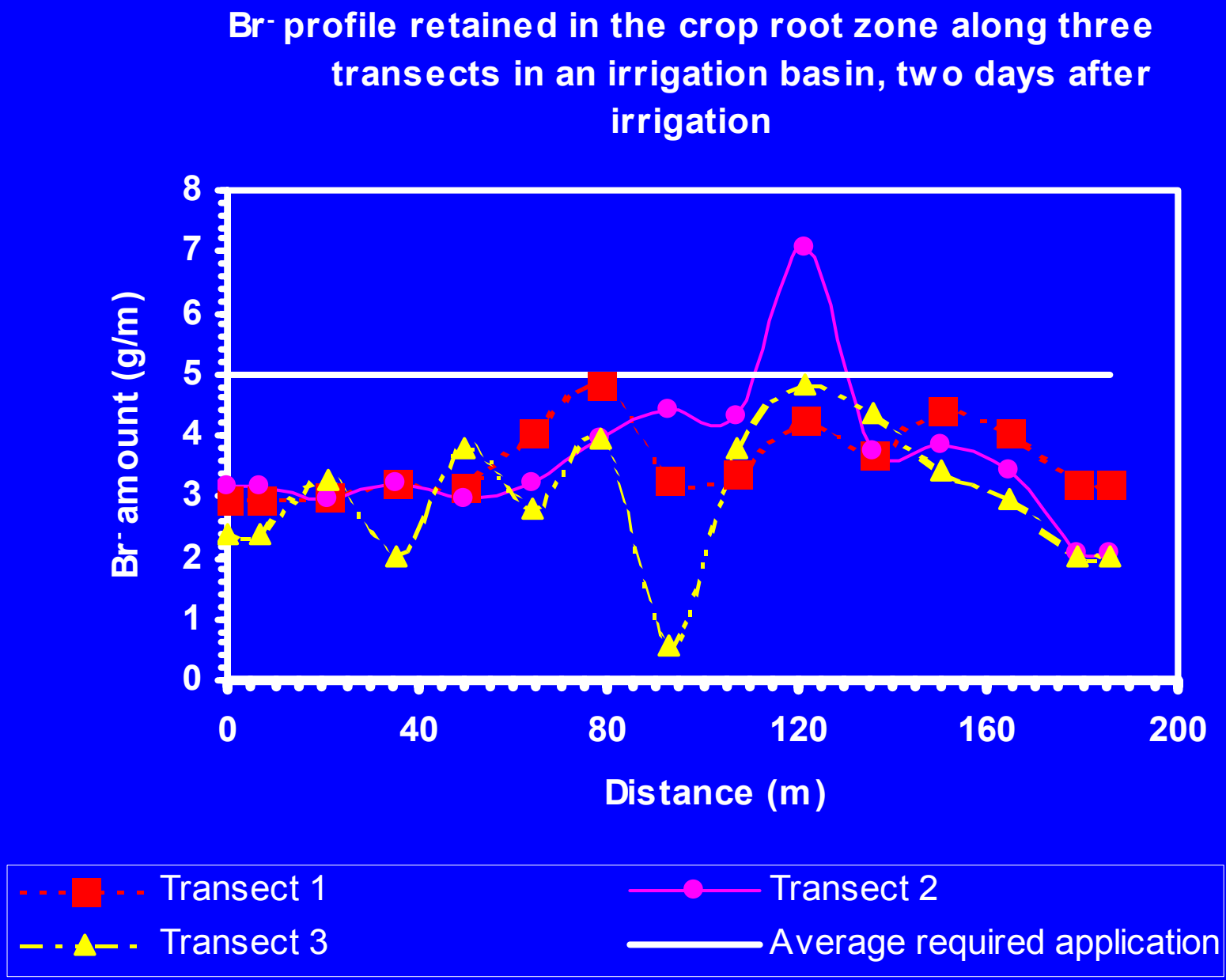


Summary

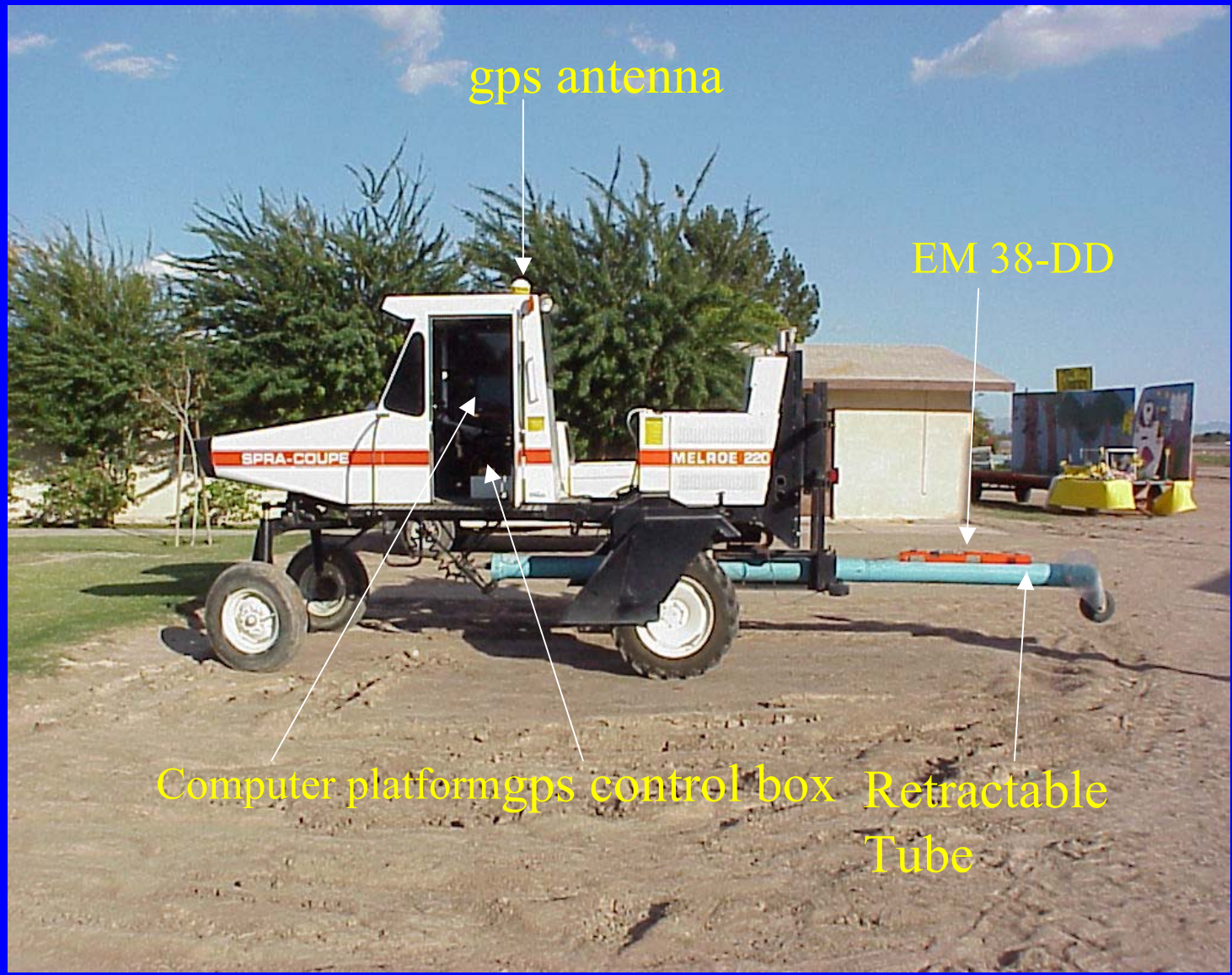
- Irrigation scheduling criteria for lettuce have been developed and validated
- Field data were used to calibrate and validate hydrological models appropriate for irrigation in the low desert.
- Simulations with the validated models evaluated alternative management scenarios and led to the development of a management package (guideline and tools) for surface irrigated citrus and vegetables.
- Implementation of the proposed guidelines will results in substantial improvements in irrigation performance.

