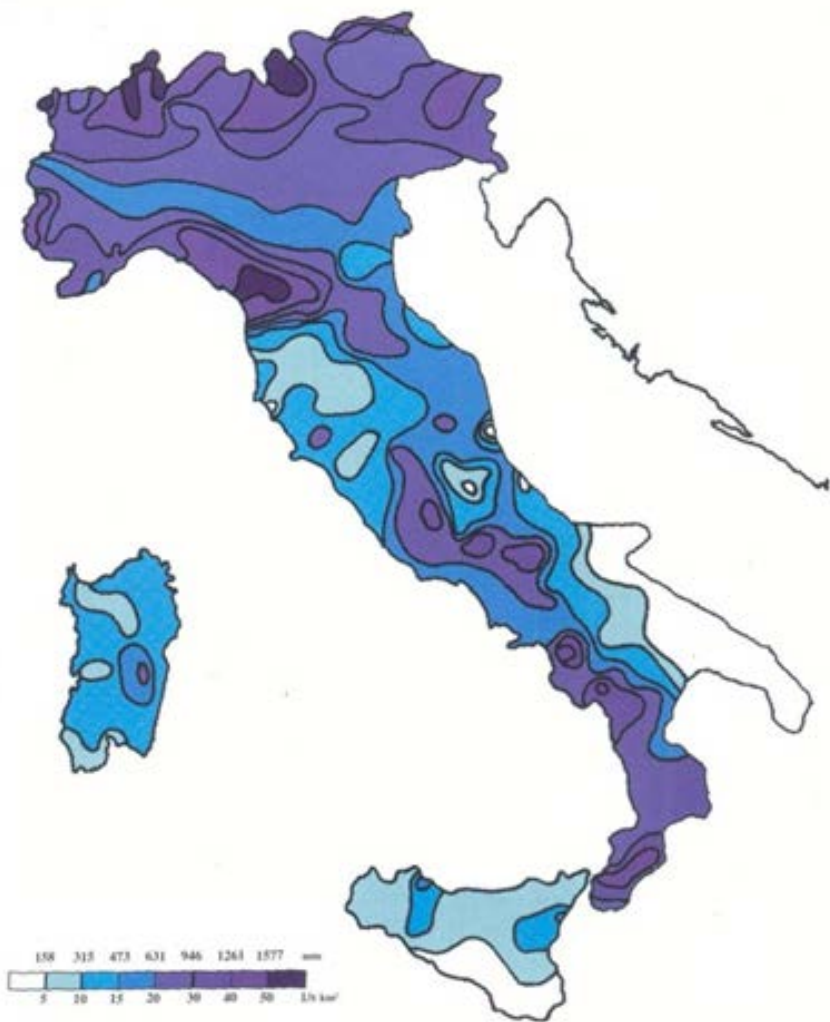




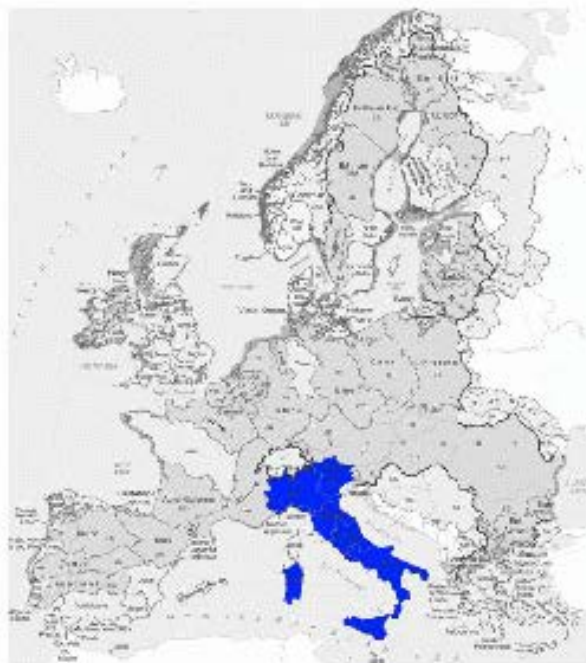
*The water
for the Mediterranean agricultural systems
is a question
of quantity and quality*

The water for the Mediterranean agricultural systems is a question of quantity and quality



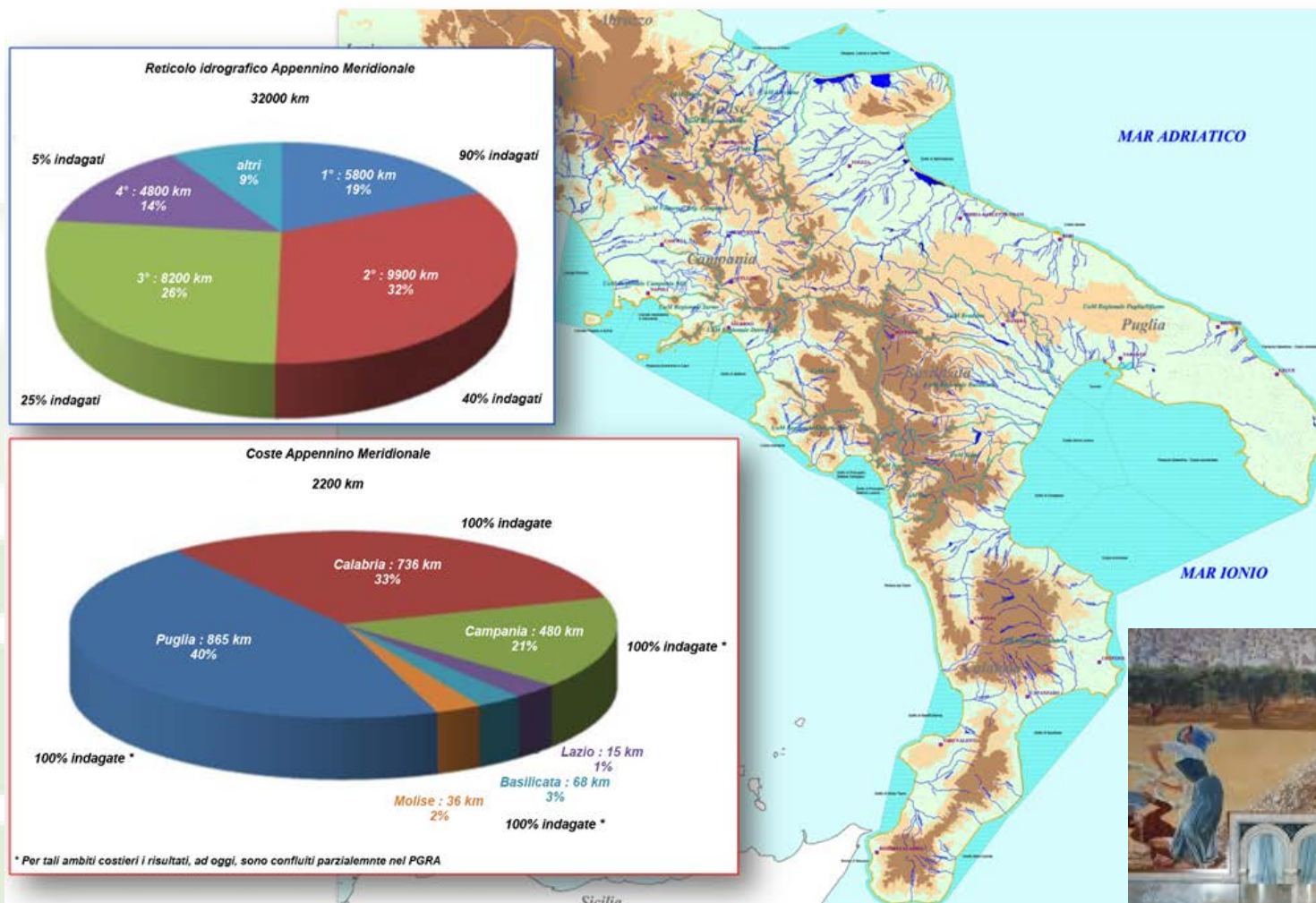
Average annual precipitation in Italy
(IRSA CNR, 1999)

