24° FORUM
MEDICINA VEGETALE

"Integrated Crop Management
e cambiamento climatico"

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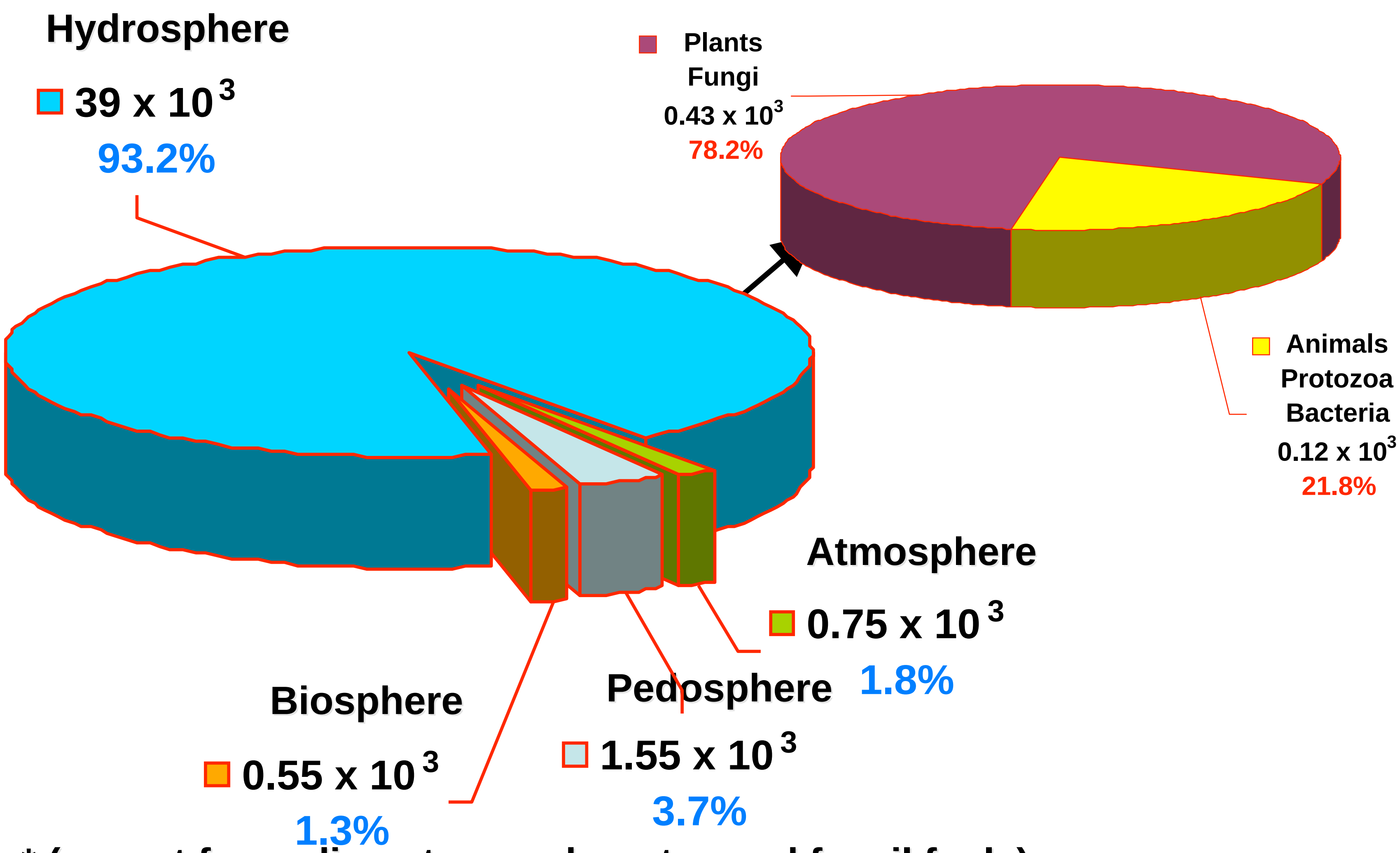
TECNICHE SOSTENIBILI PER LA RIDUZIONE DELLA *CARBON* E *WATER FOOTPRINT*

Bari, 13 Dicembre 2012 - ore 9.15
HOTEL LA BAIA - Via Veneto 29/a
Bari Palese

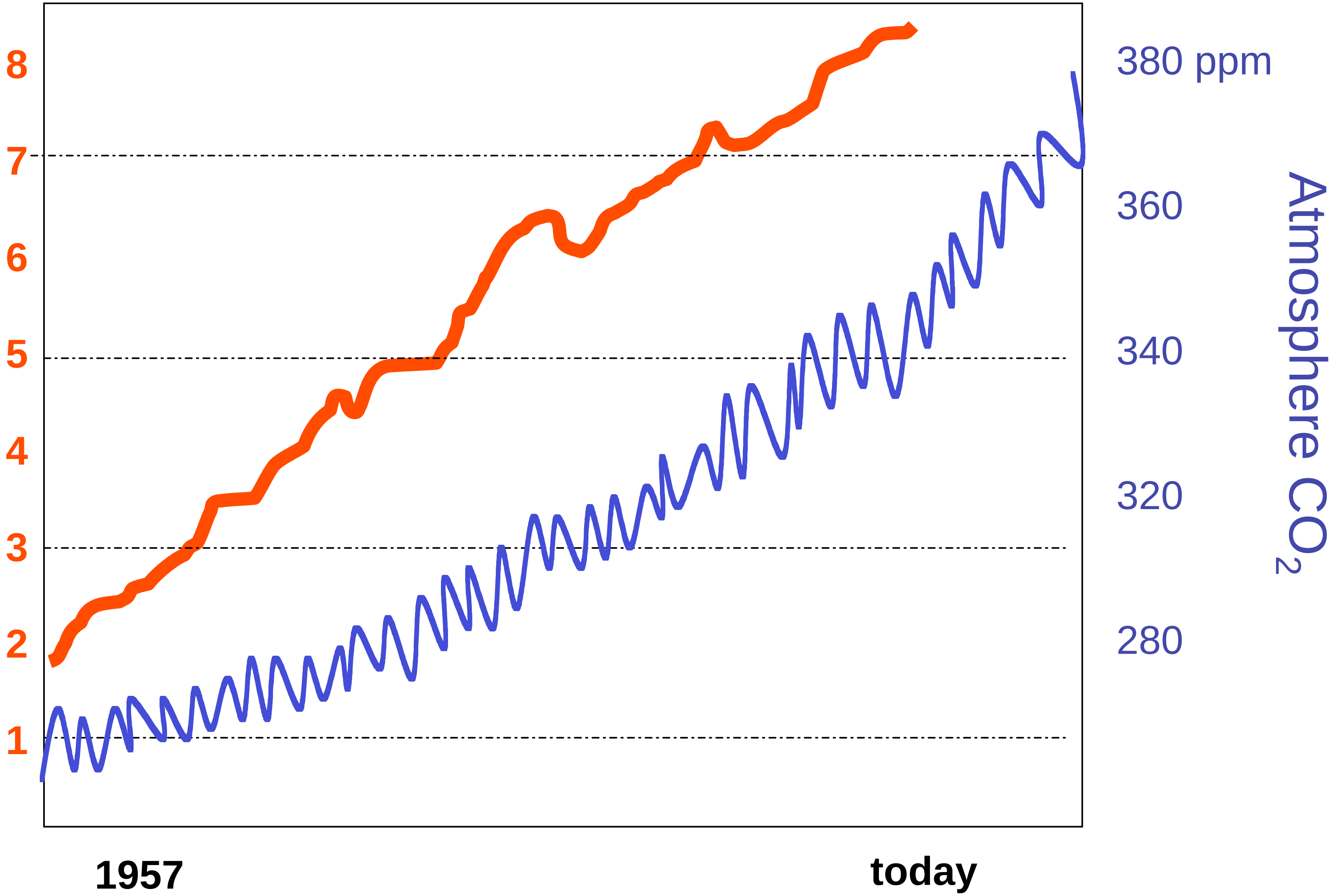
Free carbon* supplies on the Earth

(G tons) Lal, 1997; Zucconi 1999)



* (except for sedimentary carbonates and fossil fuels)

Annual global carbon emissions during the past 50 years (billions metric tons per year)



Source: National Geographic. Oct 2007 - IPC(

Background: Agriculture causing Climate Change

- Agriculture is responsible for almost half of all human-related CH_4 and N_2O emissions

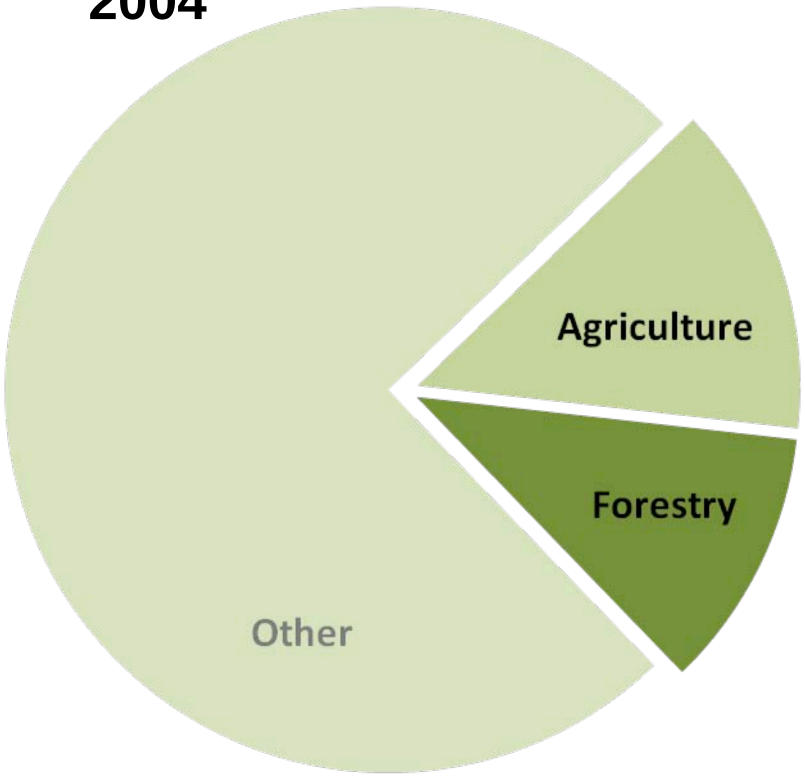
~1/2

- By 2030, these annual emissions are projected to substantially increase
  - N_2O up by 35-60%
  - CH_4 up by 60%

Source:IPCC, 2007

Background: Agriculture-related GHG Emitting Activities

25% of total GHG emissions in 2004

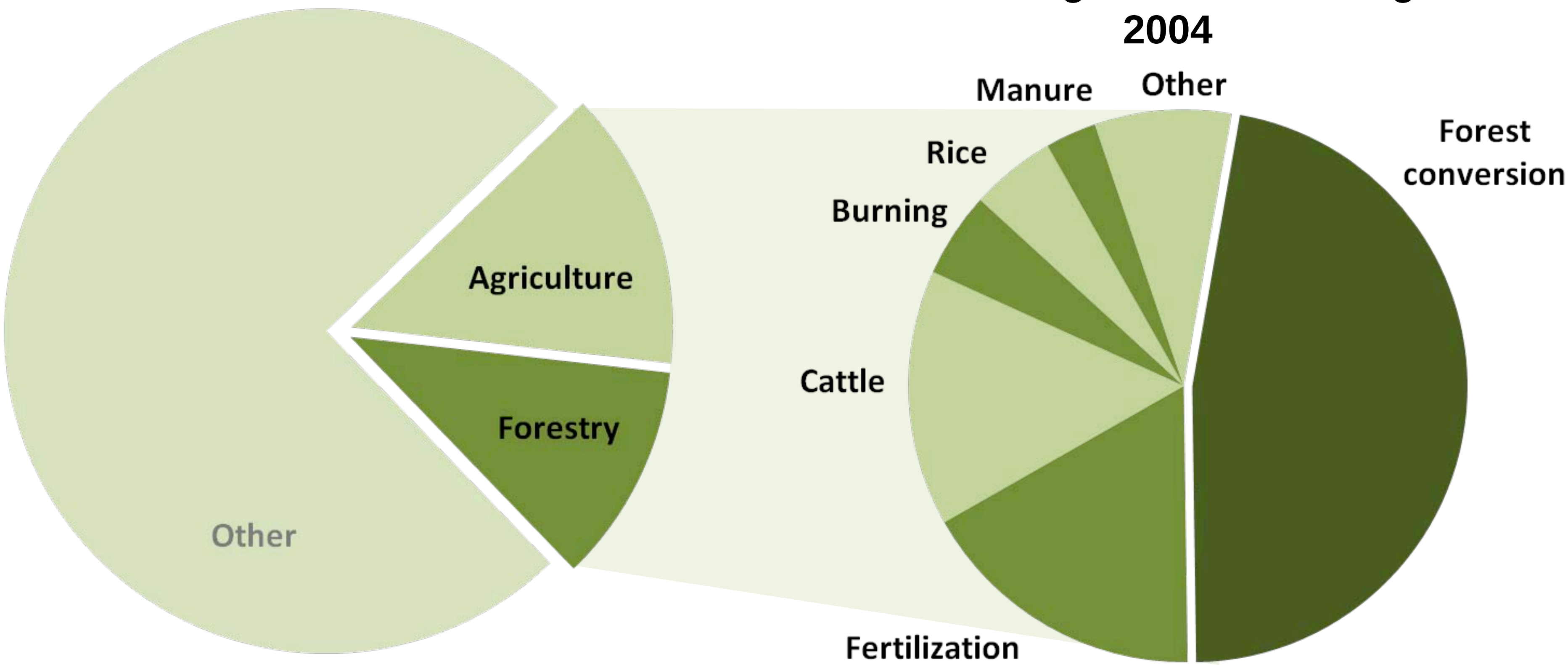


Source: Smith, et al., 2007

Background: Agriculture-related GHG Emitting Activities

25% of total GHG emissions

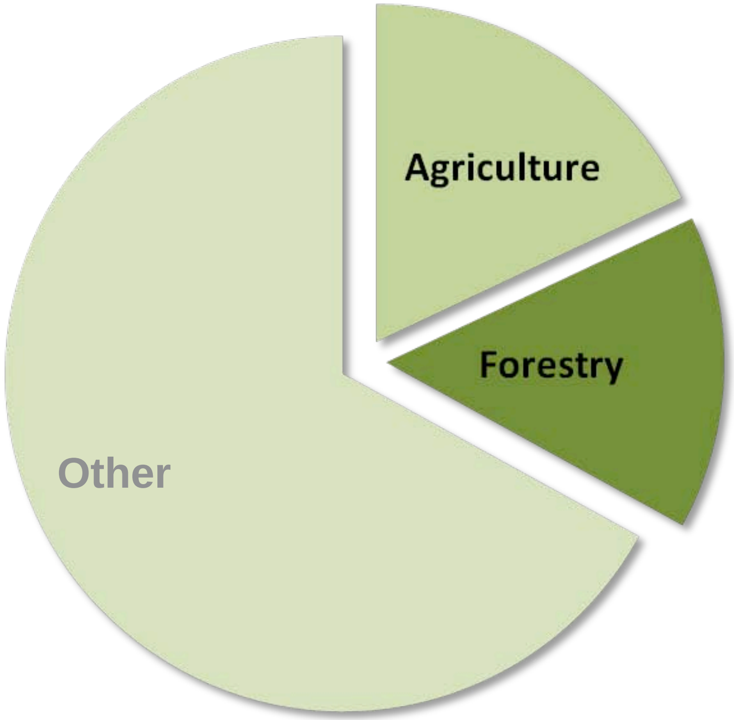
Agriculture & forest activities contributing to climate change in 2004



Source: Smith, et al., 2007

Smith, et al. 2007 DB Research 2011

The potential role of agriculture in mitigating climate change



Sources of expected GHG emission reductions

Source: Smith, et al., 2007.