Future Research

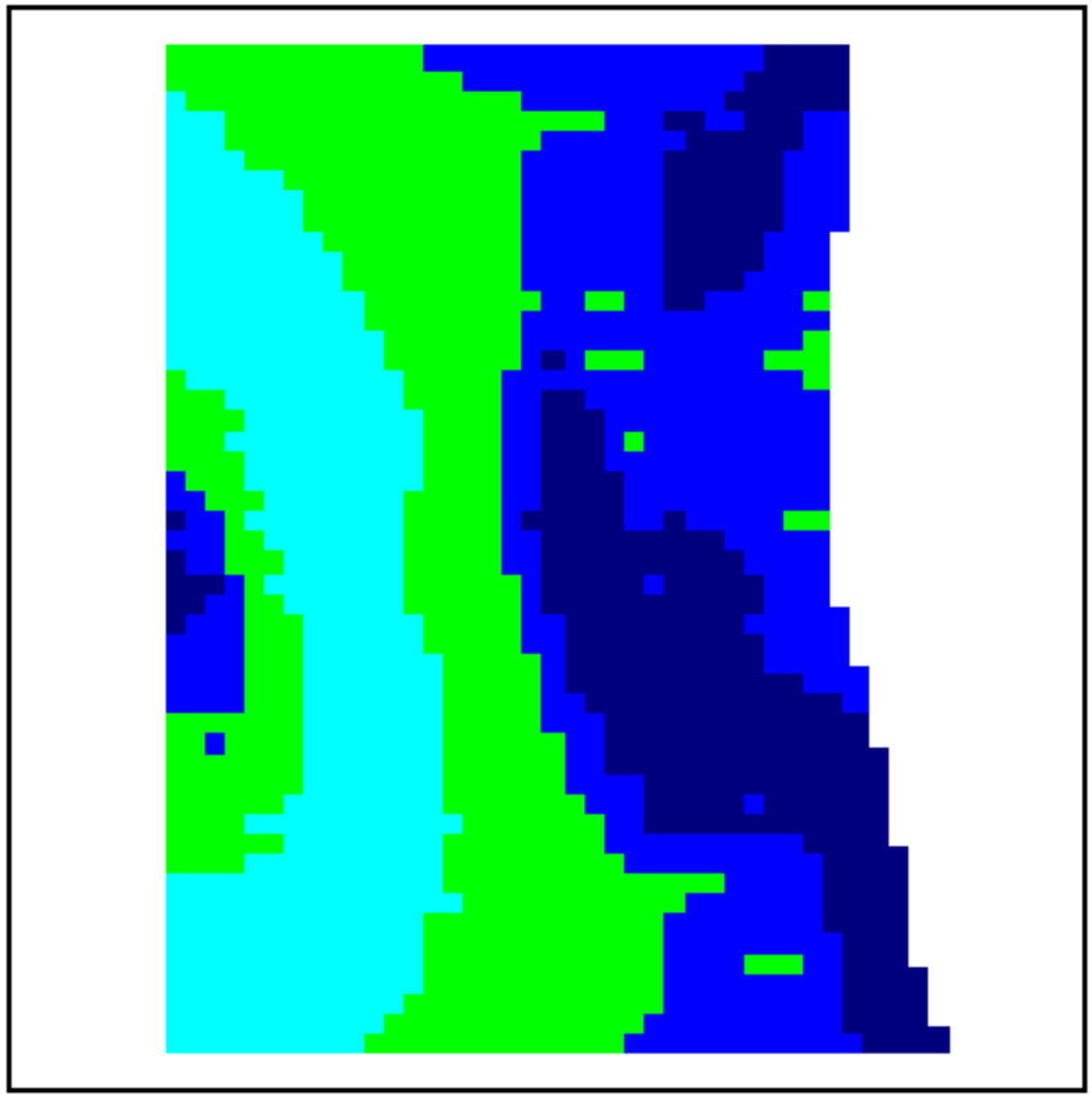
- Coupled models for concurrent optimization of irrigation and fertigation
- Management of leaching fraction


Br- profile retained in the crop root zone along three transects in an irrigation basin, two days after irrigation
Br- amount (g/m)
0
1
2
3
4
5
6
7
8
0
40
80
120
160
200
Distance (m)
Transect 1
Transect 2
Transect 3
Average required application

SALT MAPPER


gps antenna
EM 38-DD
SPRA-COUPE
MELROE 220
Computer platform
gps control box
Retractable Tube

EM 38-DD Salinity Distribution Pattern: 0-30 cm depth



Long Term

- Comprehensive irrigation decision support system