INTEGRATED MANAGEMENT OF NON CONVENTIONAL WATER RESOURCES

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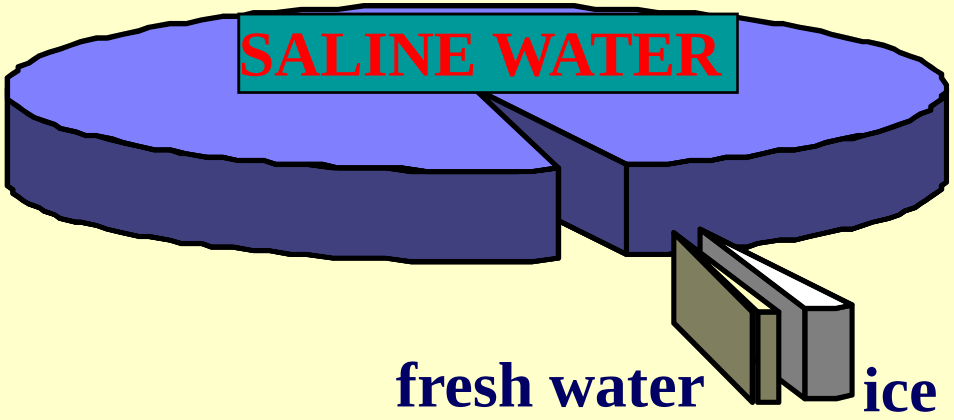
Why non-conventional water resources?

There is not enough fresh water:

It is less than one percent of the world's water reserve:
the rest is SALINE or FROZEN as ICE.



- the largest reserves on land are groundwaters
- they are the equivalent of 200 years of rainfall
- but more than half are saline: particularly in the arid regions where they are needed most for irrigation

IRRIGATION

- **When ?**
- **How much to irrigate ?**

Do we have water for irrigation?

Non- Conventional water Resources

- Sea water
- Agricultural drainage water
- Brackish groundwater
- Waste Water (treated, un-treated, domestic, Industrial, etc.)

WASTEWATER

- Urban wastewater may be a combination of some, or all, of the following:

- Domestic effluent consisting of black water (excreta, urine and associated sludge) and grey water (kitchen and bathroom wastewater)

- Water from commercial establishments and institutions, including hospitals

- Industrial effluent

USE OF SALINE WATER FOR IRRIGATION

- Globally around 43 countries, mostly from arid and semi arid regions, are using saline water for irrigation.
- The southern Mediterranean countries are using saline water in irrigation purely by necessity, rather than by choice.
- Saline water could be successfully used for irrigation, however, saline water is still only marginally practised.

Wsatewater Use

It is estimated that up to one-tenth of the world's population eats food produced using wastewater.

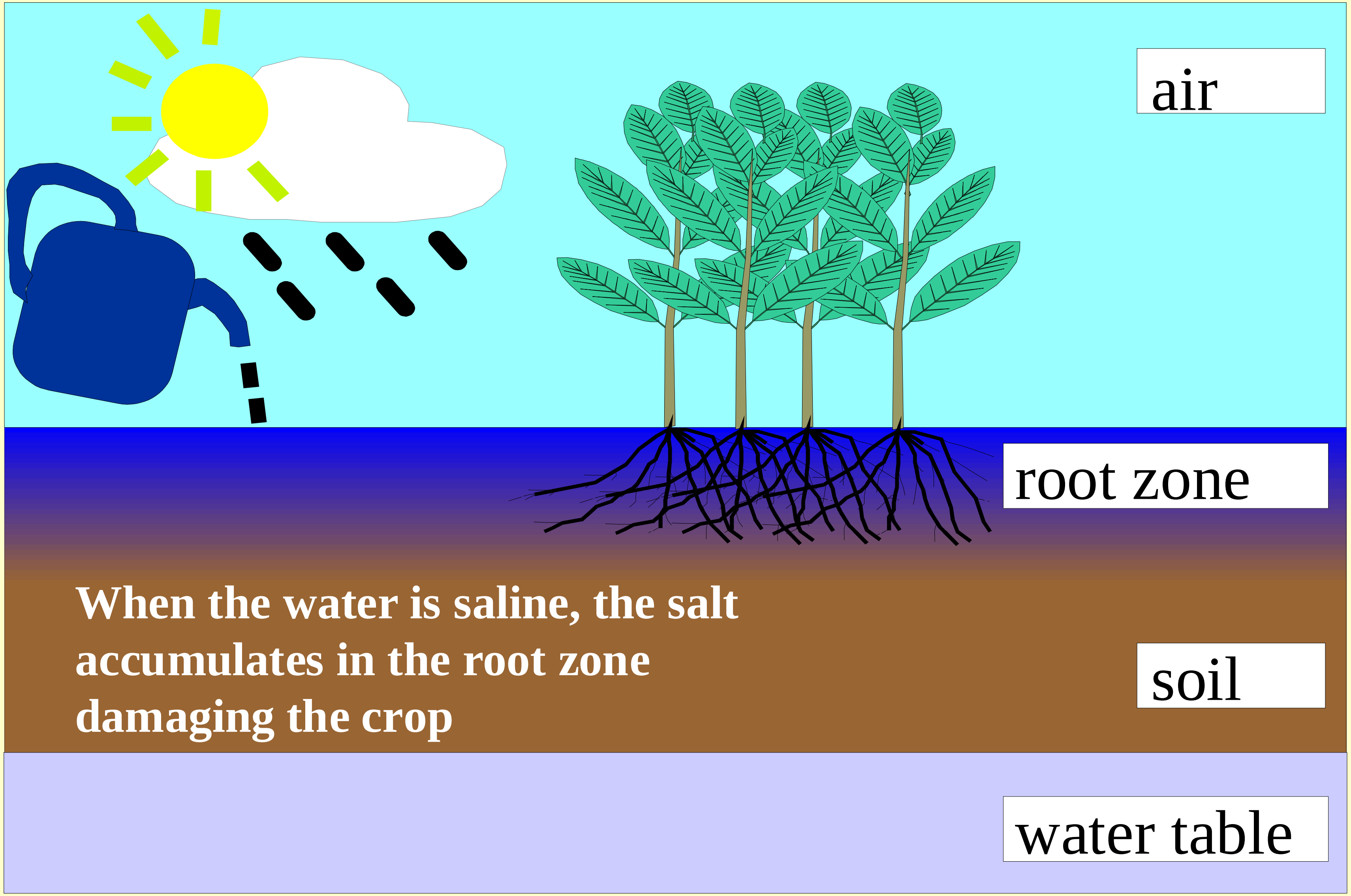
There is a claim that worldwide more than 20 million ha are irrigated with urban wastewater

Classification of saline water (Rhoades *et al*. 1992)

Water class	Electrical Conductivity dS/m	Salt Concenration mg/l	Type of water
Non-saline	< 0.7	< 500	Drinking & irriagation
Slightly saline	0.7 - 2.0	500 - 1500	Irrigation water
Moderately saline	2.0 - 10.0	1500 - 7000	Primary drainage water and groundwater
Highly saline	10.0 - 25.0	7000 - 15000	secondary drainage water and groundwater
Very highly saline	25.0 - 45.0	15000 - 35000	Very saline groundwater
Brine	> 45.0	> 35000	Seawater

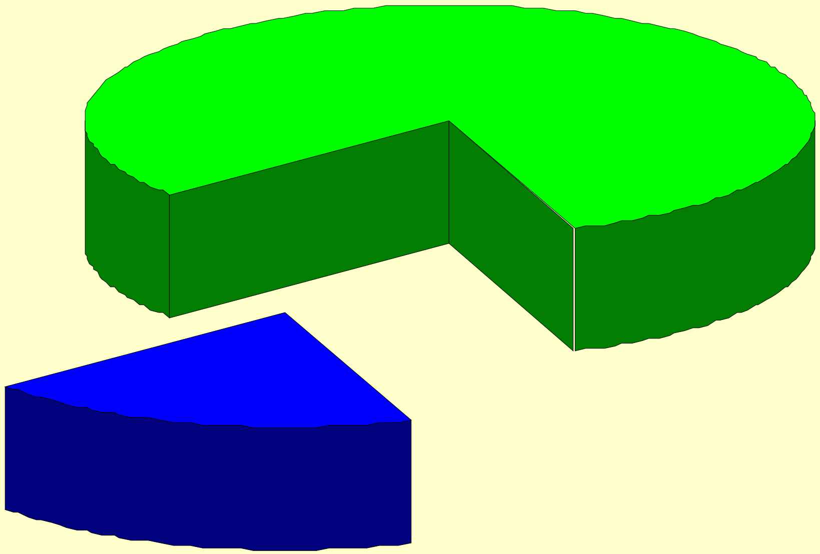
The threshold of average rootzone salinity of field crops in dS m^{-1} (Rhoades *et al*. 1992).

Crop sensitivity	Threshold dS/m
Sensitive	0 - 1.5
Moderately sensitive	1.5 - 3
Moderately tolerant	3.0 - 6.0
Tolerant	6.0 - 10.0
Very tolerant	> 10.0


air
root zone
When the water is saline, the salt accumulates in the root zone damaging the crop
soil
water table




227 million ha of land are irrigated



One ha in five is salt-affected (FAO 1989)

An area of at least 15 million ha (equivalent to 60% of the UK) has been abandoned over the last ten years

Barley production with high salinity

Evaluation of **salinity tolerance and yield** of 280 barley genotypes at 15 dS/m (12g/L)

Pearl millet production under medium-high salinity

Evaluation of **salinity tolerance and yield** of 42 pearl millet genotypes at 5, 10 and 15 dS/m

Atriplex **production with very high salinity**

Halophyte shrub *Atriplex* using very highly saline water (up to 30 dS/m) at ICBA HQ and on a demonstration site in Oman.

Halophyte grass production under very high salinity

Halophyte grasses *Sporobolus virginicus* and *Distichlis spicata* successfully **adapted to intensive irrigated production** using highly saline water (up to 30 dS/m or 24 g/L).

