CHALLENGES FOR MEDITERRANEAN AGRICULTURE TO FACE CLIMATE CHANGE

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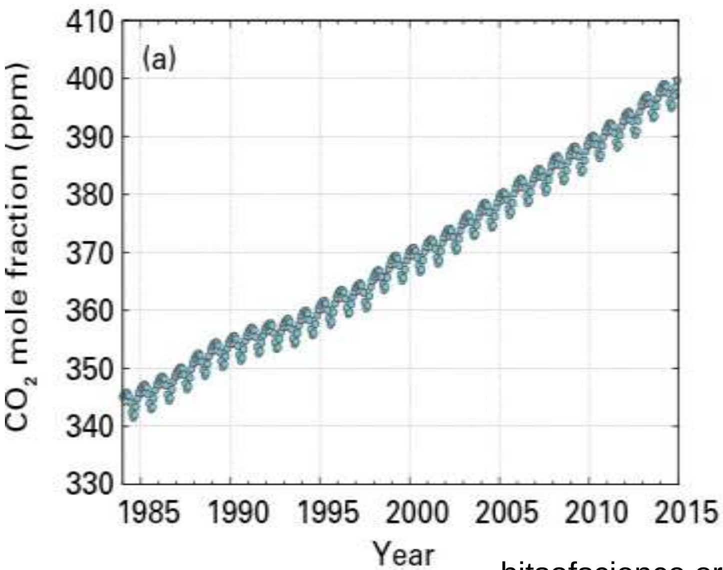
Soil is a natural capital that generates ecosystem services

REGULATING **e.g. C fluxes, soil aggregates stability, water cycle….**

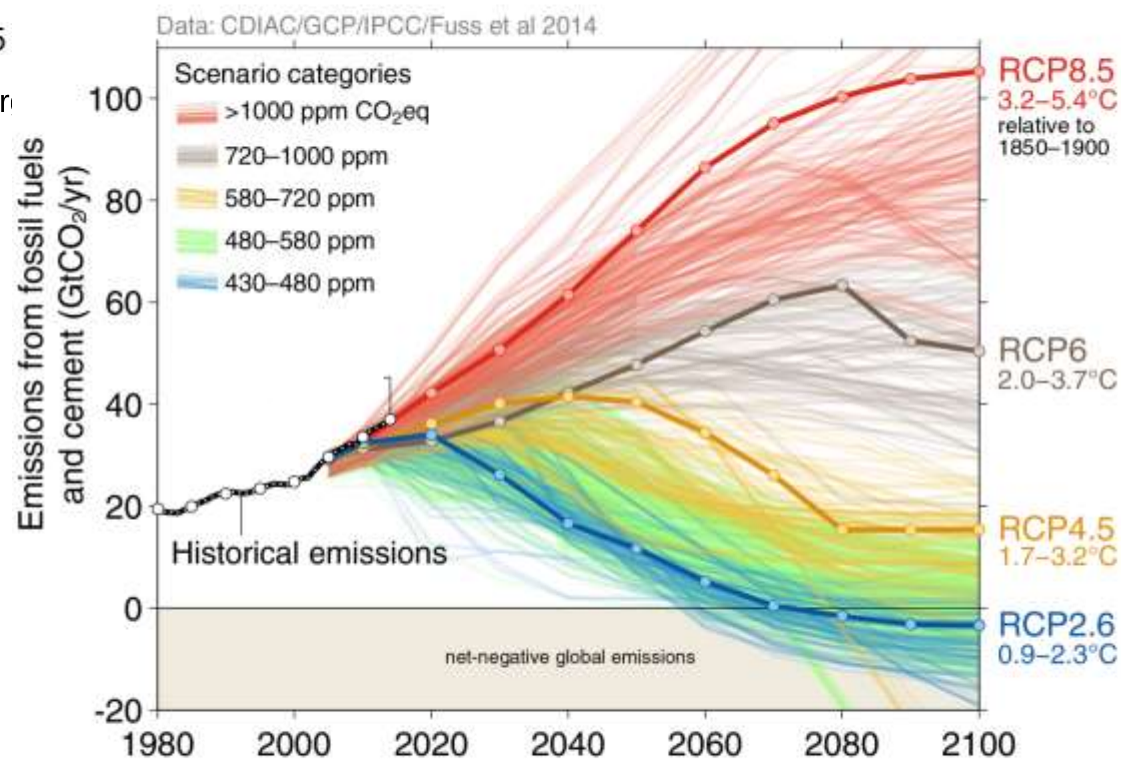
PROVISIONING **e.g. food, energy**

HABITAT, CULTURAL, RECREATION

Air carbon dioxide concentration

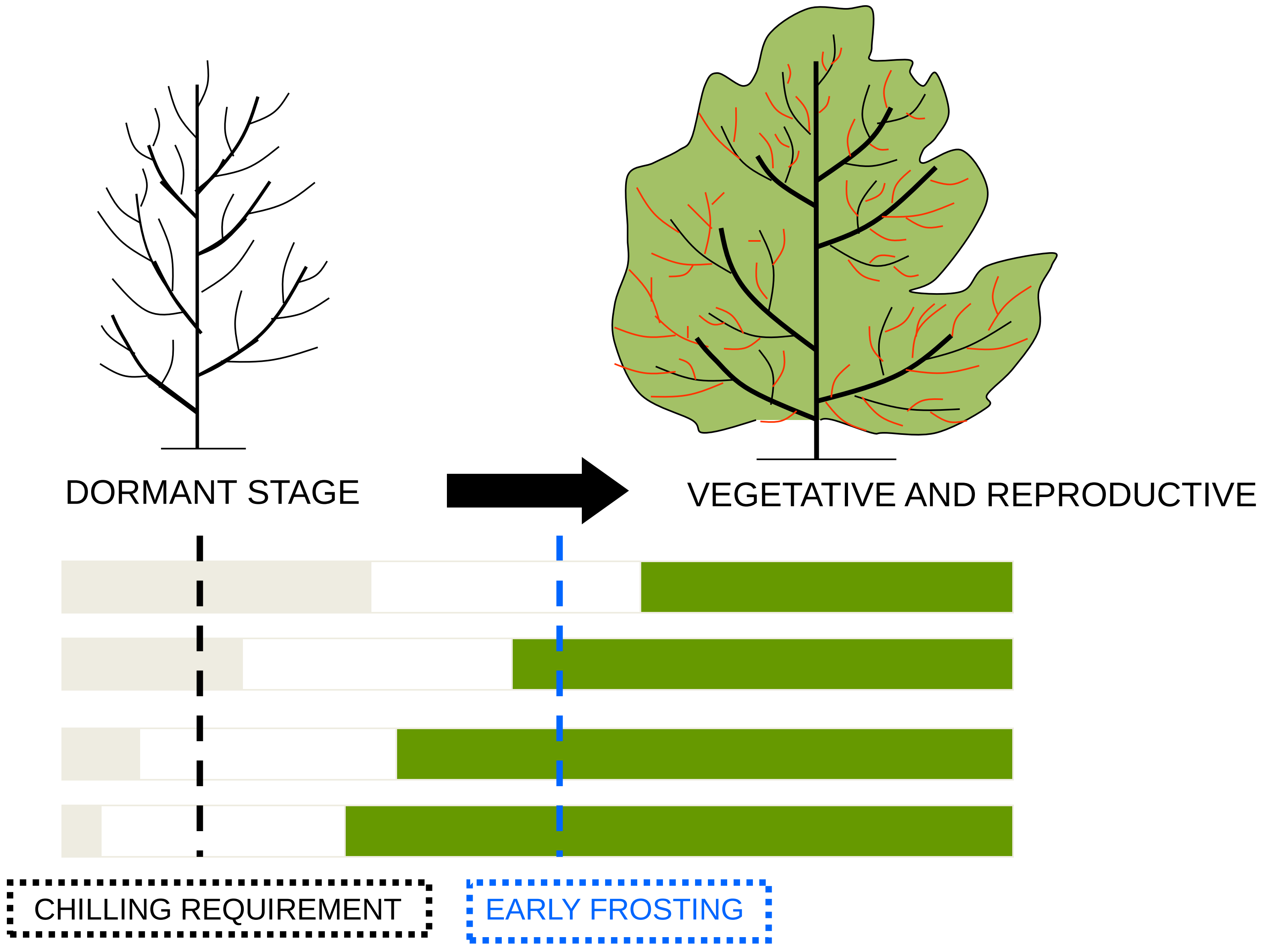


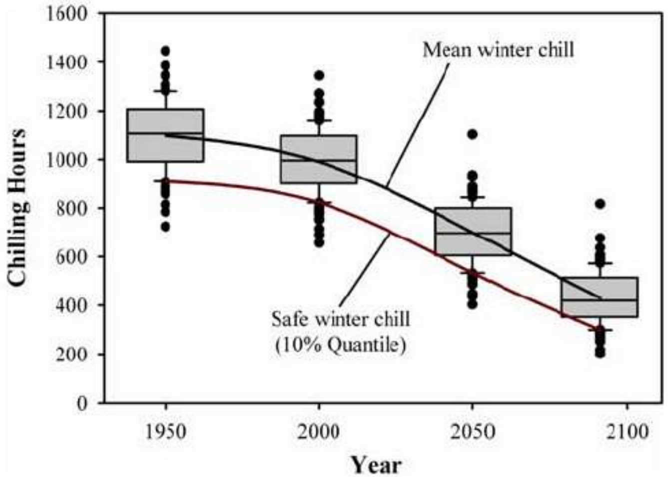
bitsofscience.or



ACCORDO INTERNAZIONALE SUL CLIMA

piano d'azione per limitare il riscaldamento globale **"ben al di sotto" dei 2ºC.**


DORMANT STAGE
VEGETATIVE AND REPRODUCTIVE
CHILLING REQUIREMENT
EARLY FROSTING



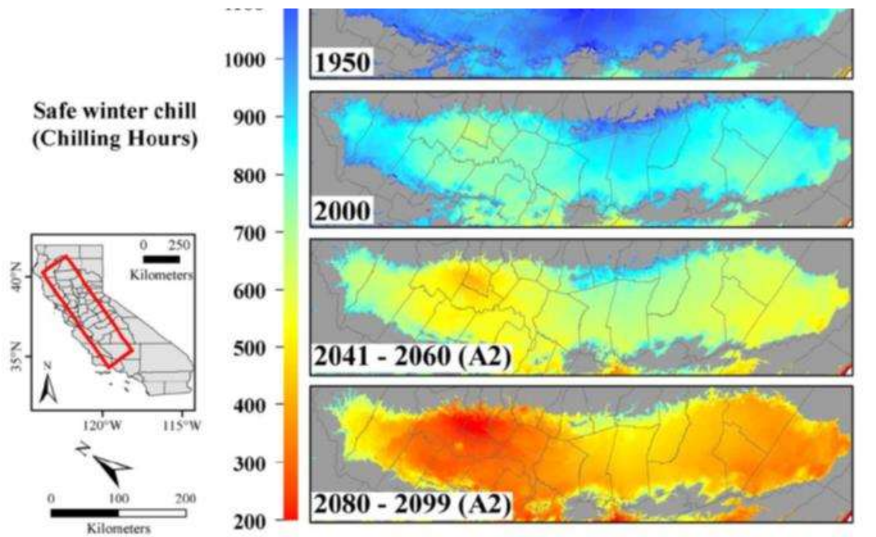


Figure 3. Safe winter chill in California's Central Valley in 1950, 2000, 2041–2060 and 2080–2099, calculated with the Chilling Hours Model. Future winter chill was quantified using the A2 IPCC greenhouse gas emissions scenario.
doi:10.1371/journal.pone.0006166.g003

OPEN ACCESS Freely available online PLoS one

Climatic Changes Lead to Declining Winter Chill for Fruit and Nut Trees in California during 1950–2099

Eike Luedeling[1,2], Minghua Zhang[1], Evan H. Girvetz[3]

… failure of the chilling requirements

fruitsandvote

Chilling Requirement (< 7 °C)

APRICOT	**250 – 1.000**
PEACH	**100 – 1.250**
JAPANESE PLUM	**700 – 1.100**
EUROPEAN PLUM	**800 – 1.200**
VITIS EUROPEA	**200**
FIGS	**0 – 200**
CHERRY	**800 – 1.700**
APPLE	**200 – 1.400**
PEAR	**200 – 1.400**
ALMOND	**200 – 500**
CITRUS	**0**