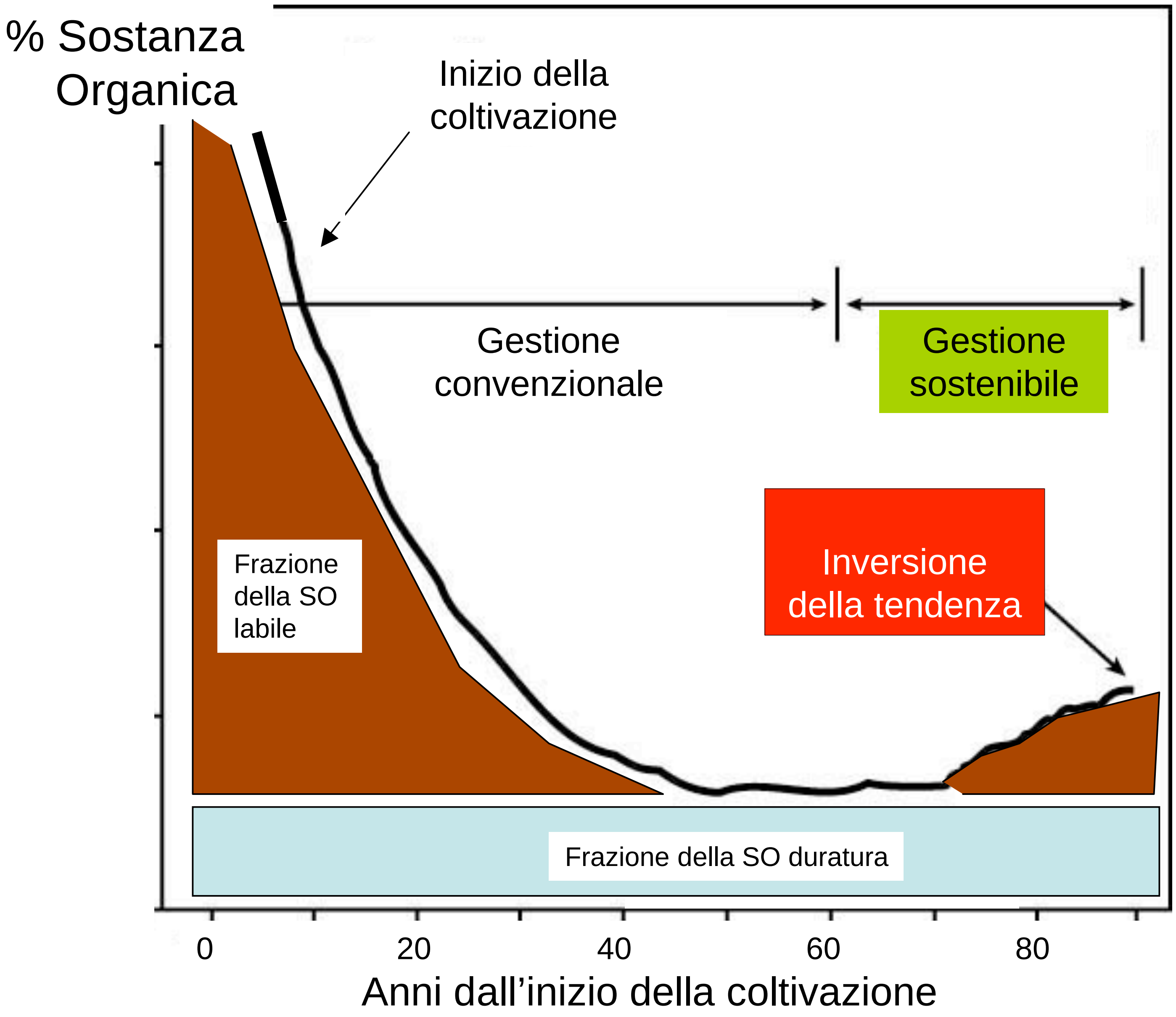
- Agriculture is expected to contribute **18%** of total GHG emission reductions
- Together with better forest management, the two sources are **33%** of the total abatement potential

What is Climate-Smart Agriculture?

CSA is agriculture that

- increases yields (poverty reduction & food security),
- makes yields more resilient in the face of worsening weather conditions (adaptation), and
- transforms the farm into a solution to the climate change problem (mitigation).

(World Bank , 2012)

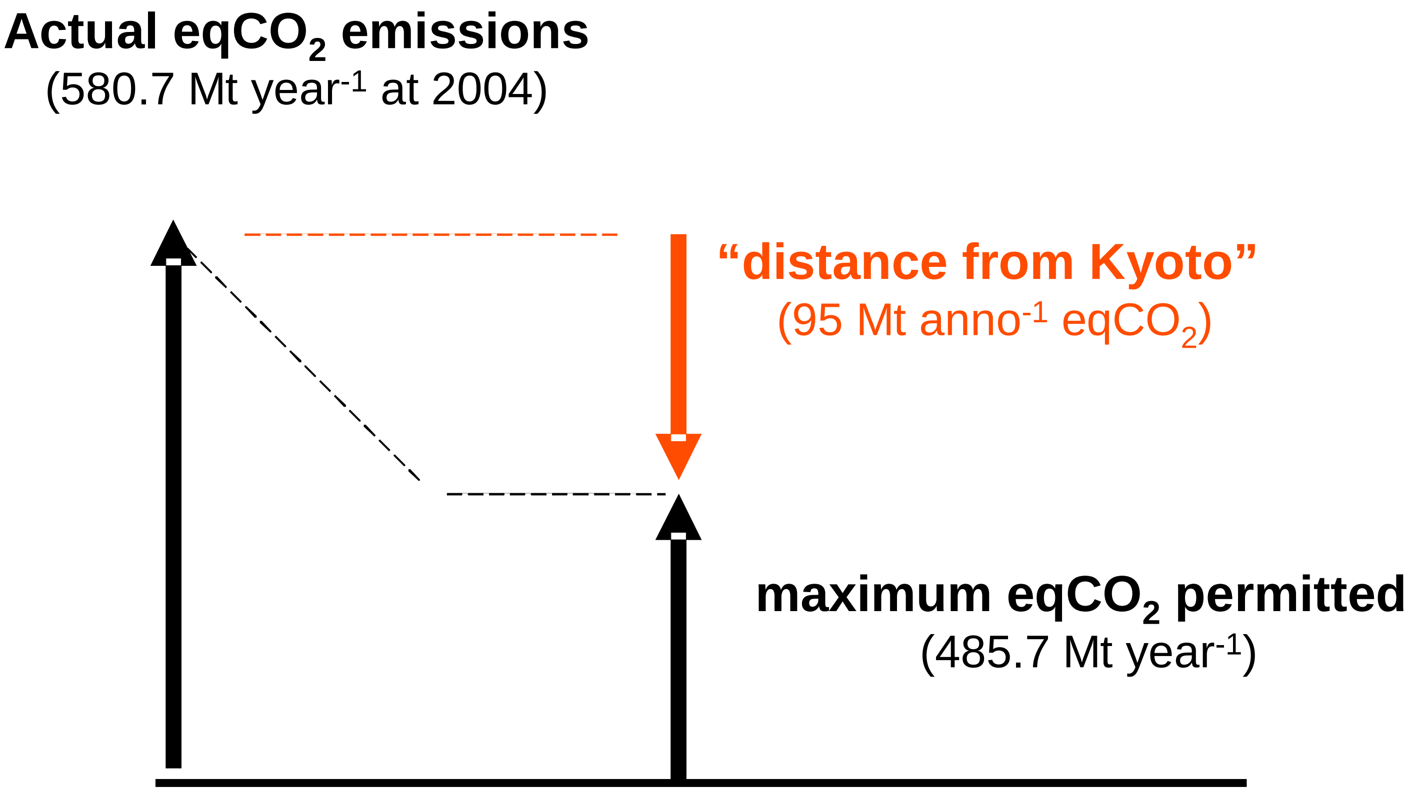


Rielaborato da WBGU Special Report:
The Accounting of Biological Sinks and Sources Under the Kyoto Protocol

CO_2 Emission in Italy (Source: EEA 2004)
(Total annual 580.7 Mt)

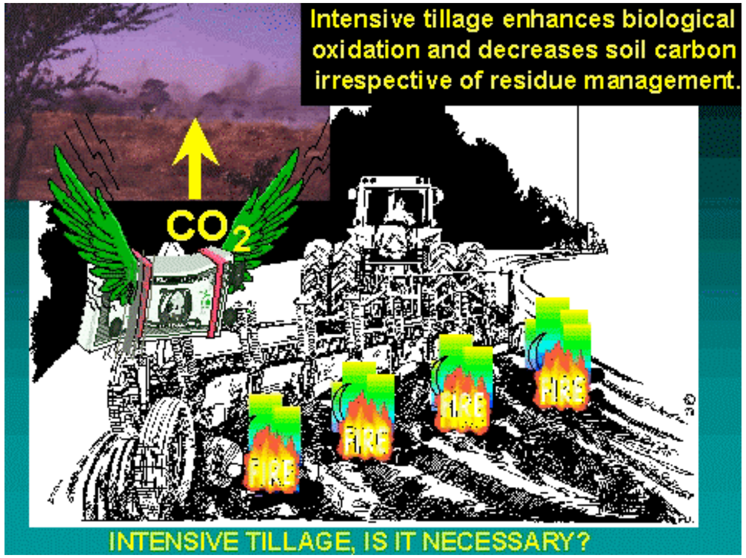
Industry	50.6%
Urban (Transport, waste + Other)	40.0%
Agriculture	9.4%

…in ITALY



Actual eqCO_2 emissions
(580.7 Mt $year^{-1}$ at 2004)
"distance from Kyoto"
(95 Mt $anno^{-1}$ eqCO_2)
maximum eqCO_2 permitted
(485.7 Mt $year^{-1}$)

La diminuzione annuale dello 0,1% di SOC nei suoli agricoli in Italia, corrisponde a 275 Mt di CO_2. Circa metà delle emissioni annue totali di CO2 (580 Mt) dell'intero Paese