hydrographic districts



Distretti idrografici europei e distretti idrografici italiani

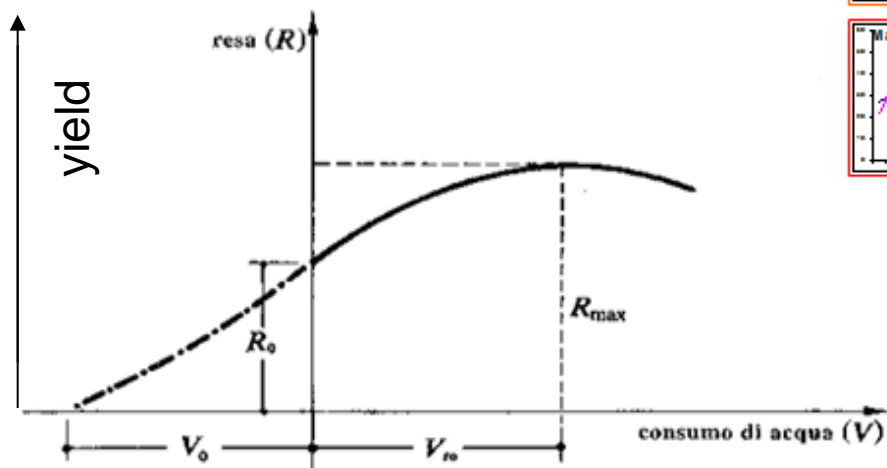
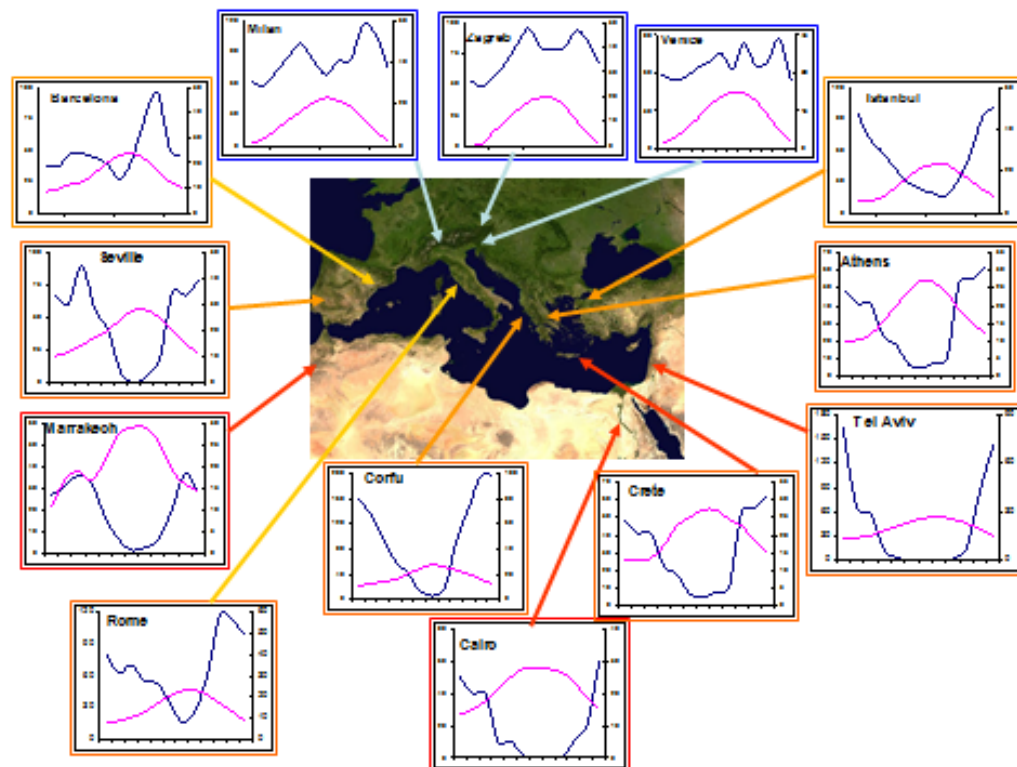
The water for the Mediterranean agricultural systems is a question of quantity and quality



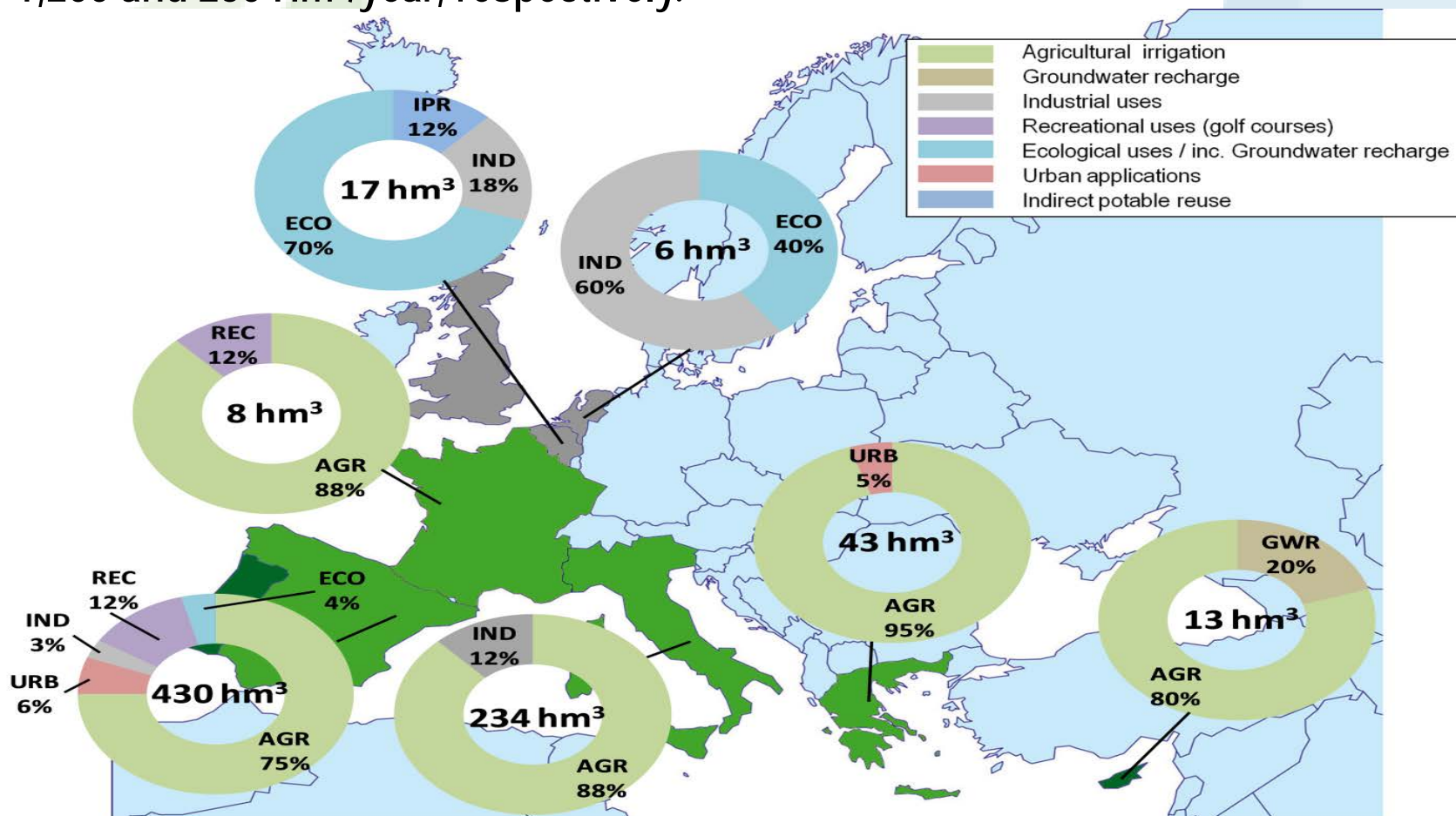
The water for the Mediterranean agricultural systems ~~is a question of quantity and quality~~



question of water balance



The estimated prediction of water reuse volume will be of 3,222 Hm³/year in Europe by 2025, with Spain and Italy showing the greatest reuse potential with 1,200 and 250 Hm³/year, respectively.



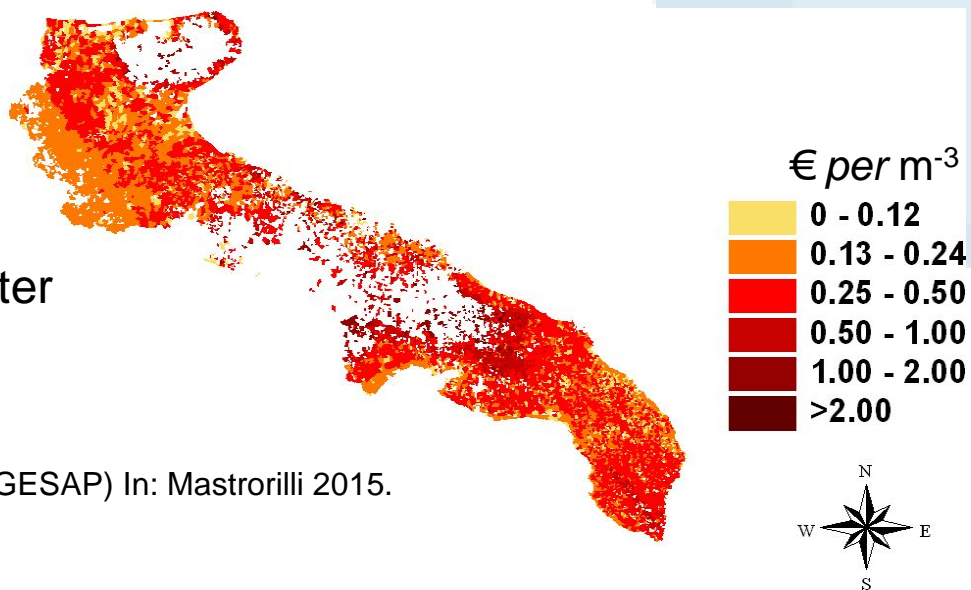
Water reuse in Europe

The water for the Mediterranean agricultural systems is a question of quantity and quality