The Experimental design

Continuous application of blended water

3	5	2	4	1	6
3	5	2	4	1	6
3	5	2	4	1	6

Trickle irrigation system

Cyclic application of fresh &saline water

1	3	6	4	2	5
1	3	6	4	2	5
1	3	6	4	2	5

Trickle irrigation system

6m **7m**

1	2	3	4	5	6
3	4	5	6	1	2
5	6	1	2	3	4

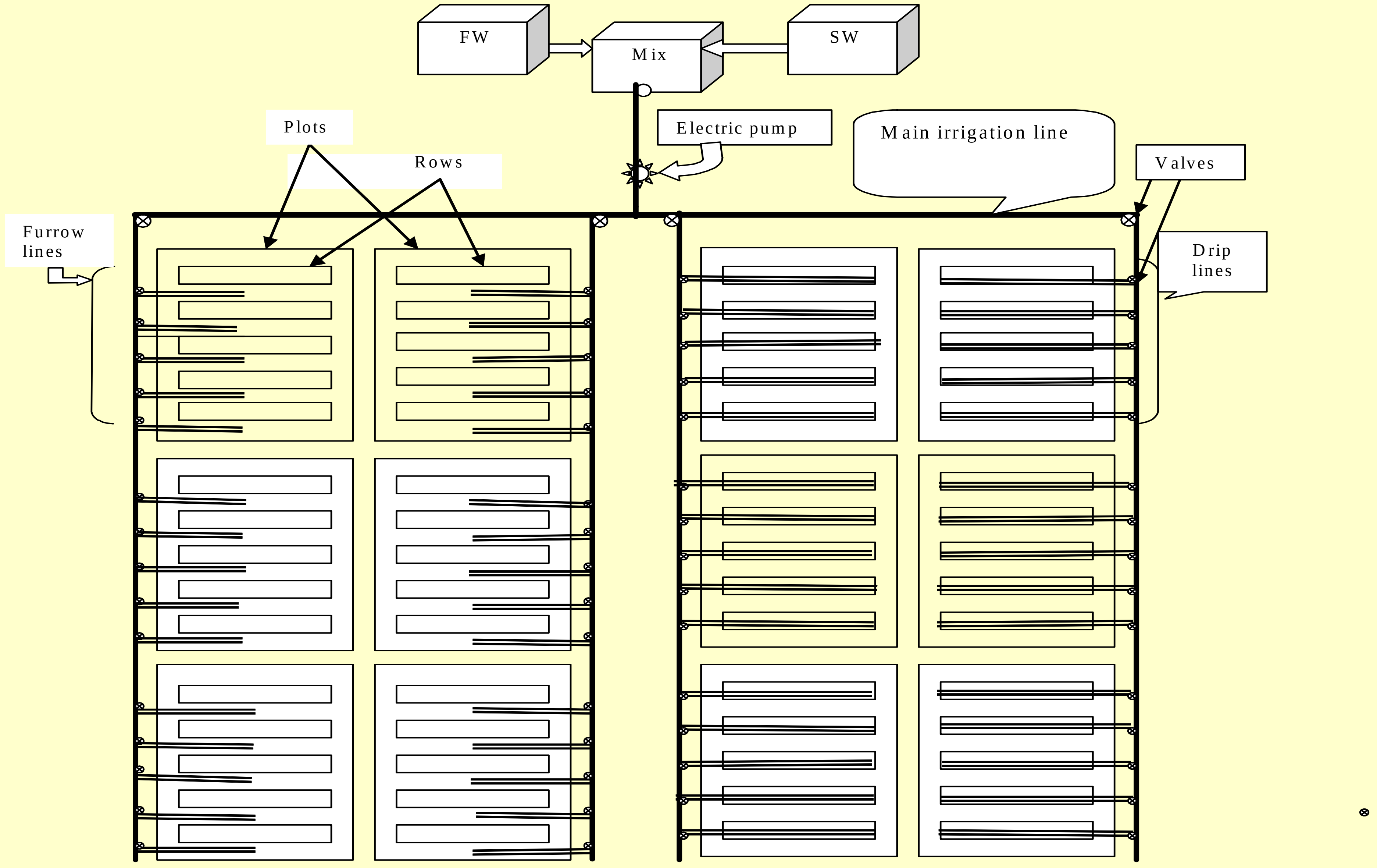
Continuous application of blended water

Furrow irrigation system

1	2	3	4	5	6
3	4	5	6	1	2
5	6	1	2	3	4

Cyclic application of fresh &saline water

Furrow irrigation system

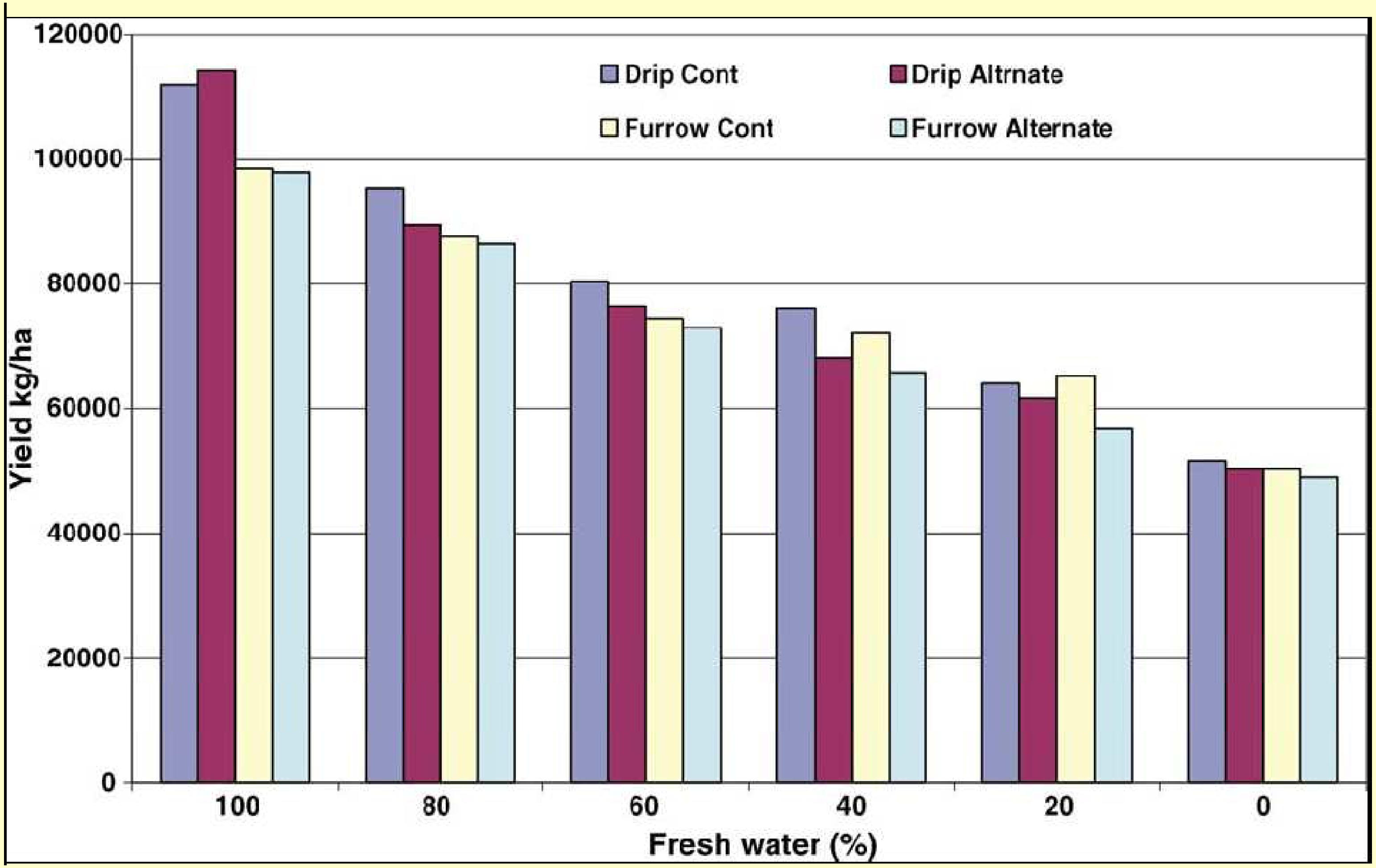


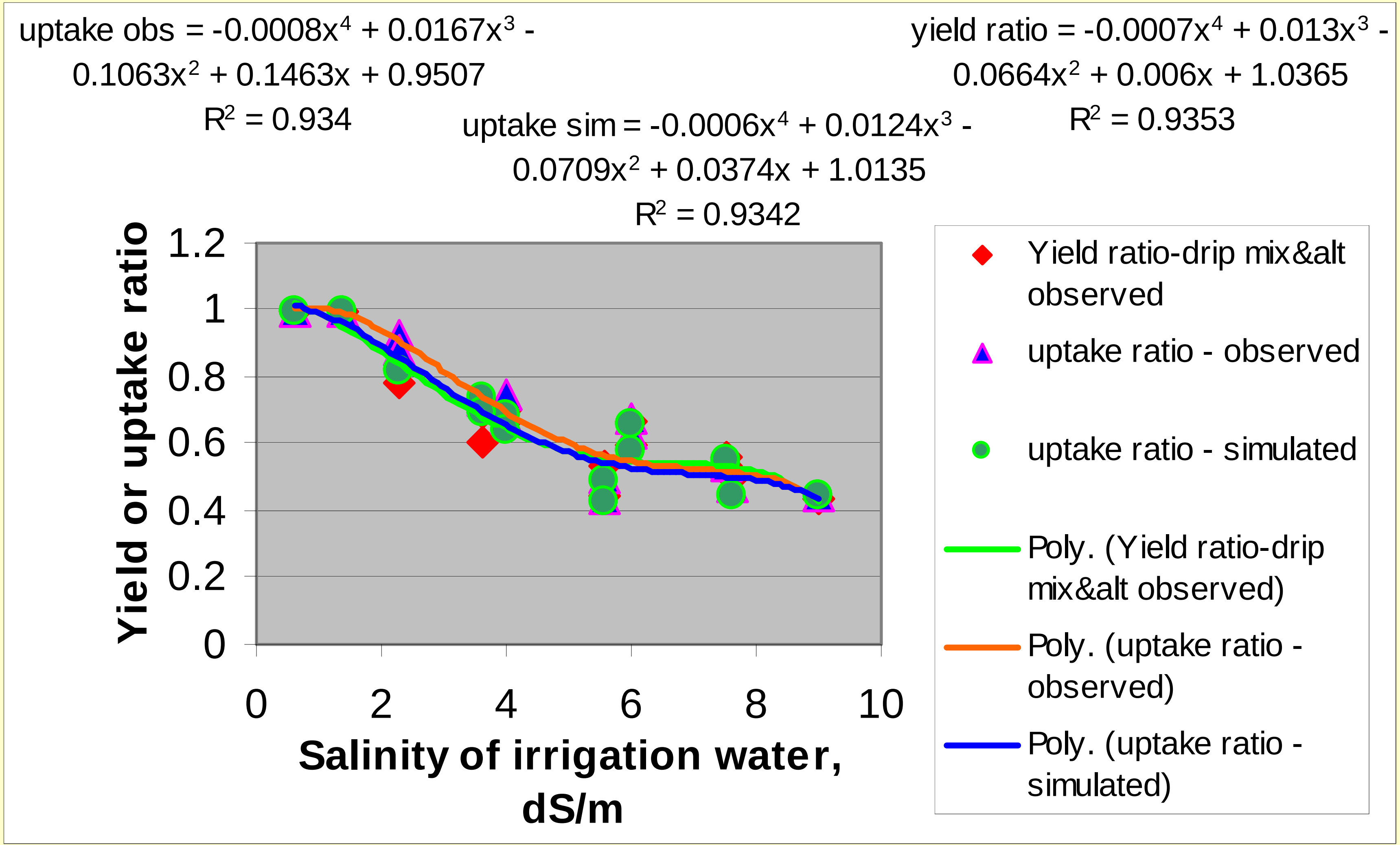
An experiment layout (one replicate) showing tanks of fresh water (FW), saline water (SW) and for mixing waters (Mix).

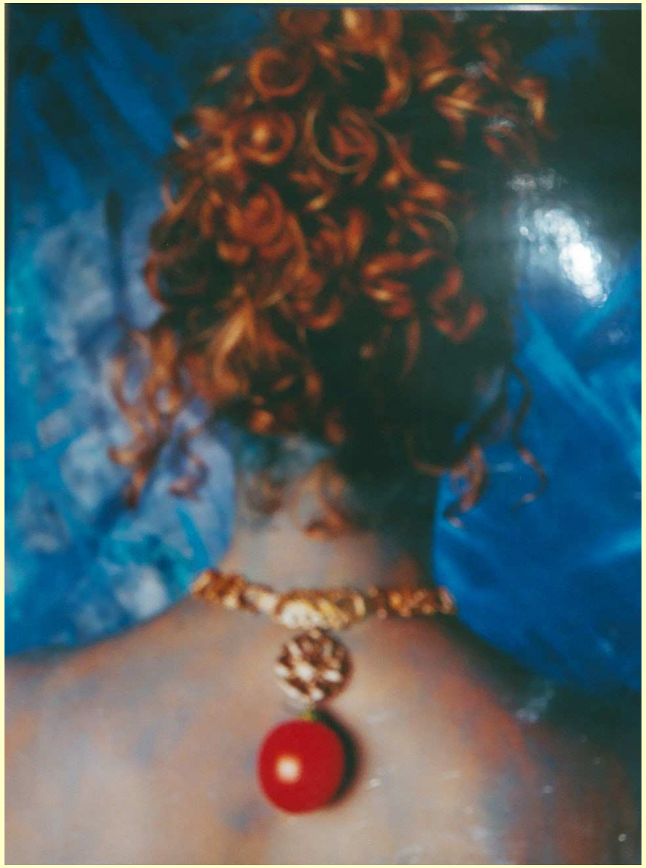
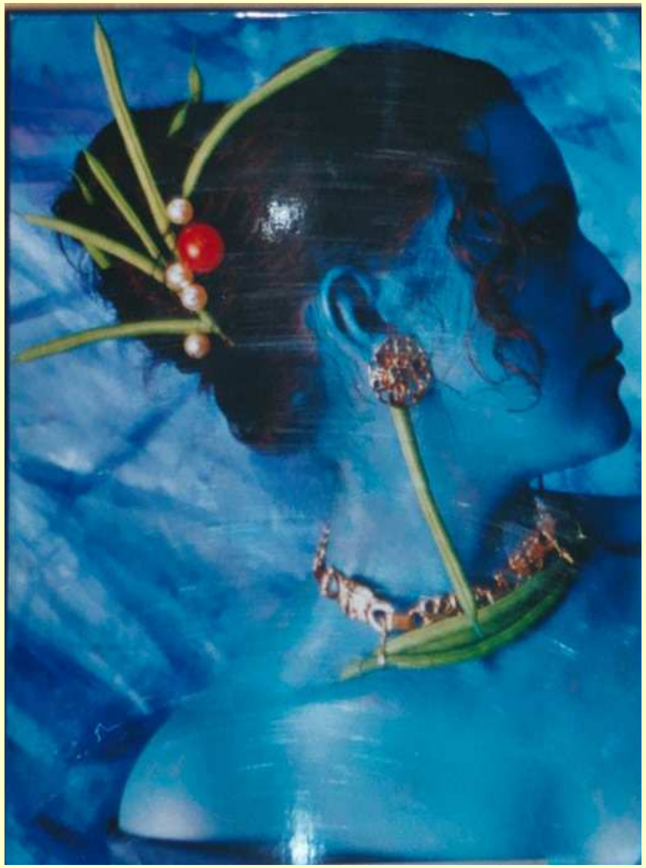
Tomatoes of high quality with high sugar content were obtained from SALTMED Field experiment in Egypt.

Tomato yield under different managements during 2000 season.

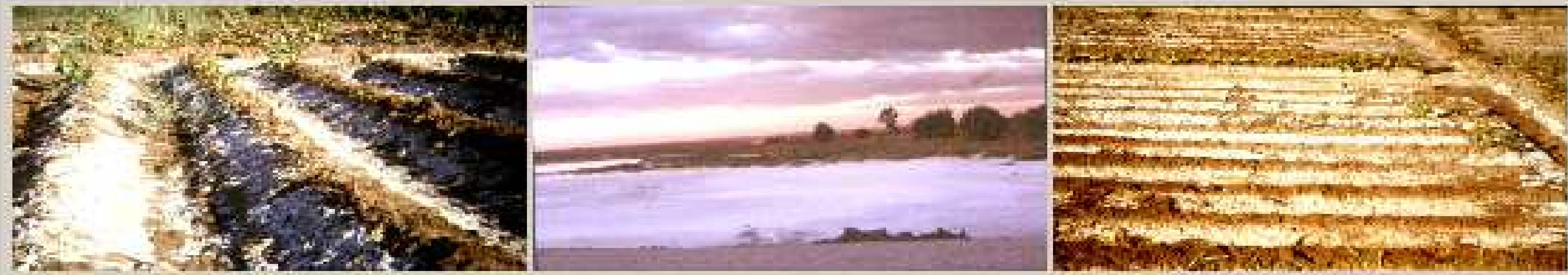
G. Abdel Gawad et al. / Agricultural Water Management 78 (2005) 46 39–53




uptake obs = -0.0008x4 + 0.0167x3 - 0.1063x2 + 0.1463x + 0.9507
R2 = 0.934
yield ratio = -0.0007x4 + 0.013x3 - 0.0664x2 + 0.006x + 1.0365
R2 = 0.9353
uptake sim = -0.0006x4 + 0.0124x3 - 0.0709x2 + 0.0374x + 1.0135
R2 = 0.9342
Yield or uptake ratio
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
Salinity of irrigation water, dS/m
Yield ratio-drip mix&alt observed
uptake ratio - observed
uptake ratio - simulated
Poly. (Yield ratio-drip mix&alt observed)
Poly. (uptake ratio - observed)
Poly. (uptake ratio - simulated)


SALTMED Version 1.1.4



SALTMED

http://www.ceh.ac.uk

Project Leader: Dr. Ragab Ragab
eMail: rag@ceh.ac.uk

SALTMED is 50% funded by the EU under INCO-DC: International Co-operation with Developing Countries: Contract number IC18-CT98-0301 and 50% funded by NERC

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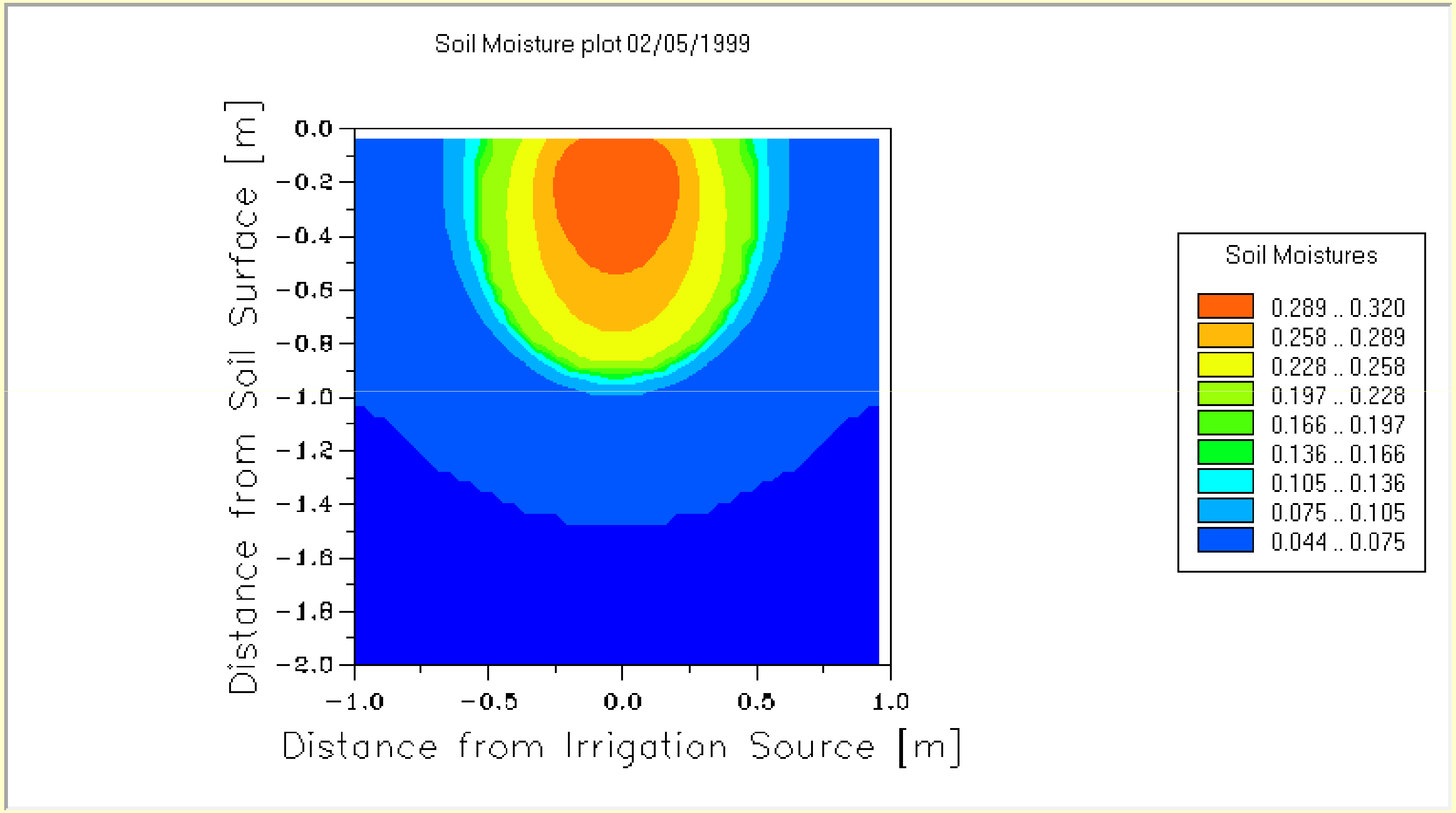
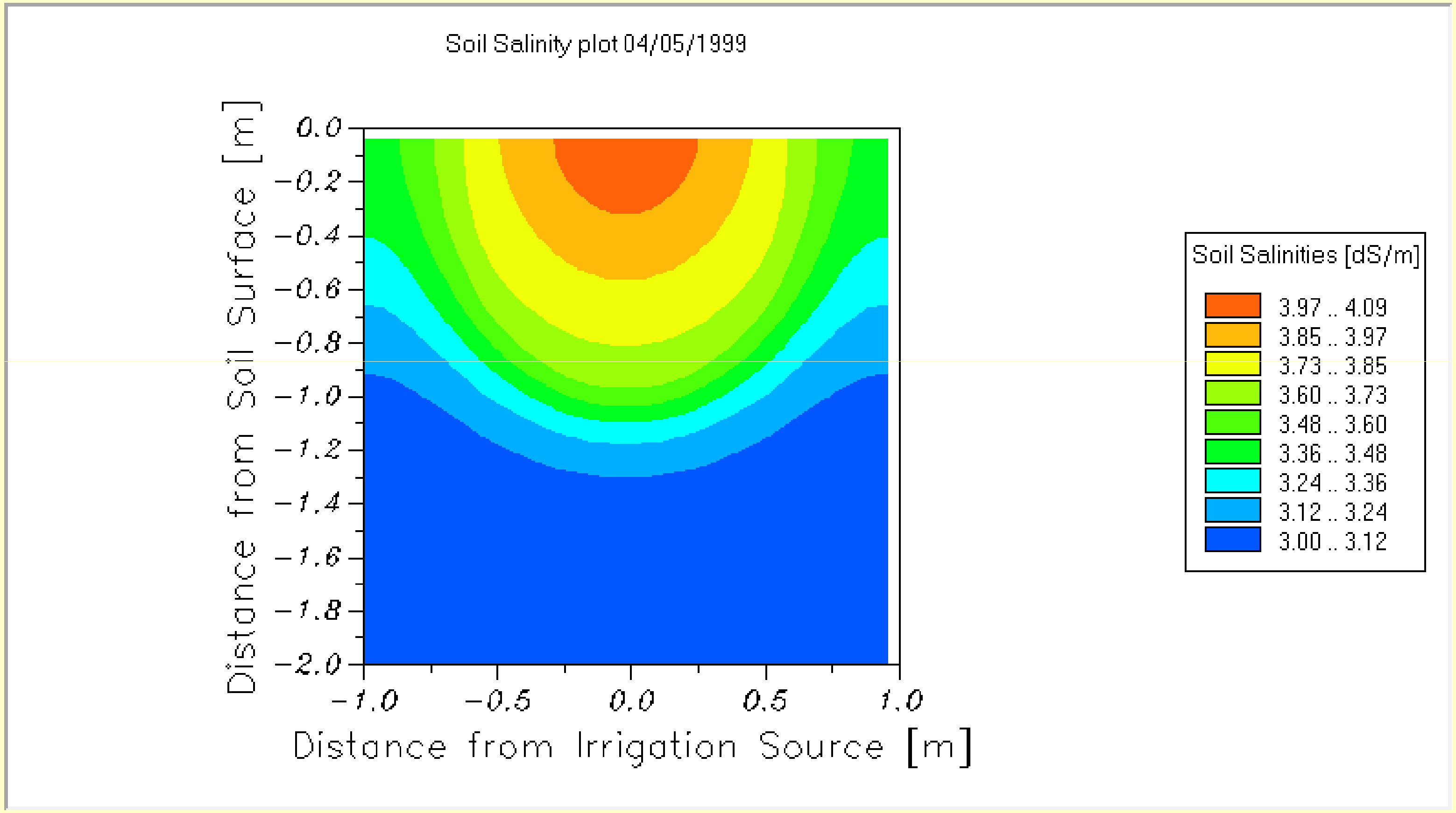
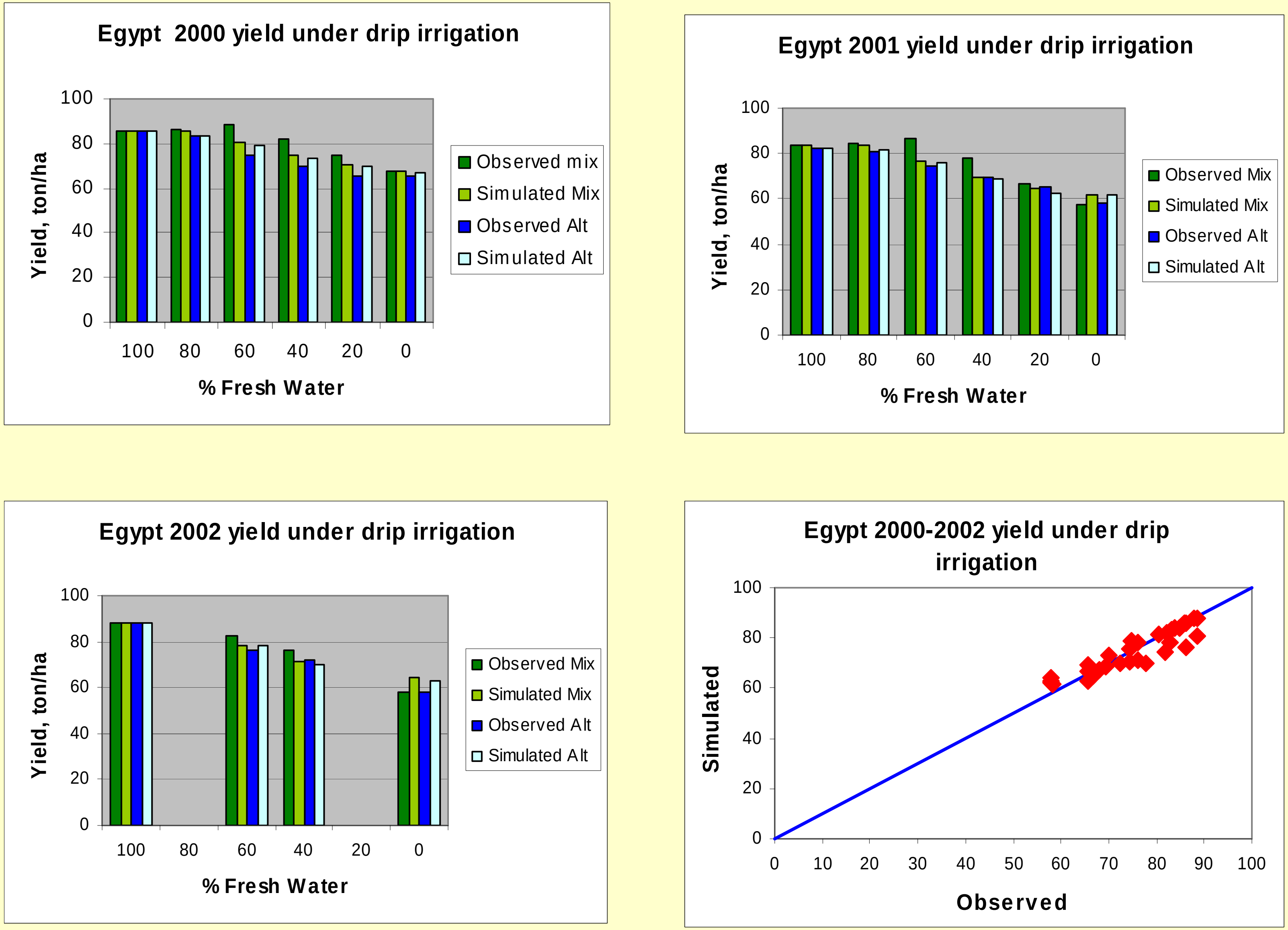
Evolution of soil moisture profile over time under trickle line source