Soil fertility

Organic matter in South Italy
0,8 - 1,3%

Sostenibile

convenzionale

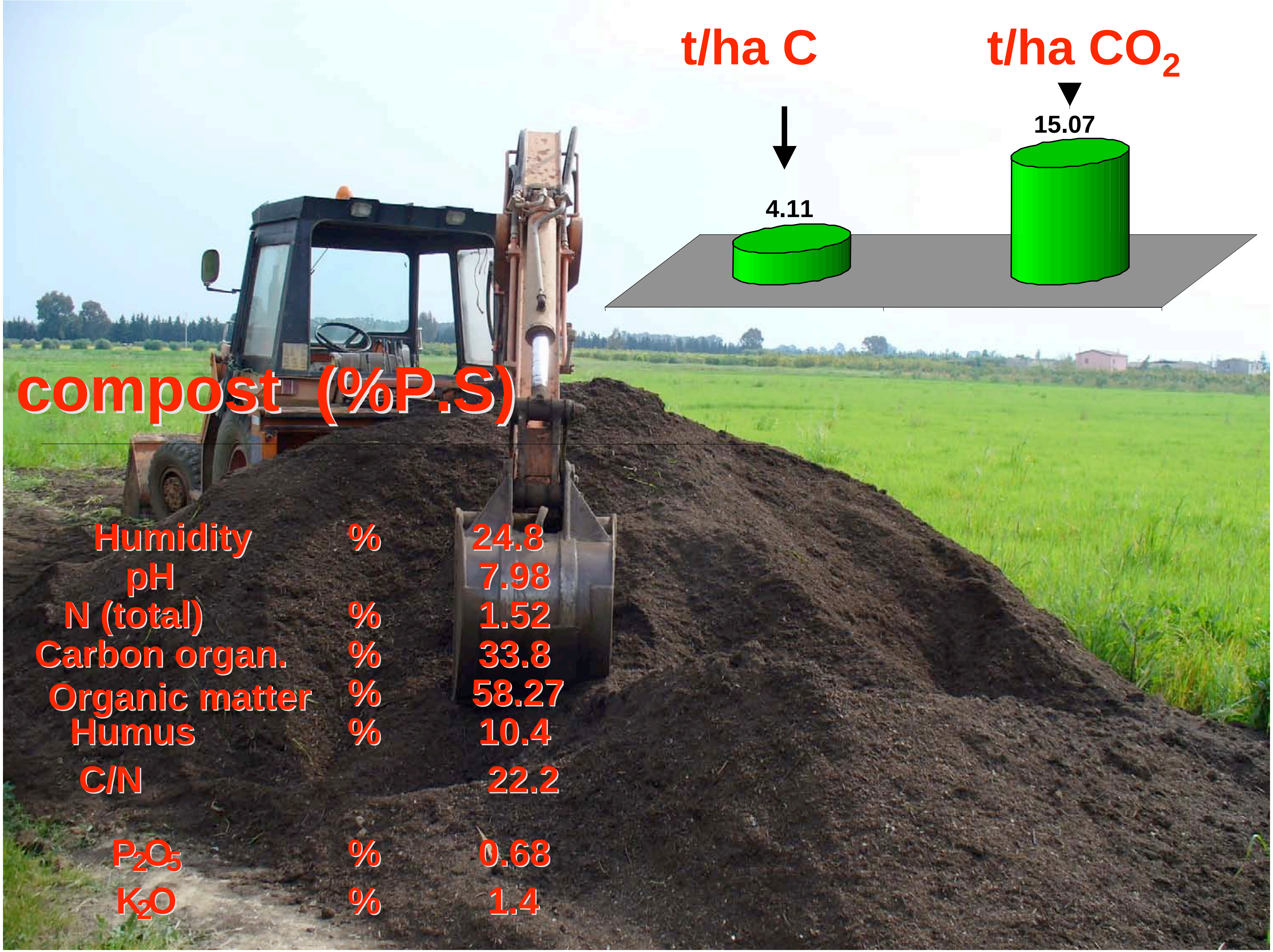
Soil management

Compost (15 t ha-1)
Mineral N if necessary

Fertilization

Mineral
fertilizers

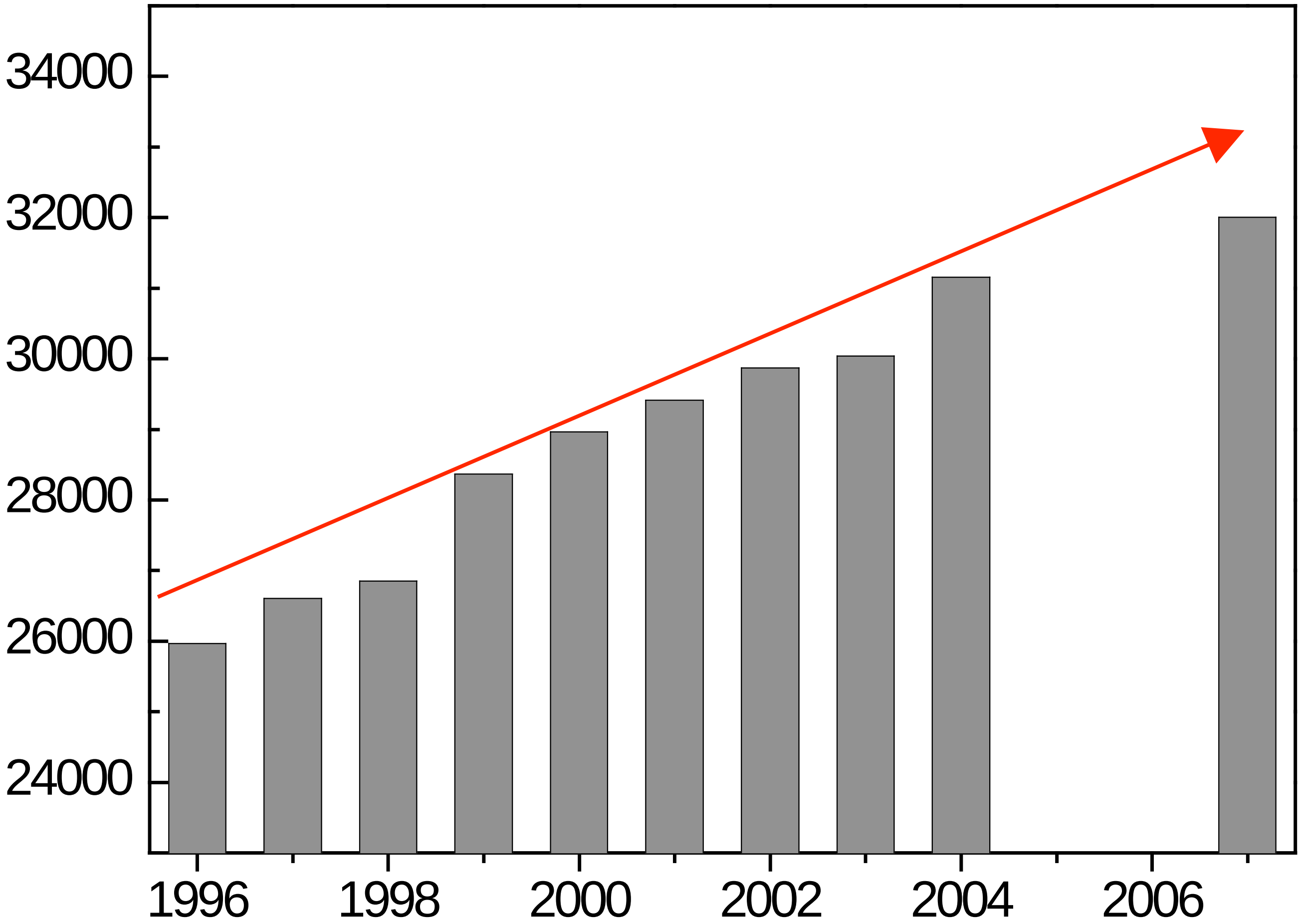
Pruning material



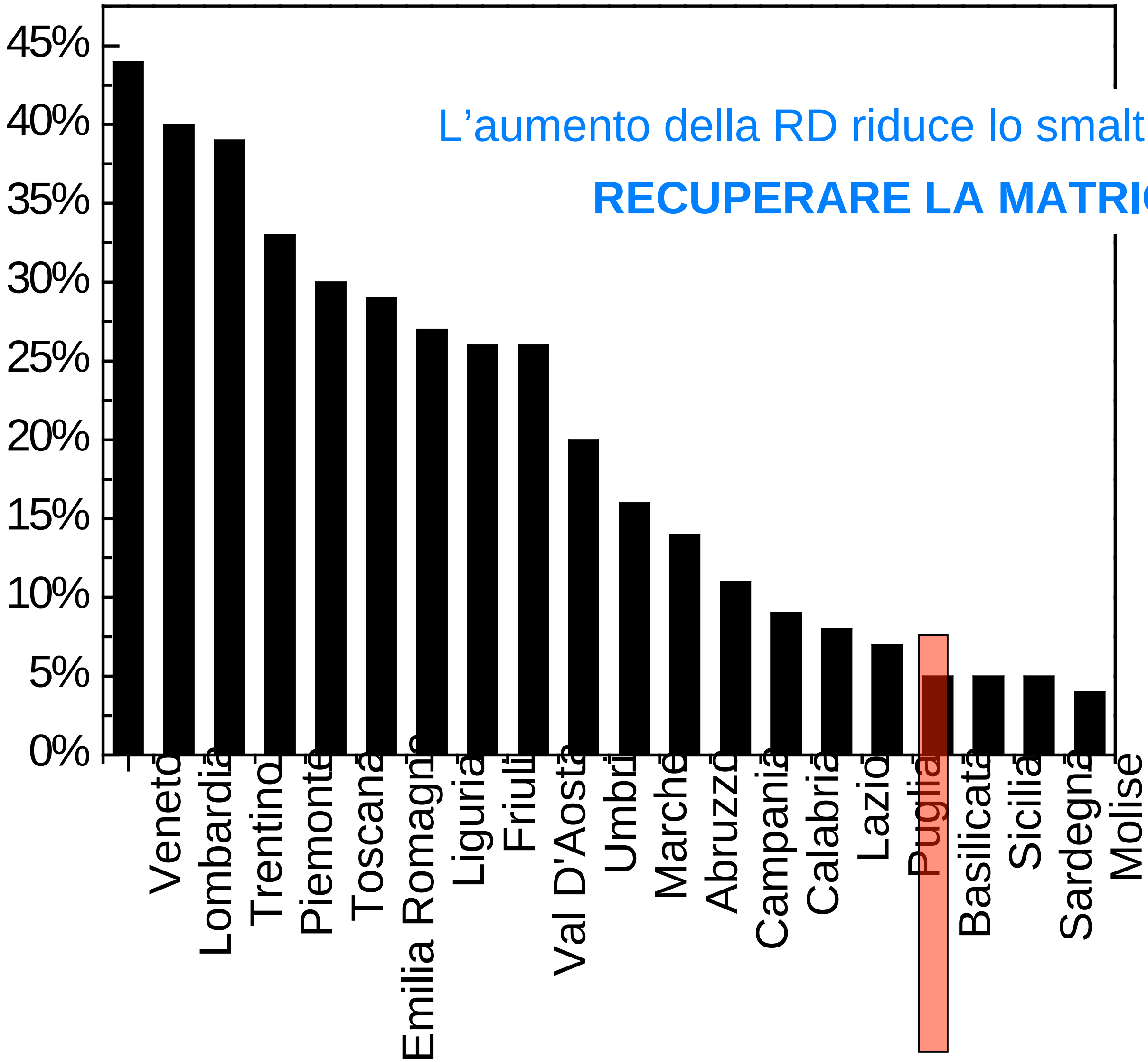
compost (%P.S)

Humidity	%	24.8
pH		7.98
N (total)	%	1.52
Carbon organ.	%	33.8
Organic matter	%	58.27
Humus	%	10.4
C/N		22.2
P_2O_5	%	0.68
K_2O	%	1.4

Produzione Rifiuti Urbani in ITALIA (t $anno^{-1}$) x 1000
(fonte ONR - APAT)



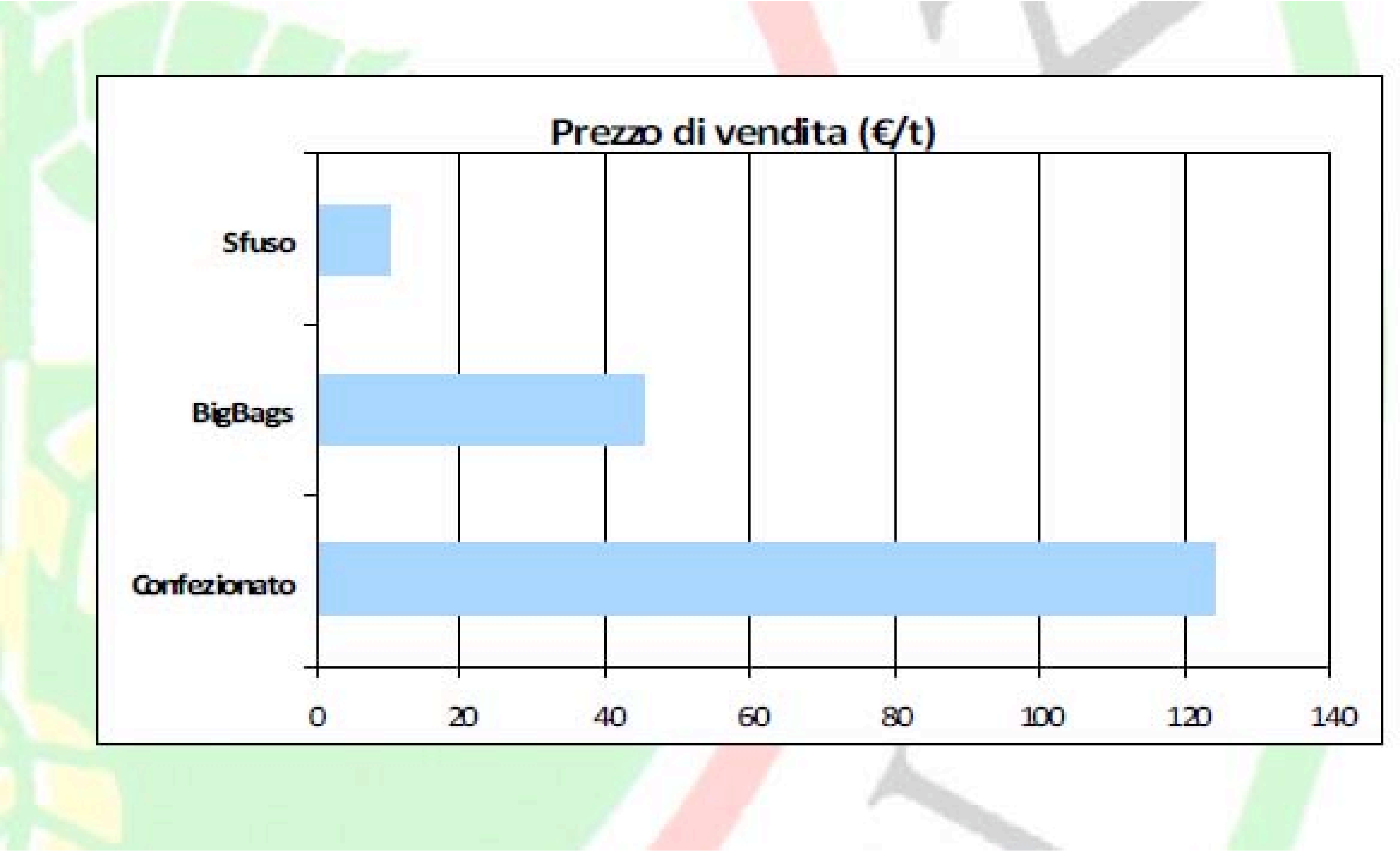
Raccolta differenziata (RD) anno 2004 (fonte ONR - APAT)



L’aumento della RD riduce lo smaltimento in discarica….

RECUPERARE LA MATRICE ORGANICA!

…la matrice organica da rifiuto a risorsa



(fonte CIC)

cost for unit of fertilizzer in the compost

	N	P	K	total	average cost
	228	33,8	130,8	**392,6**	
	N	P_2O_5	K_20	total	
compost	€ 67,95	€ 10,07	€ 38,98	€ 117,00	€ 0,30
Mineral fertilizers	€ 310,22	€ 158,81	€ 76,11	€ 545,14	**€ 1,39**

The cost of the Compost is 7.8 €/t

Se si considera il costo di trasporto (Veneto) il costo per unità fertilizzante arriva ad 1,67euro

■limit C output

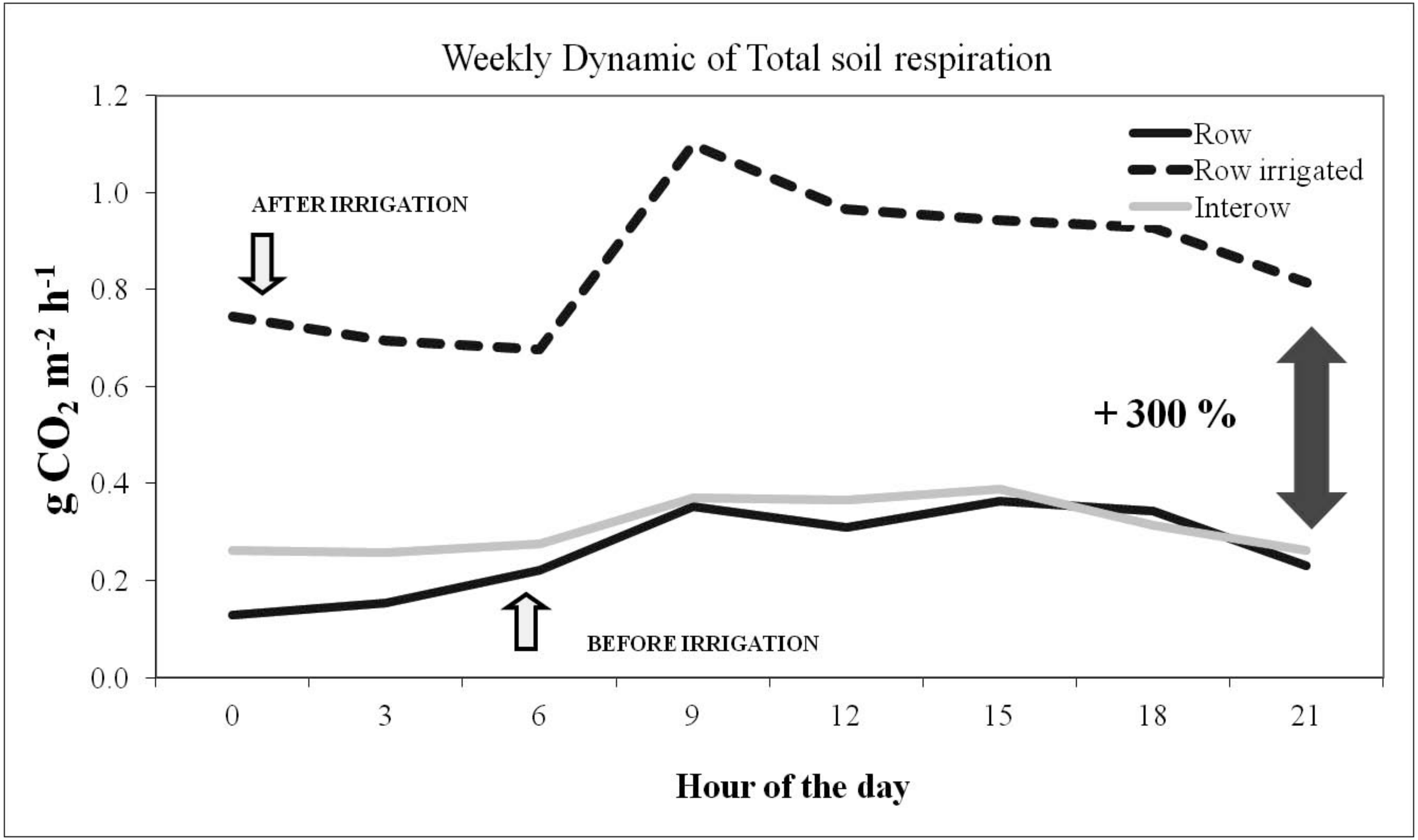
✖Reduction of natural CO_2 emissions from soil

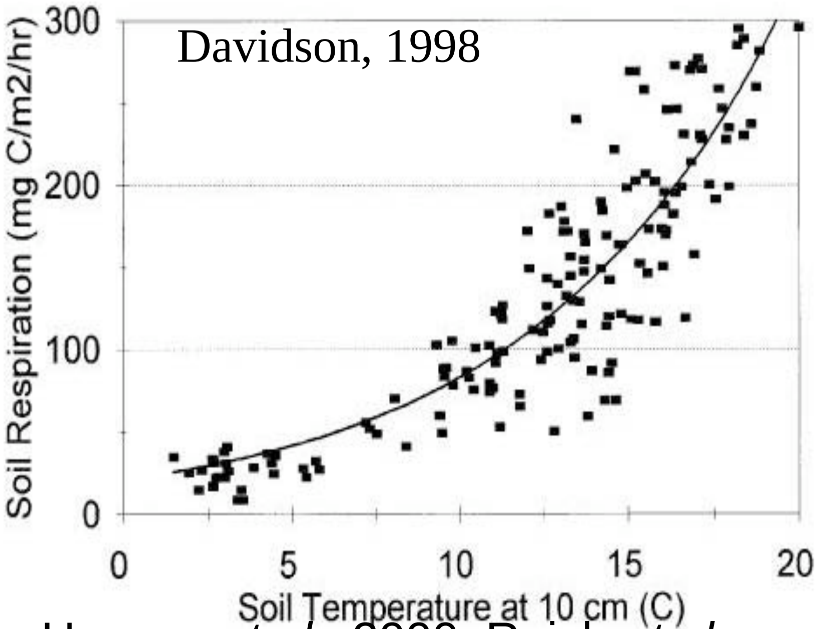
heterotrophic and autotrophic soil respiration