- **Self-fertile varieties**
- **Low chiling requirements**

FROST

-High heat requirements to avoid early frost

- Late blooming

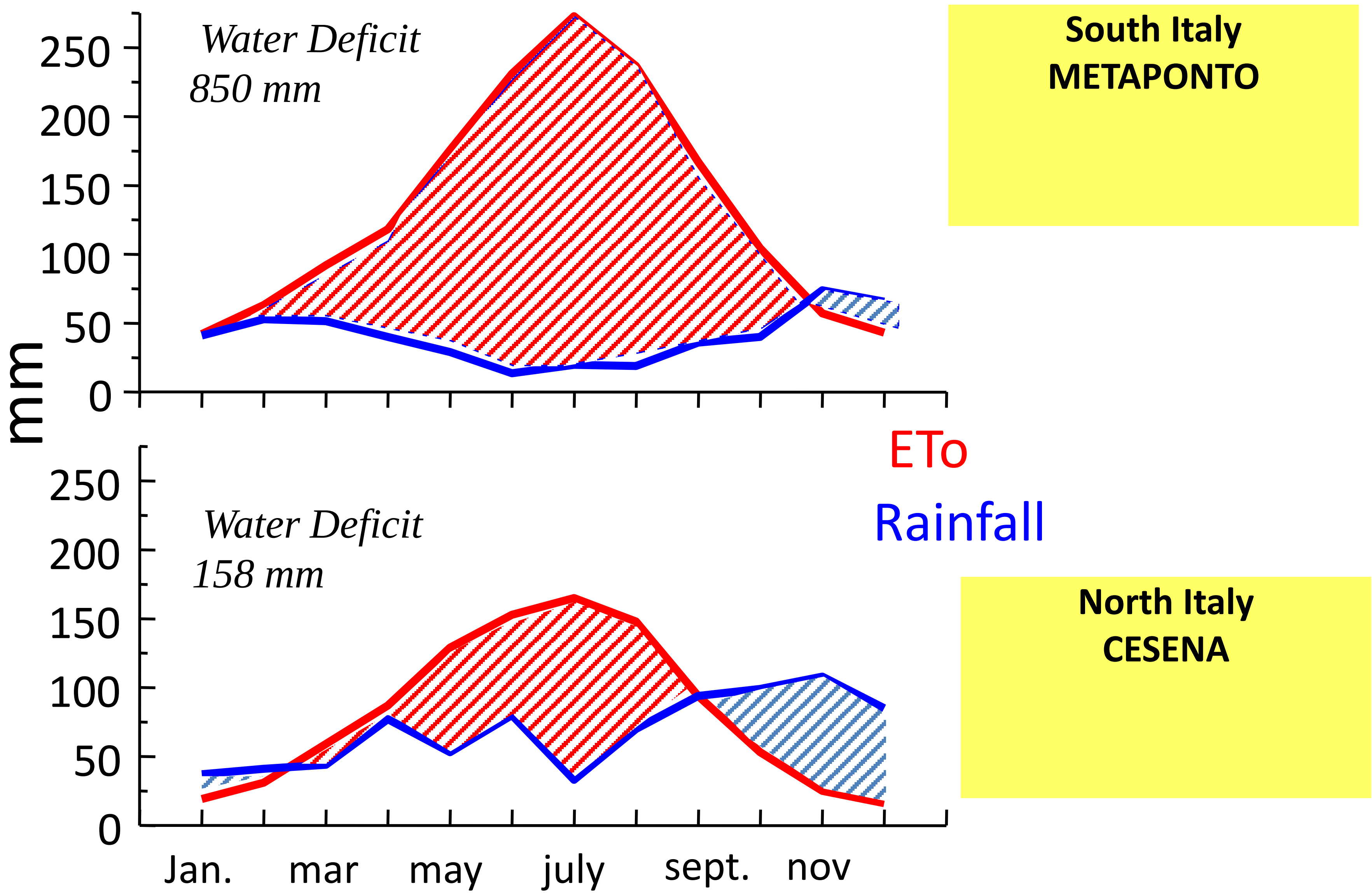
DROUGHT

Will increase evapotranspiration,

Water consumption and total

Rainfall at planet level.

FRUIT LOGISTICA


South Italy
METAPONTO
Water Deficit
850 mm
250
200
150
100
50
0
mm
ETo
Rainfall
North Italy
CESENA
Water Deficit
158 mm
Jan.
mar
may
july
sept.
nov

“water cost” to produce one Kg of peaches (*cv Springlady*) in South and North Italy.

	Yield (t ha^{-1})	Irrigation water (m^3 ha^{-1})	Irrigation water per kg (L kg^{-1})
South	15	5.000	333
North	15	1.182	79

“Water Foot-Print”

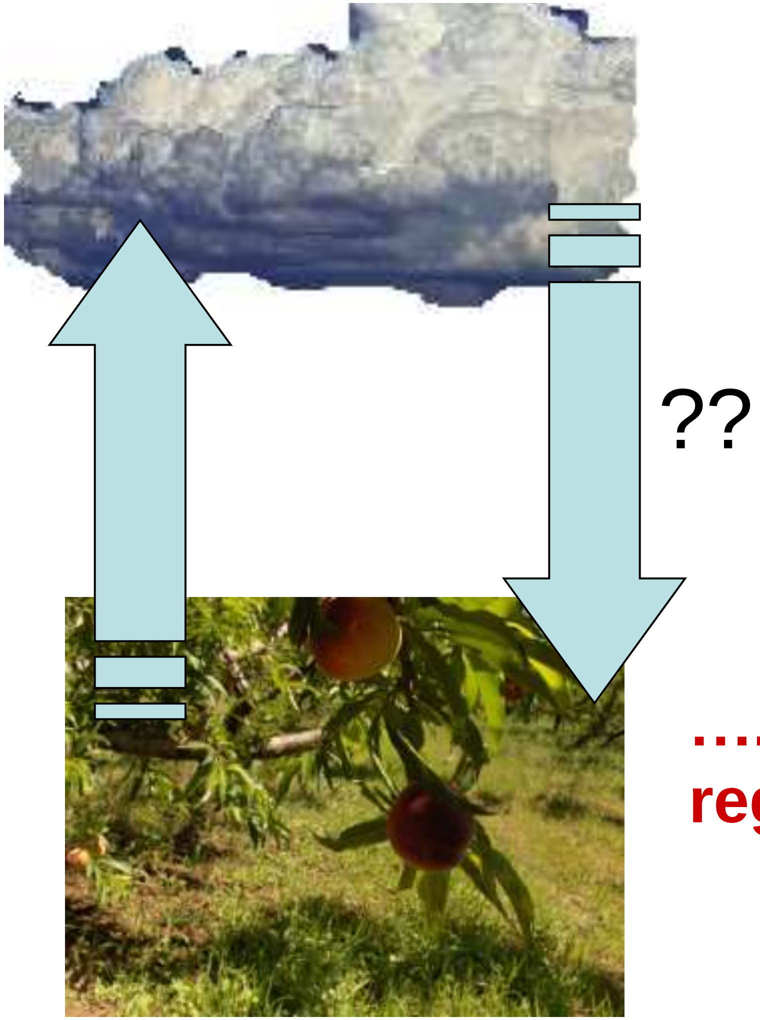
150-300 L/kg
(early – late ripening)

	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}

water evaporated and transpired from the orchard (almost 99% of the total) returns to the atmosphere…



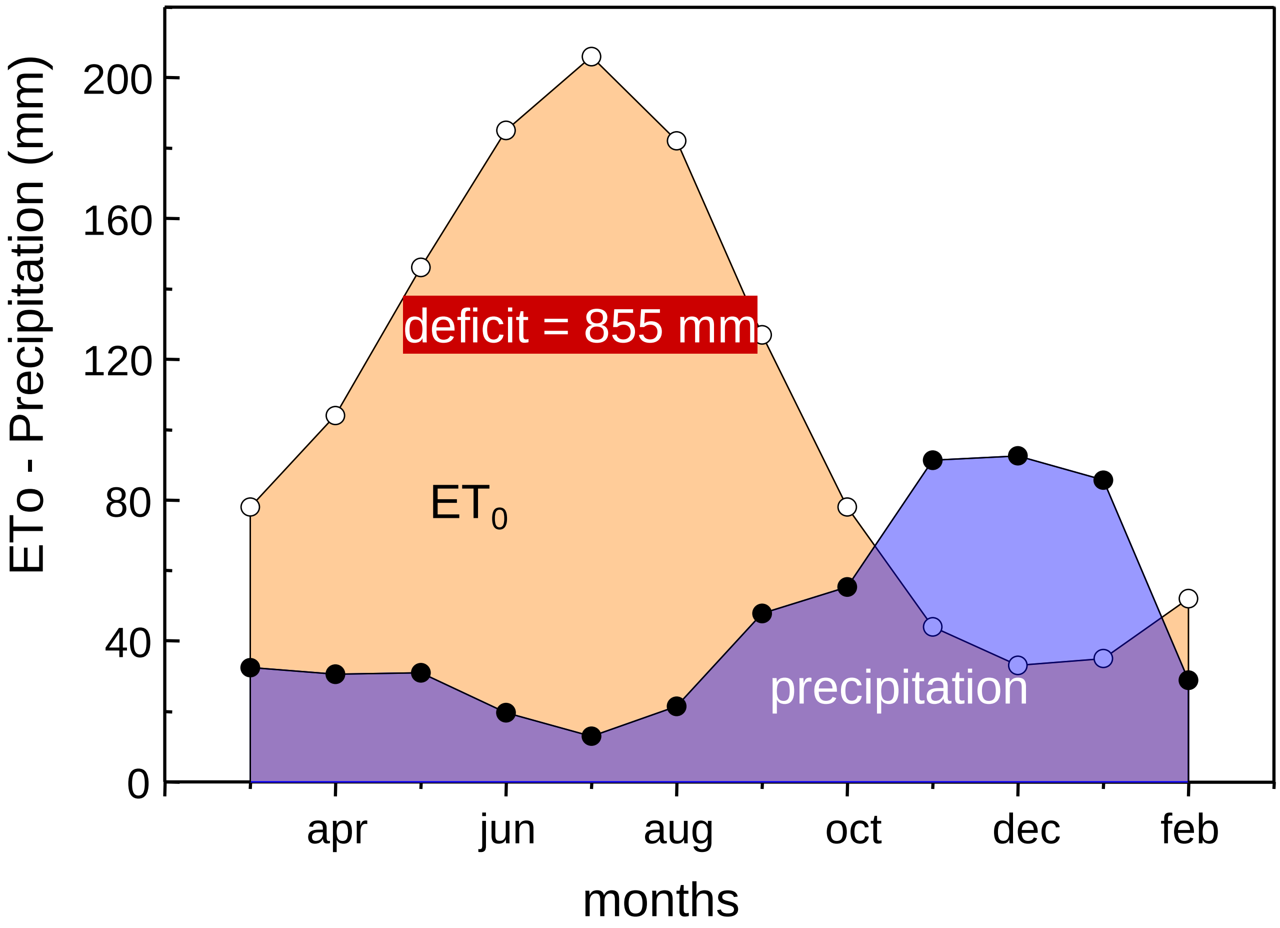
…..will it return to the same region???

DROUGHT

soil water holding capacity

FRUIT LOGISTICA

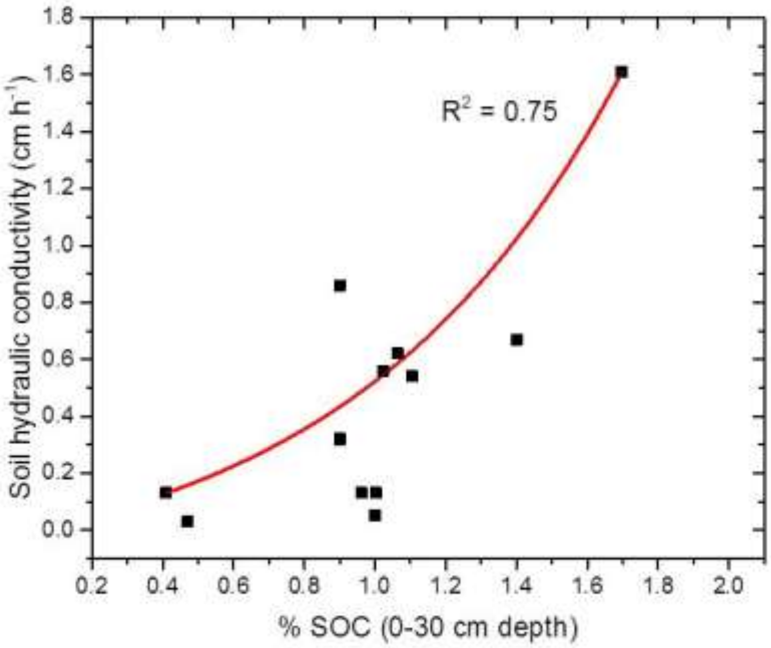
Annual deficit in semi-arid environment



SOUTHERN ITALY

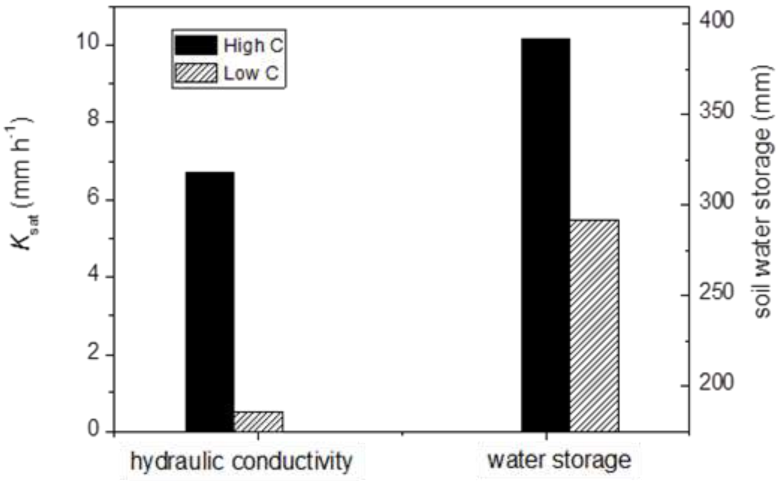
Increasing SOC improves soil hydraulic conductivity

data from peach, kiwifruit, apricot and olive orchards are grouped
(Xiloyannis, unpublished)