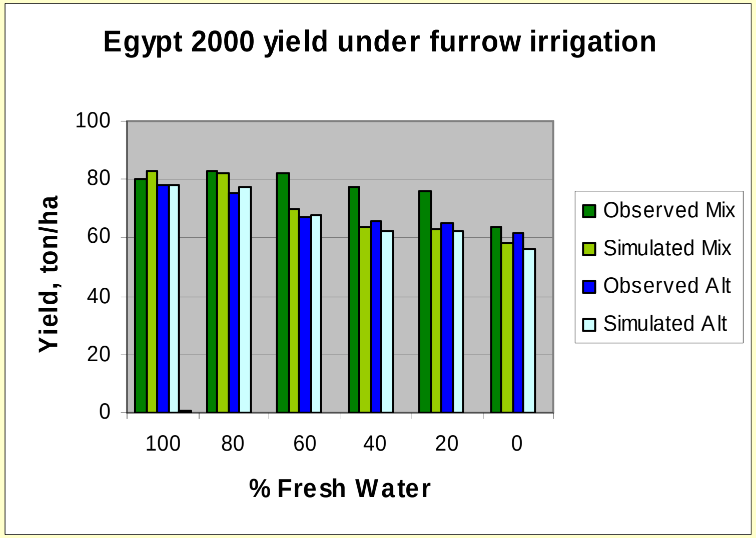


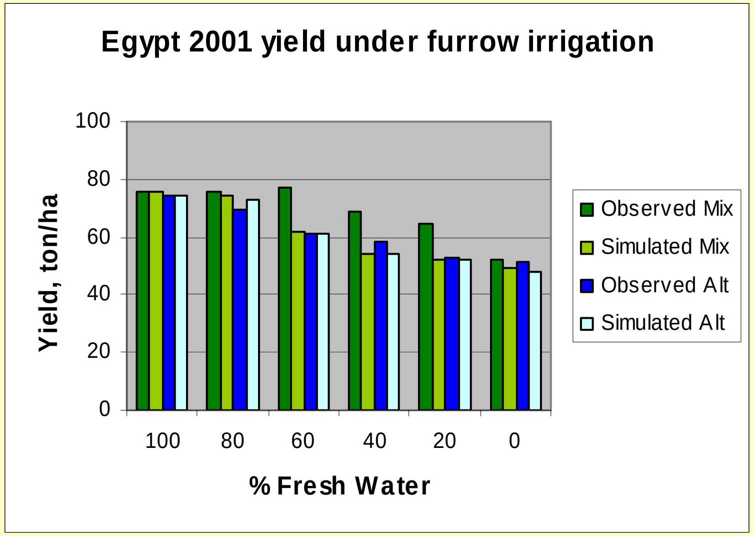
Evolution of soil salinity profile over time under trickle line source

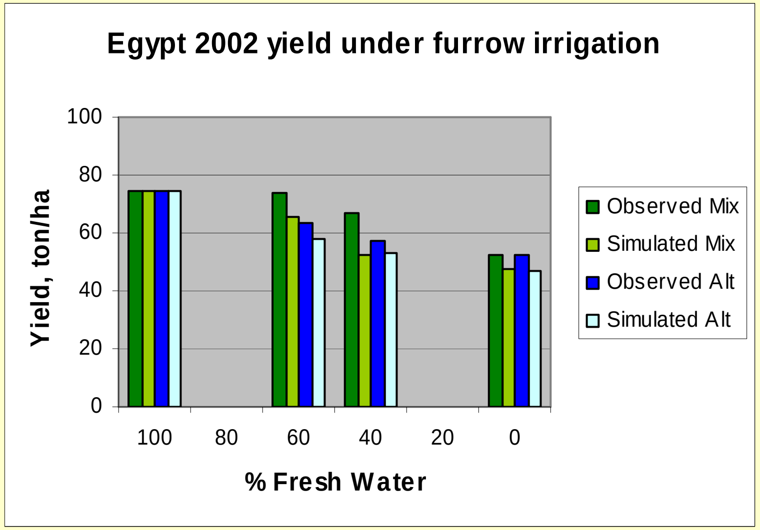


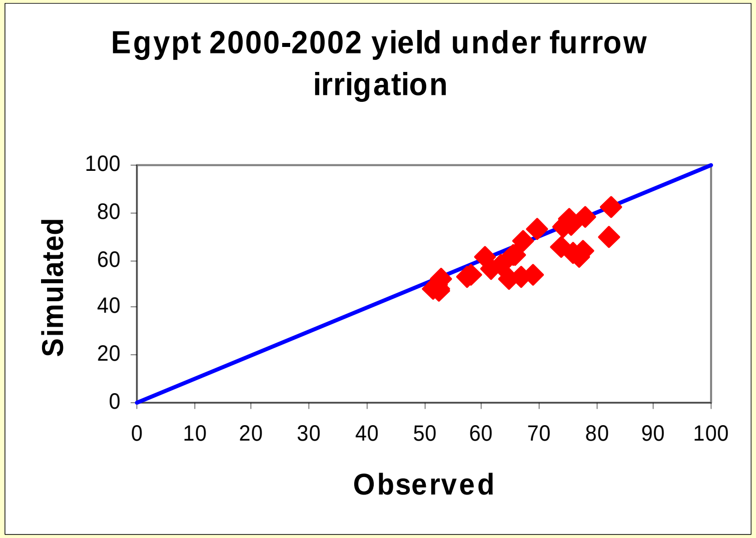


Simulated and observed yield under different drip irrigation treatments in Egypt, 2000-2002.

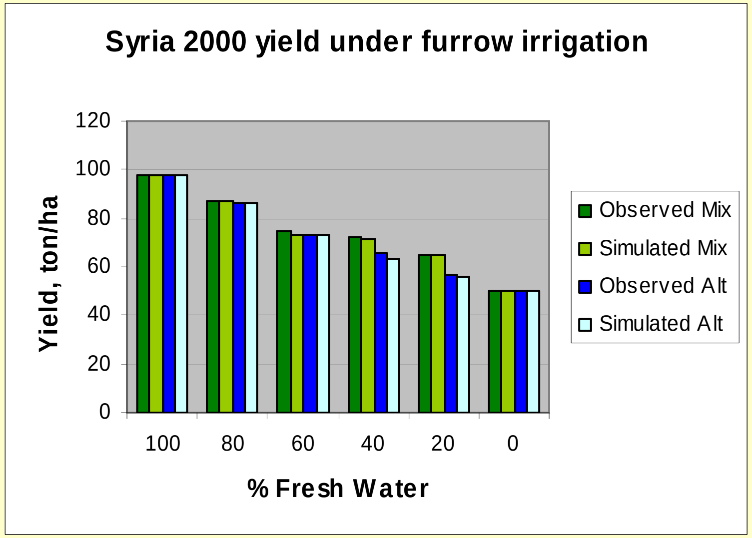


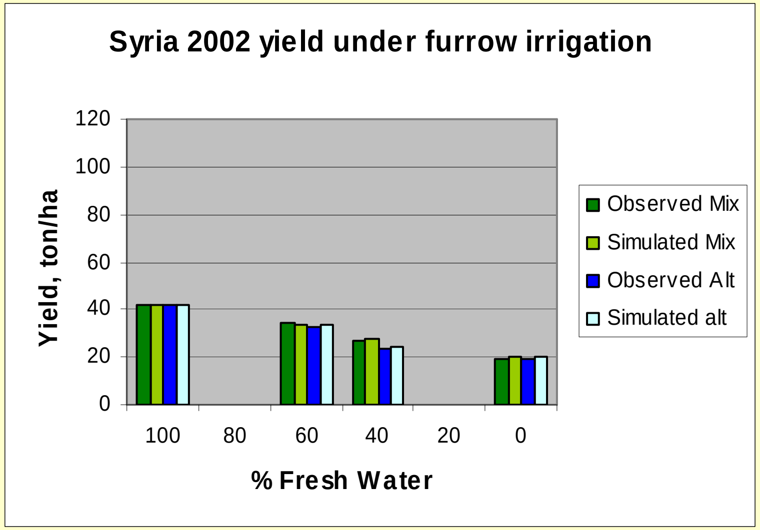


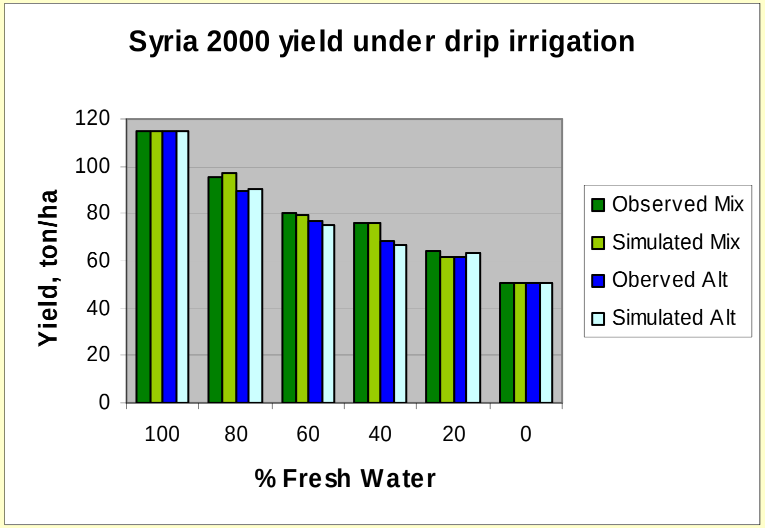


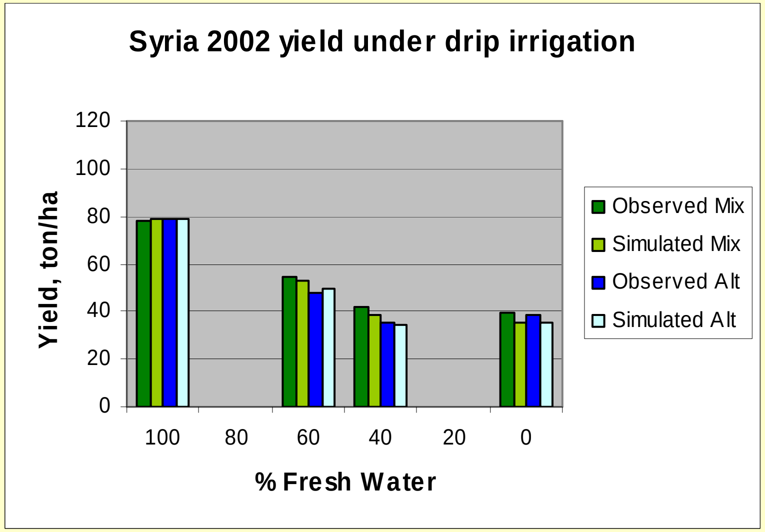


Simulated and observed yield under different furrow irrigation treatments in Egypt, 2000-2002.









Simulated and observed yield under different drip & furrow irrigation treatments in Syria, 2000-2002

Findings

- **The results indicated that the Floridade variety of tomatoes is salt tolerant and suitable to grow in the Mediterranean region.**
- **The Yield and the water use efficiency were greater for drip irrigation than furrow irrigation.**
- **Higher sugar and total dissolved solids in tomato fruits can be obtained using moderately and saline irrigation water.**
- **Using saline irrigation water for tomato saves fresh water to irrigate more lands and more crops.**
- **Using saline drainage water for irrigation reduces the agriculture drainage volume and solve the problem of disposal of saline drainage water.**
- **Increasing irrigation frequency reduces salts accumulation in soil and increases the yield.**

Findings

- **Using drip irrigation system reduces the salinity hazards as the drip irrigation is applied more frequently and keeps the soil moisture high enough to counter balance the negative impact of salinity**

- **Pre-treatments of young seedlings with drought, salinity may increase salt tolerance of tomato in later stages.**

- **There was no significant difference between alternative and mixed treatment in terms of yield. However, mixing management may be used if both fresh water and saline water are always available otherwise use alternative treatment, irrigate with saline water when fresh water is not available particularly at later stages. Alternative treatment would save more fresh water that could be used to grow more crops.**

- **Models are useful tool for management and assessments. Soil salinization is a long term process and models are useful tool to predict salinization and possible yield under combination of field, crop, soil and water salinity conditions over longer period.**

SALTMED MODEL is freely available at:

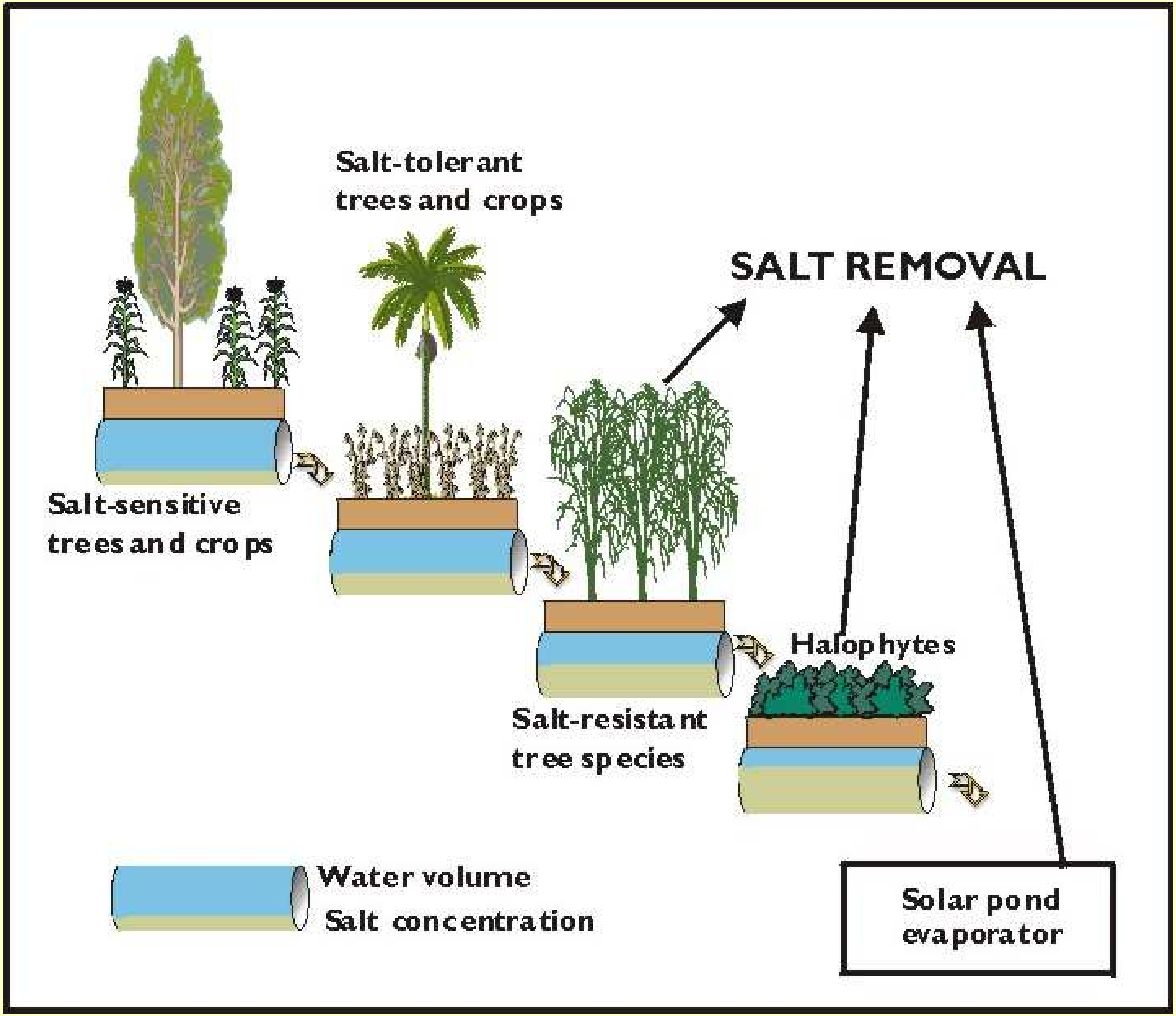
- ***http://www.ceh-wallingford.ac.uk/research/cairoworkshop***