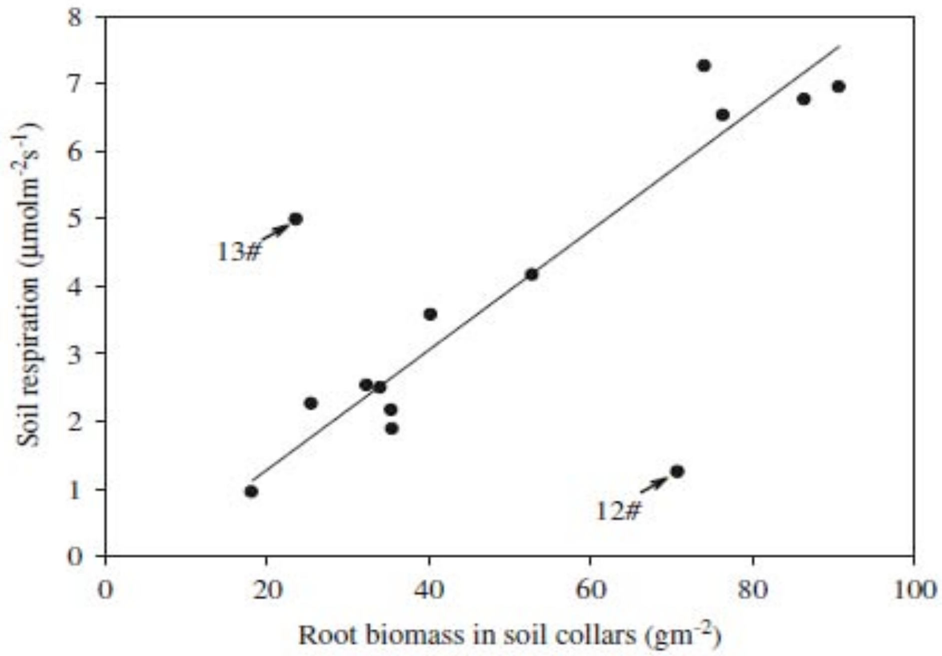
soil water availability
soil temperatures
soil microbiological fertility

factors which affect soil respiration

effect of soil water availability







Hanson *et al*., 2000; Raich *et al*., 2000;

Smith *et al*., 2003; Ryan *et al*., 2005;

Huang *et al*., 2005; Cook *et al*., 2008;

Longdoz *et al*., 2000; Qiao *et al*., 2009;

Granli e Steinkamp *et al*., 2001.

Water Content

Temperature

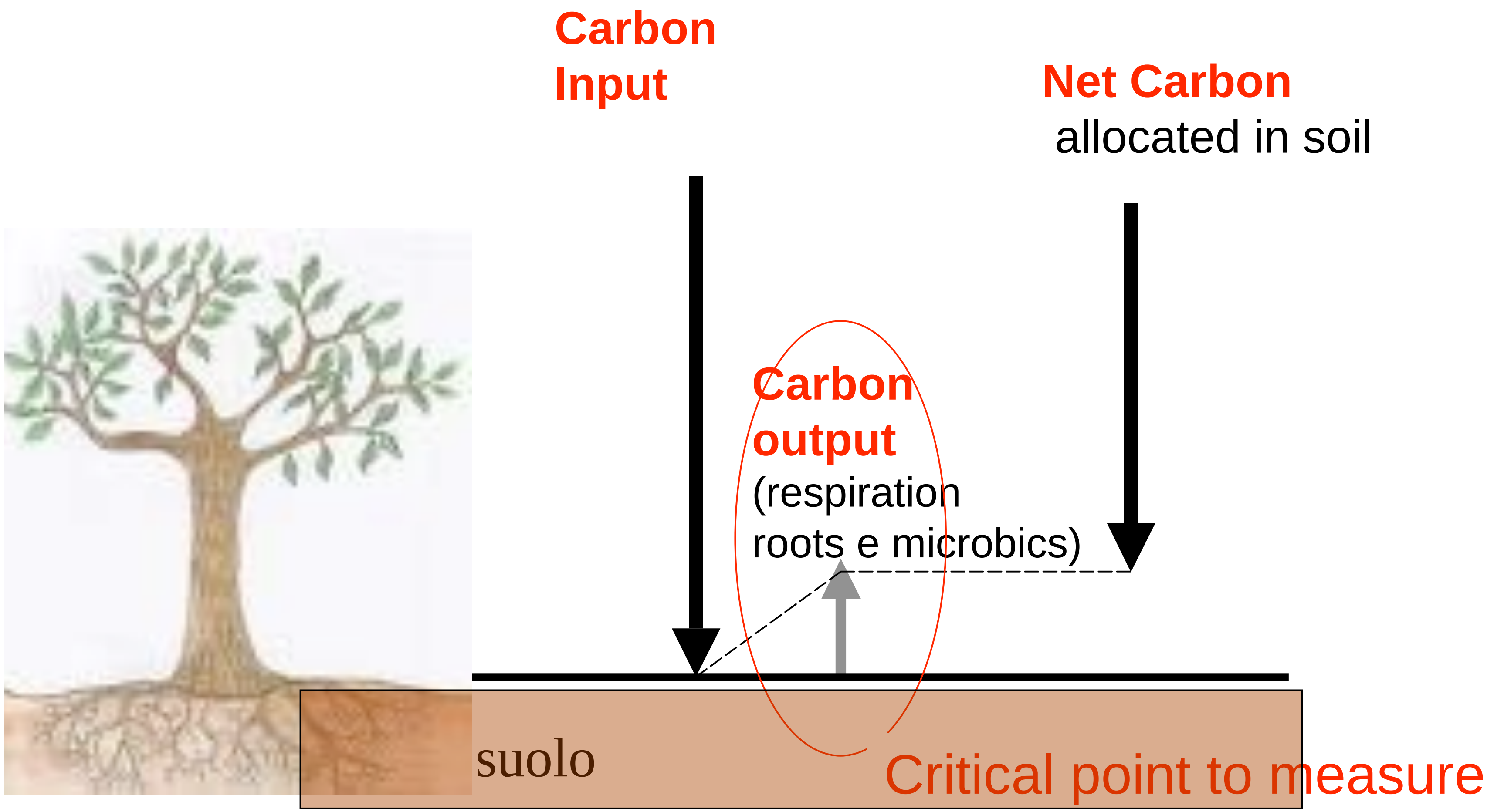
Root Density

Growing Season

Microbial biomass

….. Carbon balance into the soil

$CO_2 = DM \times 0{,}45 \times 3{,}67$
(Norby et al., 2004)



mean (2001-2008) Annual Net Primary Productivity (CO_2eq, t ha^{-1} $year^{-1}$)

Net Primary Productivity (NPP)	Sustainable System	Conventional System
	CO_2eq (t ha^{-1} $year^{-1}$)	
Above Ground NPP	**28.38**	**11.03**
Yield	9.06	3.99
Olive permanent structures[1]	0.60	0.60
Pruning material	6.11	4.84
Senescent leaves[2]	1.60	1.60
Spontaneous vegetation epigean biomass	11.01	-
Below Ground NPP	**10.43**	**5.51**
Olive root biomass[3]	7.68	5.51
Spontaneous vegetation root biomass[4]	2.75	-
Total NPP	**-38.81**	**-16.55**

1 calculated according to Almagro et al. (2010).
2 estimated according to Sofo et al. (2005).
3 estimated as the 50% of the annual biomass production of olive trees (Cannell, 1985).

4 estimated as 20% of the above-ground part (Celano et al., 2003).

CO_2eq emissions and stock variations in the 2 systems

	Sustainable System	Conventional System
	CO_2eq (t ha^{-1} $year^{-1}$)	
Total emissions	**+25.42**	**+27.37**
Anthropogenic	**+2.42**	**+1.53**
Fertilizers, pesticides		
Farm operations and transport		
Pruning residues burning	**-**	**+4.84**
Soil respiration[1]	**+23.00**	**+21.00**
Total NPP	**- 38.81**	**- 16.55**
Difference	**-13.39**	**+10.82**

[1]**elaborated from data reported by Almagro et al. (2009) and Testi et al. (2008)**

CO^2 Balance in the Orchard

Sustainable

Oil yield 1552 Kg

-8.62 Kg CO_2 equivalent/Kg oil

Conventional

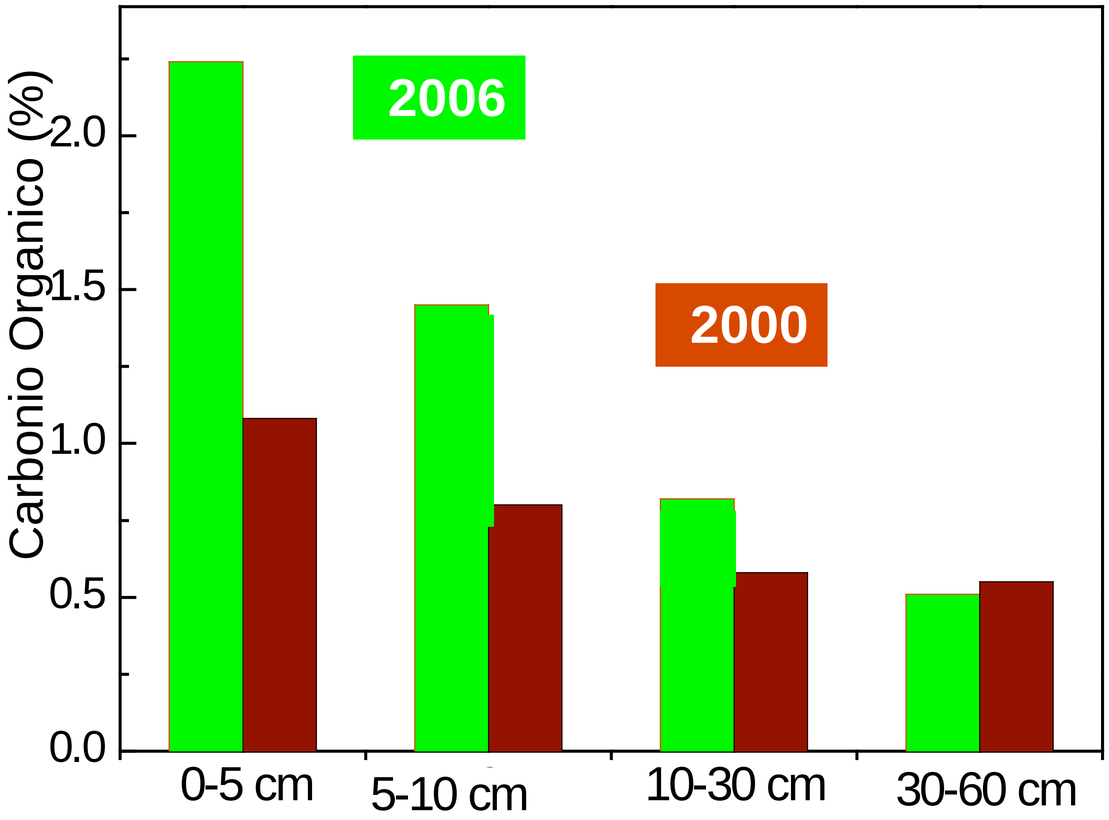
Oil yield 672 Kg

+17.59 Kg CO_2 equivalent/Kg oil

Kg of CO_2 per L of Extra Vergin Oil

	Sustain.	Conven.
CO_2 in orchard	-8.62	+17.59
CO_2 in Mill	+0.13	+0.13
Packing	+1.81	+1.81
Balance	-6.68	+19.53

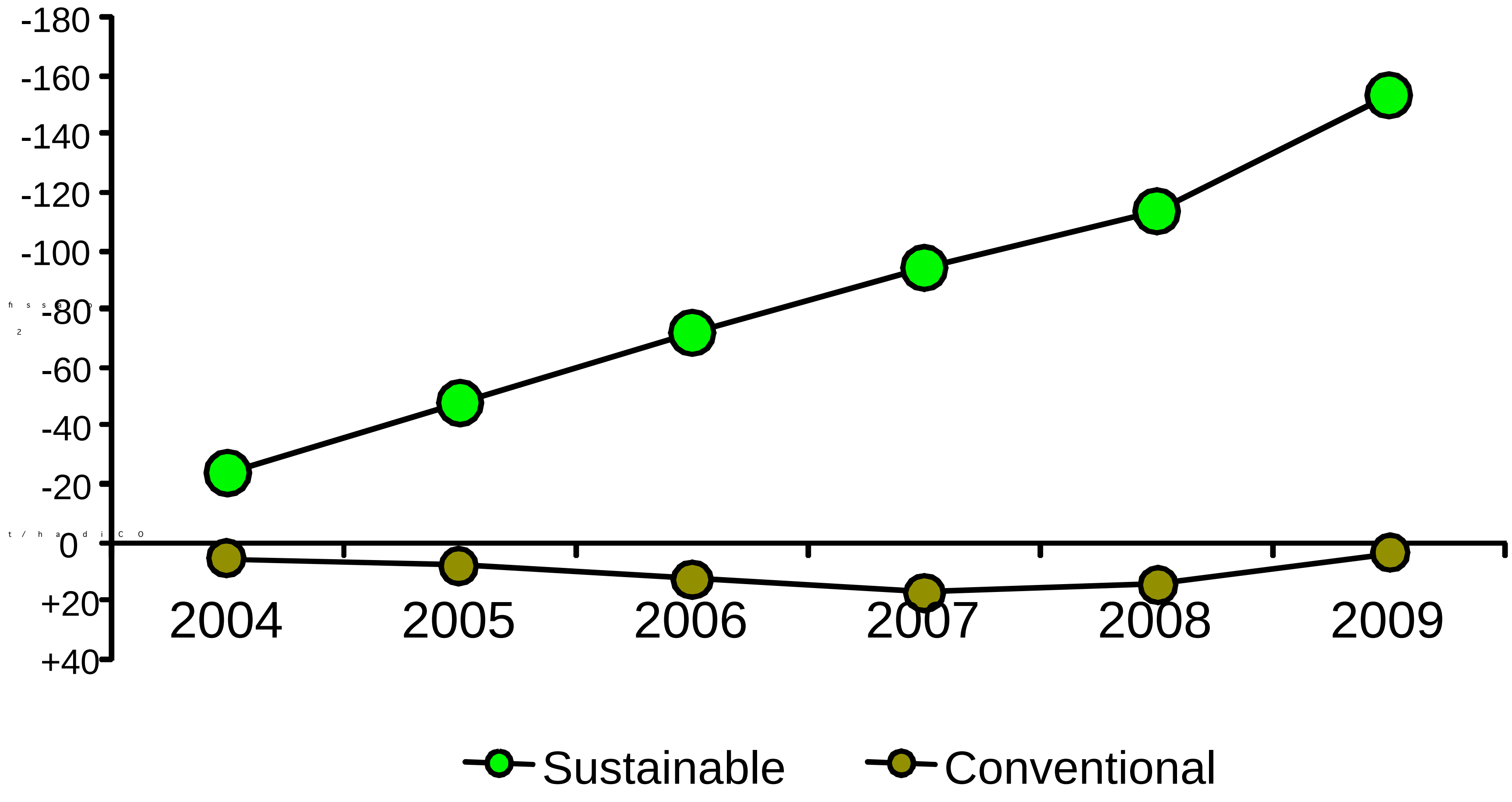
The increase of carbon in the soil of olive trees: 2000-2006 (sustainable management without compost).



Equivalent of about….