Regioni	Acqua superficiale	Acquedotto	Acqua sotterranea	Acque reflue depurate, desalinizzate e salmastre	più di una fonte	Totale
Italia	38,3	18,6	24,0	0,1	19,0	100,0
Nord	48,6	18,8	11,6	0,1	21,0	100,0
Centro	36,2	7,9	41,2	0,1	14,6	100,0
Mezzogiorno	17,1	20,9	46,2	0,1	15,7	100,0
Puglia	6,9	12,1	67,6	0,2	13,2	100,0

is a question of money

Costs for water supply from groundwater

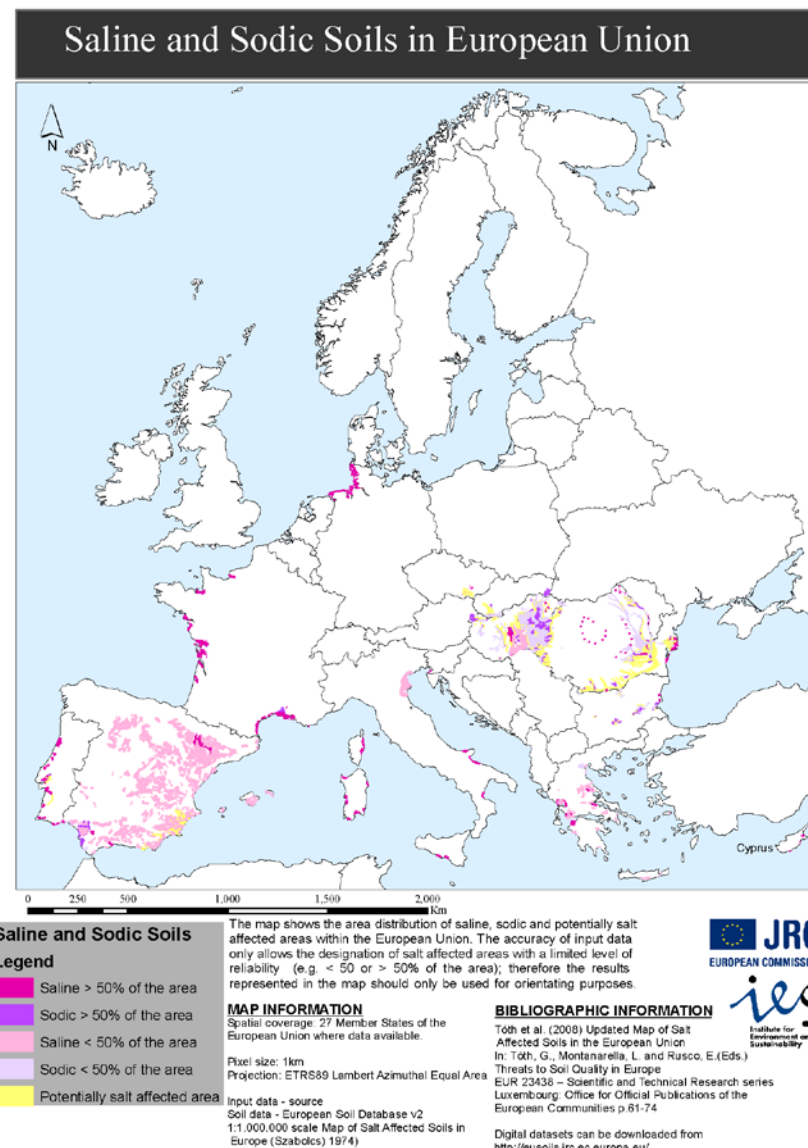


A model of sustainable management of aquifers Puglia (GESAP) In: Mastroiilli 2015.
L'acqua in Agricoltura, Edagricole, 403 pp

Soil salinization

- Worldwide: 1128 million Ha
- Europe: 20,7 millions Ha
- Natural and anthropogenic causes
- Loss of soil fertility
- Slow down or reverse through
lixiviation
- Three types: saline, sodic, saline-
sodic

Institute for Environment and Sustainability (2009).
Wicke et al. (2011). Energy Environ. Sci. 4:2669-2681.



© European Communities, 2008

Soil salinization

Main parameters distinguishing the soils affected by salinity and alkalinity

- Worldwide:
- Europe: 20,
- Natural and
- Loss of soil fertility
- Slow down or reverse through
lixiviation
- Three types: saline, sodic, saline-
sodic

Tipi di suolo	EC _e (dS m ⁻¹)	ESP (%)	pH
Suoli salini	> 4	< 15	< 8,5
Suoli alcalini	< 4	> 15	> 8,5
Suoli salino-alcalini	> 4	> 15	> 8,5

EC = electrical conductivity of saturated paste extract; ESP = exchangeable sodium percentage.

$$ESP = \frac{[Na^+]}{[Na^+ + K^+ + Ca^{2+} + Mg^{2+}]}$$

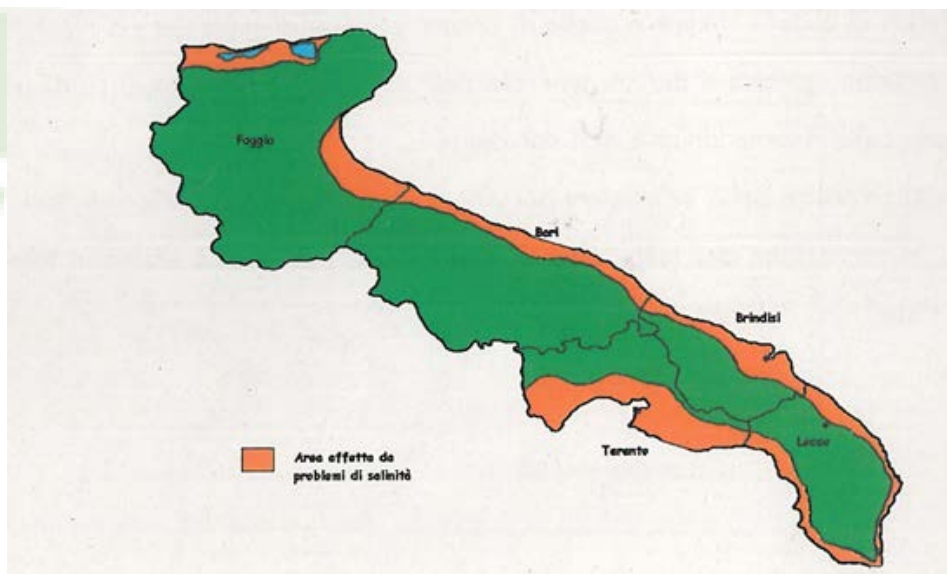
Salinity problem

0.25-1.5 million irrigated hectares per year are lost because of salinization

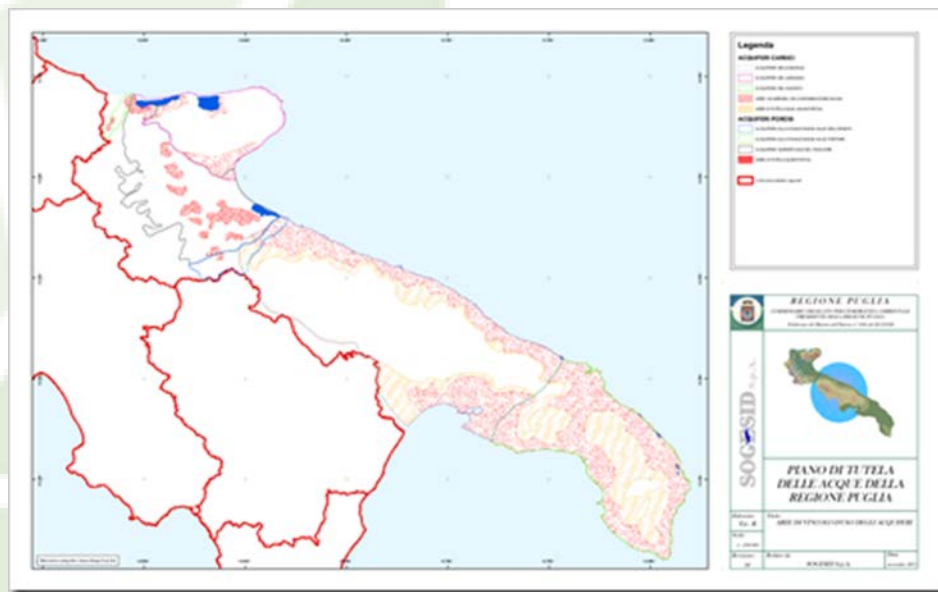
Soil secondary salinization in the semi-arid regions seriously affects the productivity of at least **20-30 million ha**