Or Simply go to Google and search for SALTMED

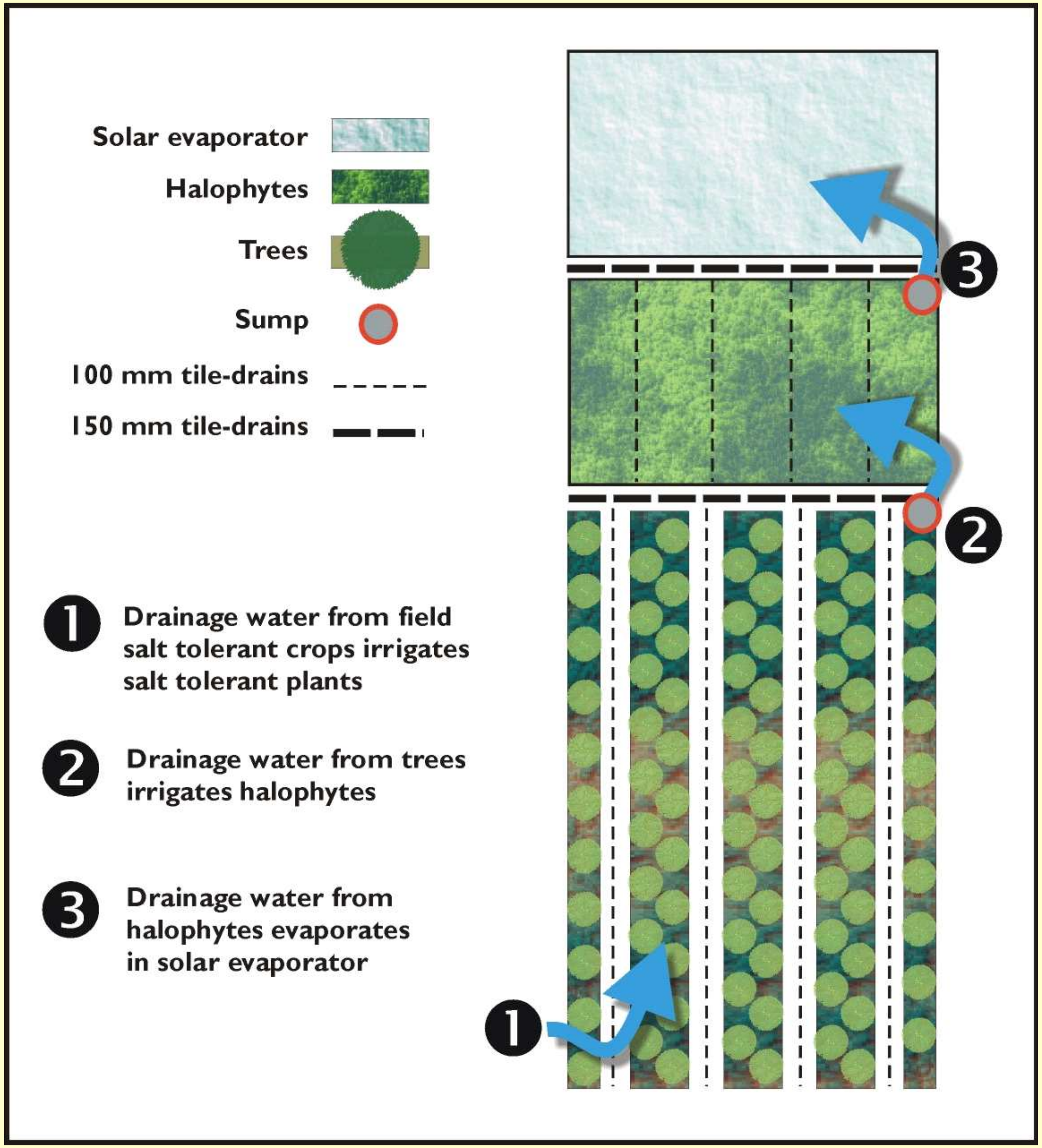
- ***RAGAB, R. (Editor), 2005. Advances in integrated management of fresh and saline water for sustainable crop production: Modelling and practical solutions. International Journal of Agricultural Water Management (Special Issue), volume 78- Issues 1-2, pages 1-164***

- ***Huibers, F.P., Raschid-Sally, L. and RAGAB, R (Editors), 2005. Wastewater Irrigation. Journal of Irrigation and Drainage (Special Issue), Volume 54 (1-118).***

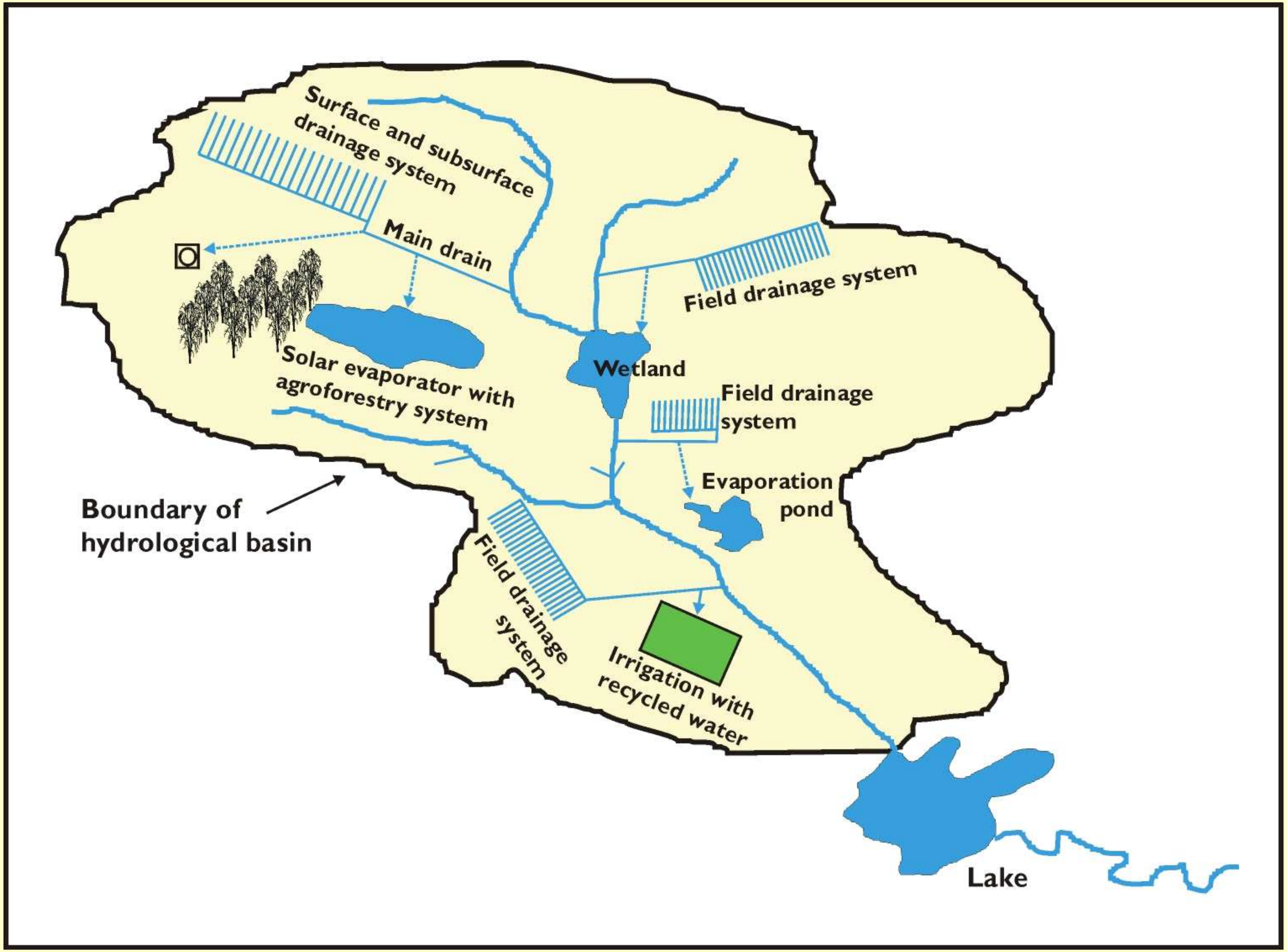
Regional drainage water reuse plan

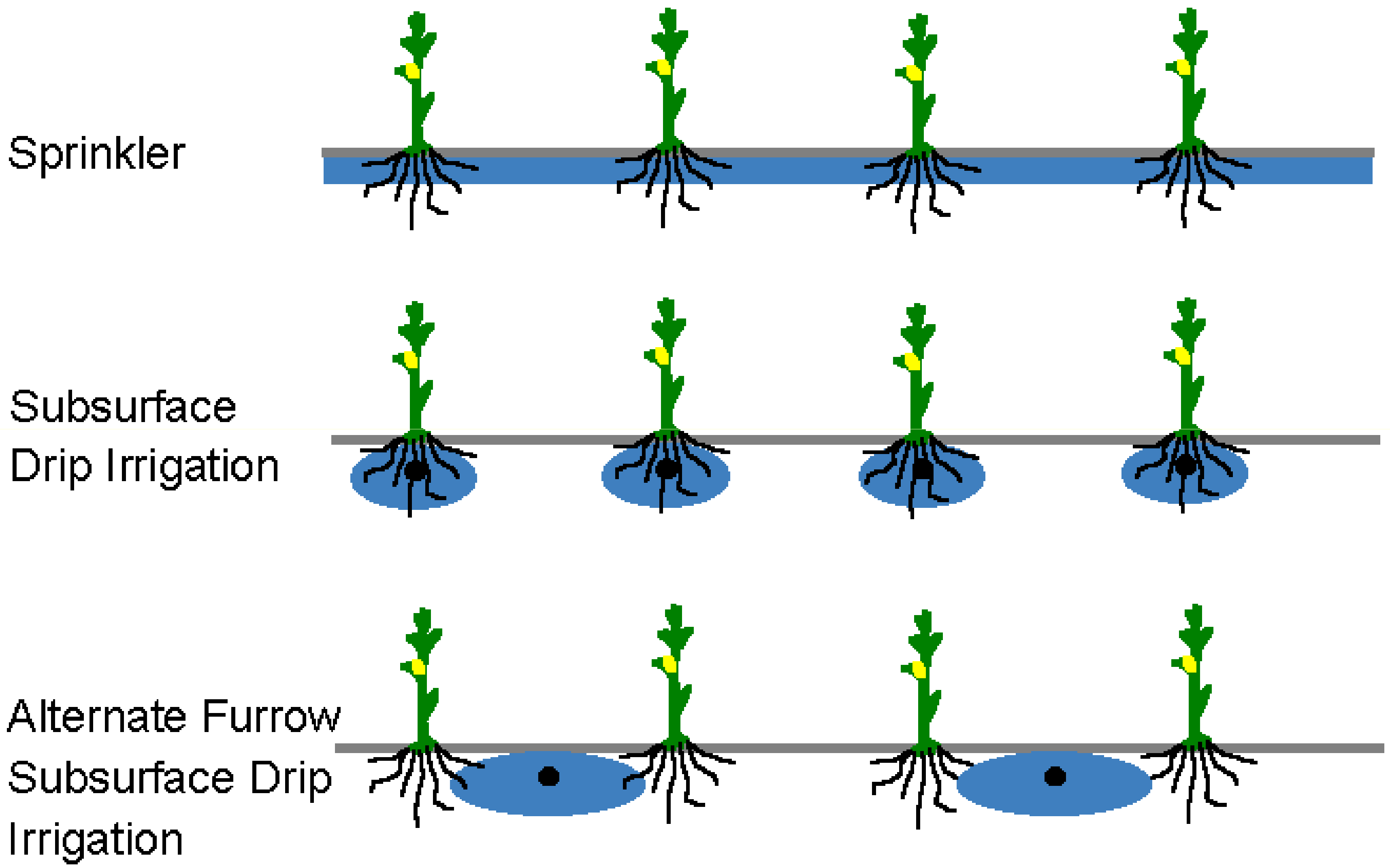


Example of sequential saline drainage water reuse

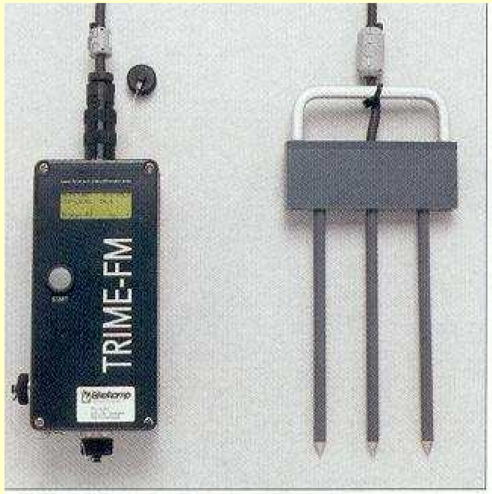


Drainage water disposal options within a watershed




Sprinkler
Subsurface Drip Irrigation
Alternate Furrow Subsurface Drip Irrigation

EA513-135 Salinity bridge measuring instrument



rime FM-3 with three-pin probe

nree-pin bore hole probe + adapter

Surface Capacitance Insertion Probe (SCIP)

Surface soil moisture transect across arable margin

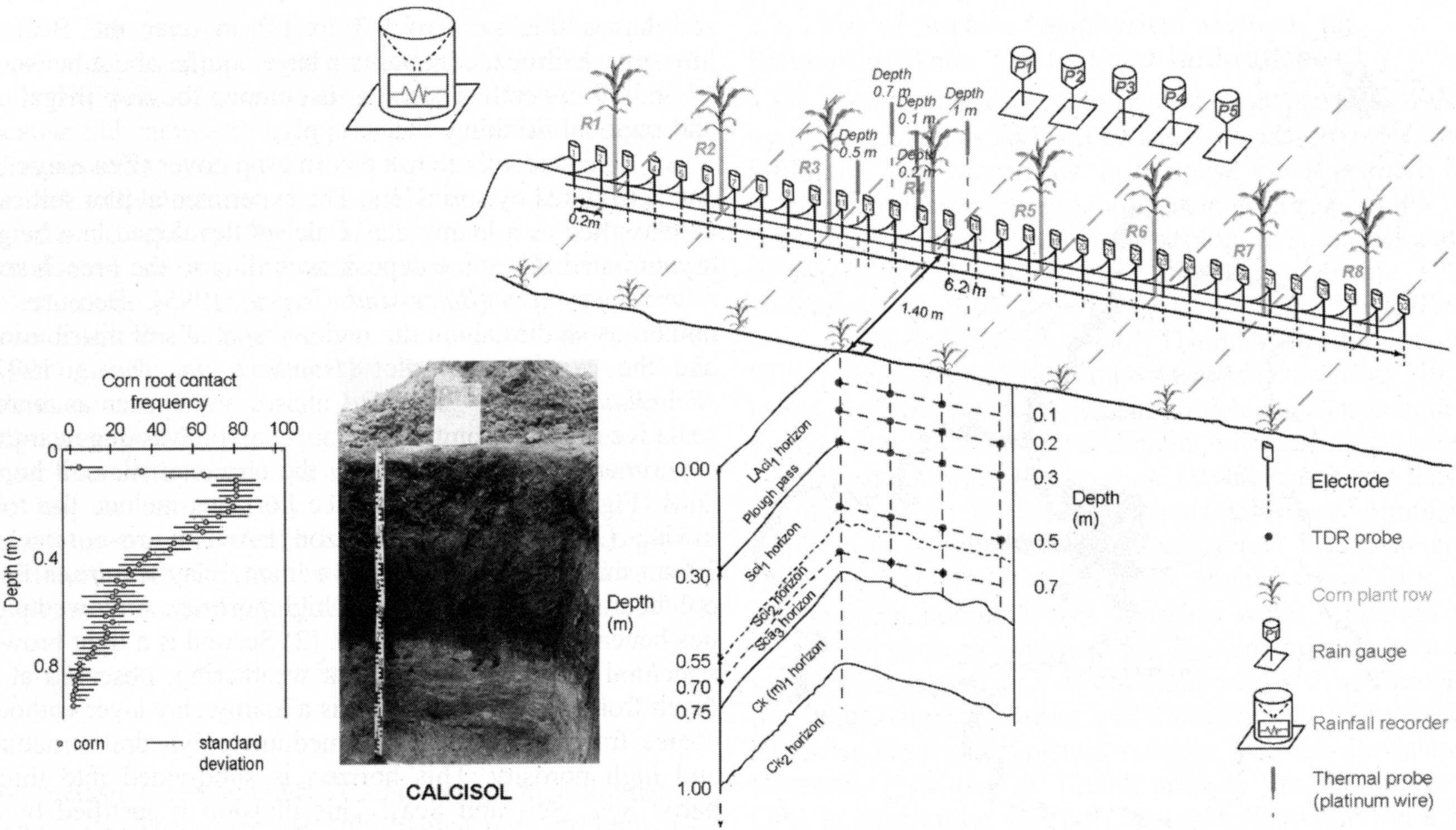
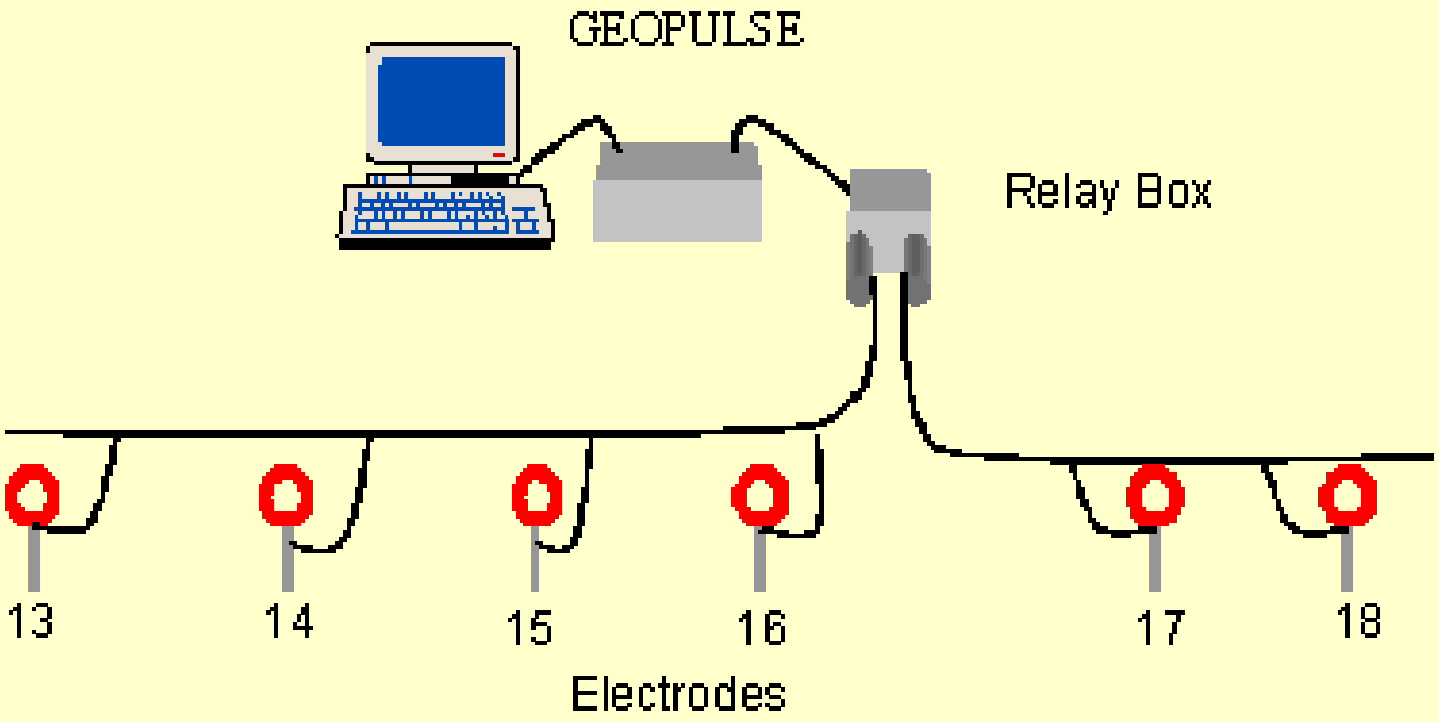


Figure 2. Water flow monitoring; experimental setup by 2-D electrical resistivity tomography in its pedological and agricultural context.