61 t ha^{-1} of CO_2
In the top 30 cm of soil

CO_2 Balance in a Mature Peach Orchard



CARBON FOOTPRINT

	Sustainable	Conventional
FIELD (Materials & Machines) Fertilizers, Oils, Human labour, Steel, Iron, Wood, Pesticides, Irrigation.	0.63	0.84
Plant/soil C-BALANCE Soil Respiration, Cover Crops, Pruning material, Production, Compost, etc.	- 1.31	2.05
Winery Phase Water, Chemical products, Steel, Manpower, Energy, Fermentation.	0,13	0,13
Packing Phase Glass, Cork, Paper, Aluminum, Glue, Labor, Energy.	1,02	1,02
Distribution From Italy to Germany	0,44	0,44
Kg CO_2 bottle^{-1}	0.91	4.48

- 80 %

(9500 bottles, 0.75 L)

To increase the Carbon content in the soil of one hectare of orchard (30 cm depth) from 1% to 2% are necessary about 10 years and the soil will fix about 15 t ha^{-1} $year^{-1}$ of CO_2

Carbon accumulated in plant structures:

$12\text{-}\ 20\ t\ ha^{-1}$ Carbon

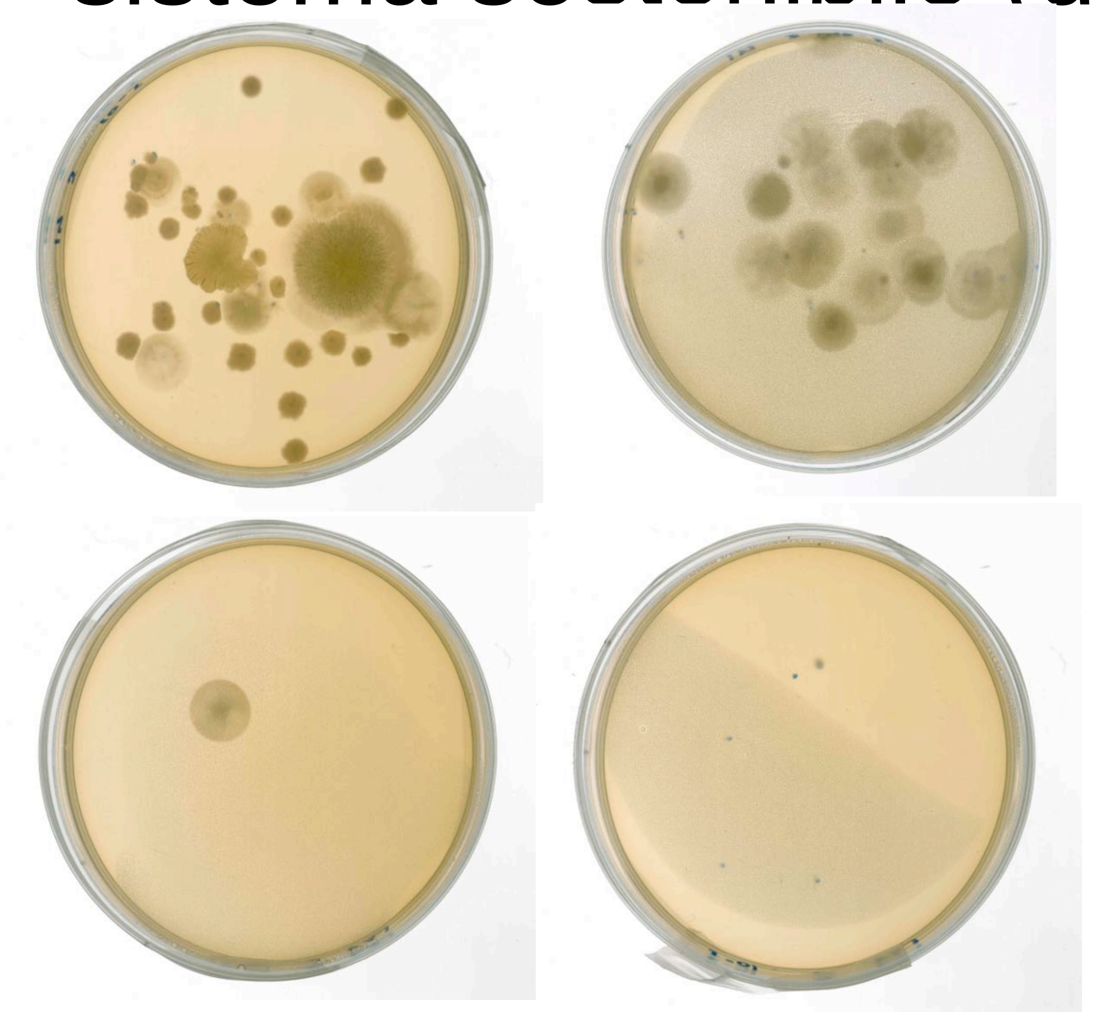
($45\text{-}75\ t\ ha^{-1}\ CO_2$)

In 15 years

Genereri più rappresentati (sono di più nel sistema sostenibile, alcuni producono glomalina)

Sostenibile	Convenzionale
Aspergillus	*Aspergillus*
Streptomices	*Mucor*
Phaeoacremonium	
Penicillium	
Armillaria	
Cladosporium	*Rosellinia*
	Mucor
Acremonium	Cladosporium
Alternaria	
Phaeoacremonium	
Rosellinia	
Phyalophora	
Cylindrocarpon	
Microdochium	

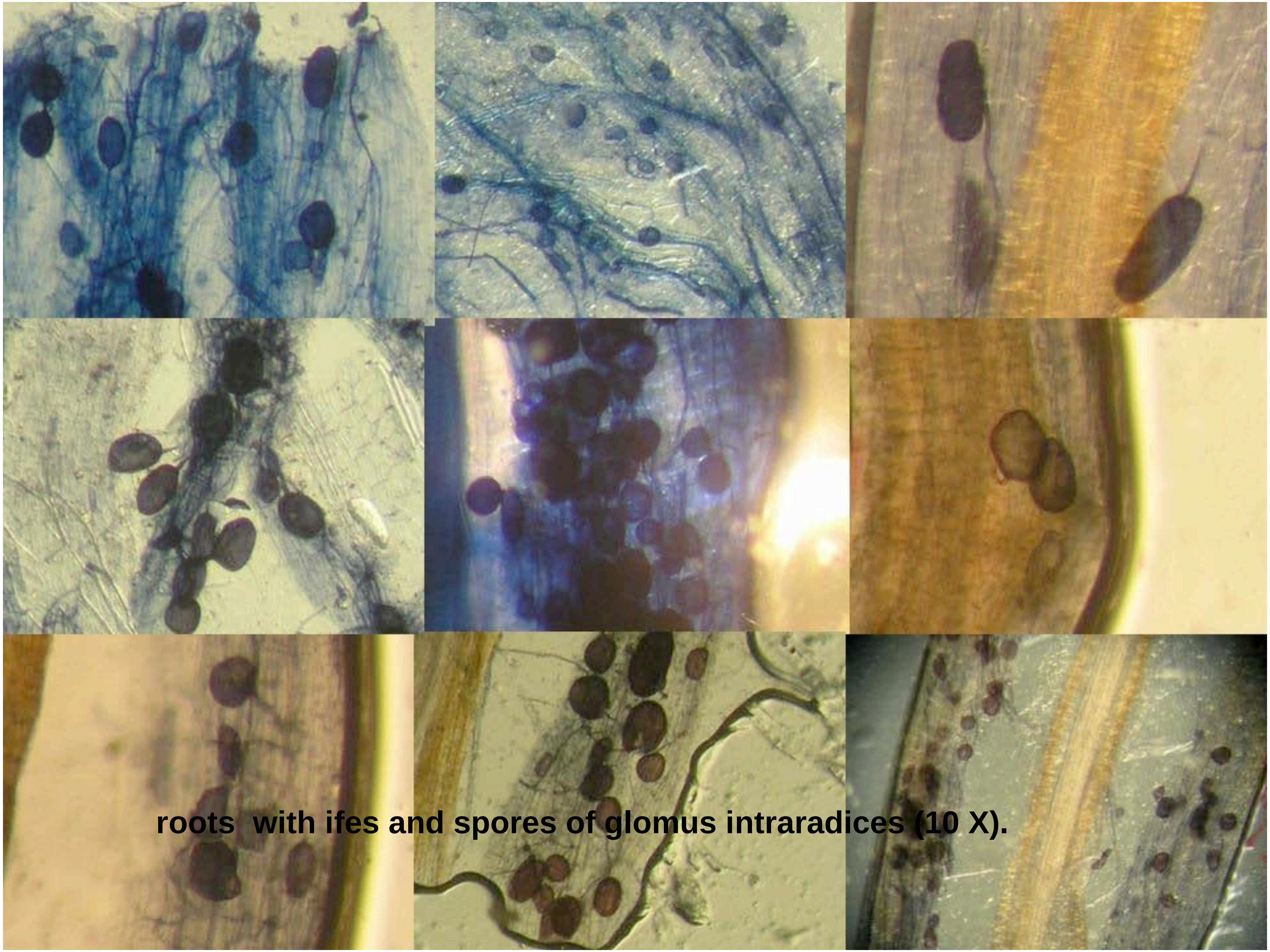
Maggior numero di funghi (e anche di batteri, non mostrati qui) nel sistema sostenibile (diluizione 10^{-2})



Sostenibile

Convenzionale

…….as intestinal flora for humans……………..



roots with ifes and spores of glomus intraradices (10 X).

….economic advantage?