11% of the total irrigated surface

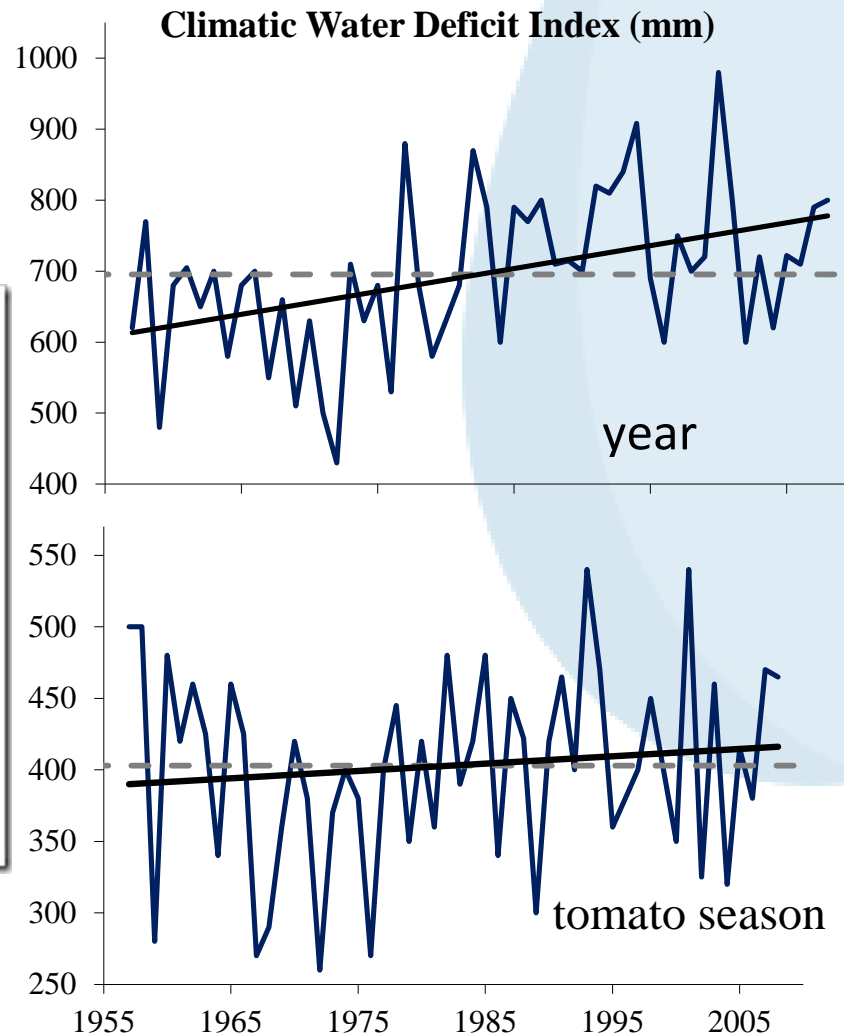
An estimated **100,000** hectares are irrigated with water from aquifers, of which 85% have a very high level of salts



Salinity problem



“Aree di vincolo d’uso degli acquiferi”
(Tav. B della Relazione del PTA) 2006



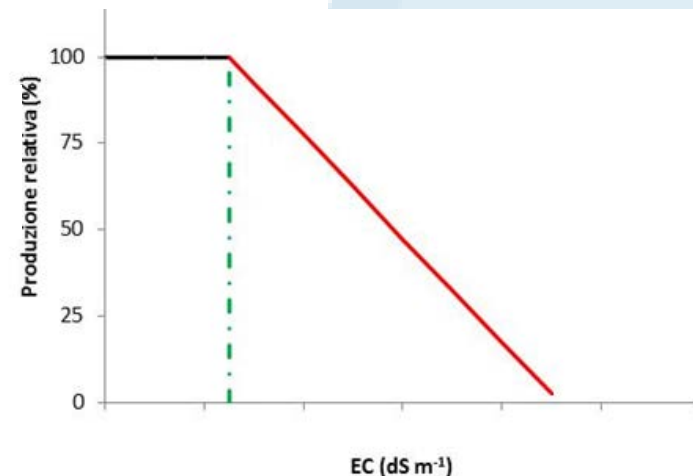
Guidelines for assessing water quality for irrigation (Ayers and Westcot, 1994)

Problemi potenziali dell'irrigazione	Parametro		Limitazione d'uso		
			Nessuna	da lieve a moderata	severa
Salinità (influenza la disponibilità di acqua per la coltura)	EC _w (dS m ⁻¹)		< 0,7	0,7-3,0	> 3,0
	TDS (mg L ⁻¹)		< 450	450-2.000	> 2.000
Infiltrazione (influenza la velocità di infiltrazione dell'acqua nel terreno tenendo conto, contemporaneamente, di EC _w e SAR)	SAR = 0-3	con EC _w	> 0,7	0,7-0,2	< 0,2
	SAR = 3-6	con EC _w	> 1,2	1,2-0,3	< 0,3
	SAR = 6-12	con EC _w	> 1,9	1,9-0,5	< 0,5
	SAR = 12-20	con EC _w	> 2,9	2,9-1,3	< 1,3
	SAR = 20-40	con EC _w	> 5,0	5,0-2,9	< 2,9
Tossicità (effetti da ioni specifici su specie vegetali sensibili)					
Sodio (Na)					
Irrigazione superficiale	SAR		< 3	3-9	> 9
Irrigazione a pioggia	meq L ⁻¹		< 3	> 3	
Cloro (Cl)					
Irrigazione superficiale	meq L ⁻¹		< 4	4-10	> 10
Irrigazione a pioggia	meq L ⁻¹		< 3	> 3	
Boro (B)					
	mg L ⁻¹		< 0,7	0,7-3,0	> 3,0

Salinity and agronomic options



general model: yield vs.
salinity
(Maas and Hoffman, 1977)



biphasic growth response to
salt stress of 3
genotypes:

1. sensitive (S)
2. moderately tolerant (M)
3. tolerant (T)

(adapted by Munns, 1993)

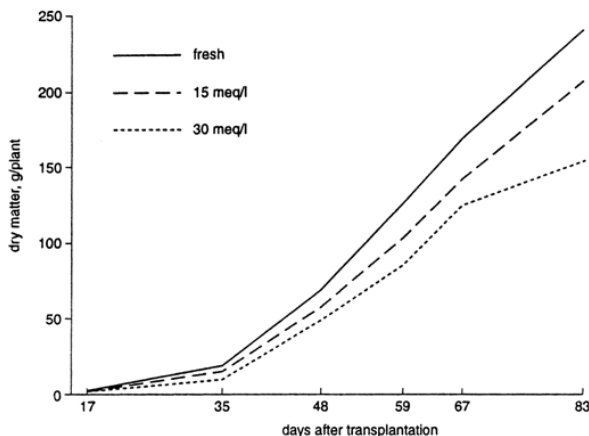
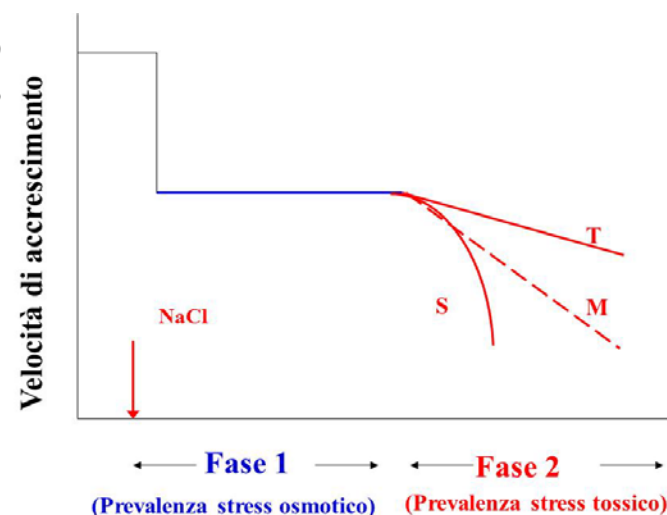