Basic equipment layout for resistivity surveys



College Field Top Transect Sheepdrove Farm 21-04-2006

64 electrode ERT transect at 0.5m spacing crossing 3 distinct vegetation types – winter cereal (foreground), 'beetle-belt' (centre), spring cereal (distance)

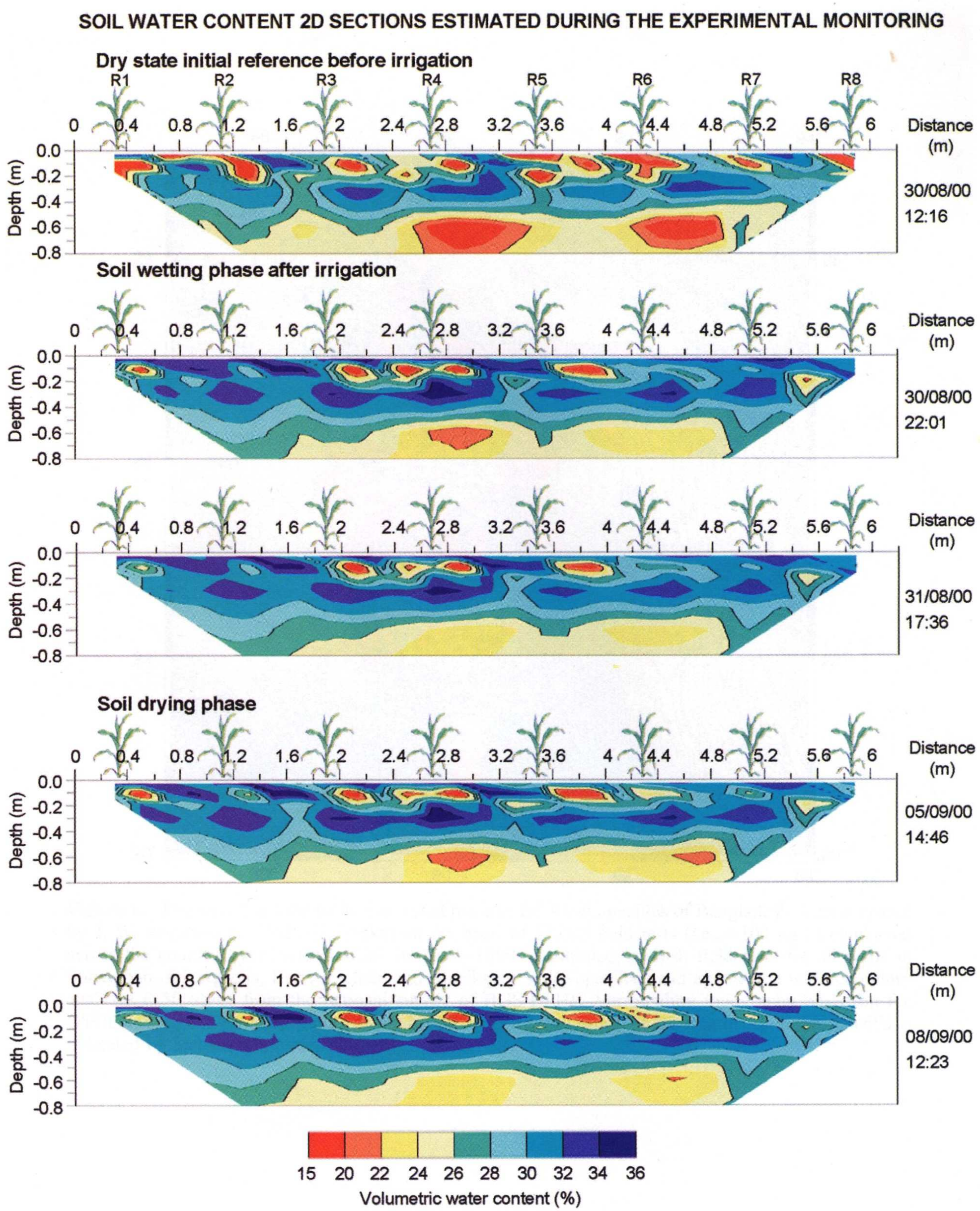
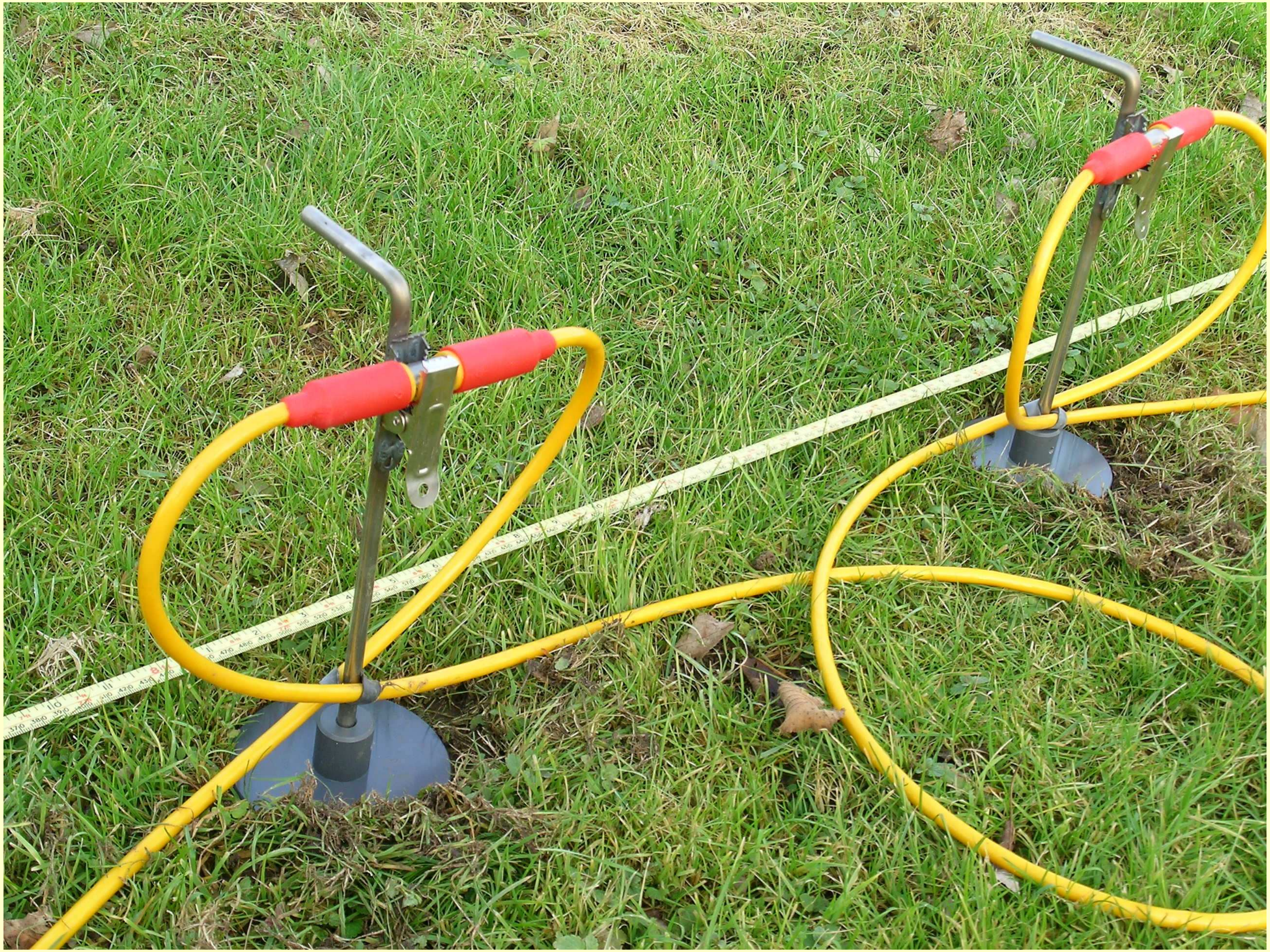


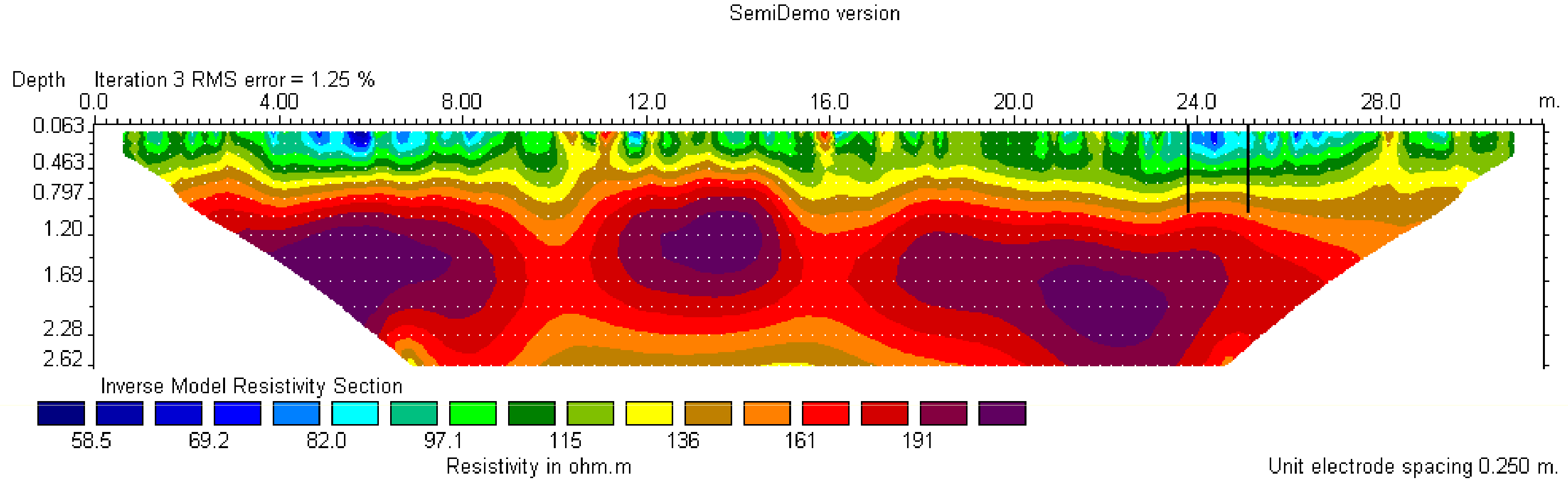
Figure 12. Characteristic soil moisture content sections computed over time during the experimental monitoring period.