Sustainable

CO_2

CO_2 CO_2

CO_2 CO_2 CO_2

CO_2 CO_2 CO_2 CO

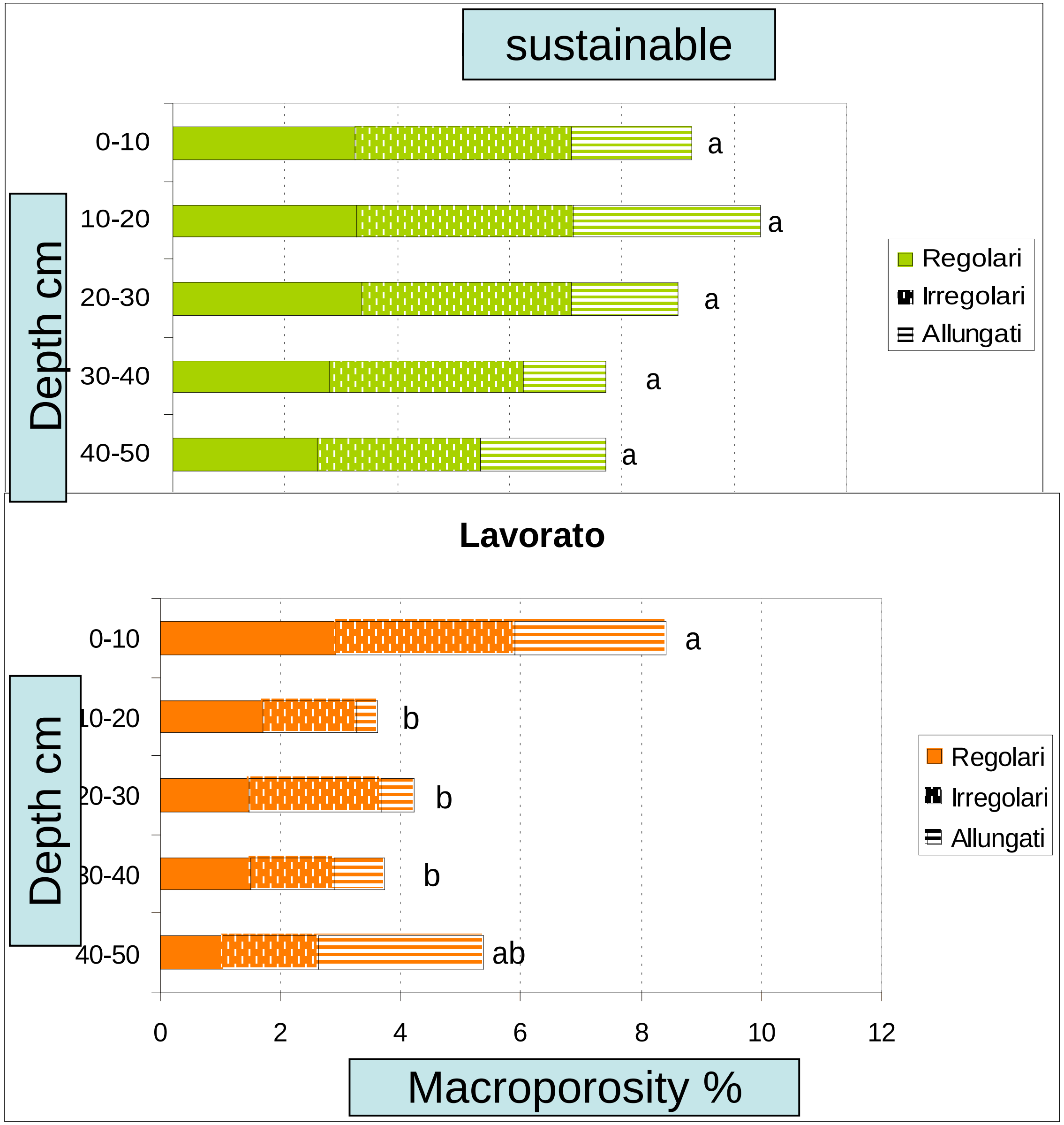
Conventional

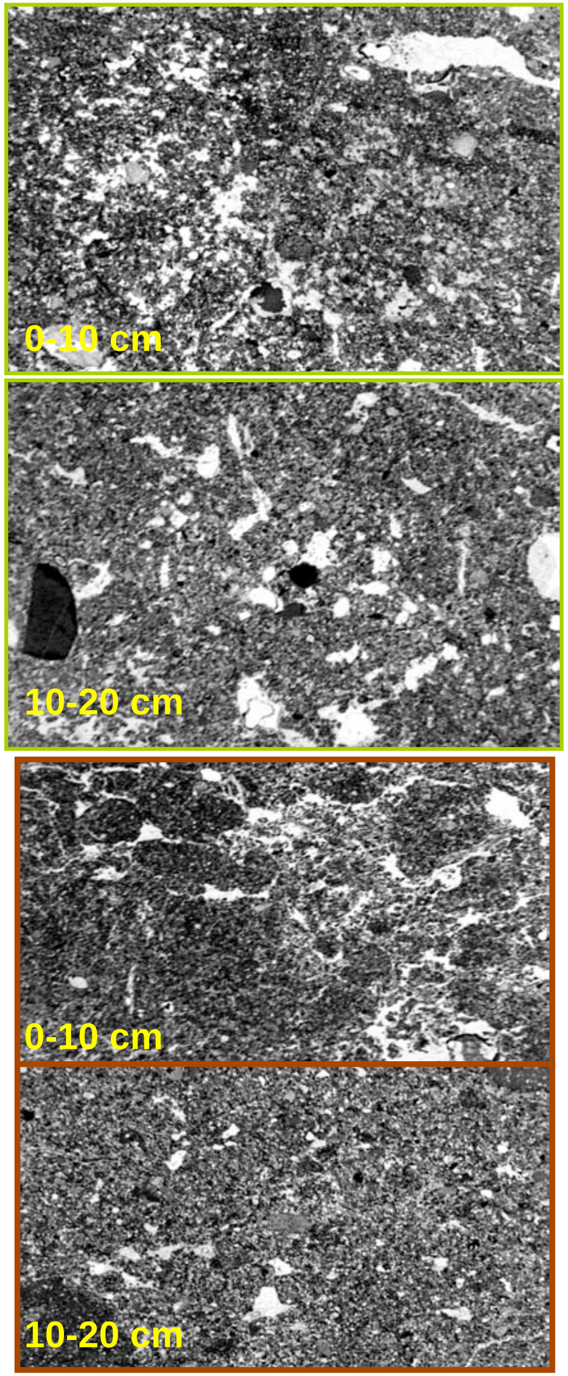
CO_2 CO_2 CO_2 CO_2 CO_2 CO_2 CO_2

???? Euro per t CO_2

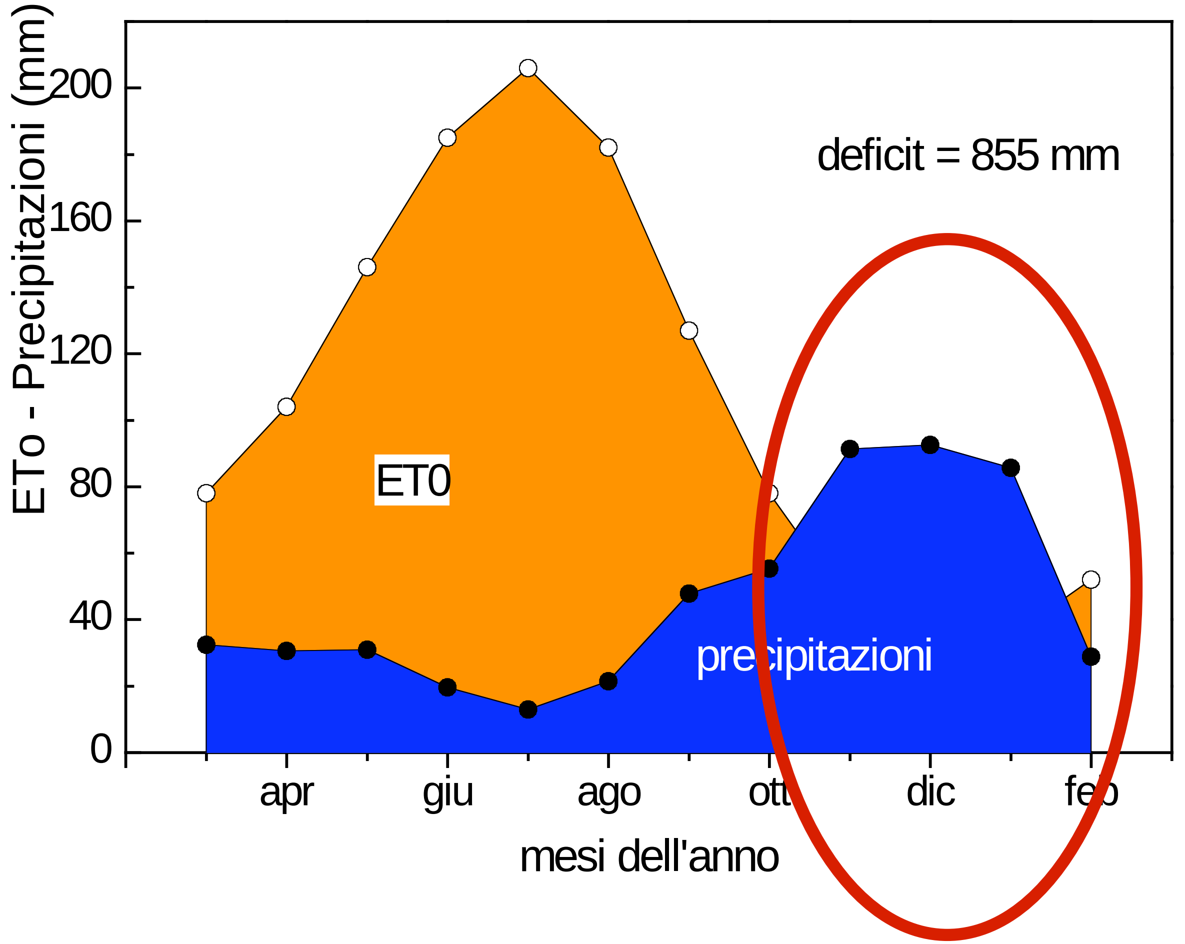
SUSTAINABLE SOIL MANAGEMENT AND

soil water holding capacity


sustainable
Depth cm
0-10
10-20
20-30
30-40
40-50
a
a
a
a
a
Regolari
Irregolari
Allungati
Lavorato
Depth cm
0-10
10-20
20-30
30-40
40-50
a
b
b
b
ab
Regolari
Irregolari
Allungati
0
2
4
6
8
10
12
Macroporosity %


0-10 cm
10-20 cm
0-10 cm
10-20 cm

	K_{sat} (Guelph) (mm d^{-1})	K_{sat} class (Rossi Pisa, 1997)
Sustainable (confined)	160	medium-low
Conventional (confined)	13	very low



Massimizzare l'immagazzinamento delle acque meteoriche nel suolo esplorato dalle radici

Soil Water Content – SWC (mm)
TOP POSITION

	29-03-2007			31-03-2008		
Soil layer (cm)	SS	CS	Δ	SS	CS	Δ
0-50	108.6	85.6	**23.0**	110.9	102.1	**8.8**
50-100	115.7	59.2	**56.5**	110.0	91.2	**18.8**
100-150	104.3	39.0	**65.3**	111.1	90.3	**20.8**
150-200	80.1	39.0	**41.1**	110.1	80.9	**29.1**
total 0-200	**408.7**	**222.8**	**185.9**	**442.0**	**364.5**	**77.5**

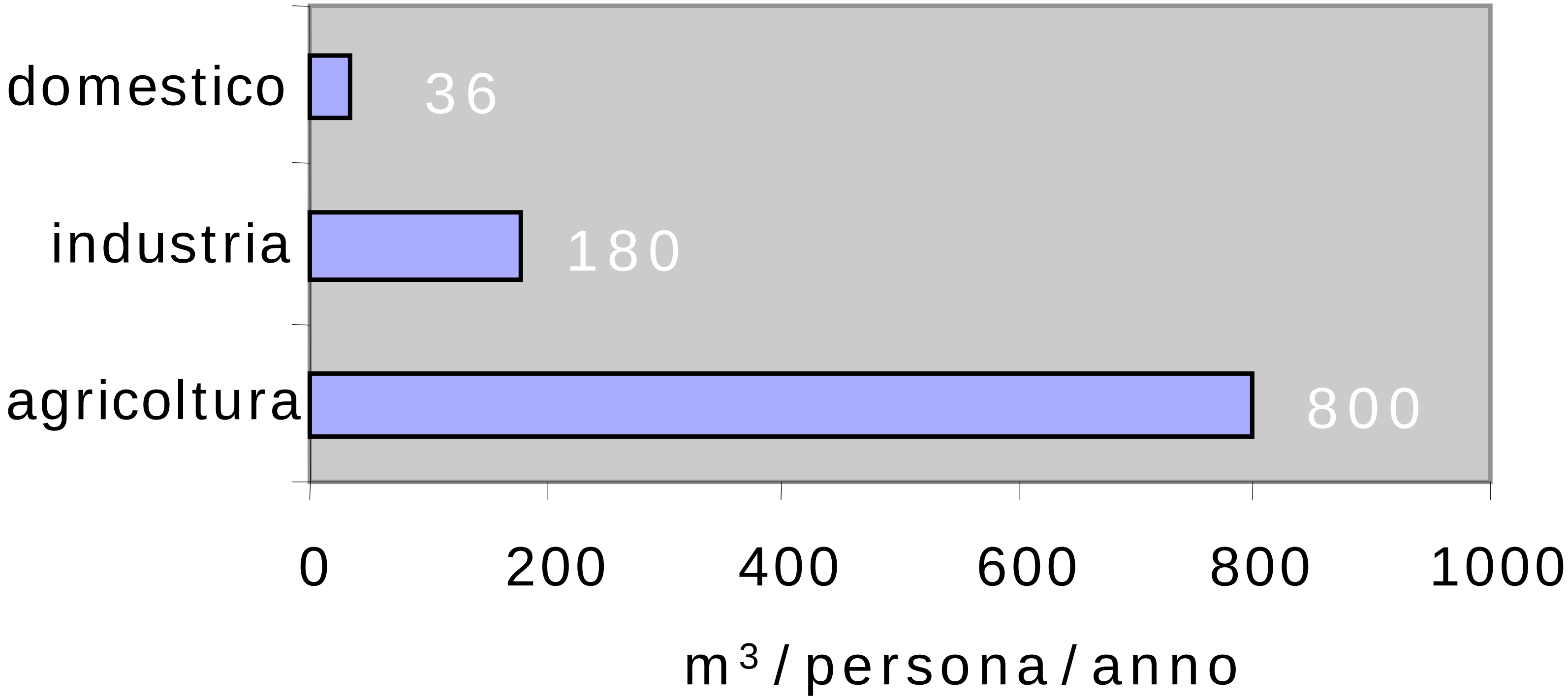
SS: Sustainable System
CS: Conventional System

S. Giuliano’s Dam

…..soil management

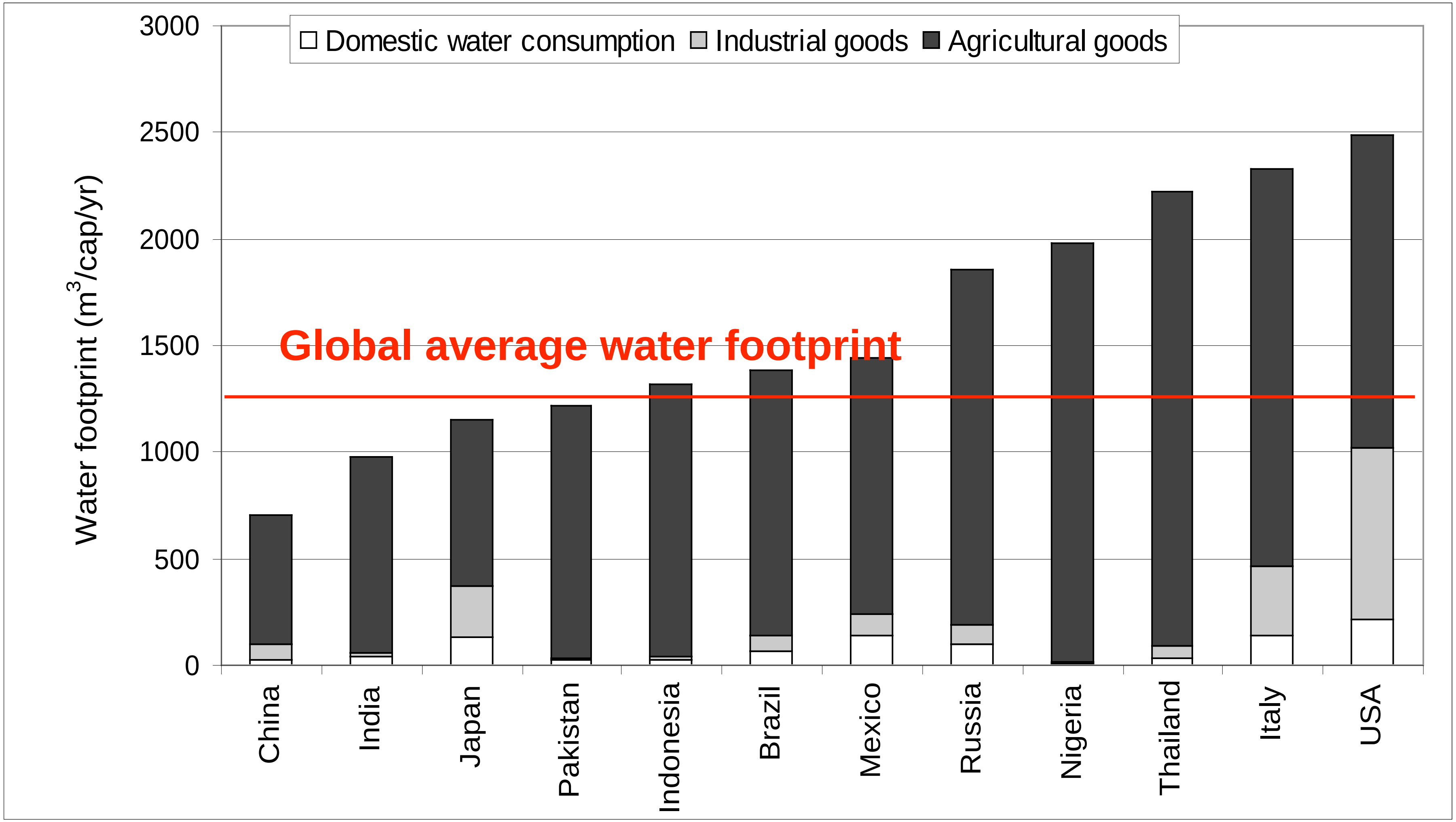
Was it only a rainfall intensity effect ?????

Domanda mondiale di acqua nei diversi settori

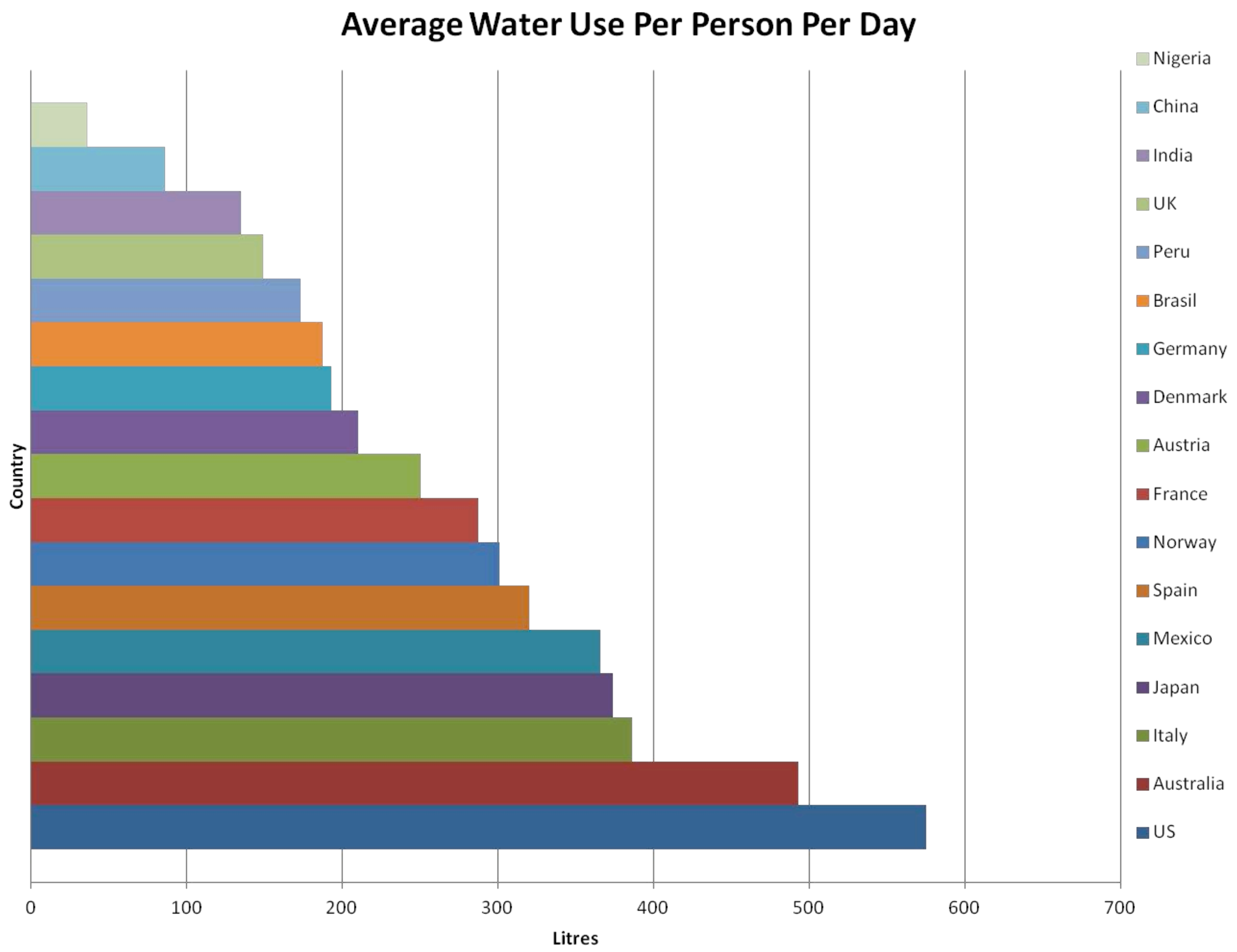


(Thames Water)

Water footprint per capita



[Hoekstra & Chapagain, 2008]



Average Water Use Per Person Per Day
Country
Litres
0
100
200
300
400
500
600
700
Nigeria
China
India
UK
Peru
Brasil
Germany
Denmark
Austria
France
Norway
Spain
Mexico
Japan
Italy
Australia
US

The water footprint components

Green water footprint

► volume of rainwater evapotranspirated or incorporated into product

Blue water footprint

► volume of surface or groundwater evapotranspirated, incorporated into product or returned to other catchment or the sea.