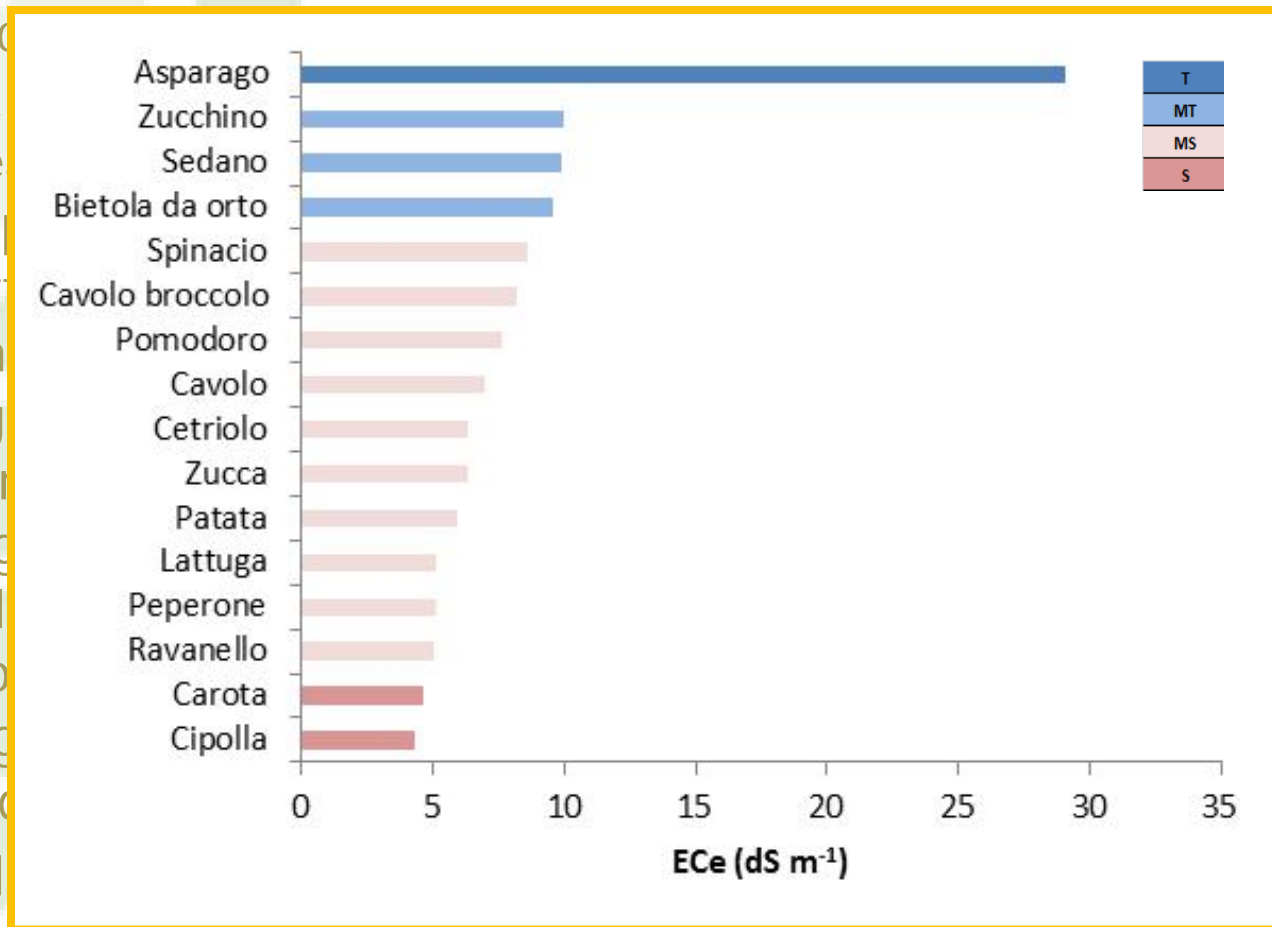
Fig. 4. Leaf area vs. days after transplantation on loam.

agro-techniques prescriptions

- choice of crops to be irrigated
- leaching of solutes supplied through irrigation water
- drainage network
- breaking and / or removal impervious soil layers (and superficial crusts)
- crop rotation (irrigated – rainfed crops)
- vertical tillage
- scheduling crop fertilization at different rates
- organic amendment supply
- blending saline and fresh waters
- irrigation methods which do not favor the accumulation of solutes in the soil volume where the roots of the crop are more active
- short irrigation intervals
- irrigation volumes in excess, higher than those required to bring to the field capacity the soil layer colonized by the roots (leaching requirement)

agro-techniques prescriptions

- choice of crops to be irrigated



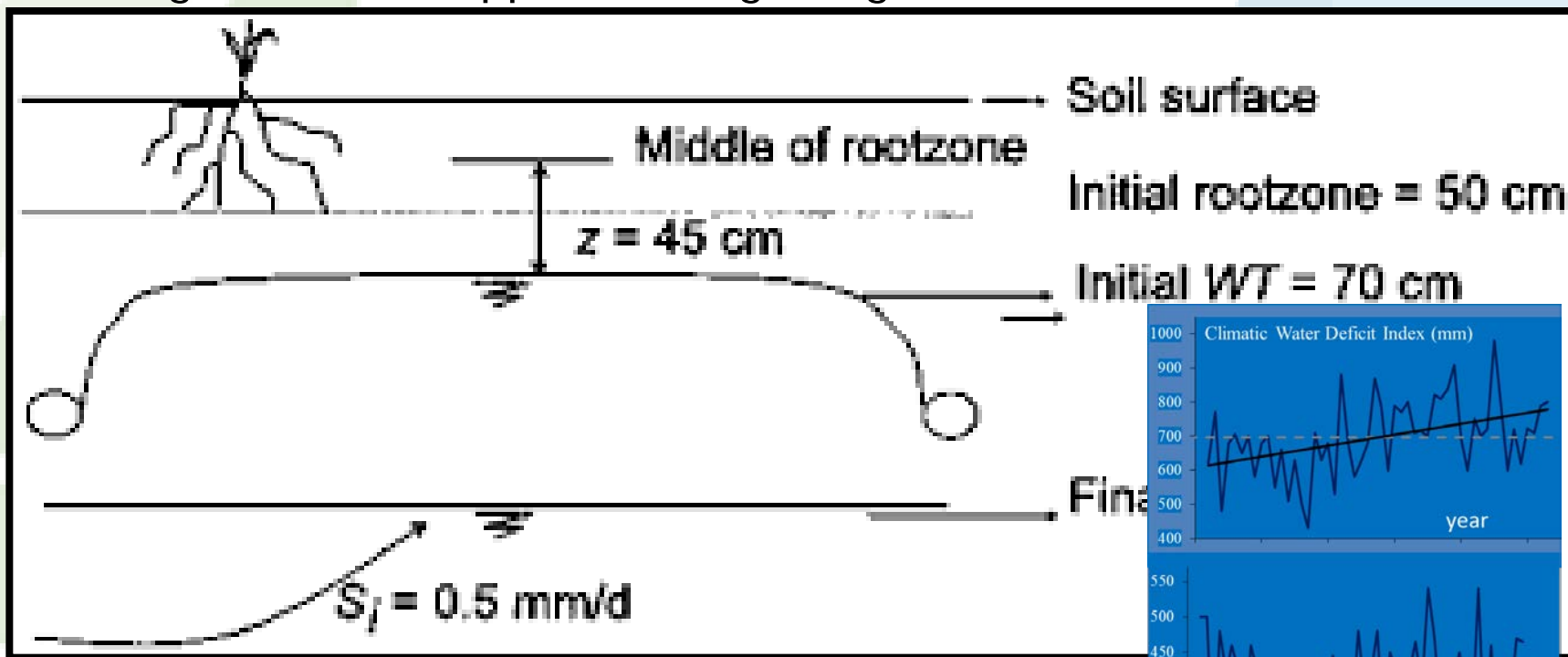
erficial crusts)

f solutes in the

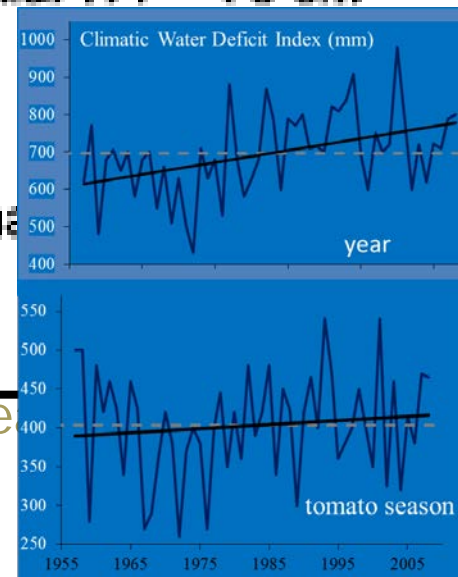
o bring to the
g

agro-techniques prescriptions

- choice of crops to be irrigated
- leaching of solutes supplied through irrigation water