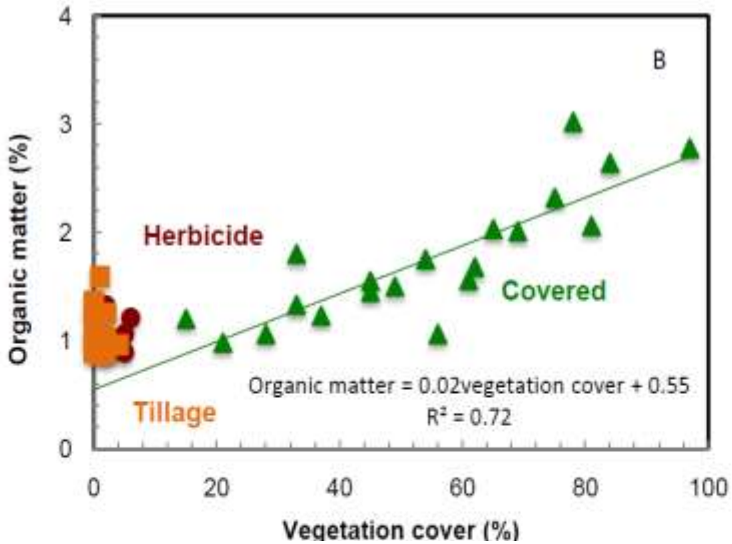


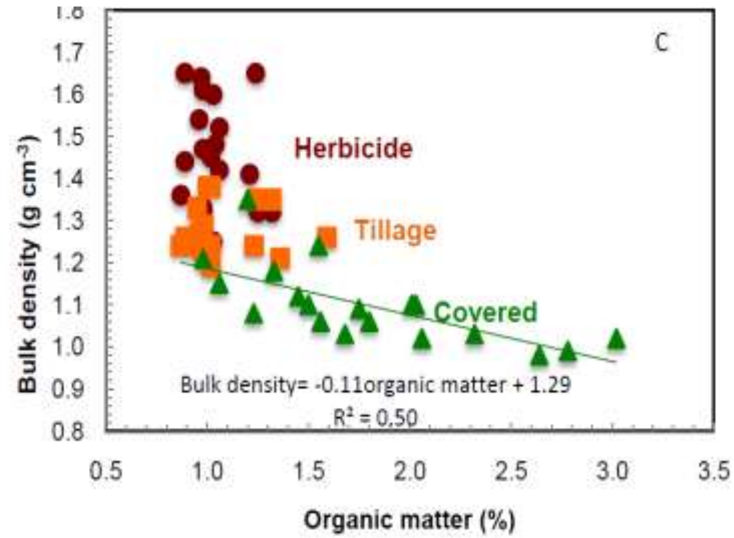
....and water storage capacity

Redrawn from Palese et al., 2014

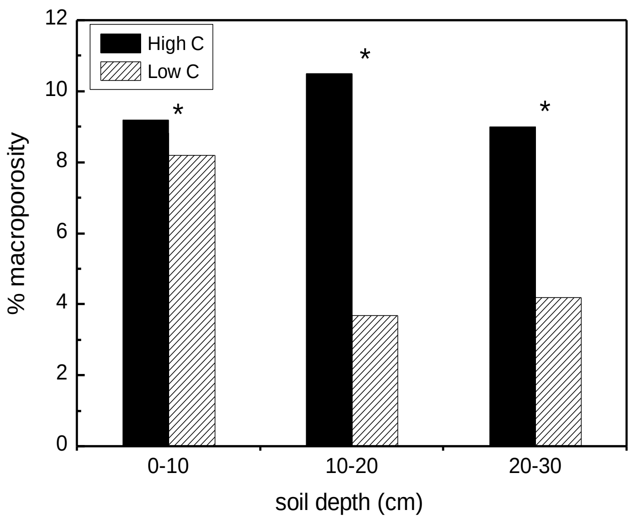


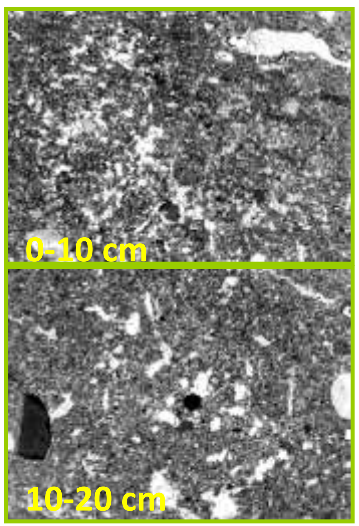
Regulating services





S. Keesstra et al. / Science of the Total Environment 551–552 (2016) 357–366





Adapted from Palese et al., 2014

Saturated hydraulic conductivity measurements

(Model 2800 Guelph Permeameter, Santa Barbara, USA)

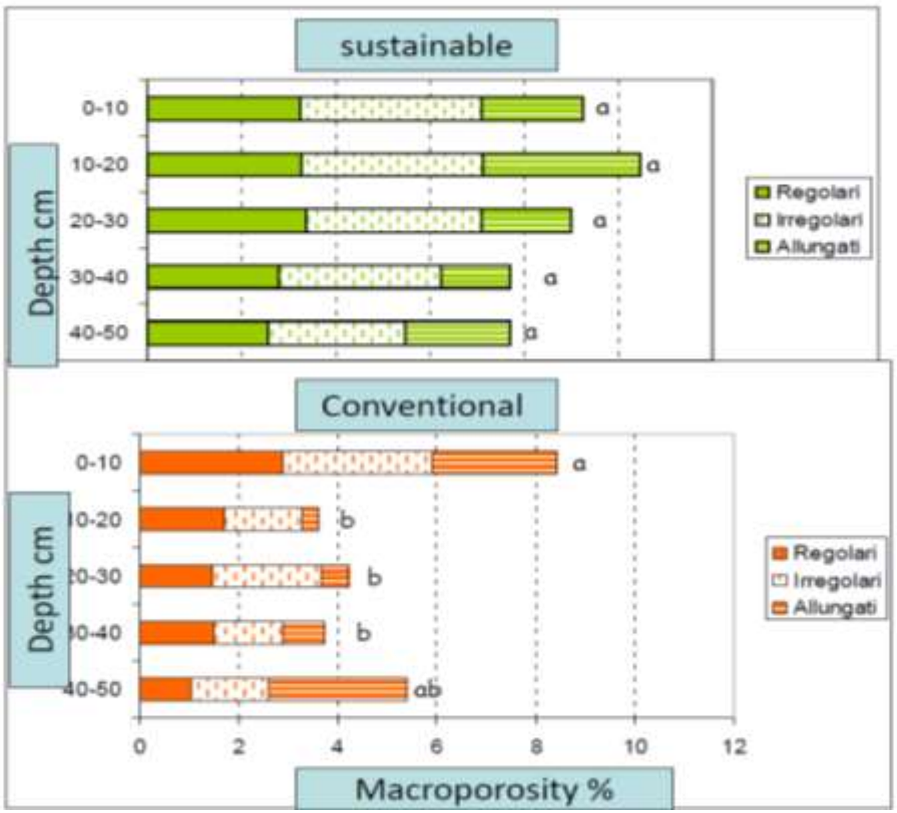
Evaluation of the vertical water flux (using a plastic tube as confined well)

	K_{sat} (Guelph) (mm d^{-1})	
Sustainable (confined)	**160**	
Conventional (confined)	**13**	

Increase of soil water reserve

High infiltration capacity H_20

Reduction of water stress



Effect of soil management on water infiltration	
Management	Infiltration (mm/day)
Sustainable	160
Conventional	13

At 12 cm of depth (point of compacted layer) Palese et al., 2014

Increase of soil water reserve

SOIL WATER CONTENT (TILL TO 2 m of depth)
in two different orchard management system

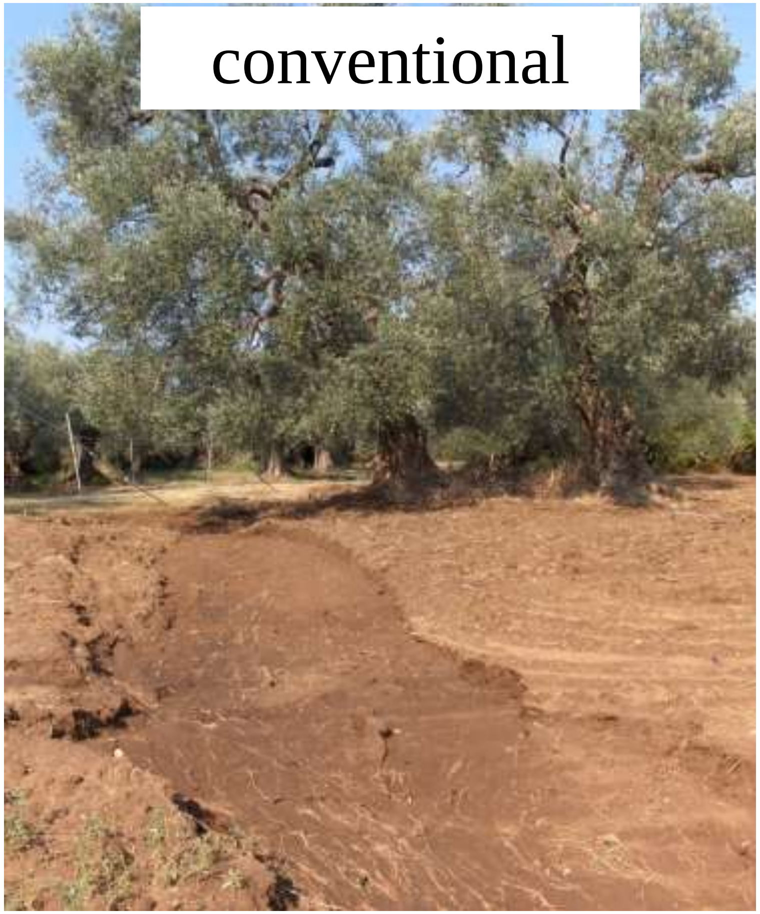
SUSTAINABLE

4250 m^3/ha

CONVENTIONAL

2934 m^3/ha

Celano et al., 2011; Palese et al., 2014



Soil losses

60-105 t ha^{-1} y^{-1}

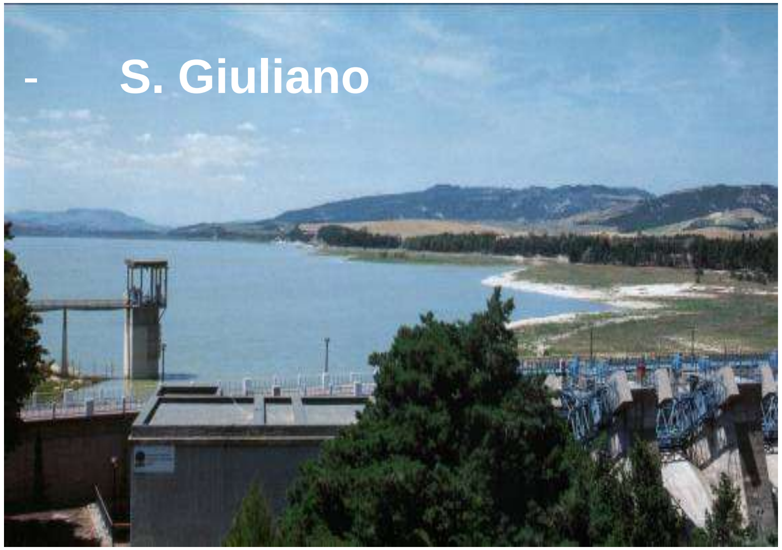
(a soil layer of about 1 cm)

Soil losses

< 1 t ha^{-1} y^{-1}

Effetto ambientale/economico del “disservizio” erosione sulle dighe

- Perdità capacità di invaso
- costo maggiore manutenzione
- Costi straordinari per il dragaggio (10-30€/m^3)
- Inondazioni più frequenti



- ENTRATA IN SERVIZIO 196
- Perdita di capacità 30 Mm^3.
- Costo dragaggio 300 M€

…..soil management

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

Foto 3 – Particolare del ristagno idrico che si verifica prevalentemente da metà filare a fine filare in impianto di actinidia irrigato per scorrimento.