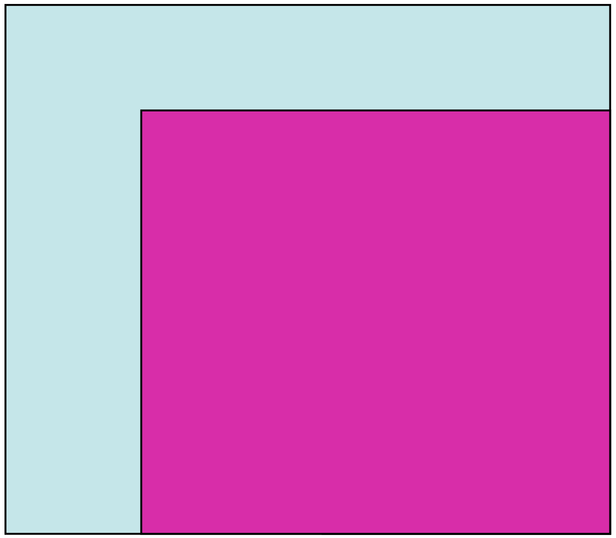
Grey water footprint

► volume of polluted water.

- Risorsa limitata????

- Aumento domanda settore agricolo e di altri settori

- Incremento popolazione ……



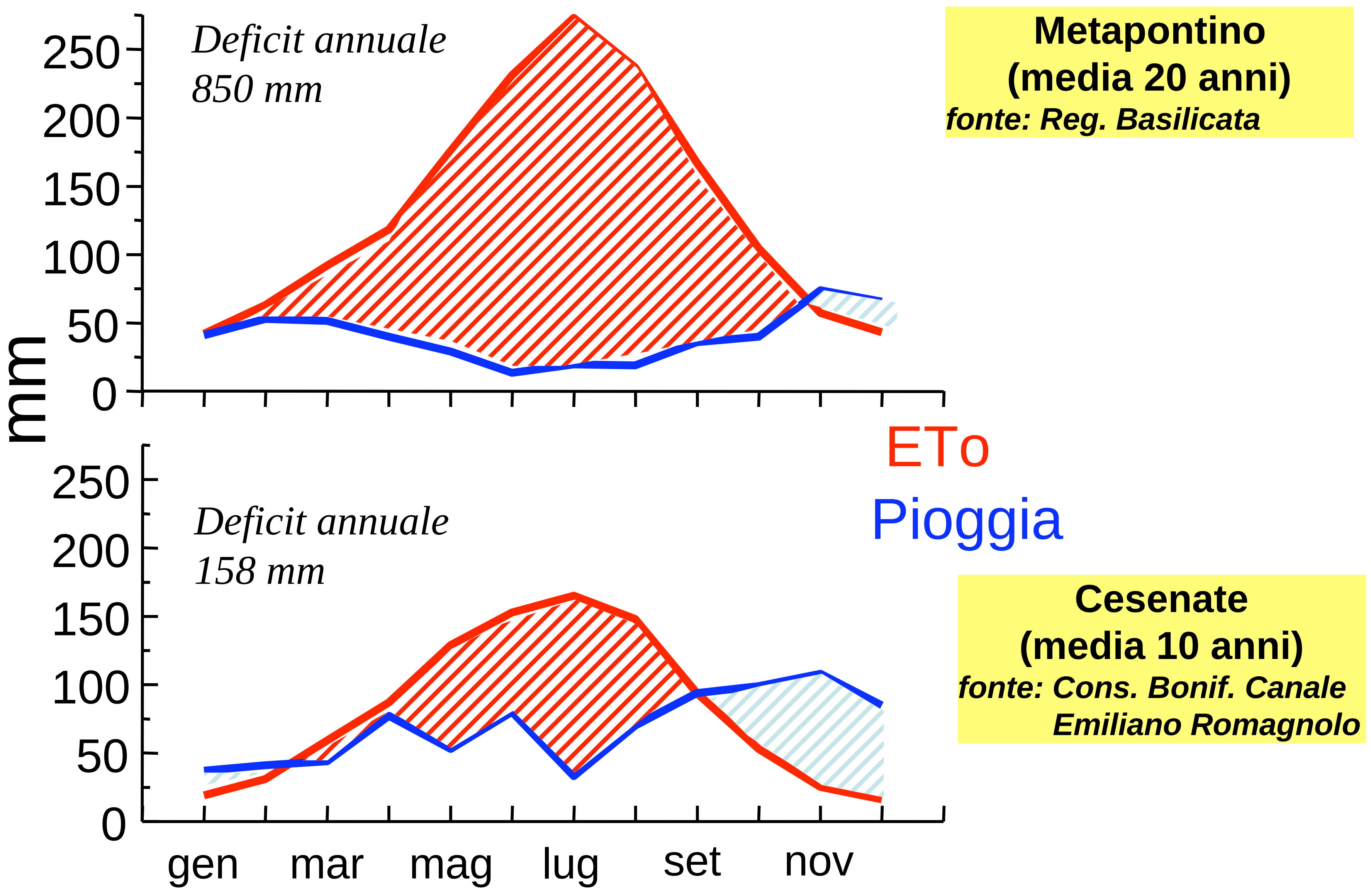
70% Agricoltura

30% industria, civile

water footprint (blue)

annual rainfall – 400-500 mm, water deficit 800-1000 mm/year, drip irrigation

species	irrigation volume m^3/ha	yield t/ha	H_2O/Kg fresh weight	H_2O/ liter of product
olive (traditional)	1000	4	250	1515
olive (high density)	3000	8	380	2273
olive (super high-density)	5000	10	500	3030
grapevine (wine)	1000	10	100	143
peach	5000	25	200	-
apricot	3000	20	150	-
kiwi	8000	40	200	-

Deficit annuale
850 mm
Metapontino
(media 20 anni)
fonte: Reg. Basilicata
mm
250
200
150
100
50
0
ETo
Pioggia
Deficit annuale
158 mm
Cesenate
(media 10 anni)
fonte: Cons. Bonif. Canale
Emiliano Romagnolo
250
200
150
100
50
0
gen
mar
mag
lug
set
nov

“water cost” (blue component) to produce one Kg of peaches in South and North Italy.

	yield t ha^{-1}	Water cons. $m^3\ ha^{-1}$	Irrigation $m^3\ ha^{-1}$	Liters H_2O Kg of peaches	Liters H_2O irrigation of kg peach
Springlady					
South	20	6.000	5.000	300	250
North	20	3.000	1.182	150	59
Fayette					
South	30	8.000	7.000	267	233
North	30	4.000	2.339	133	78

“Water Foot-Print”

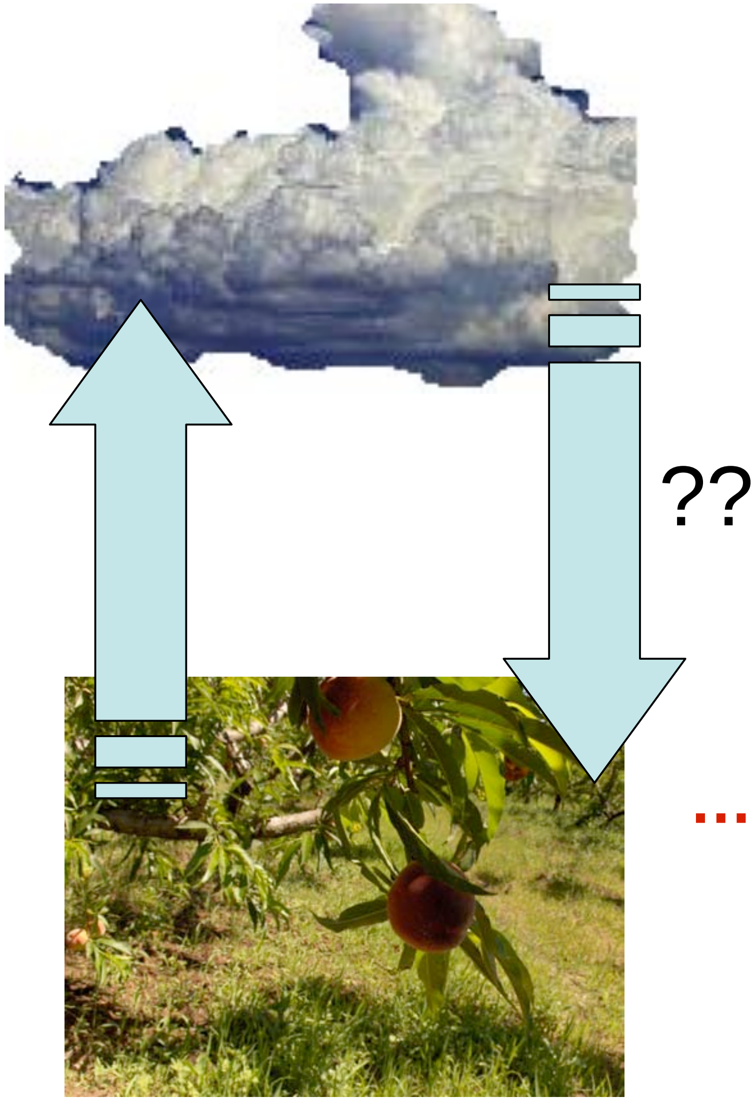
150-250 L/kg
(early – late ripening)

	m3/ha
LEAVES	19.0
FRUITS	16.8
WINTER PRUNNING	1.7
SUMMER PRUNNING	1.9
total (m³)	**39.4**

<1% of distributed water

YIELD 20 t ha-1,
Irrigation volume 4000 m^3 ha^{-1}

L’acqua evapotraspirata dal pescheto entra nel ciclo dell’acqua…..



…..ritornerà allo stesso suolo???




Efficienza di distribuzione dell’acqua nei vari metodi irrigui

sommersione	45%
infiltrazione	55-75 %
aspersione	65-75%
microirrigazione	90-95%

ETc = (Kc * ETo)/ efficienza metodo*

*Oscilla da 0,5 a 0,95 in piena produzione

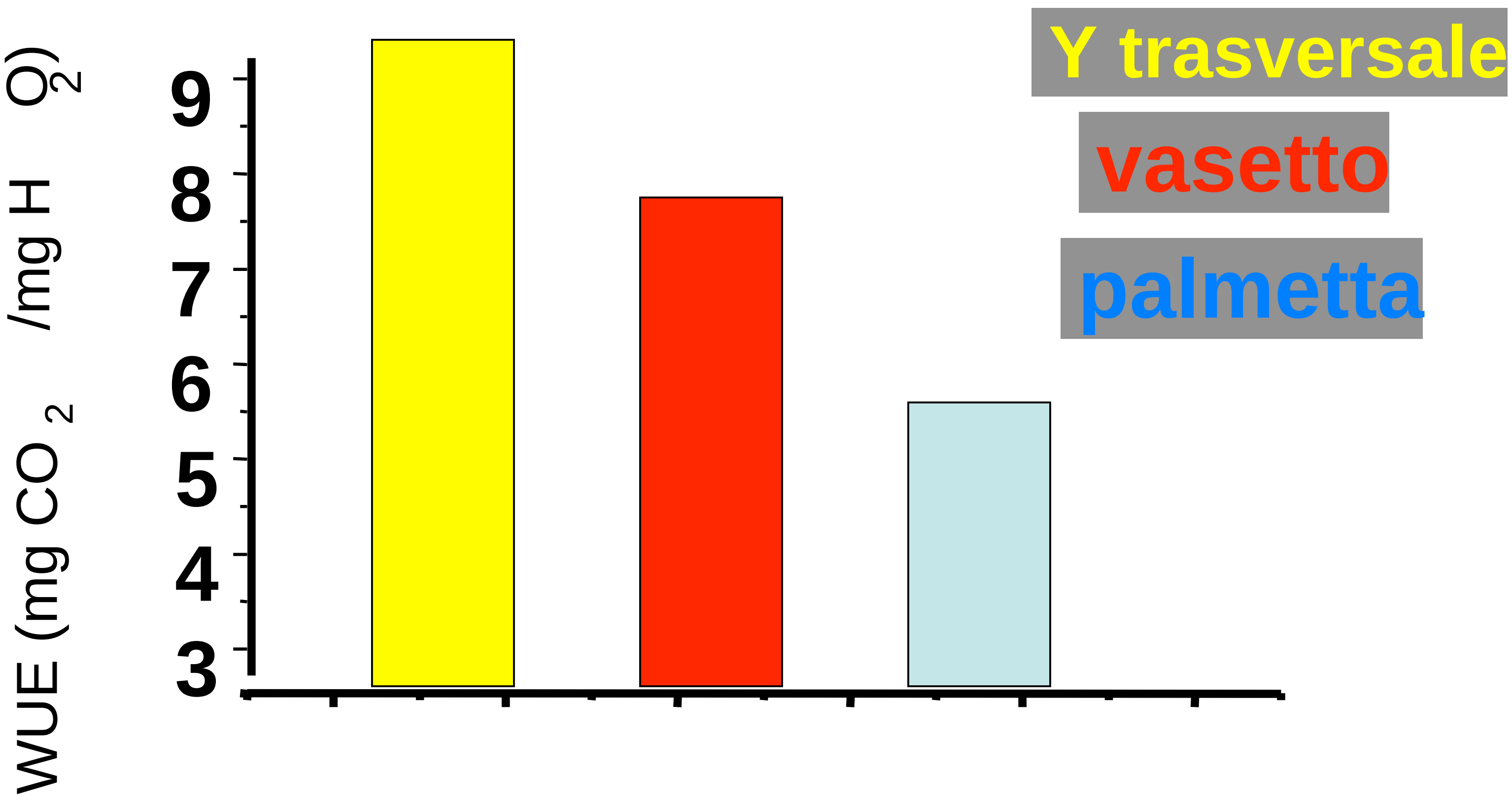
Regione Basilicata

Delibera 2359/2001

“Miglioramento dell’efficienza dei sistemi irrigui”

conversione verso sistemi irrigui a microportata, realizzazione vasche, sostituzione tubazioni adduttrici fatiscenti

WUE media giornaliera in chiome intere di piante di pesco.



Rielaborata da Giuliani et al.