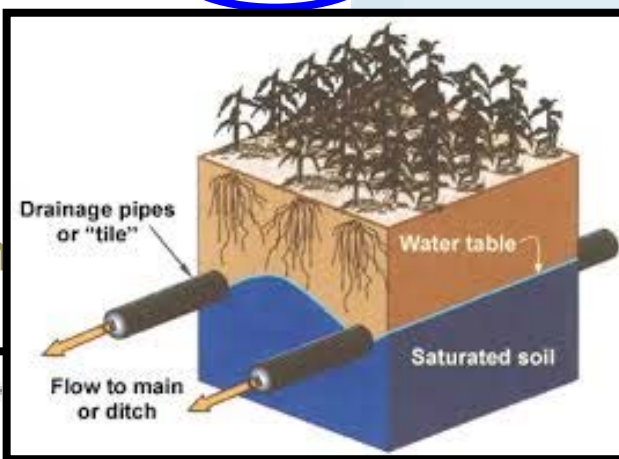
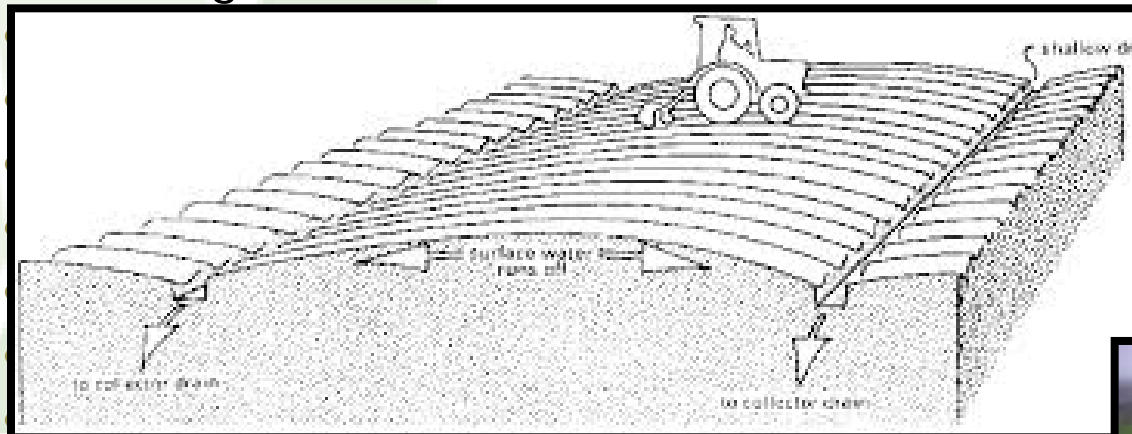


field capacity the soil layer colonized by the roots (le requirement)



agro-techniques prescriptions

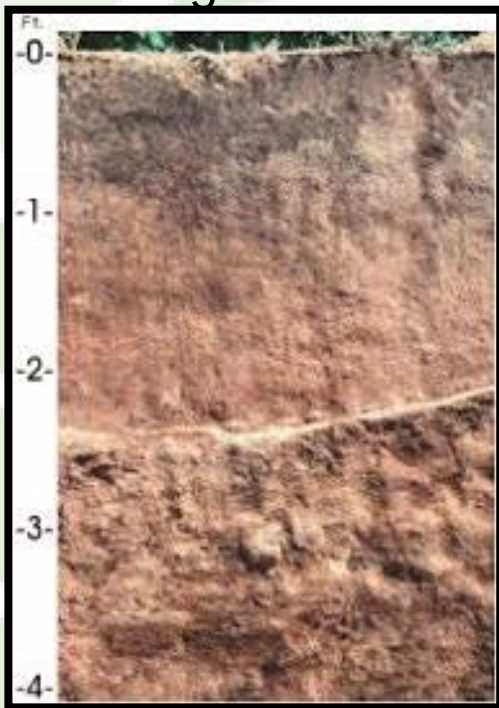
- choice of crops to be irrigated
- leaching of solutes supplied through irrigation
- drainage network



- soil volume where the roots of the crop are
- short irrigation intervals
- irrigation volumes in excess, higher than the field capacity the soil layer colonized by the (requirement)

agro-techniques prescriptions

- choice of crops to be irrigated
- leaching of solutes supplied through irrigation water
- drainage network
- breaking and / or removal impervious soil layers (and superficial crusts)



agro-techniques prescriptions

- choice of crops to be irrigated
 - leaching of solutes supplied through irrigation water
 - drainage network
 - breaking and / or removal impervious soil layers (and superficial crusts)
 - crop rotation (irrigated – rainfed crops)
 - vertical tillage
 - scheduling crop fertilization at
 - organic amendment supply
 - blending saline and fresh waters
 - irrigation methods which do not
 - soil volume where the roots of the
 - short irrigation intervals
 - irrigation volumes in excess, high
- leaching of solutes in the
bringing to the
field capacity the soil layer colonized by the roots (leaching requirement)



agro-techniques prescriptions

- choice of crops to be irrigated
- leaching of solutes supplied through irrigation water
- drainage network
- breaking and / or removal impervious soil layers (and superficial crusts)
- crop rotation (irrigated – rainfed crops)
- vertical tillage



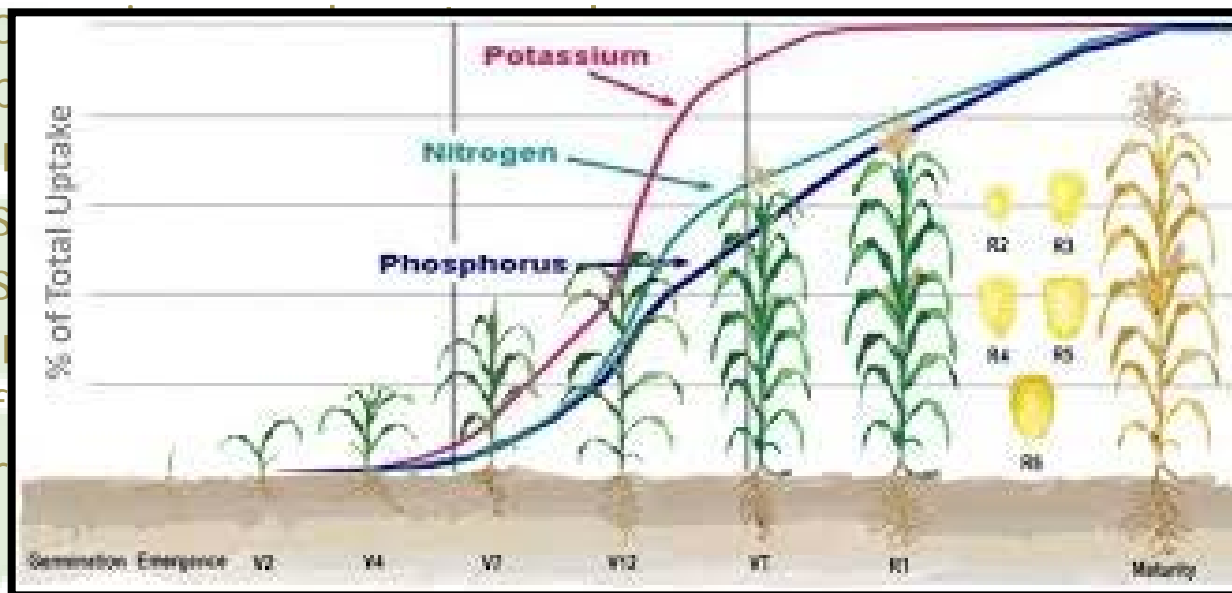
field capacity the soil layer coloniz
requirement)

the

he

agro-techniques prescriptions

- choice of crops to be irrigated
- leaching of solutes supplied through irrigation water
- drainage network
- breaking and / or removal impervious soil layers (and superficial crusts)
- crop rotation (irrigated – rainfed crops)
- vertical tillage
- scheduling crop fertilization at different rates

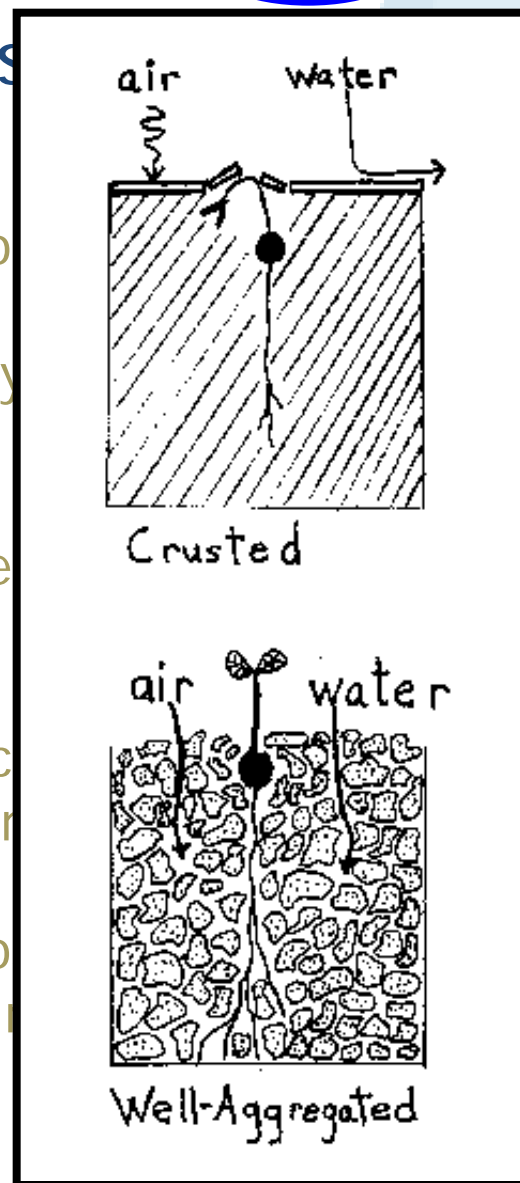
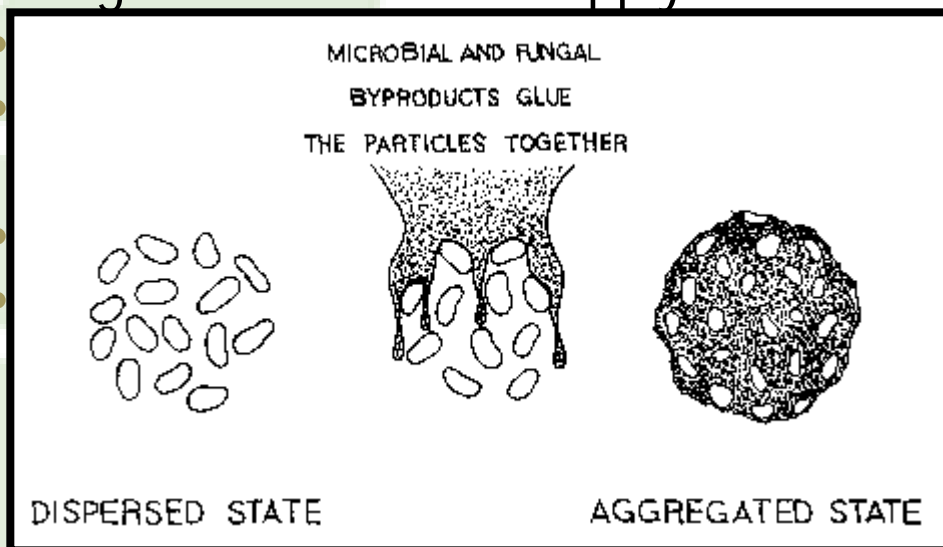