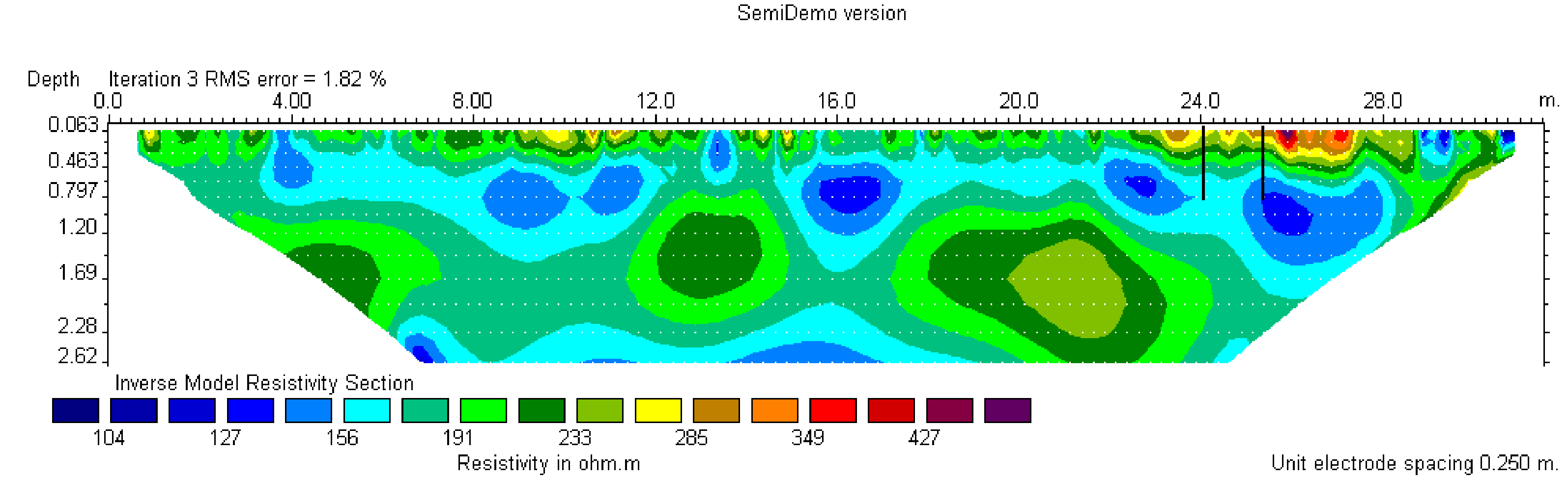
Conventional Permanent Pasture

Transect Runs Downslope

Downslope



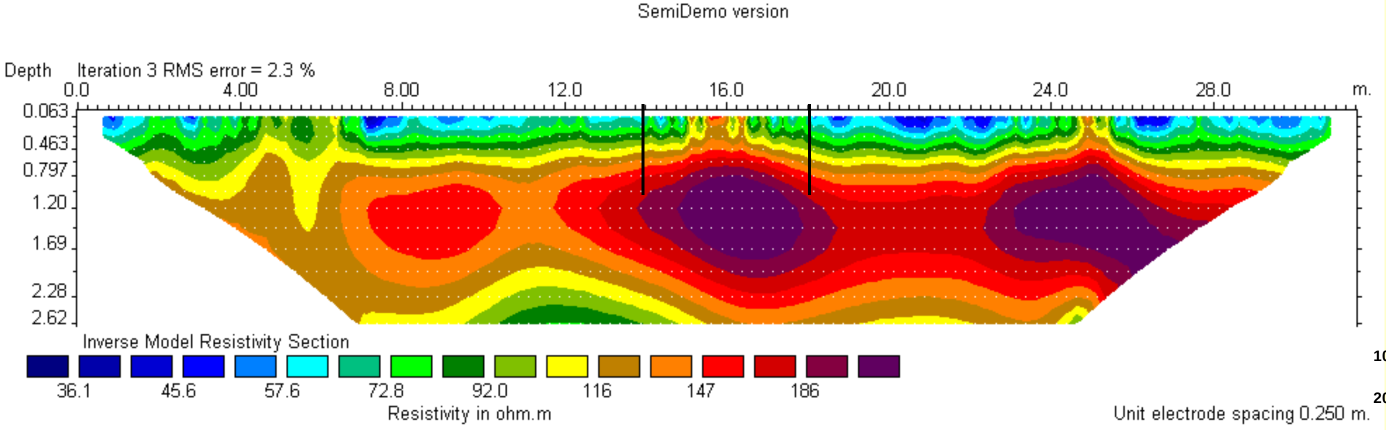
04 May 2006

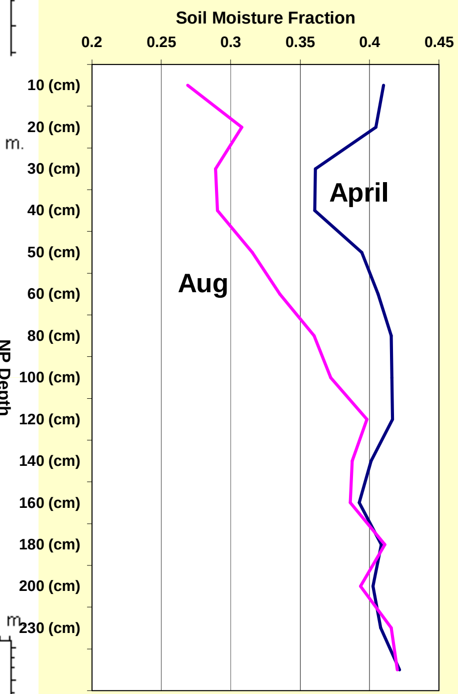


22 Aug 2006

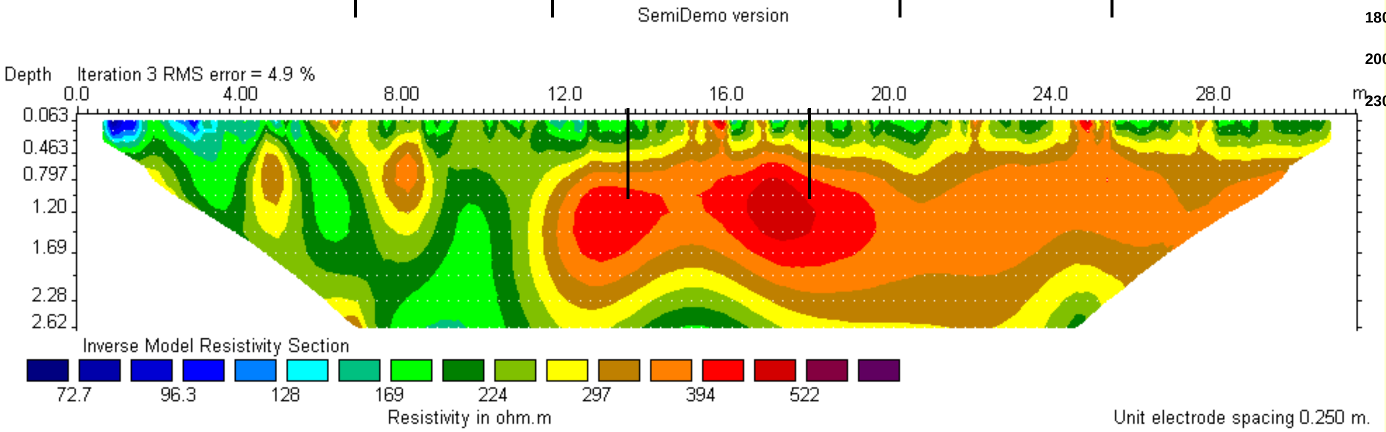
College Top

21 April 2006



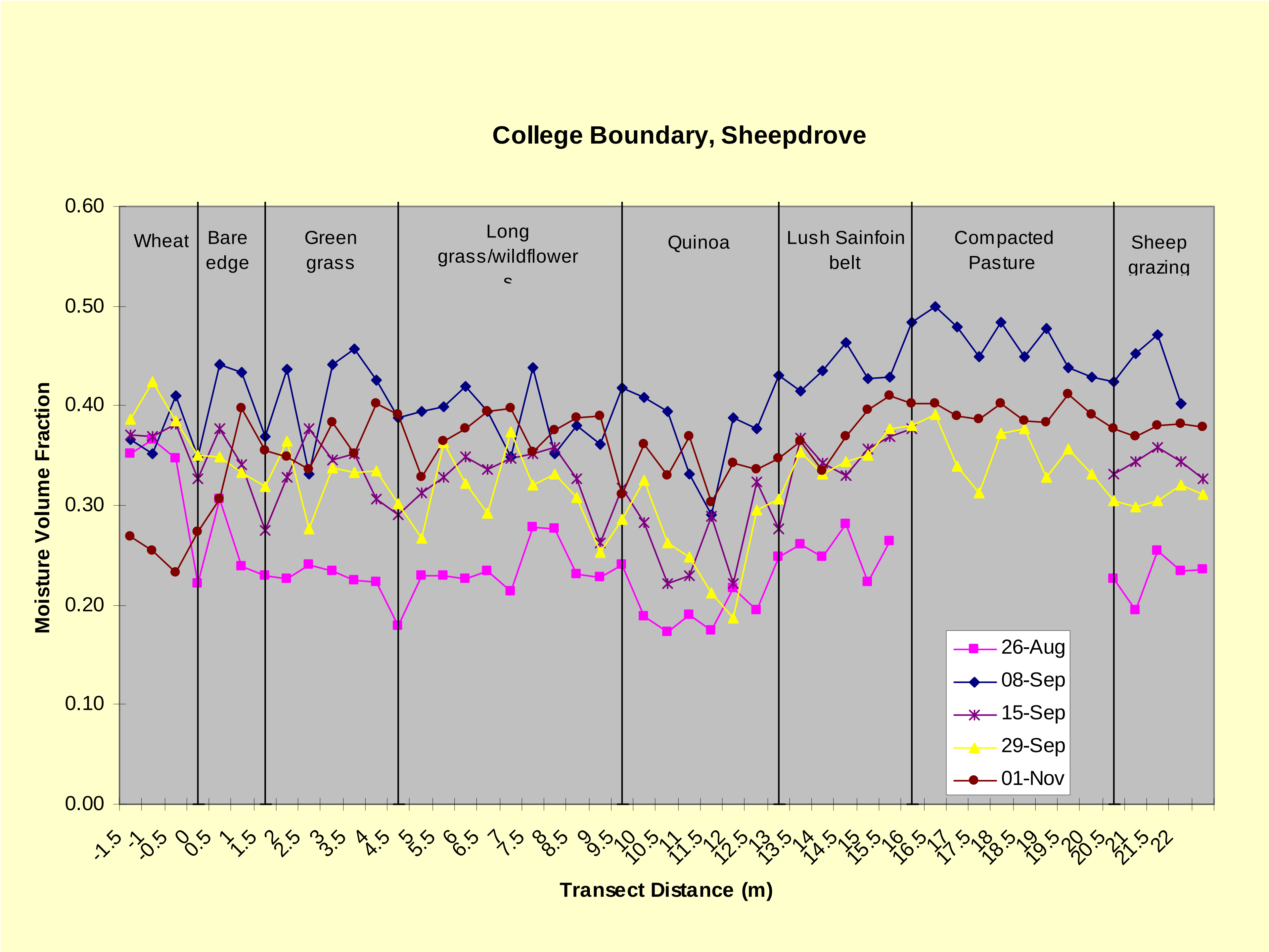


Winter Barley | **Compacted Grass (Short)** | **Beetle Belt** | **Compacted Grass (Long)** | **Spring Wheat**



23 Aug 2006

Resistivity Measurements in Spring Wheat, College Field
22 August 2006


College Boundary, Sheepdrove
Moisture Volume Fraction
Transect Distance (m)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Wheat
Bare edge
Green grass
Long grass/wildflower s
Quinoa
Lush Sainfoin belt
Compacted Pasture
Sheep grazing
26-Aug
08-Sep
15-Sep
29-Sep
01-Nov
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
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11
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12
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13
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14
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15.5
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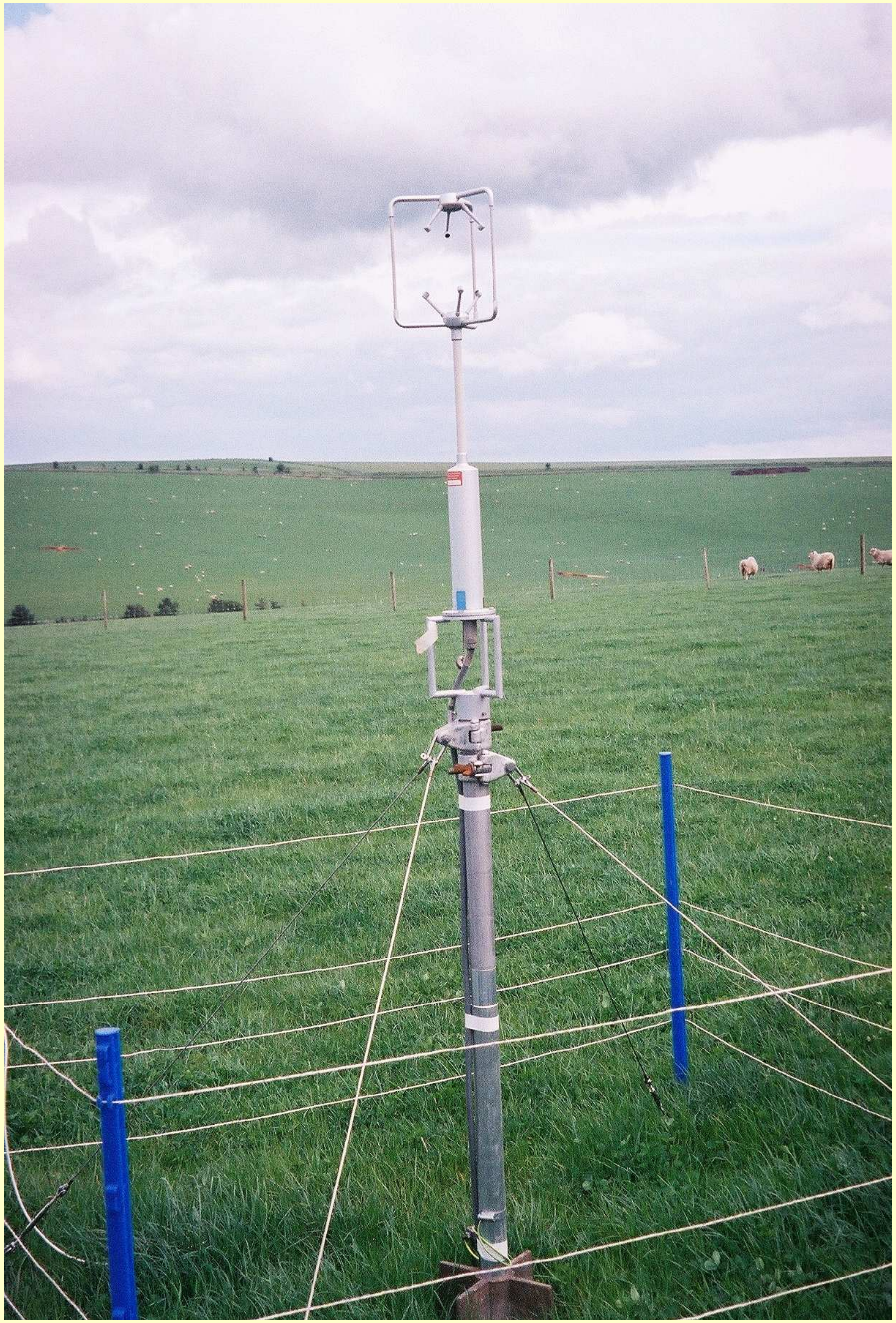
19
19.5
20
20.5
21
21.5
22

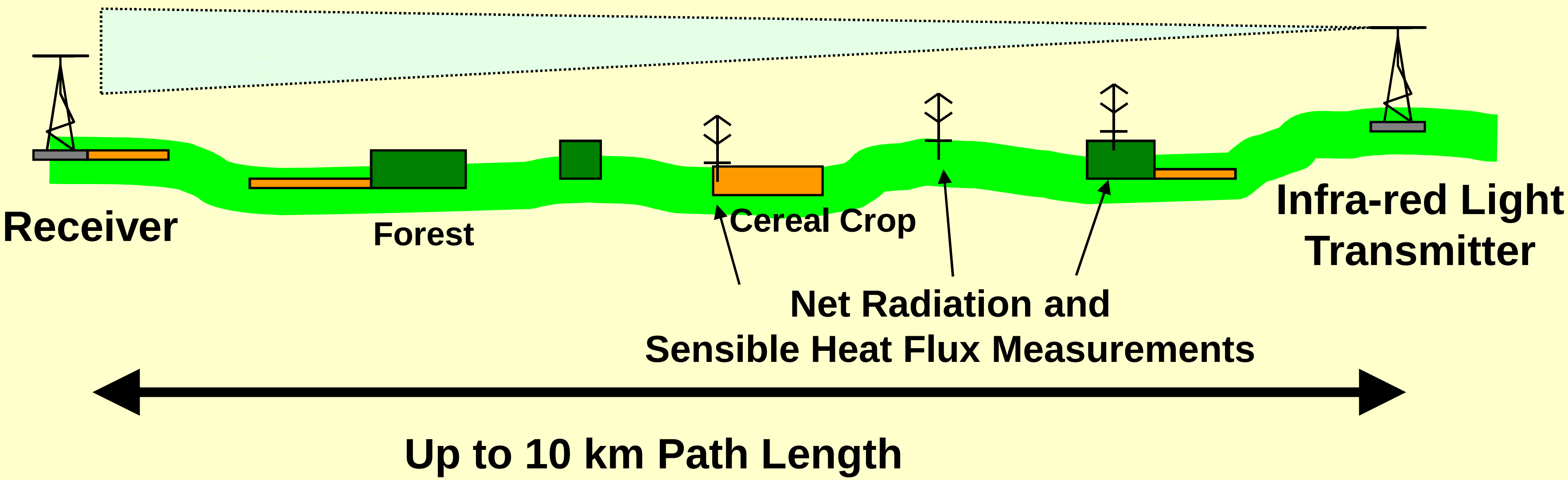
Class A Pan for Evaporation measurements




Skye
Data


24/10/2003

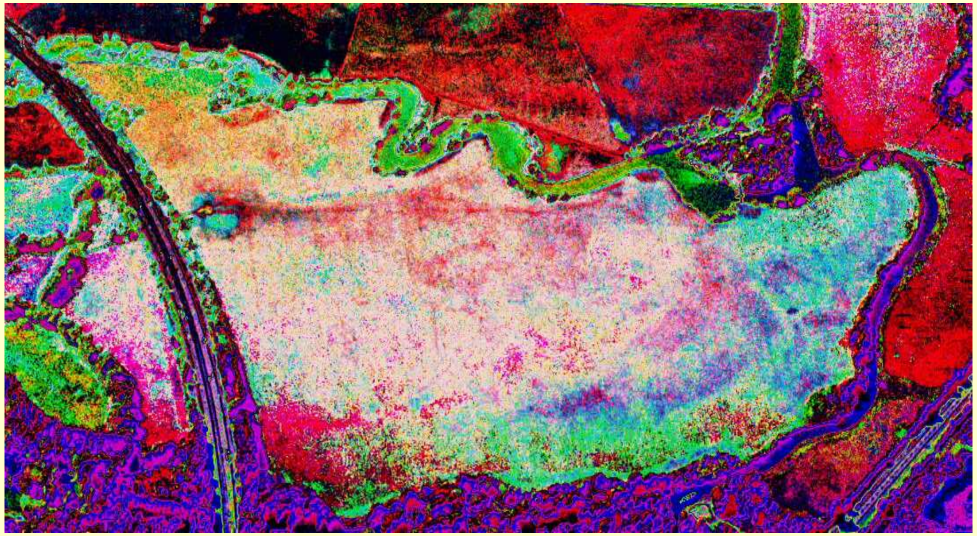
Scintillometer Beam Measures Catchment-Scale Sensible Heat Flux



- The Scintillometer measures path-averaged Sensible Heat Flux, H.
- Evaporation is derived by the Energy Balance
- Area-averaged Net Radiation is required, from ground point measurements or satellite grid estimates

Hydrology of Oxford Meadows: Environment Agency

Colour infrared aerial photo of Pixey Mead taken after 4 weeks of drought stressing (04-09-03)



Enhanced image showing vegetation differences influenced by soil type and moisture availability

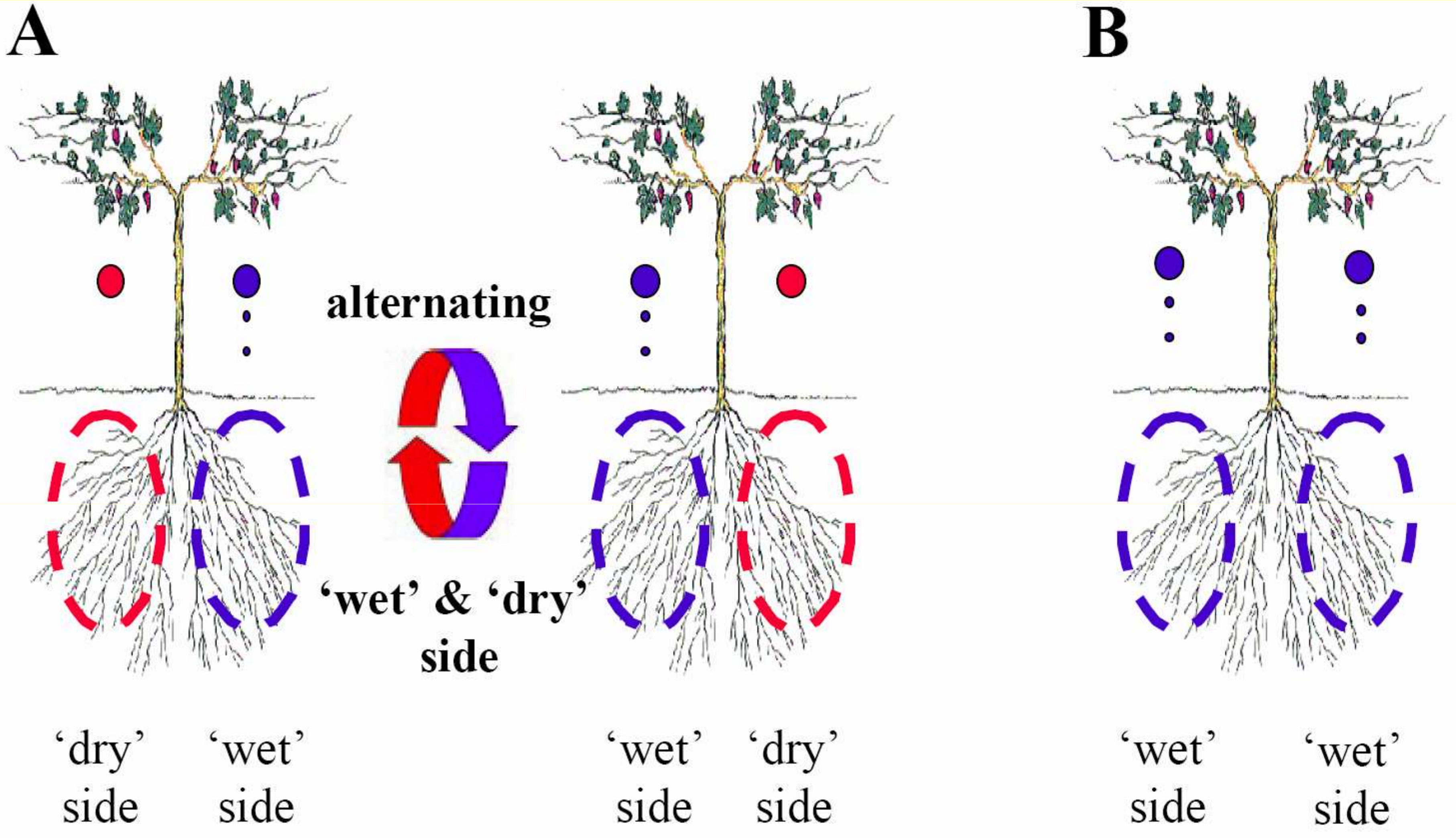


Figure 2.1 Implementation of PRD irrigation set up: A) PRD: at any time water was withheld from one side; B) control: vines received water on both sides.