Foto 4 - Durante il periodo estivo caratterizzato da elevata domanda evapotraspirativa, nelle piante irrigate a scorrimento, il imitato apparato radicale esistente (privo di radici fini) non è in grado di soddisfare le esigenze idriche della parte aerea con conseguente riduzione della traspirazione delle foglie e conseguente aumento della temperatura fogliare e disseccamento. (Foto Cipriani M.).

Efficienza di distribuzione dell'acqua nei vari metodi irrigui

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

Summer Pruning materials

10.34 m^2/tree LAI=0,517

3,650 g di DM/tree
785 g of leaves

-24 l H_20 $d^{-1}tree^{-1}$

…..Promuovere consumo idrico ‘a domanda’

….a superficie

….a volumi

rootstocks

CORRECT CHOICE OF ROOTSTOCK

ROOTSTCKS MORE TOLLERANT TO WATER STRESS

-EFFICIENT AND RAPID COLONISATION OF THE SOIL AVAILABLE

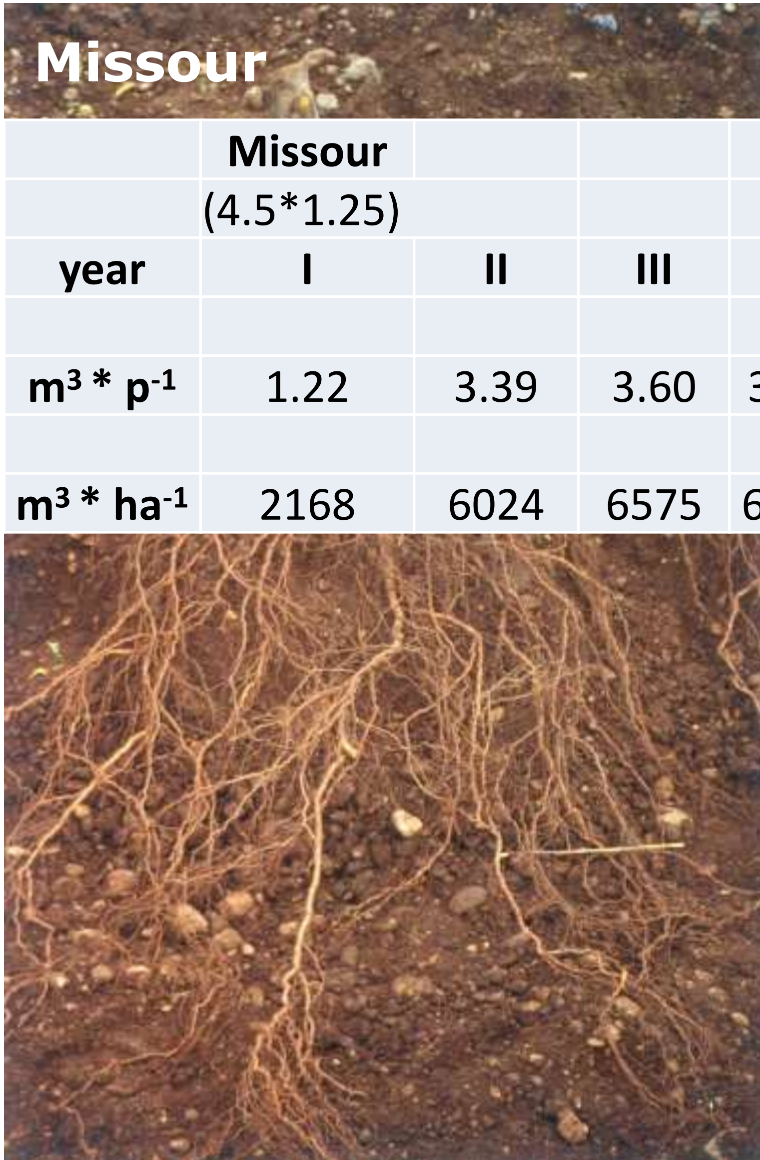
-GROWTH OF ROOTS IN THE DEEP SOIL LAYERS

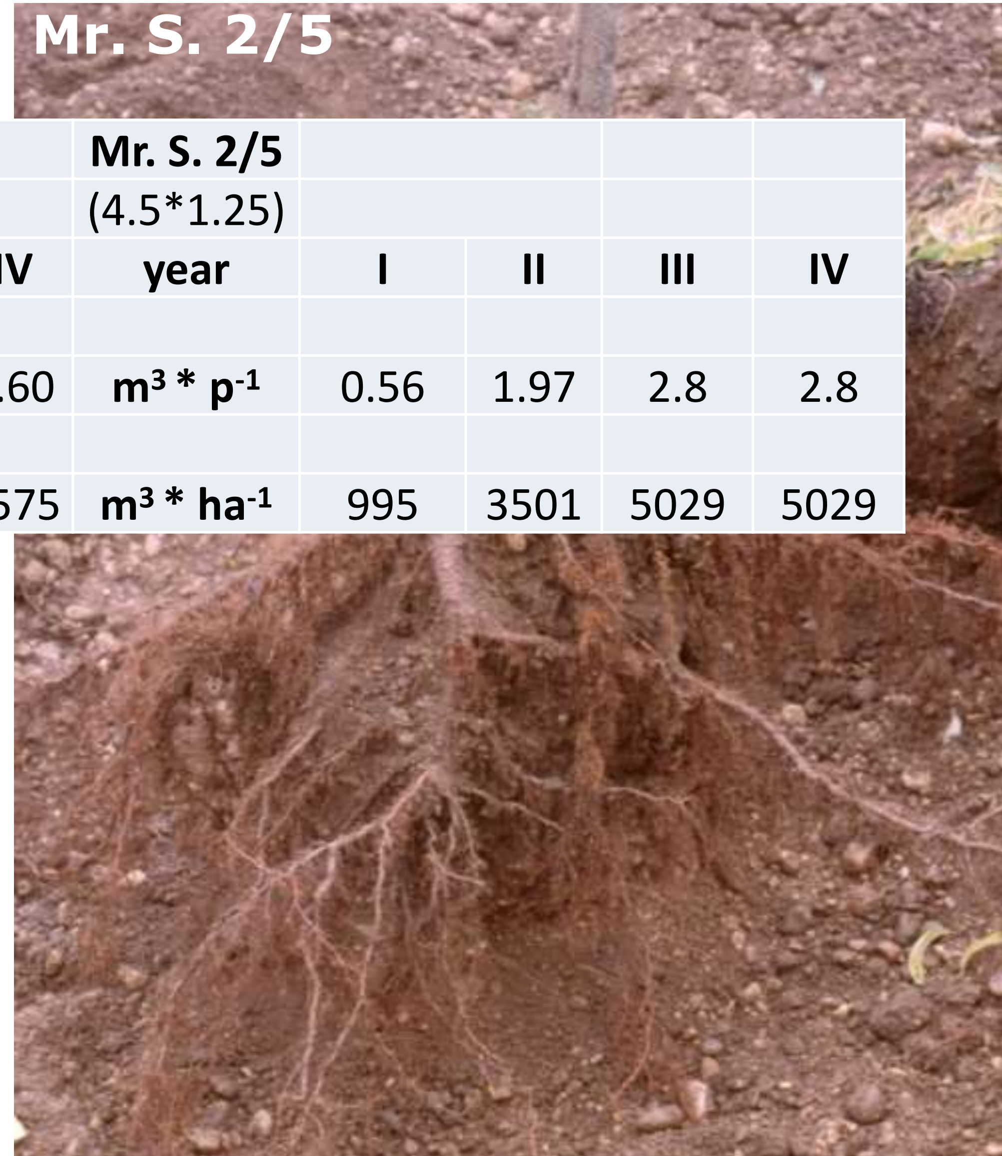
-HIGH RATIO BETWEEN ROOTS AND LEAVES

-RESISTANT TO SOIL PATHOGENS (BIOTIC STRESS-NEMATODES, ARMILAREA, PHYTOPHTORA…..)

CHARACTERISTICS OF ROOTS

Soil volume explored cv Vega on 2 rootstocks





	Missour				**Mr. S. 2/5**				
	(4.5*1.25)				(4.5*1.25)				
year	**I**	**II**	**III**	**IV**	**year**	**I**	**II**	**III**	**IV**
$m^3 * p^{-1}$	1.22	3.39	3.60	3.60	**$m^3 * p^{-1}$**	0.56	1.97	2.8	2.8
$m^3 * ha^{-1}$	2168	6024	6575	6575	**$m^3 * ha^{-1}$**	995	3501	5029	5029

Water storaged in the soil volume explored by roots in peach orchard in the first 4 years after planting

(Vega/ Missour , Xiloyannis et. al 1993).

	1st year	2nd year	3rd year	4th year
Volume of soil explored by roots	1.22 m^3 p^{-1}	3.39 m^3 p^{-1}	3.60 m^3 p^{-1}	3.60 m^3 p^{-1}
Water available	134 L p^{-1}	373 L p^{-1}	407 L p^{-1}	407 L p^{-1}