on of solutes in the
ve

ed to bring to the
ching

agro-techniques prescriptions

- choice of crops to be irrigated
- leaching of solutes supplied through irrigation
- drainage network
- breaking and / or removal impervious soil layer
- crop rotation (irrigated – rainfed crops)
- vertical tillage
- scheduling crop fertilization at different rates
- organic amendment supply



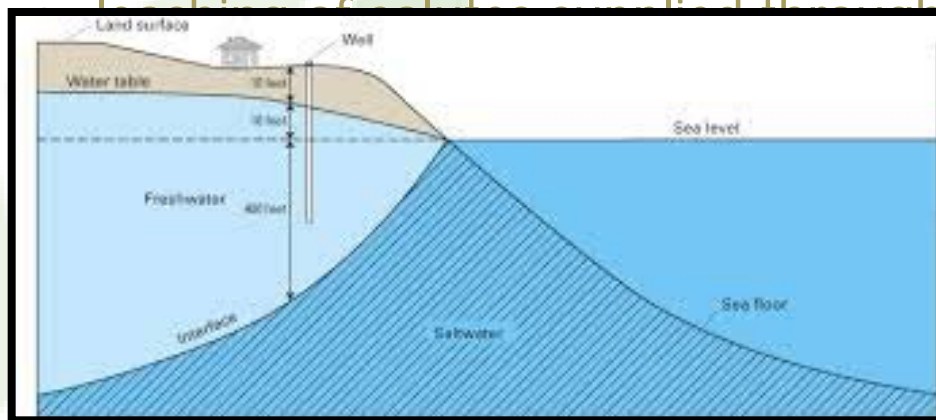
usts)

in the

the

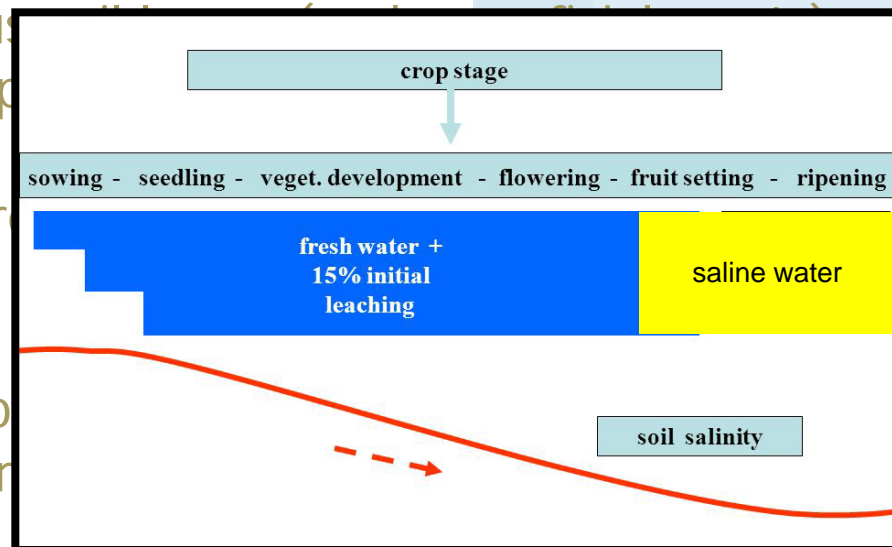
agro-techniques prescriptions

- choice of crops to be irrigated



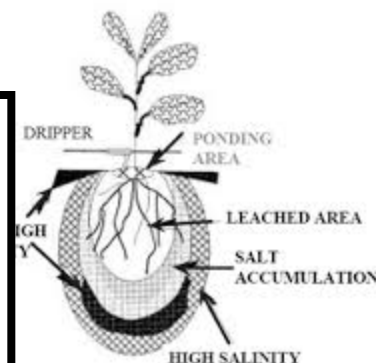
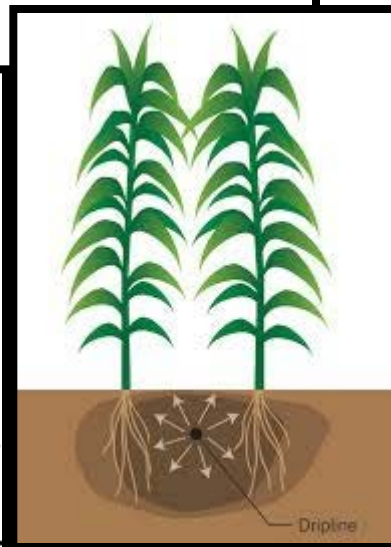
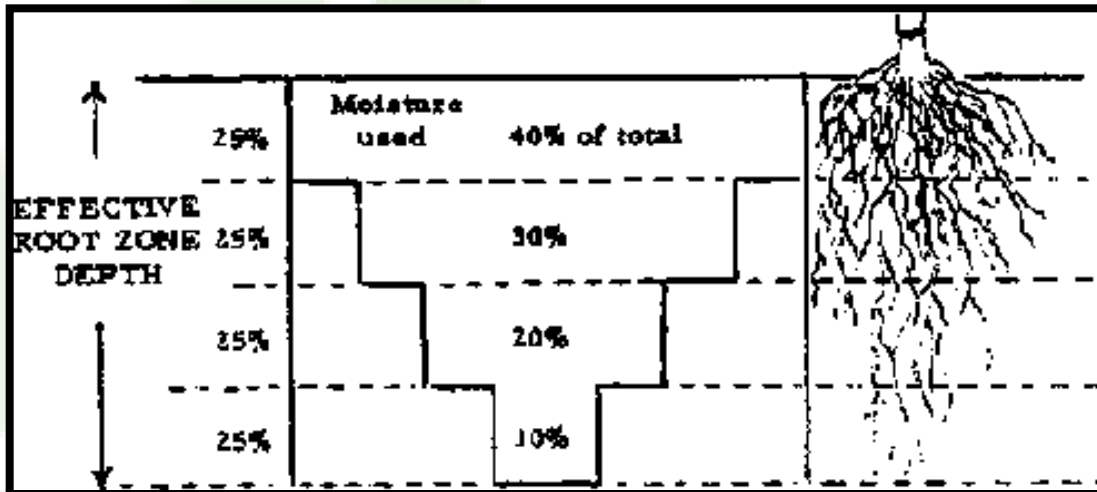
- blending saline and fresh waters
- irrigation methods which do not favor soil volume where the roots of the crop are located
- short irrigation intervals
- irrigation volumes in excess, higher than those required to bring to the field capacity the soil layer colonized by the roots (leaching requirement)