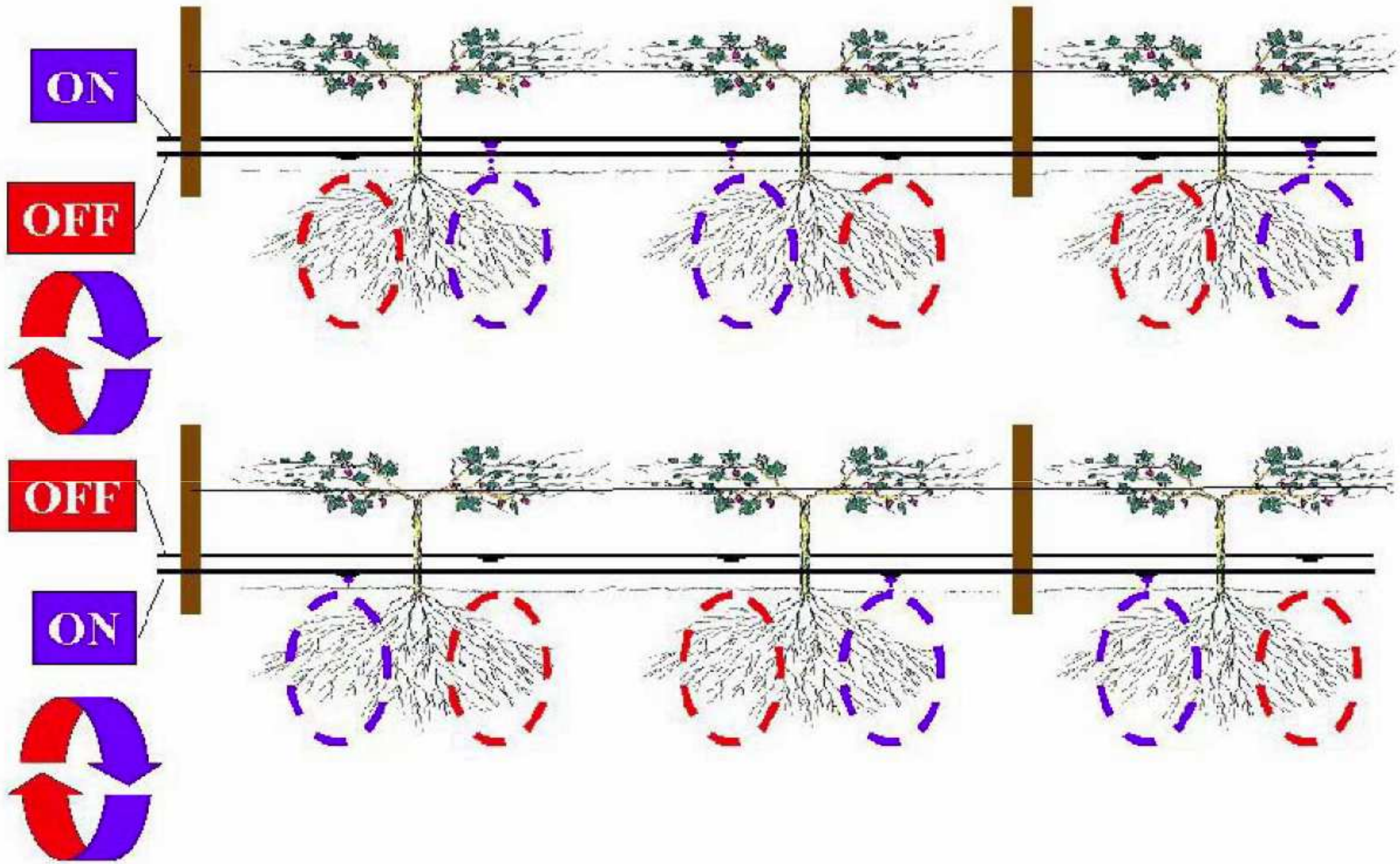


Figure 9.1 Implementation of an above ground drip irrigation system


VORN

Furrow irrigation

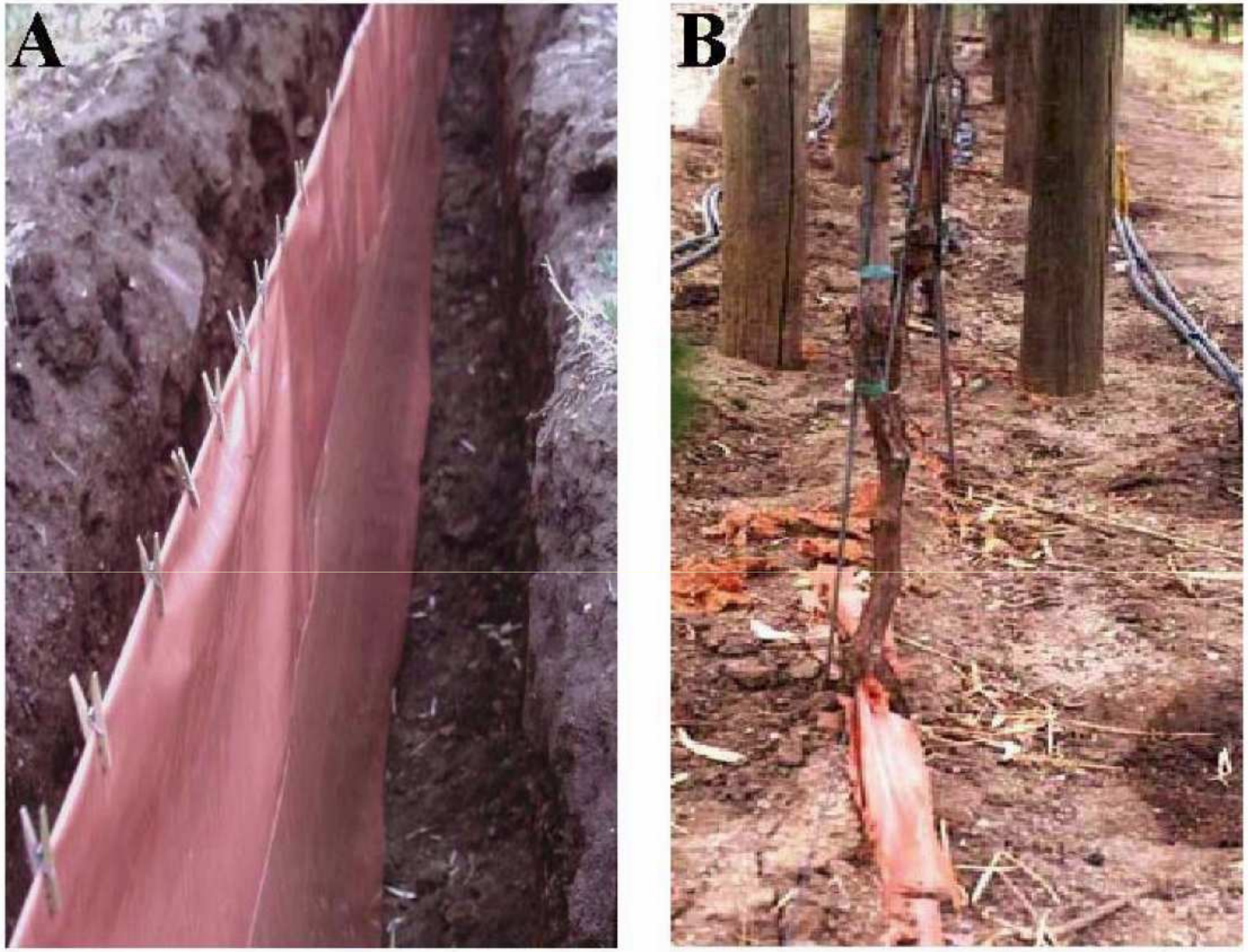


Figure 2.2 Field planting: **A)** trench burying a plastic membrane vertically to a depth of 1.5m **B)** vines planted with half of the root system on either side of the plastic membrane (*Vitis vinifera* L. cv. Cabernet Sauvignon on own roots)

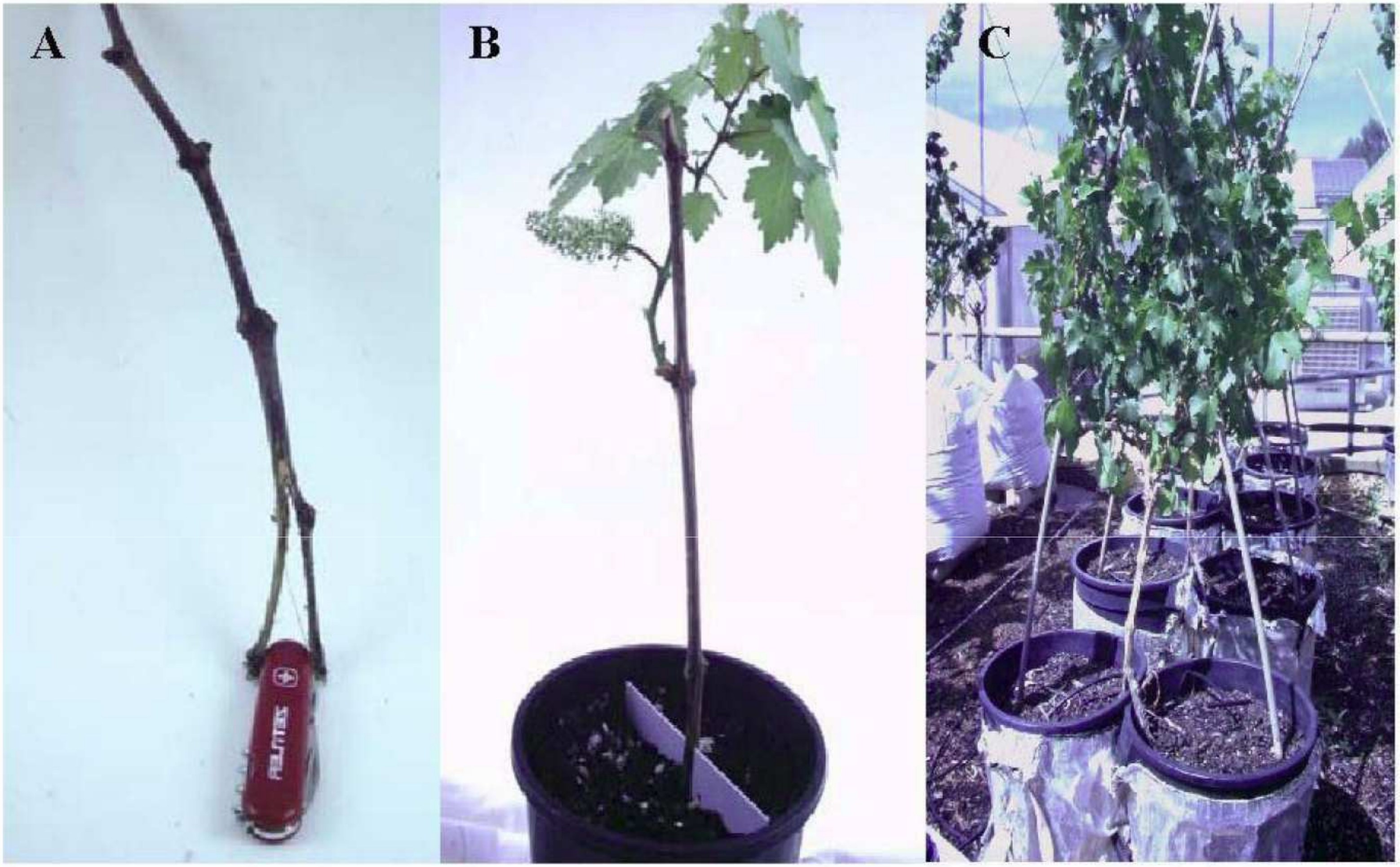


Figure 2.4 Propagation of split-root vines: **A)** split winter cutting **B)** split-root vine divided with a plastic sheet **C)** split-root vines into two pots.

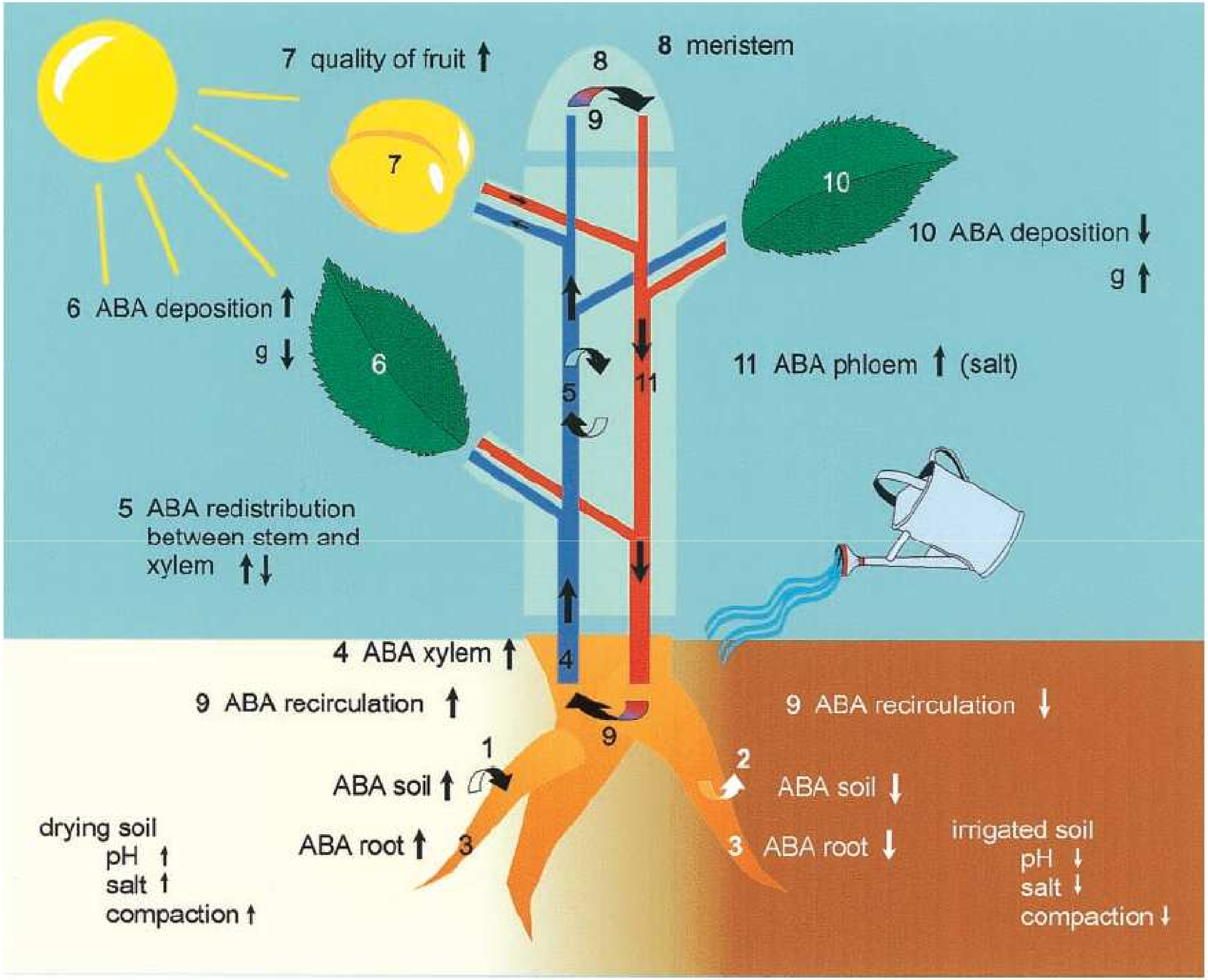


Fig. 1. The numbering of the model plant indicates several factors that influence the formation and intensity of the ABA long-distance signal. On the left hand side of the plant water shortage is demonstrated, the right hand side depicts a sufficient water supply.

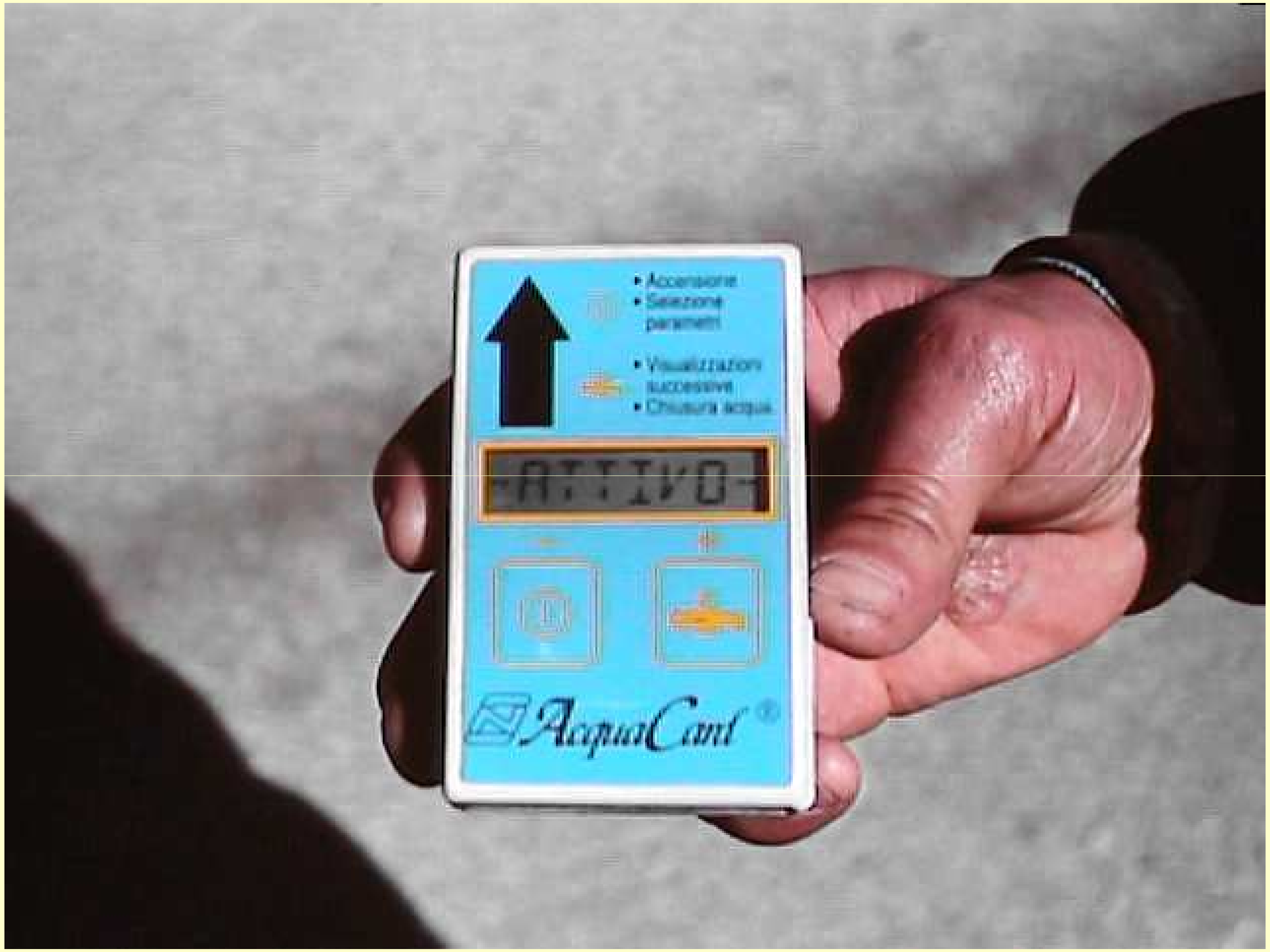
Sauter *et al*. 2001

Table 9.1 Commercial experience with PRD in different regions in Australia.

region		TSS (°Brix)	pH	TA (g/L)	yield (t/ha)	irrigation water applied (ML/ha)	water use efficiency (t/ML)
McLaren Vale Shiraz	**control**	13.4	3.7	6.7	20	2	13
	PRD	13.3	3.7	6.9	19	1	25
	% diff				-6	-50	86
Sunraysia Shiraz	**control**	13.1	3.8	5.6	29	7	4
	PRD	13.1	3.6	6.0	27	4	6
	% diff				-7	-40	55
Padthaway Shiraz	**control**	13.0			13	4	3
	PRD	13.3			10	2	4
	% diff				-28	-44	29
Adelaide Cabernet Sauvignon	**control**	13.0	3.4	6.6	10	1	17
	PRD	13.3	3.4	7.0	11	0	37
	% diff				7	-50	113
Riverland Riesling	**control**	9.7			38	5	7
	PRD	10.2			37	3	13
	% diff				-2	-49	90

PRD is compared to conventional irrigation practice (control) and the differences are expressed PRD as % of control (Stoll *et al*., 2000a).