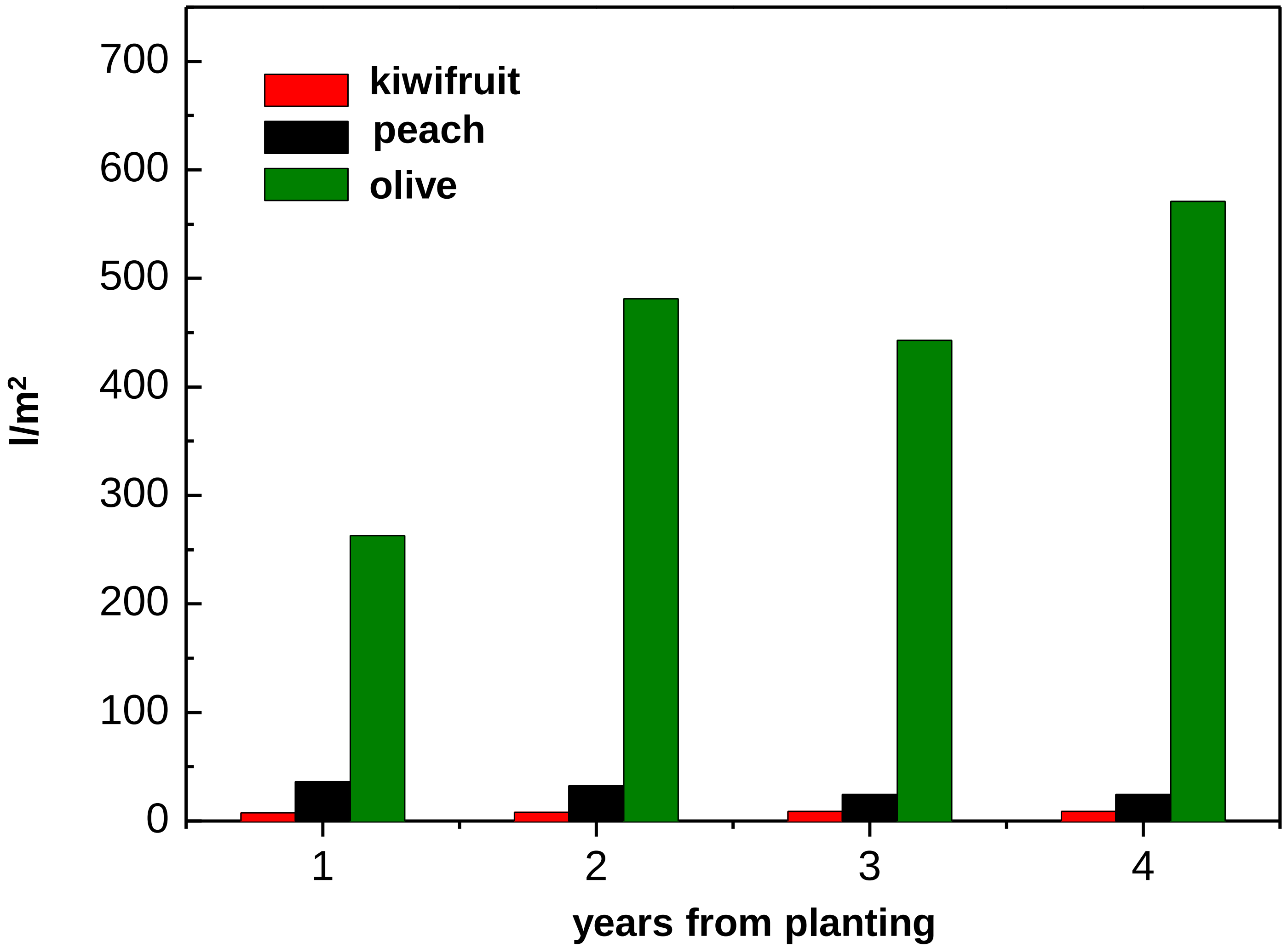
Water available

Volume of soil explored by roots

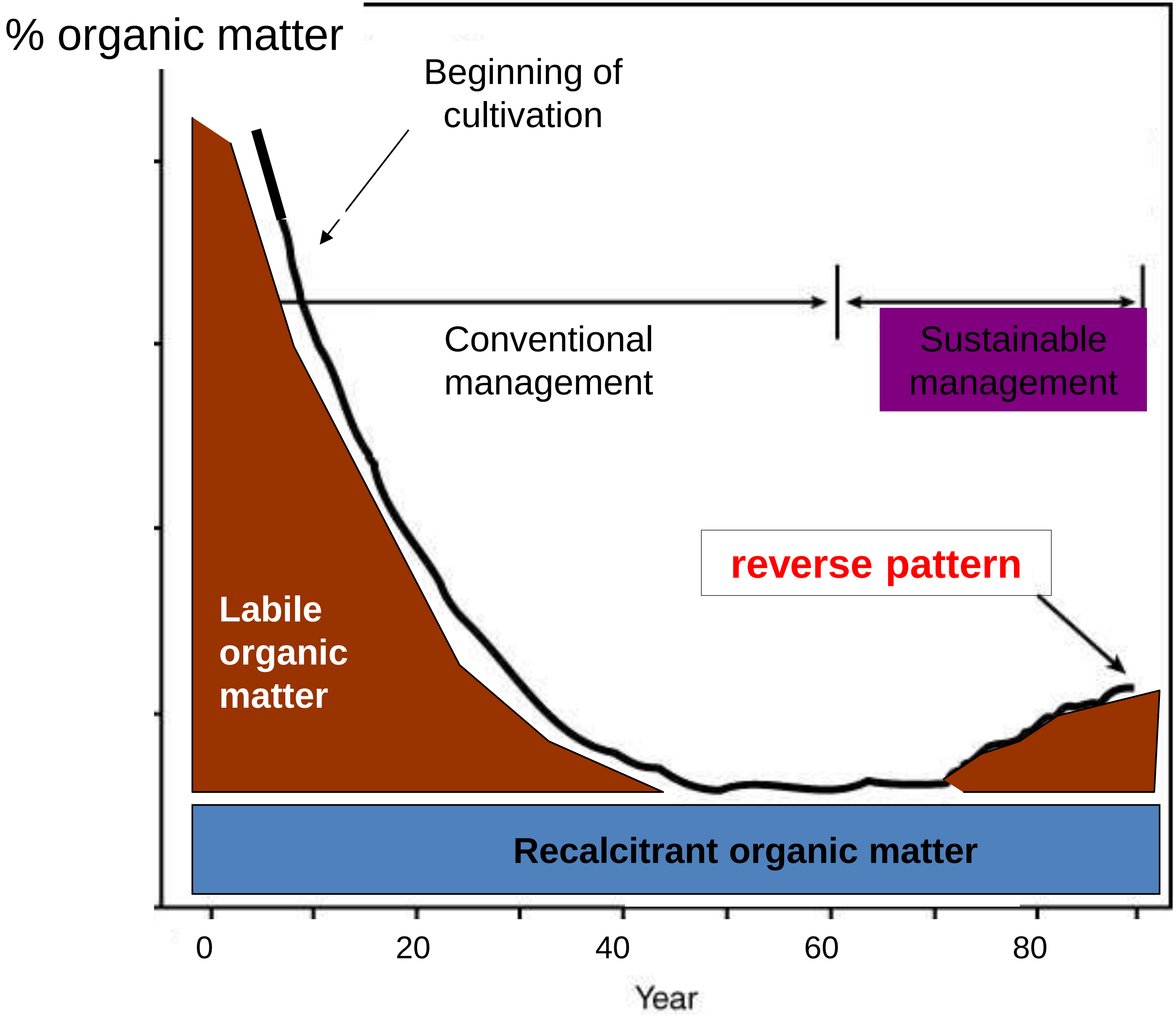
Species and variety

- Short interval from blooming to harvesting
-Early ripining varieties
-Tolerant to water stress

Water available per m² of leaf in olive, peach and kiwifruit orchards in the first 4 years from planting



BILDING THE SOIL



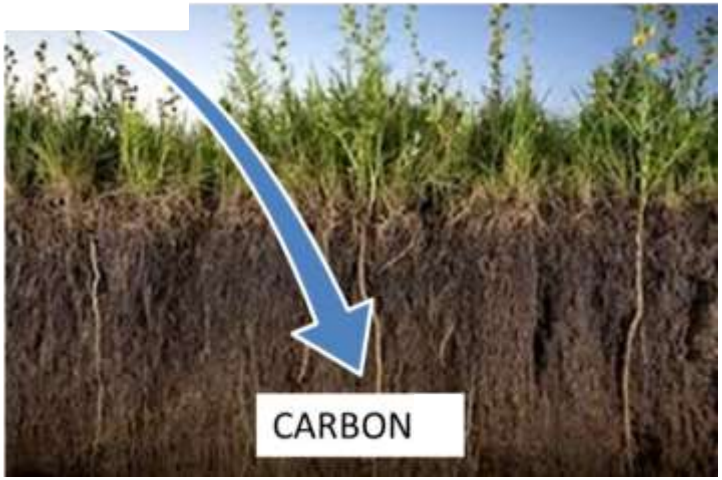
Adapted from WBGU Special Report:
The Accounting of Biological Sinks and Sources Under the Kyoto Protocol

Soils impoverishment

Basilicata Region

Soil Organic Matter 0,8 - 1,3%

CO_2



The 1% increase of carbon in the soil corresponds to 260 t / ha of CO_2 stably stored

(50 cm depth, 1.4 t/m3 bulk density)

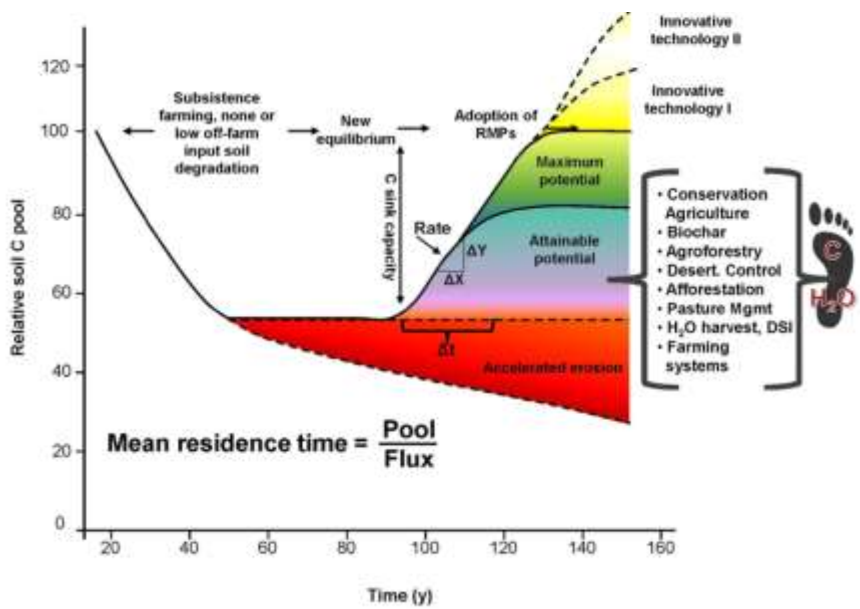
Increasing soil carbon sequestration:
0.4% a year (40 cm depth)…

VIEWPOINT

doi:10.2489/jswc.71.1.20A

Beyond COP21: Potential and challenges of the "4 per Thousand" initiative

Rattan Lal



	increasing SOC rate t C ha-1 yr-1	experiment duration	soil depth	
		years	(m)	refs
"4 thousand initiative"	18-20	-	0.4	
case 1	2.0	17	0.3	Palese et al., 2014
case 2	2.2	13	0.3	Palese et al., 2014
case 3	1.4	13	0.3	Mohamad et al., 2016

Carbon stored in above- and belowground biomass in olive trees

	After 11-12 years	Mean annual rate	
330 trees/ha rainfed	**10.1** t C ha^{-1}	**0.9** t C ha^{-1} yr^{-1}	Ilarioni et al., 2013
330 trees/ha rainfed	**7.0** t C ha^{-1}	**0.7** t C ha^{-1} yr^{-1}	Proietti et al., 2014
	42 years		
144 trees/ha rainfed	**14.0** t C ha^{-1}	**0.3** t C ha^{-1} yr^{-1}	Zuazo et al 2014
	100 years		
107 trees/ha rainfed	**300** t C ha^{-1}	**3.0** t C ha^{-1} yr^{-1}	Almagro et al., 2010

Mineral elements
(15t/ha FW

kg ha^{-1}	
N	270.60
P2O5	80.53
K2O	214.36
CaO	1406.72
MgO	59.35
S	17.60
B	0.70
Cb	0.04
Cu	1.41
Fe	65.37
Mn	3.03
	-
Zn	3.06

Ricavi impianto di compostaggio? Possibilità di economizzare la vendita del compost………

Rifiuti in ingresso

98 % dei ricavi

Compost sfuso in uscita

2 % dei ricavi

Apporti con compost e letame

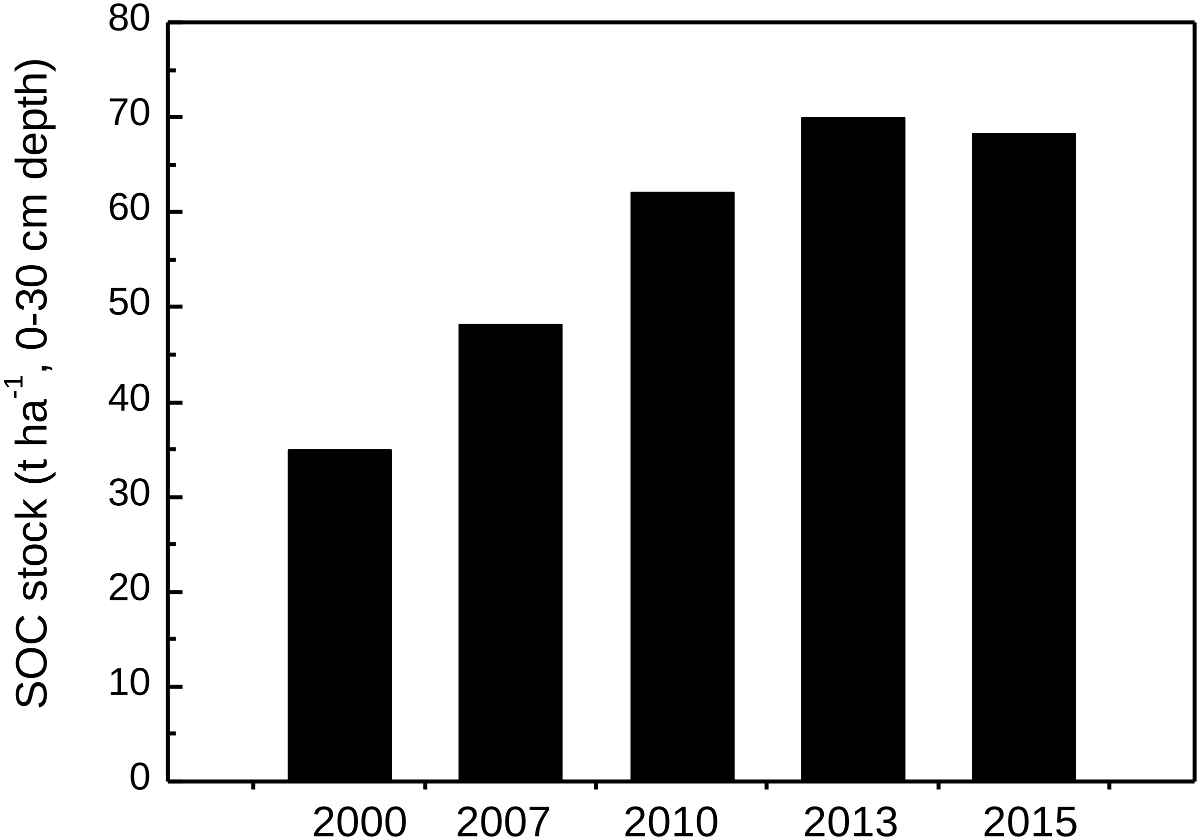
	COMPOST			LETAME
	20	t/ha tal quale		20
	9.28	SS t/ha		5.72
CARBONIO	3.3	t/ha		1.5
AZOTO TOT.	195	Kg/ha		84
P	43	Kg/ha		16
K	149	Kg/ha		86
Ca	975	Kg/ha		544
Mg	65	Kg/ha		31