irrigation water



agro-techniques prescriptions

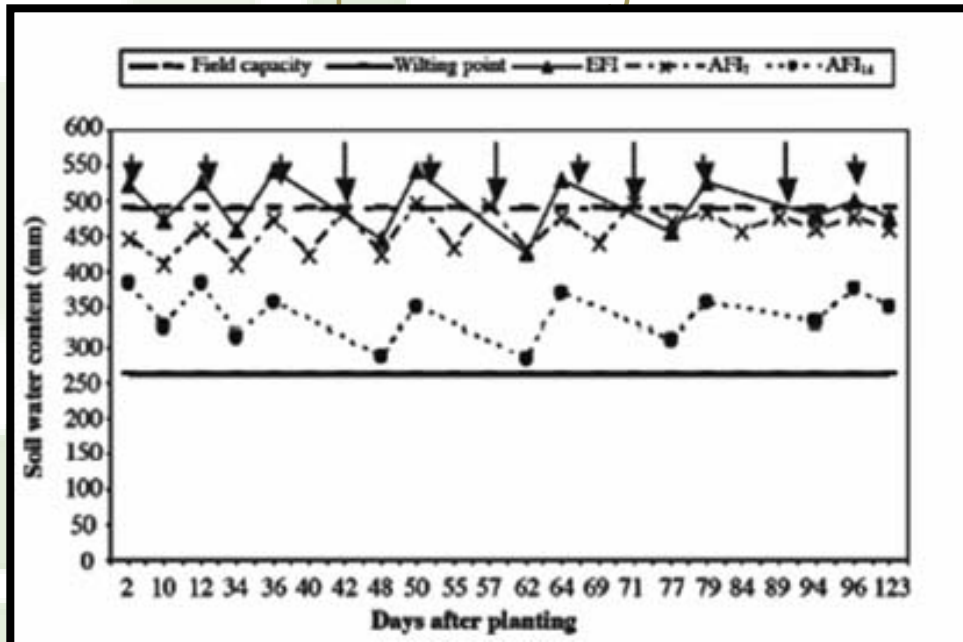
- choice of crops to be irrigated



- irrigation methods which do not favor the accumulation of solutes in the soil volume where the roots of the crop are more active
- short irrigation intervals
- irrigation volumes in excess, higher than those required to bring to the field capacity the soil layer colonized by the roots (leaching requirement)

agro-techniques prescriptions

- choice of crops to be irrigated



- short irrigation intervals
- irrigation volumes in excess, higher than those required to bring to the field capacity the soil layer colonized by the roots (leaching requirement)

irrigation water

oil layers (and superficial crusts)

rates

the accumulation of solutes in the
are more active

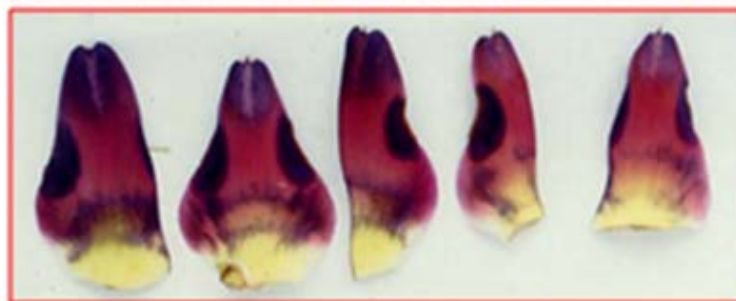
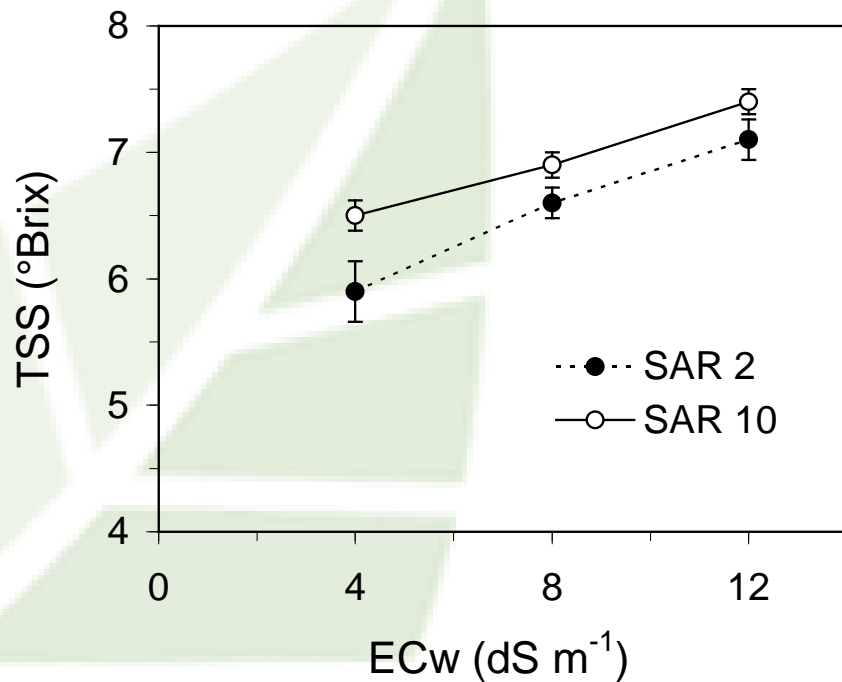
agro-techniques prescriptions

- choice of crops to be irrigated
- leaching of solutes supplied through irrigation water
- drainage network
- breaking and / or removal impervious soil layers (and superficial crusts)

$$LR = EC_w / EC_{dw} = D_{dw} / D_w$$

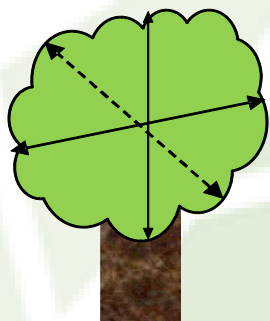
- LR = leaching requirement, in percento del volume di adacquamento;
- EC_w = conducibilità elettrica ($dS\ m^{-1}$) dell'acqua d'irrigazione;
- EC_{dw} = conducibilità elettrica ($dS\ m^{-1}$) dell'acqua di drenaggio dallo strato radicale, massima compatibile con la produzione ipotizzata della coltura;
- D_{dw} = quantità di acqua di drenaggio espressa in altezza (mm);
- D_w = quantità di acqua irrigua espressa in altezza (mm).

- irrigation volumes in excess, higher than those required to bring to the field capacity the soil layer colonized by the roots (leaching requirement)



Periodic plant measurements

**Tree
Canopy**



**Leaf
Analysis**



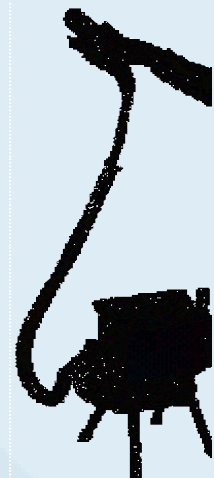
**Fruit
Diameter, fruit set**



**Stem water
potential**



**Leaf gas
exchange**



Yield assessment
(kg.tree⁻¹)

**Diameter
distribution**

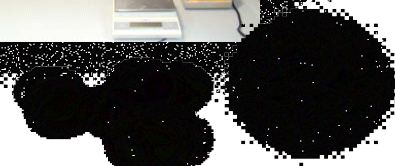


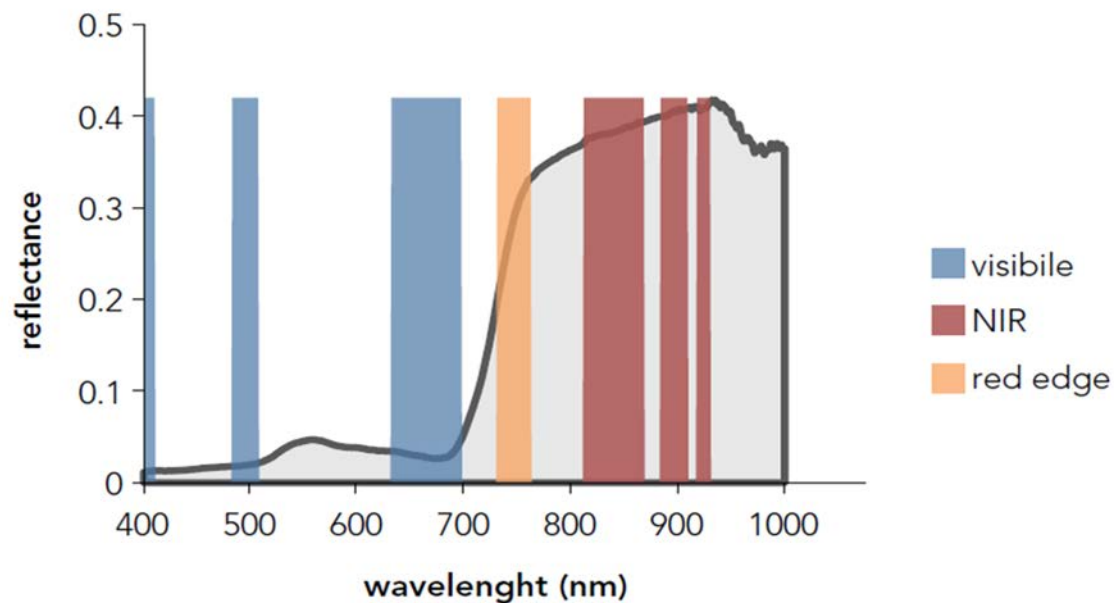
**Quality
indexes**



- ☐ TA
- ☐ SSC
- ☐ pH
- ☐ **Vitamin C**

Fruit safety





Soil measurements

Soil water content

- Matric soil water potential
- Soil solution water quality





*The water
for the Mediterranean agricultural systems
is a question
of quantity and quality*

grazie