AcquaCard
Nicotra
Sistemi spa - MI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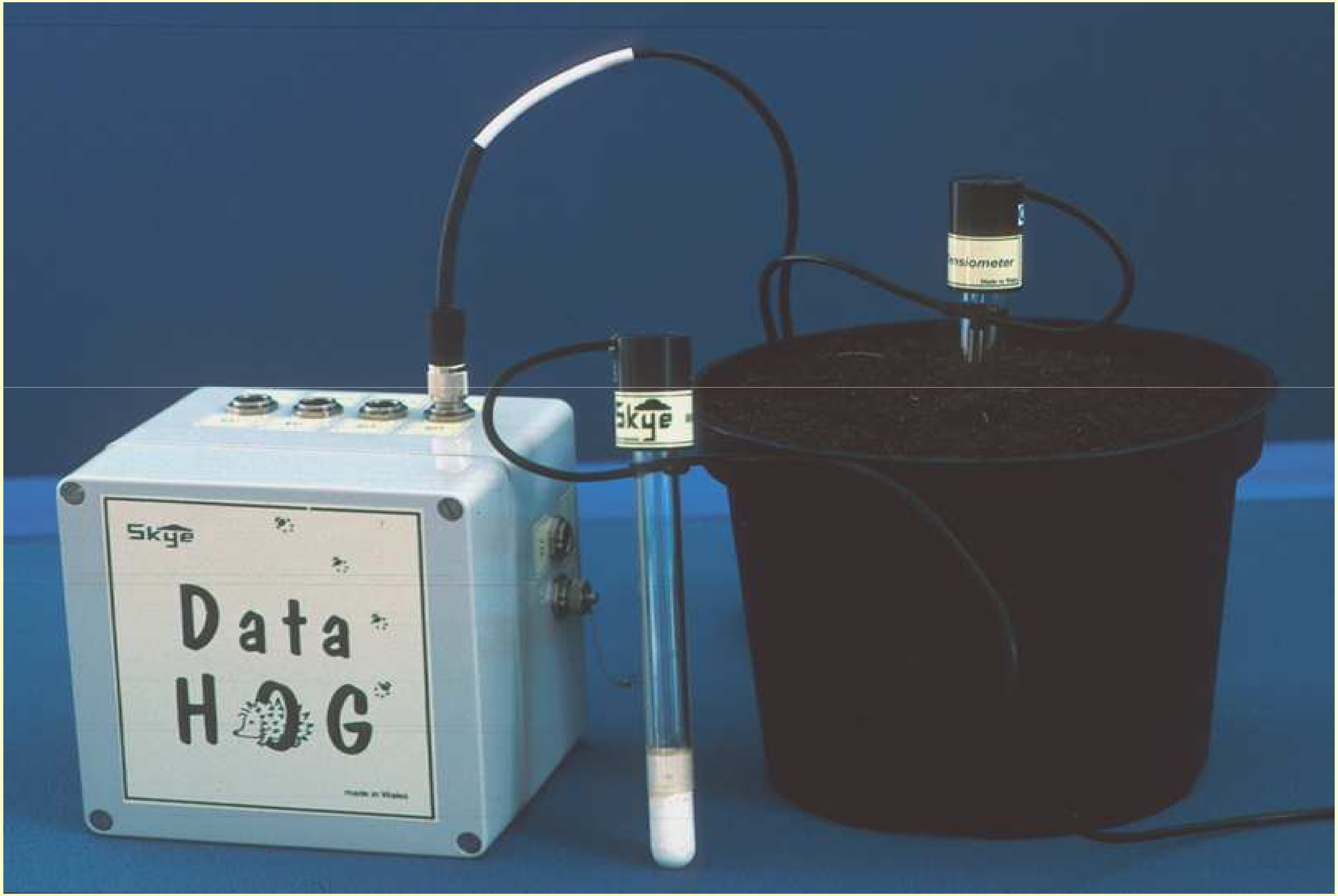
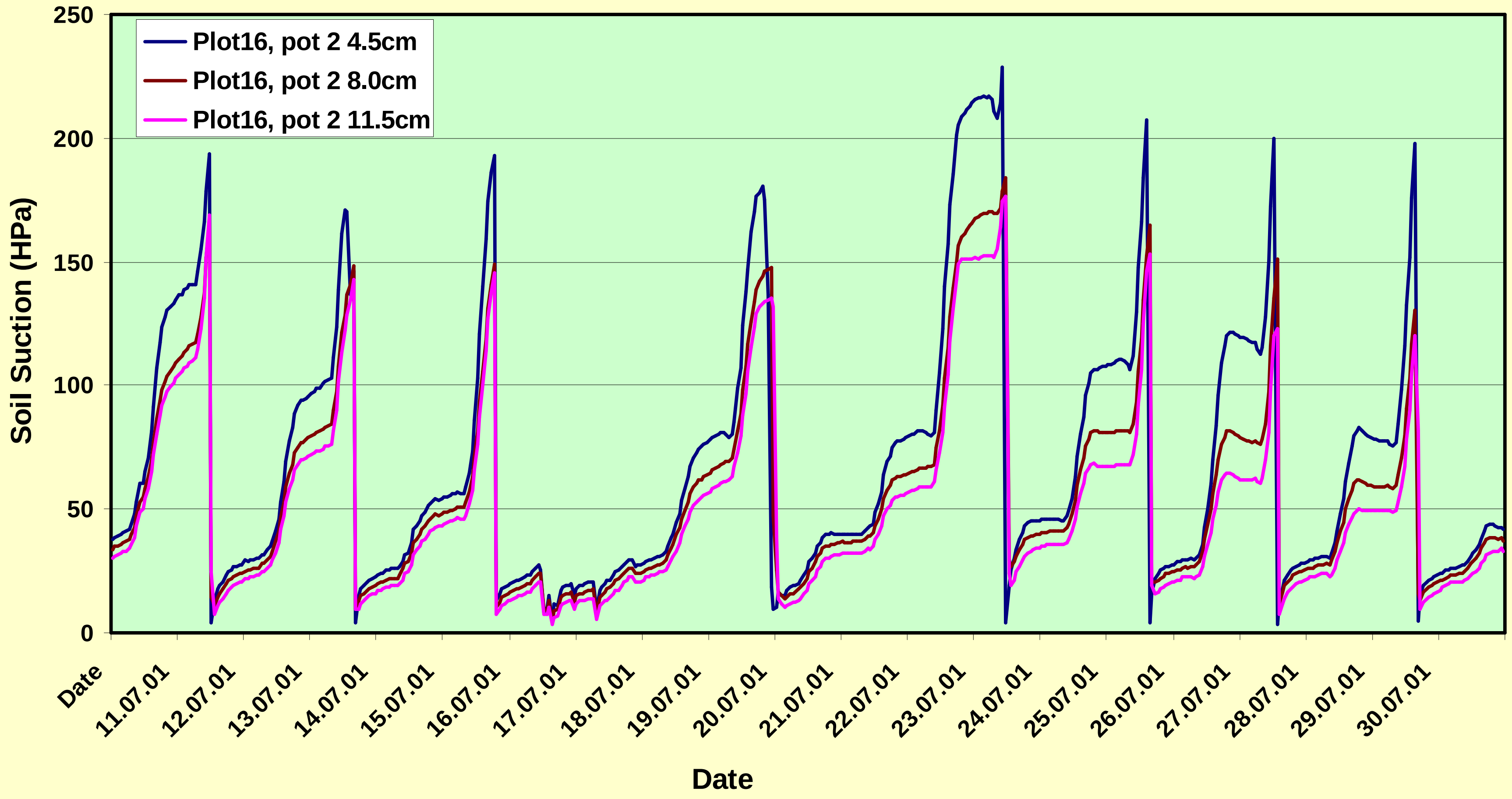
AcquaCard

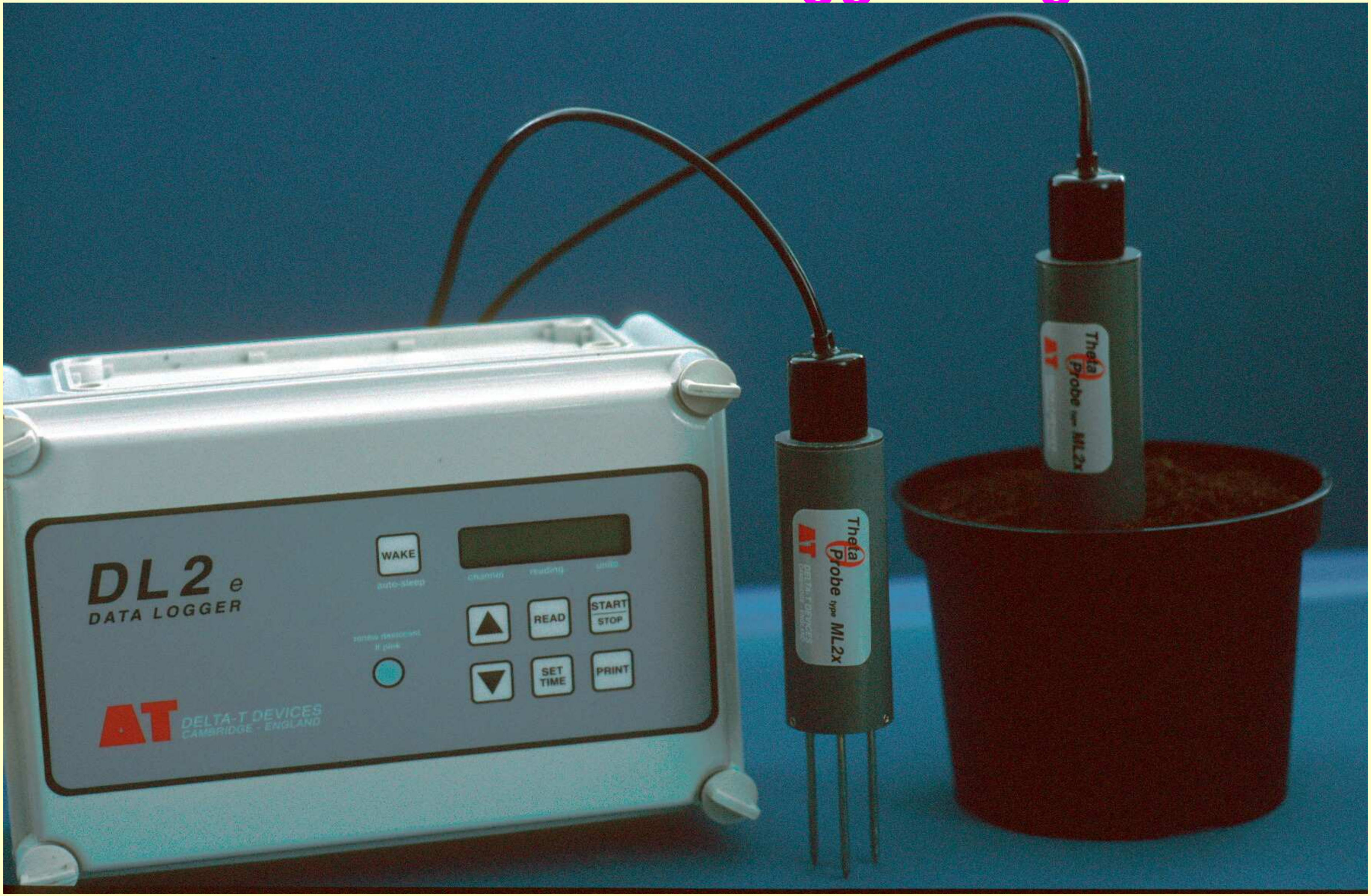
Tensiometers



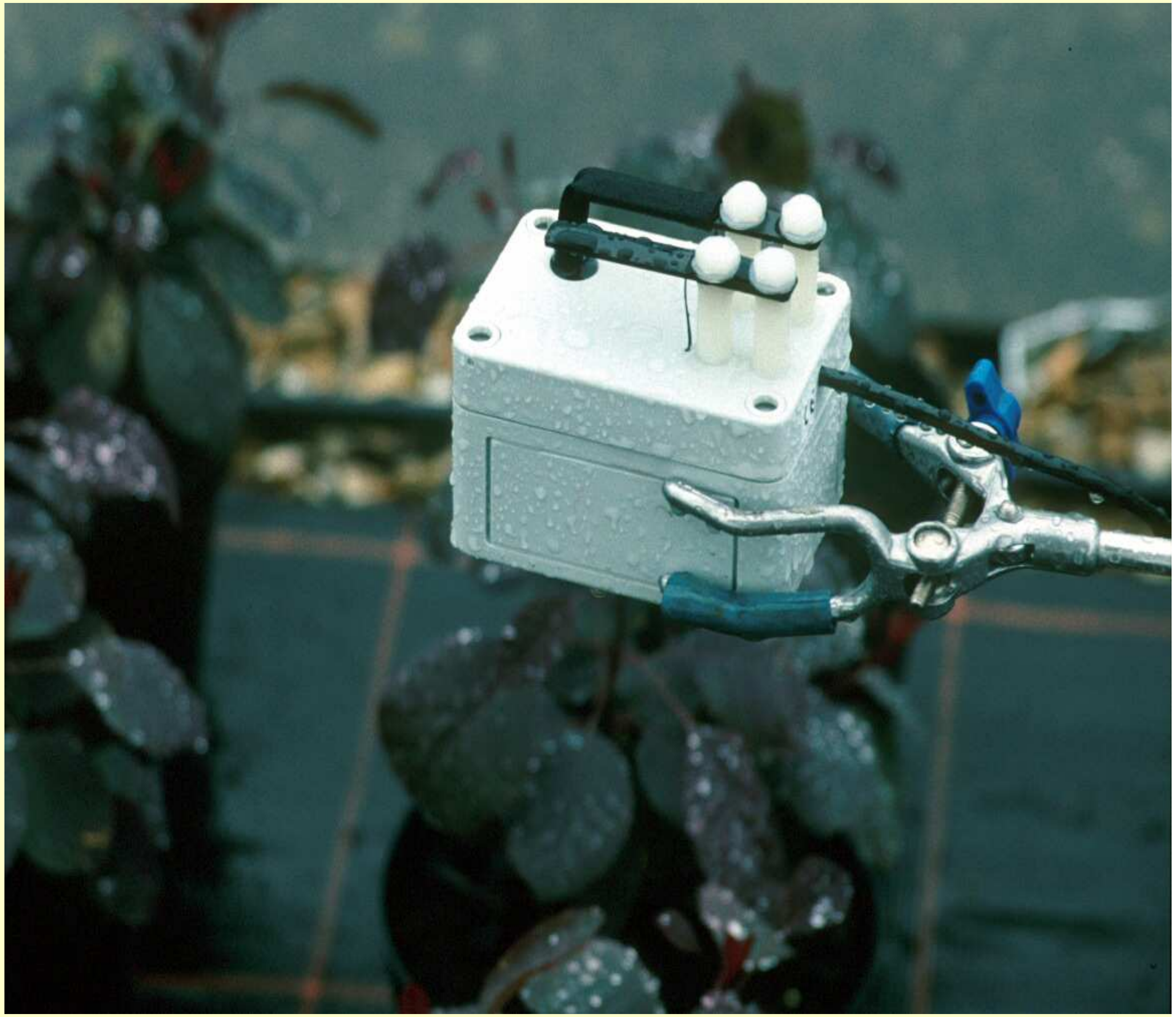
Tensiometers during a period of normal irrigation



Delta-T Theta Probe used to measure soil moisture and to trigger irrigation



Estimation of daily evaporation using the Skye Evaposensor



Delta-T prototype irrigation control unit using single ThetaProbe


Helios Evapometer
OMEGA


AT
Tinytag

Automatic weather station used for calculation of evaporative demand

Water Equivalent (FAO, 1997)

Food product	Unit	Equivalent water, m^3
Cattle	head	4,000
Sheep and Goats	head	500
Fresh beef	kg	15
Fresh Lamb	kg	10
Fresh poultry	kg	6
wheat	kg	1
Paddy	kg	5
Rice	kg	2
Citrus fruits	kg	1
Palm oil	kg	2
Pulses, roots, tubers	kg	1

Crop water requirement (FAO, 1997)

Crop	Typical water Requirement Litre / Kg
Cotton	7,000 – 29,000
Rice	3,000 – 5,000
Sugar Cane	1,500 – 3,000
Soya	2000
Wheat	900
Potatoes	500

In conclusion

- Saline water can be used in an integrated management system.
- Need to consider plant tolerance level, soil type, suitable irrigation system, adequate drainage system, irrigation management to control salinity, good tillage and use proper technologies to accurately estimate crop water requirements.


Thank you!

SALTMED MODEL Can be Downloaded at:

- ***http://www.ceh-wallingford.ac.uk/research/cairoworkshop***

- ***Special Issue of International Journal of Agriculture Water Management Volume 78 (1-2), September, 2005.***