Amount of nutrients supplied through compost (10 t ha^{-1} fw) application and related amount of avoided CO_2 emissions

Nutrients	*Nutrients (kg/ha)*	*Avoided CO_2 emissions (CO_2 eq t/ha)*	
		1 year	*50 years*
N_{tot}	***170***	***1.55***	***77.52***
P_2O_5	***120***	***0.192***	***9.6***
K_2O	***160***	***0.106***	***5.28***

SOC stock changes in a sustainable olive grove

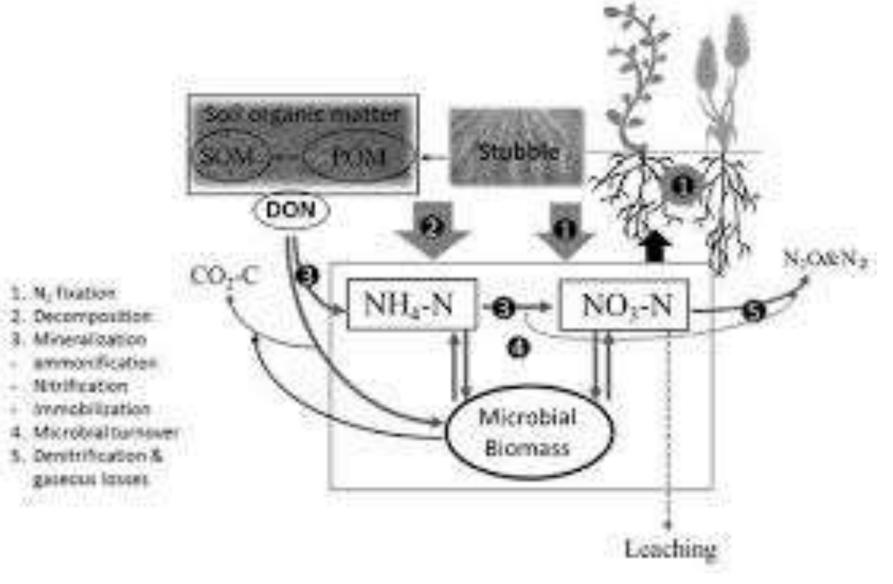
2.2 t/ha/yr C



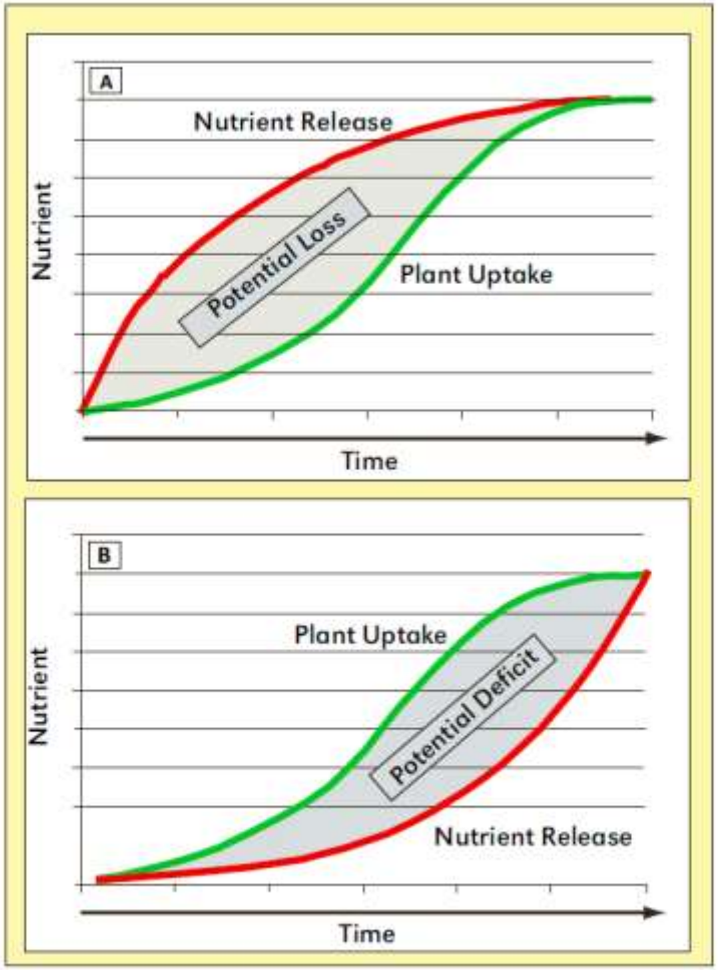
Cristos Xiloyannis - UNIBAS

criticità nell’uso di alcuni concimi organici per apporti ridotti di N

Processo di mineralizzazione dipende da numerose variabili incluso:
temperatura e umidità suolo, condizioni chimico/fisiche e biologiche, C:N



criticità nell'uso di alcuni concimi organ per apporti ridotti di N

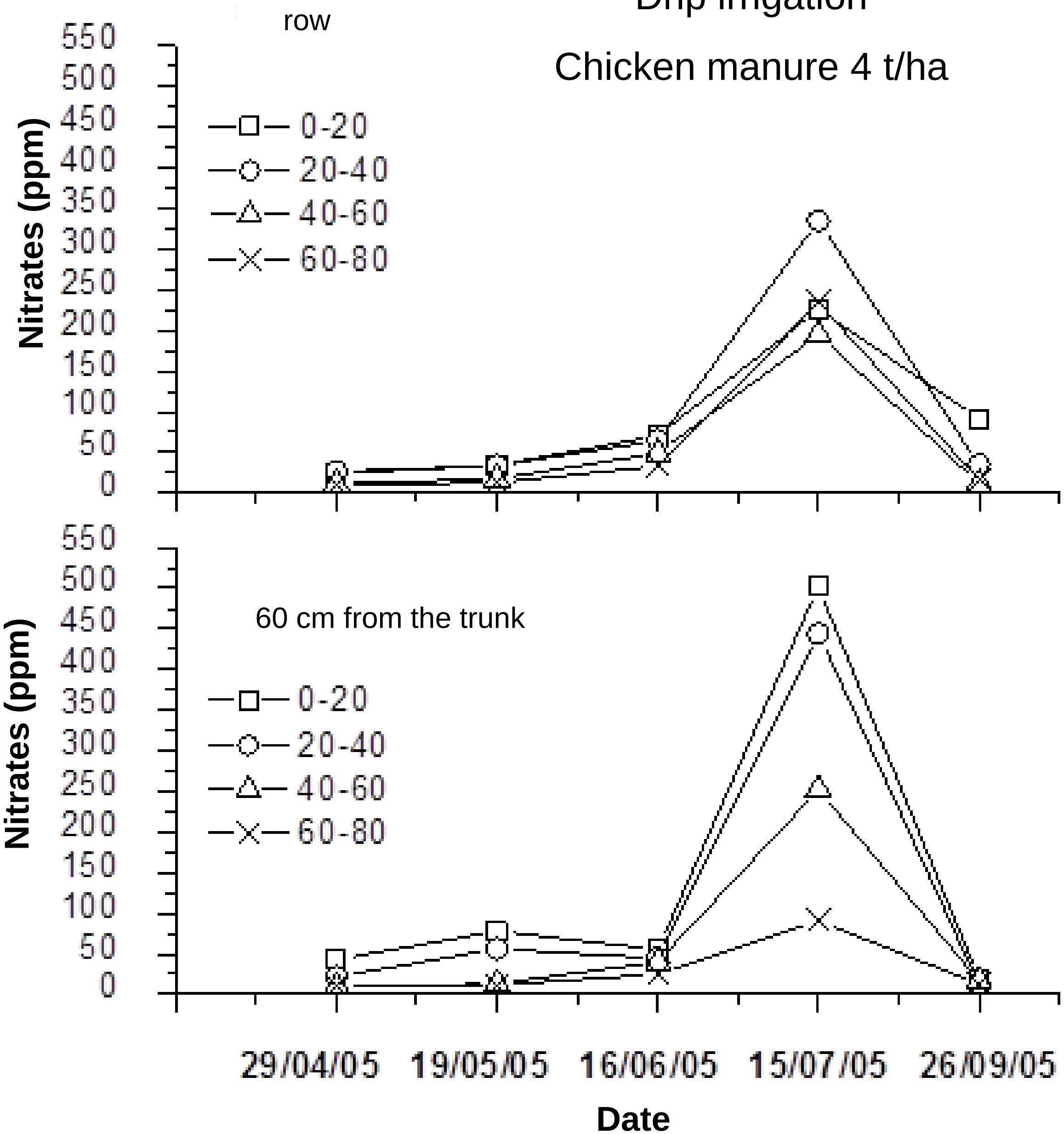


Sincronizzazione difficile fra N rilasciato e richiesto dalla pianta

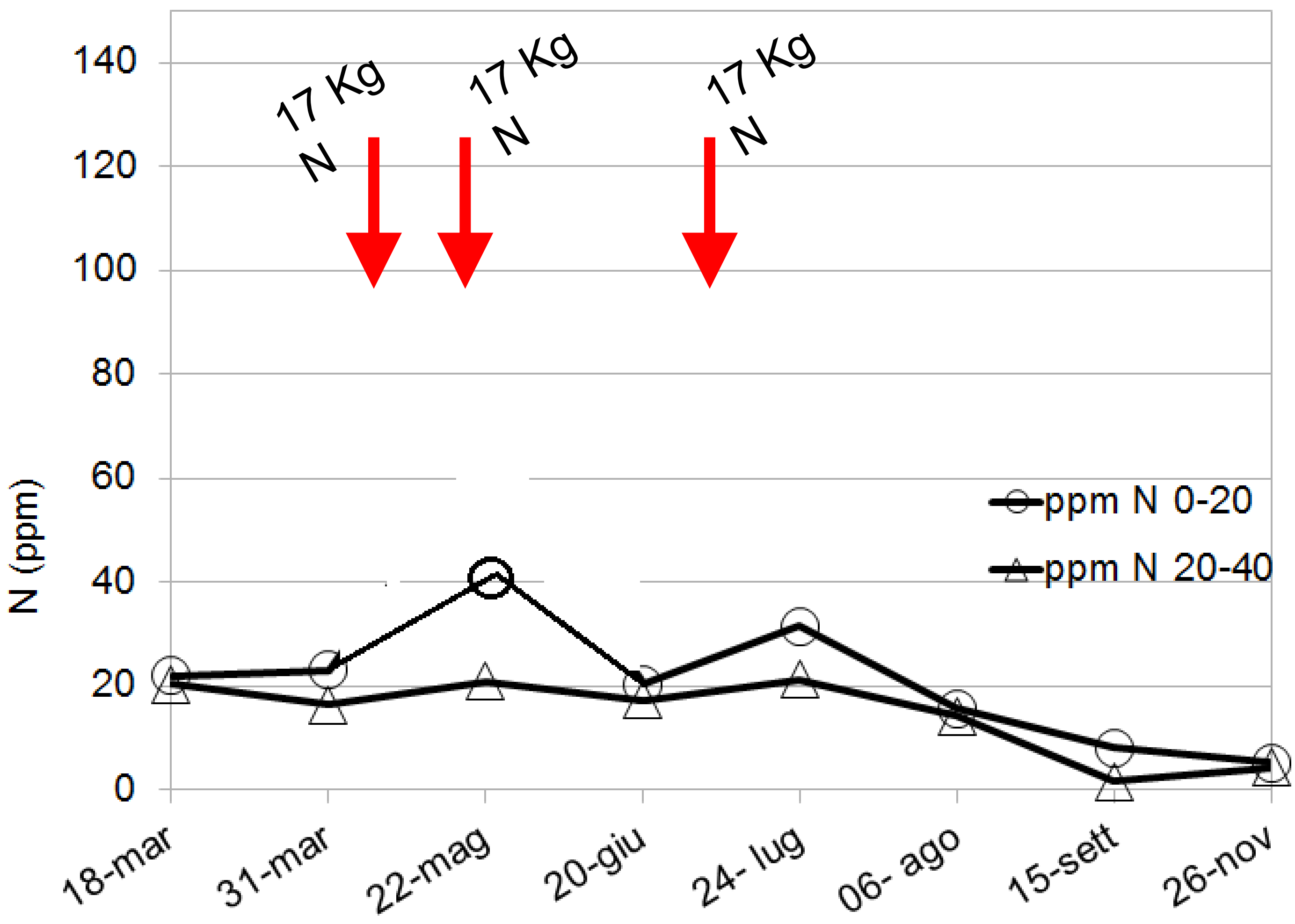
Mikkelsen and Hartz, 2008

Drip irrigation

Chicken manure 4 t/ha



Esempio di oscillazione NO_3 in caso di concimazione minerale



CARBON FOOTPRINT (Kg CO_2eq/L)
functional unit = 1 L bottled olive oil

	Field (removal – emissions)	Mill	Package	CF
Sustainable Oil produced 1,552 Kg	-16.04	0.13	1.81	**-14.09**
Conventional Oil produced 672 Kg	0.48	0.13	1.81	**+2.42**




Carbon footprint (CO_2 per unit yield)

	sustainable	conventional
6-year average yield (t/ha)	25.86	19.86
	t/ha CO_2	
input *	- 48.0	- 25.8
output **	24.8	30.8
permanent structures	-3.8	-3.8
fertilization	0.6	0.3
farm operations	5.9	1.3
balance	-20.5	2.8
carbon footprint (KgCO_2/kg fruit)	**-0.79**	**0,14**

*input = cover crops, leaves, roots turnover, yield, pruning material and compost -only for sustainable)

** output = soil respiration, farm operations and burning of pruning material (conventional)

….economic advantage?