Ottimizzazione ed Applicazione stress idrico controllato

Dal germogliamento

alla raccolta 100% ETc

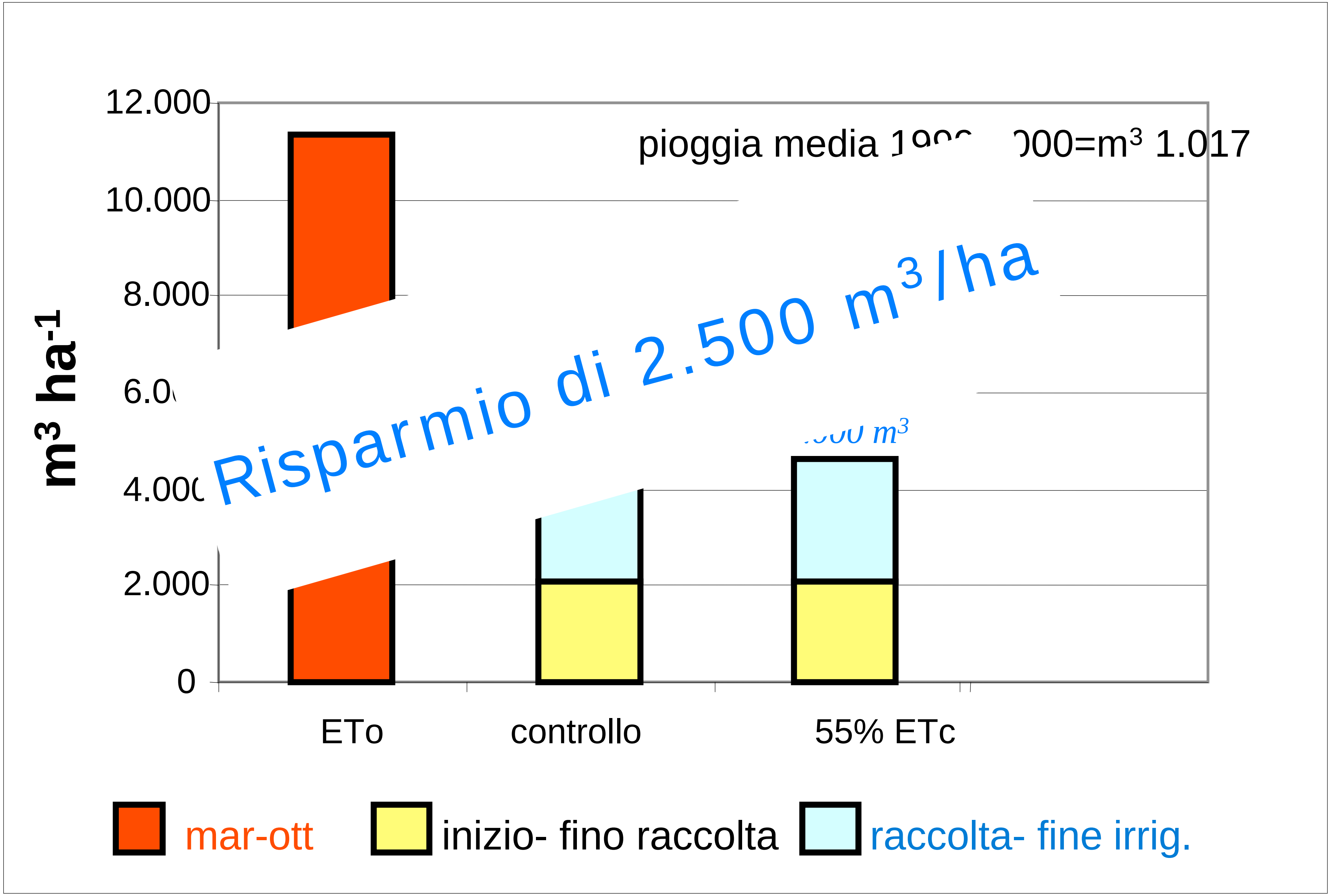
Periodo post raccolta

Stress idrico

Kc ridotti=0,5

marzo/iniz.luglio.

Fine settembre



12.000
10.000
8.000
6.0
4.000
2.000
0
m^3 ha^{-1}
pioggia media 1 000=m^3 1.017
Risparmio di 2.500 m^3/ha
000 m^3
ETo
controllo
55% ETc
mar-ott
inizio- fino raccolta
raccolta- fine irrig.

$$\mathbf{EWUE} = \frac{\text{Marketable Yield value (€)}}{\text{Irrigation water (m}^3\text{)}}$$

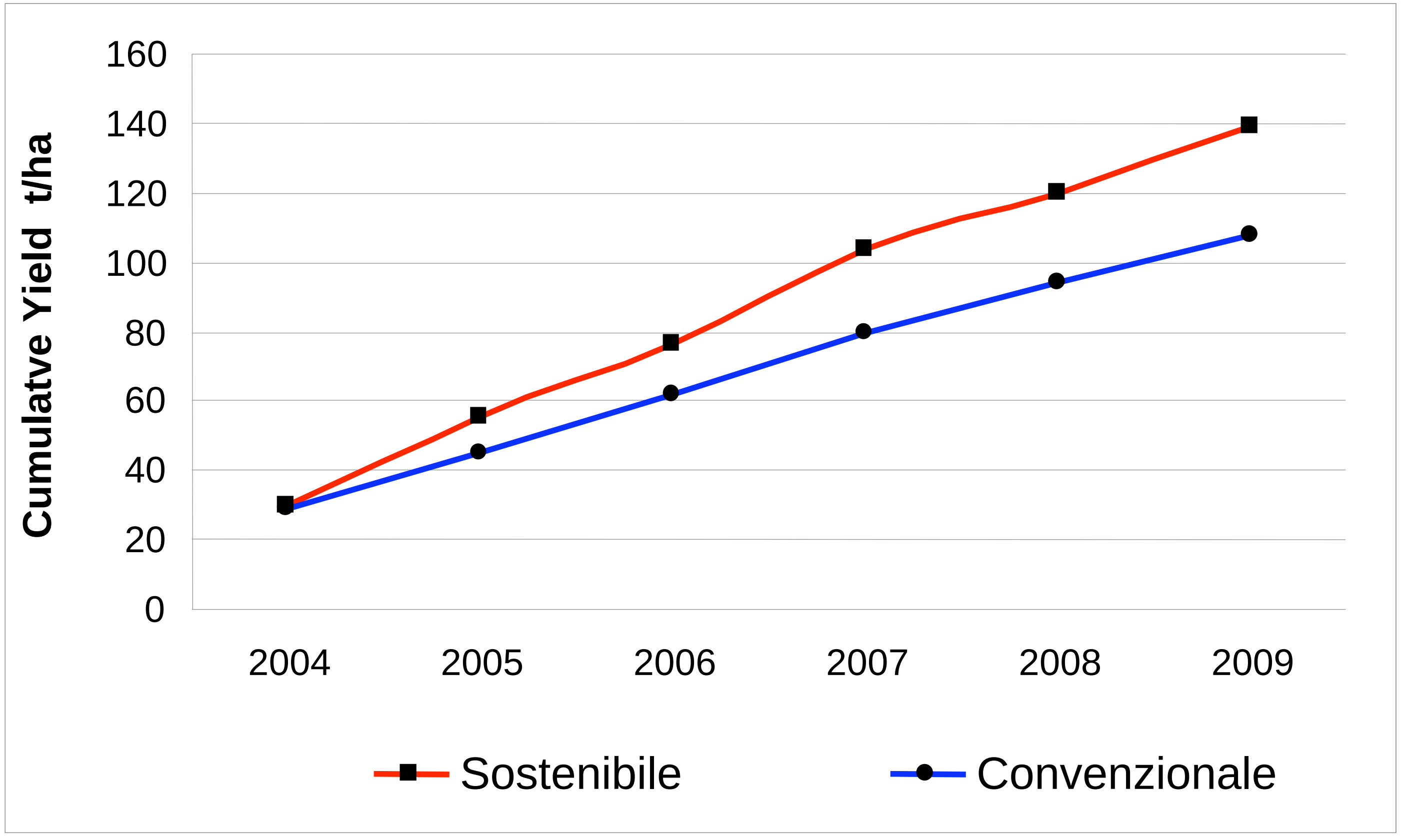
Volume irriguo (L) /Kg di frutta

Sostenibile 220

Convenzionale 380

Sostenibile € 2,11

Convenzionale € 1,34



Consorzio di Bonifica Bradano e Metaponto

TARIFFE MEDIE

QUOTA FISSA (area ionica): **€ 115 / ha**
(bonifica + irrigazione)

CONSUMI

NO CONTATORI (a prenotazione): **€ 180,76 / ha**

SI CONTATORI (valle Bradano – Metaponto): **€ 0,031 / m^3**
(altre zone): **€ 0,041 / m^3**

….a superficie

….a volumi

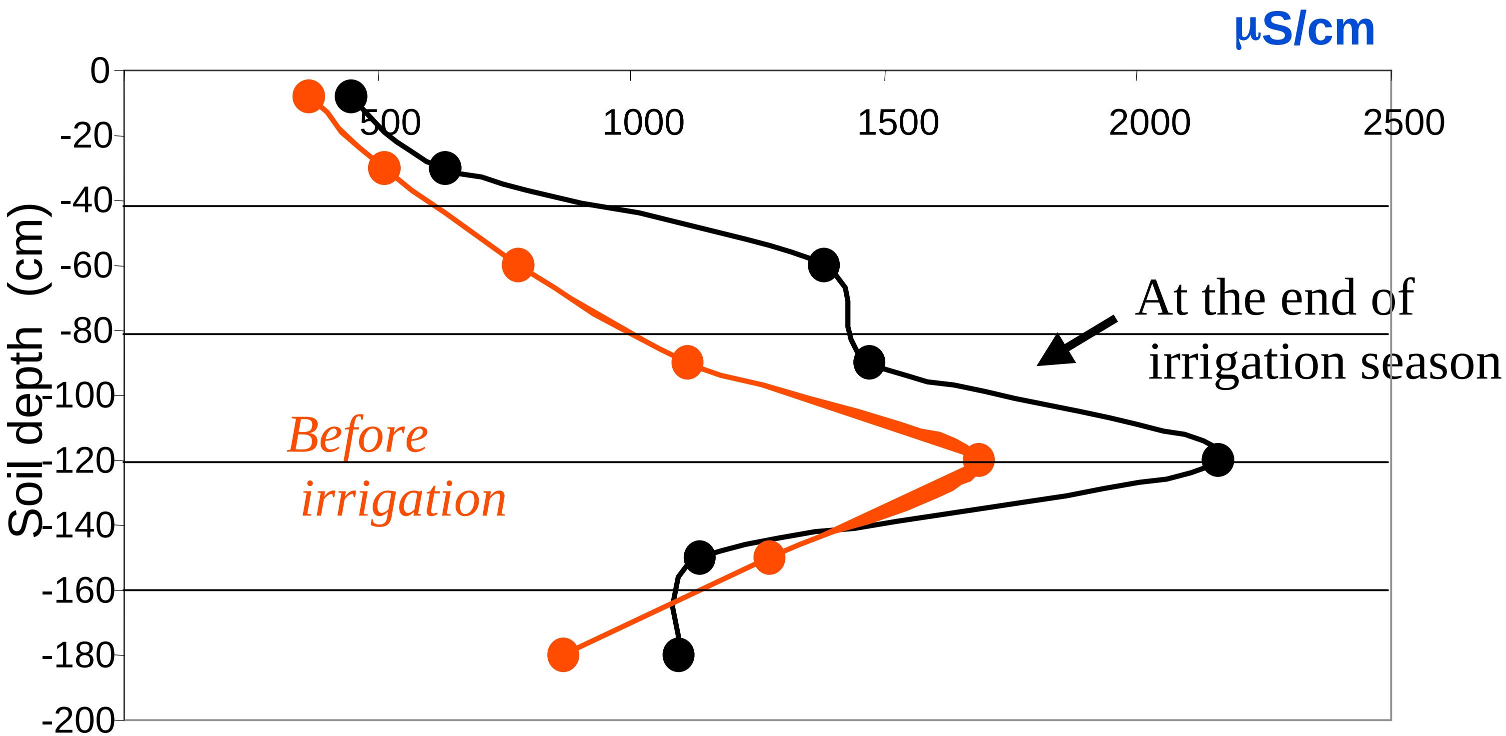
Elementi minerali apportati kg ha^{-1} *con l'acqua d'irrigazione (7.000 m^3 ha^{-1}) di pozzi della Val d'Agri*

	1 anno	*Nell'intera durata del frutteto, 15 anni*	Asportaz.	Diff.
cloruri	1.036	15.540		
solfati	511	7.665		
bicarbonati	2.303	34.545		
sodio	1.218	18.270		
magnesio	406	6.090	45	6.045
calcio	924	13.860	45	13.815
azoto	37	555	1.350	-798
potassio	112	1.680	560	1.120

PARTICOLARE DEL PRELIEVO DEI CAMPIONI

SITE 1 ….soil conductivity under the emitter

before beginning irrigation and at the end of irrigation season

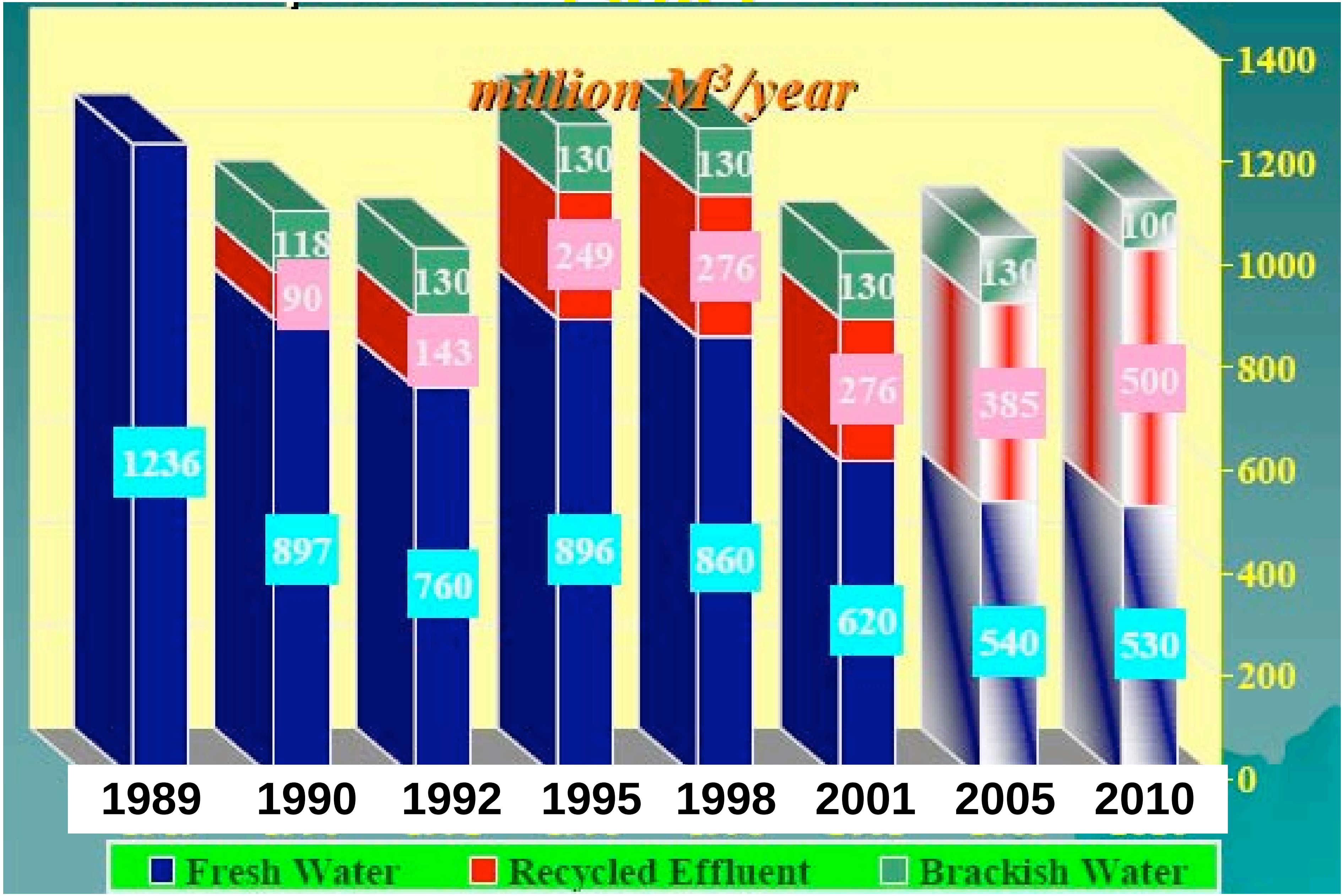


2004 Rainy days (>10 mm)

source: ALSIA - Basilicata Region

	(mm)
01 Apr 2004	25.1
25 Apr 2004	16
13 May 2004	13.2
26 July 2004	66.4

Water sources for agriculture in Israel



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Total and per capita CO_2 emissions in various country

(source: UNFCCC, EEA, DIW Berlin)

	Total emissions CO_2 (Mt)		Per capita emissions (t/year)
	1990	2000 (* = 2001)	2000 (* = 2001)
Australia	259	502	26,8
Canada	421	726	24,0
USA	4844	7001	19,0
Arabia Saudita	160	271	13,1
EU 15 *	3152	4120	11,0
Sud Africa	291	354	8,5
Cina (+ Hong Kong)	2389	2893	2,3
India	595	908	0,9