Sustainable

Soil

CO

CO_2 CO_2 CO_2

CO_2 CO_2 CO_2

CO_2 CO_2 CO_2 CO_2

???? Euro per t CO_2

Conventional

CO_2 CO_2 CO_2 CO_2 CO_2 CO_2 CO_2

Soil

Decision EC 529/2013

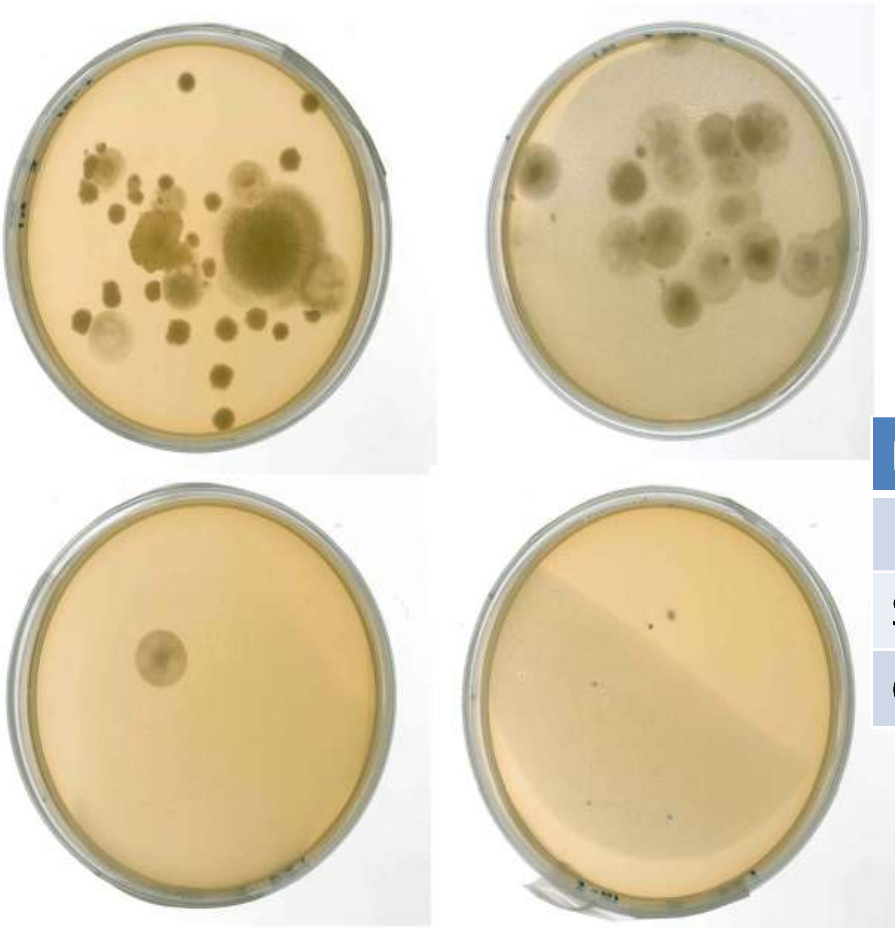
By Jan 1st 2021, EU Member States must monitor and account for carbon sequestration in cropland (including orchards) (Art. 3 Decision 529/2013)

SOIL BIODIVERSITY

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

Restore of soil fertility

SUSTAINABLE



CONVENTIONAL

Fungi and bacterial communities in the soils		
Management	Fungi	Bacterial
Sustainable	214.000	35.600.000
Conventional	29.000	10.000.000

1 g of dry soil

Sofo et al., 2014. Pascazio et al., 2015

Restore of soil fertility

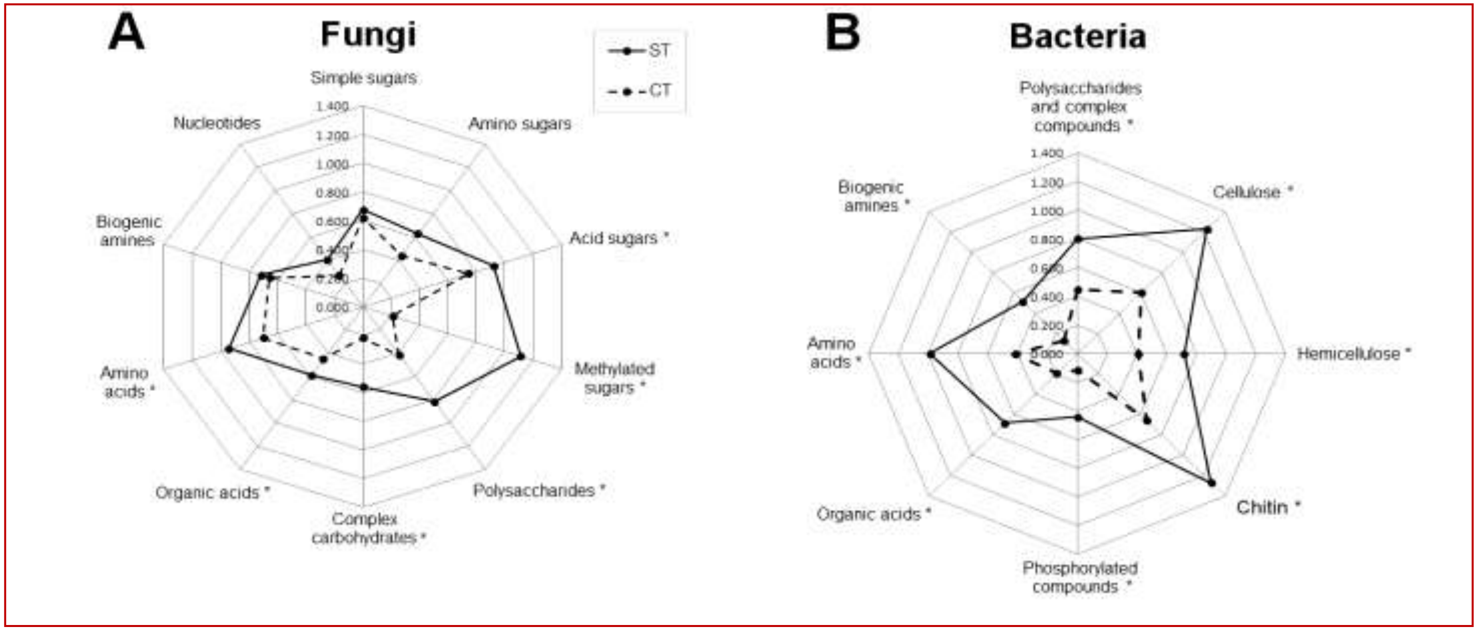
Improvment of Phyllosphere and carposphere by soil sustainable management

Table 1. Classification of the bacterial species from olive fruit pulp (mesocarp) identified on the basis of their genomic sequences (NCBI BLAST® hits).

N. species	Phylum	Class	Order	Family	Genus	Species
Sustainable						
8	Proteobacteria	γ-Proteobacteria	Enterobacteriales	Enterobacteriaceae	*Rahnella*	aquatilis
5	Firmicutes	Bacilli	Lactobacillales	Enterococcaceae	*Enterococcus*	unknown
5	Proteobacteria	γ-Proteobacteria	Enterobacteriales	Enterobacteriaceae	*Kluyvera*	*intermedia*
4	Actinobacteria	Actinobacteridae	Actinomycetales	Microbacteriaceae	*Curtobacterium*	unknown
2	Proteobacteria	γ-Proteobacteria	Enterobacteriales	Enterobacteriaceae	*Averyellaa*	*dalhousiens*
1	Actinobacteria	Actinobacteridae	Actinomycetales	Microbacteriaceae	*Frondihabitans*	*suicicola*
1	Proteobacteria	γ-Proteobacteria	Enterobacteriales	Enterobacteriaceae	*Hafnia/Rahnella*	*alvei*
1	Proteobacteria	α-Proteobacteria	Rhizobiales	Methylobacteriaceae	*Methylobacterium*	unknown
1	Proteobacteria	γ-Proteobacteria	Enterobacteriales	Enterobacteriaceae	*Pantoea*	unknown
1	Proteobacteria	γ-Proteobacteria	Enterobacteriales	Enterobacteriaceae	*Serratia/Rahnella*	unknown
1	Proteobacteria	γ-Proteobacteria	Enterobacteriales	Enterobacteriaceae	*Serratia*	unknown
Conventional						
2	Proteobacteria	γ-Proteobacteria	Enterobacteriales	Enterobacteriaceae	*Pantoea*	*agglomerans*

[page 18] [International Journal of Plant Biology 2015; 6:6011] OPEN ACCESS

da Pascazio et al., 2015



Radar diagrams of (A) fungal and (B) bacterial AWCD of all the main classes of carbon substrates in soils sampled from the ST (continuous line) and CT (dashed line). Statistic like in Table 1. Asterisk: significant difference at P ≤ 0.05.

The adoption of sustainable agricultural practices had positive effects on soil microbiota, leading to a deep change in the structure of soil microbial communities and to a significant increase in microbial diversity

SPECIFIC BACTERIAL COUNTS

Bacteria involved in nitrogen cycle (*Azotobacter*, proteolytic bacteria, ammonifying bacteria and *Pseudomonas*) were identified and counted in specific culture media.

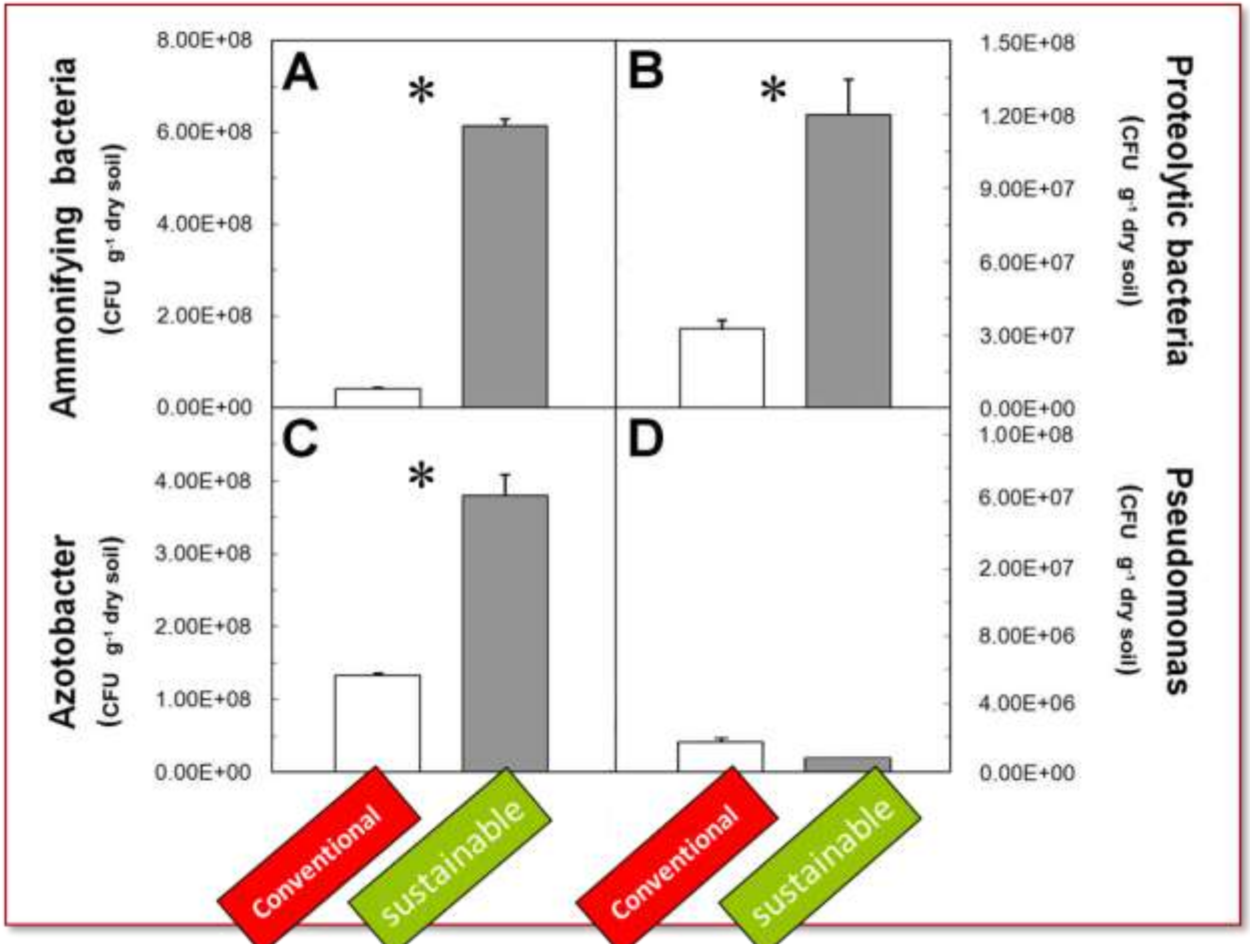


Figure. *Ammonifying bacteria (A), proteolytic bacteria (B), Azotobacter (C) and Pseudomonas (D) in the CT (white bars) and ST (grey bars). Asterisk: significant difference at P ≤ 0.05.*

(Sofo et al.,)

Conclusions

- **Microorganisms significantly responded to a sustainable orchard management** characterized by the medium-term application of endogenous sources (cover crops and pruning residues) of organic matter.

- …Working Hypothesis…

Role of microorganisms in cycling of nutrient elements and in plant nutrient uptake and growth…through Elements analysis in xylem sap…

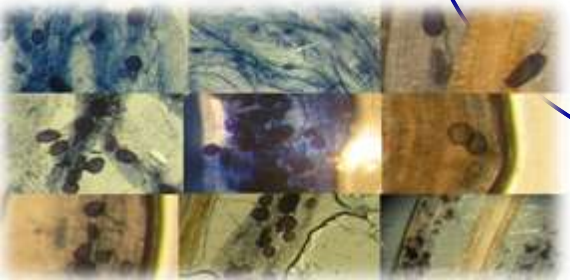
…is lacking knowledge on how bacterial communities and the ecosystem processes are related and how these links may affect production and ecosystem multi-functionality.

??

Our Hypothesis…

SUSTAINABLE ORCHARD MANAGEMENT INFLUENCE MICROBIOME BIODIVERSITY

Determining ecosystem multi-functionality and enhancing plant resilience against biotic and abiotic stresses



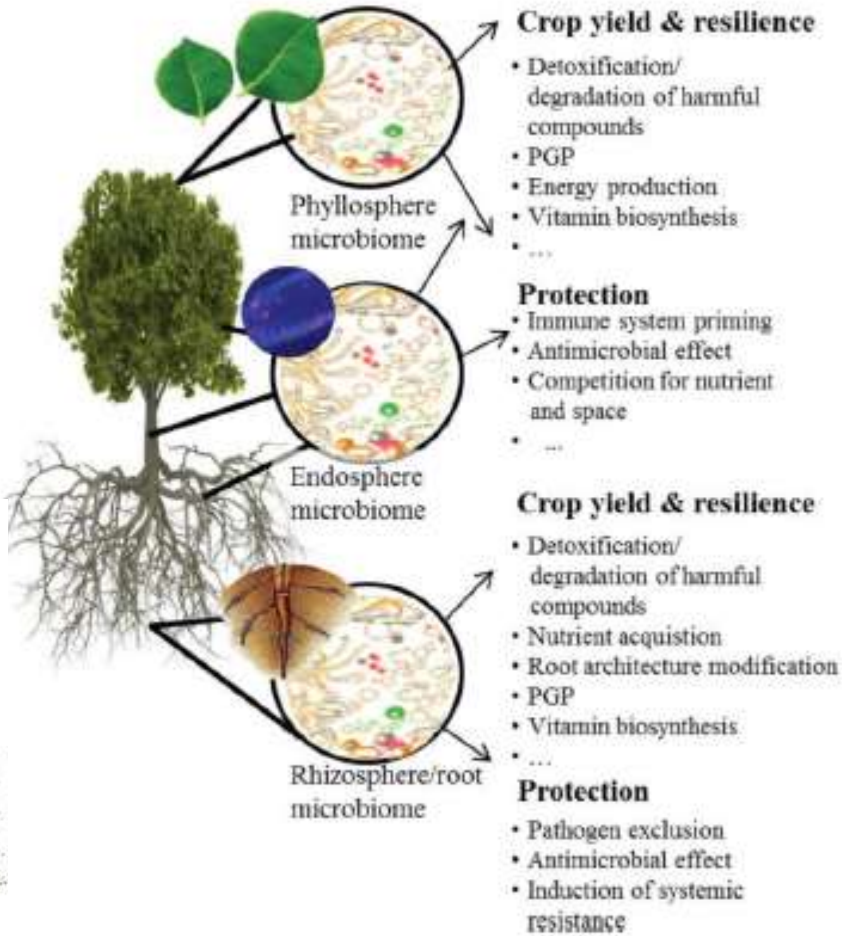
Endophytes' role in protection against plant pathogens and productivity of agricultural ecosystem

Plant secondary genome

Microbiome

Important for physiological functions…

….as intestinal flora in humans



Thijs et al., 2017

Plant Pathology & Microbiology

Gai et al. J Plant Pathol Microbiol 2011, 2:3
http://dx.doi.org/10.4172/2157-7471.1000109

Research Article Open Access

Endophytic Bacteria Associated to Sharpshooters (Hemiptera: Cicadellidae), Insect Vectors of *Xylella fastidiosa* subsp. *pauca*

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Abstract

Xylella fastidiosa subsp. *pauca* causes citrus variegated chlorosis (CVC) disease in Brazil, resulting in significant production losses in the citrus industry. *X. fastidiosa* subsp. *pauca* is mainly transmitted by three species of sharpshooters (Hemiptera: Cicadellidae) in Brazil; *Dilobopterus costalimai* (Young), *Acrogonia citrina* Marucci & Cavichioli and *Oncometopia facialis* (Signoret). We identified bacterial communities associated with the heads of surface-sterilized insect vectors of *X. fastidiosa* subsp. *pauca* that were collected from CVC affected citrus groves in Brazil. Bacteria were isolated and analyzed by amplified ribosomal DNA restriction analysis (ARDRA) and sequencing, revealing the presence, among the most abundant genera, of the well-known citrus endophytes *Methylobacterium* spp. and *Curtobacterium* spp. Specific PCR systems for the detection of these genera indicated high frequencies of presence of these bacteria in sharpshooters. The remaining bacterial community was compared in distinct vector species and at different period of the year by denaturing gradient gel electrophoresis (DGGE), showing its responsiveness to the climate change over the year. These results represent a new basis for the knowledge about the interaction symbiotic-pathogenic bacteria inside insect vectors and provide a basis for further work on the biocontrol of plant bacteria like *X. fastidiosa*.

Keywords: citrus variegated chlorosis (CVC); *Curtobacterium* sp.; *Methylobacterium* sp.

the xylem-feeding habit of sharpshooters and their ability to transmit *X. fastidiosa* [24-27]. In Brazilian citrus groves, *Dilobopterus costalimai*,

Tree and Forestry Science and Biotechnology ©2009 Global Science Books

Interactions of *Xylella fastidiosa* and Endophytic Bacteria in Citrus: A Review

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X. fastidiosa interacts with endophytic bacteria present in the xylem of sweet orange, and that these interactions, particularly with *Methylobacteriurn mesophilicum* and *Curtobacterium flaccumfaciens*, may affect disease progress.

X. fastidiosa

X. fastidiosa + C. flaccumfaciens

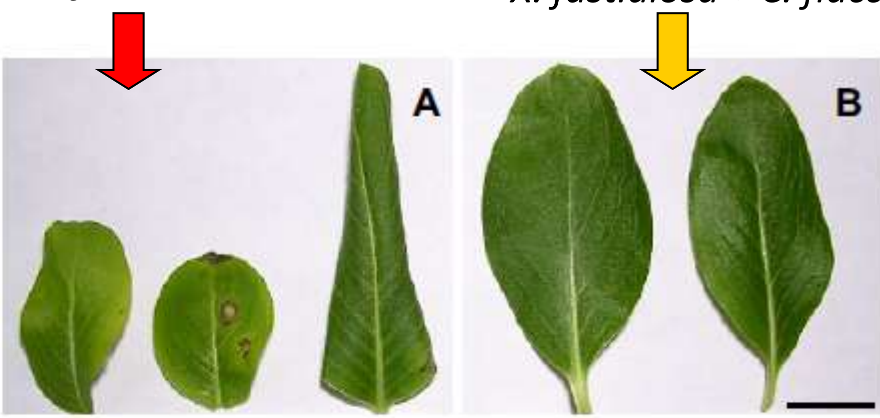


Fig. 1 Leaf stunting and chlorosis induced in *Catharanthus roseus* leaves 2 months after inoculation with **(A)** *X. fastidiosa* subsp. *pauca* (left). **(B)** Symptom free leaves from a plant doubly-inoculated with *X. fastidiosa* subsp. *pauca* and *C. flaccumfaciens* (right). Scale bar: 1 cm.

Lacava et al., 2009

The biggest fruit is not always the best in quality

new marketing approaches that allow to sell also the not perfect, from aesthetic point of view and size, fruit /nuts

Lost and Tossed: Fruit and Vegetables

Every year some 2.9 trillion pounds of food—about a third of all that the world produces—never get consumed. Along the supply chain fruits and vegetables are lost or wasted at higher rates than other foods. Easily bruised and vulnerable to temperature swings en route from farm to table, they're also usually the first to get tossed at home.

TRACKING THE DIVIDE

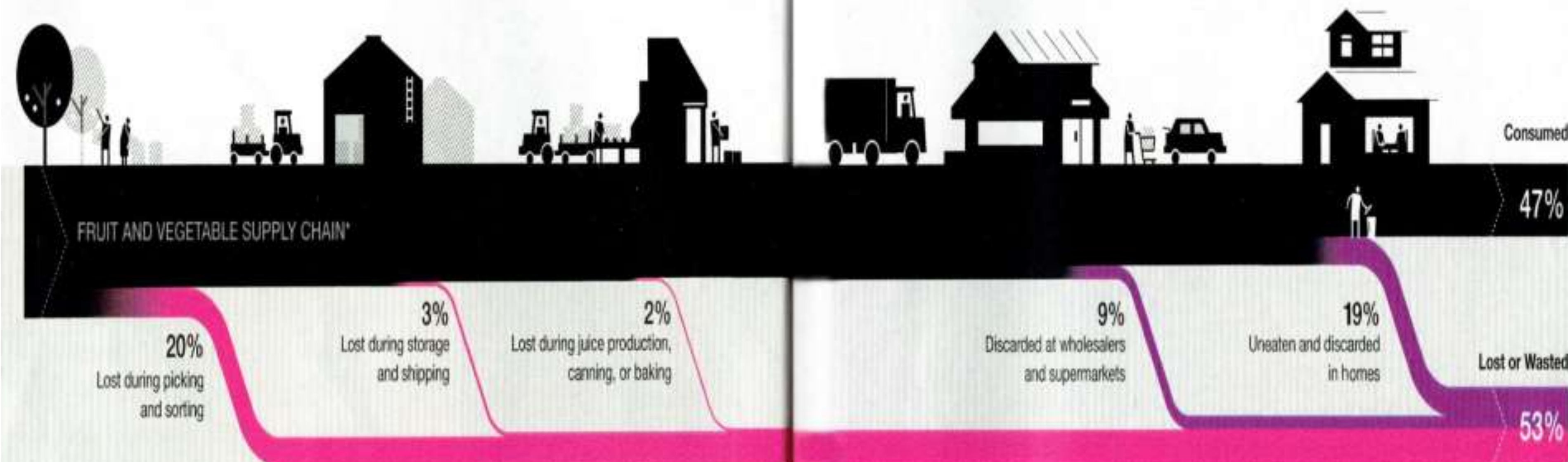
Industrialized countries lose fewer fruits and vegetables in production, but consumers there waste more. In developing countries more is lost in production, but consumers throw out less.

LOST

Produce abandoned or discarded during harvesting, shipping, or processing

WASTED

Produce discarded by vendors or consumers, often because of damage or expiration dates



*AUSTRALIA, CANADA, NEW ZEALAND, AND U.S. DATA ONLY

MANUEL CANALES, NGM STAFF; TONY SCHICK. SOURCE: FAO

Apricot cv Flopria

Size and Price to the growers

55+ gr → 0.70 €

35/40 gr → 0.10 €

Kiwifruit/yellow flesh

Size and Price

75/85 1 €

150/160 1.9 €

Brix 14.65

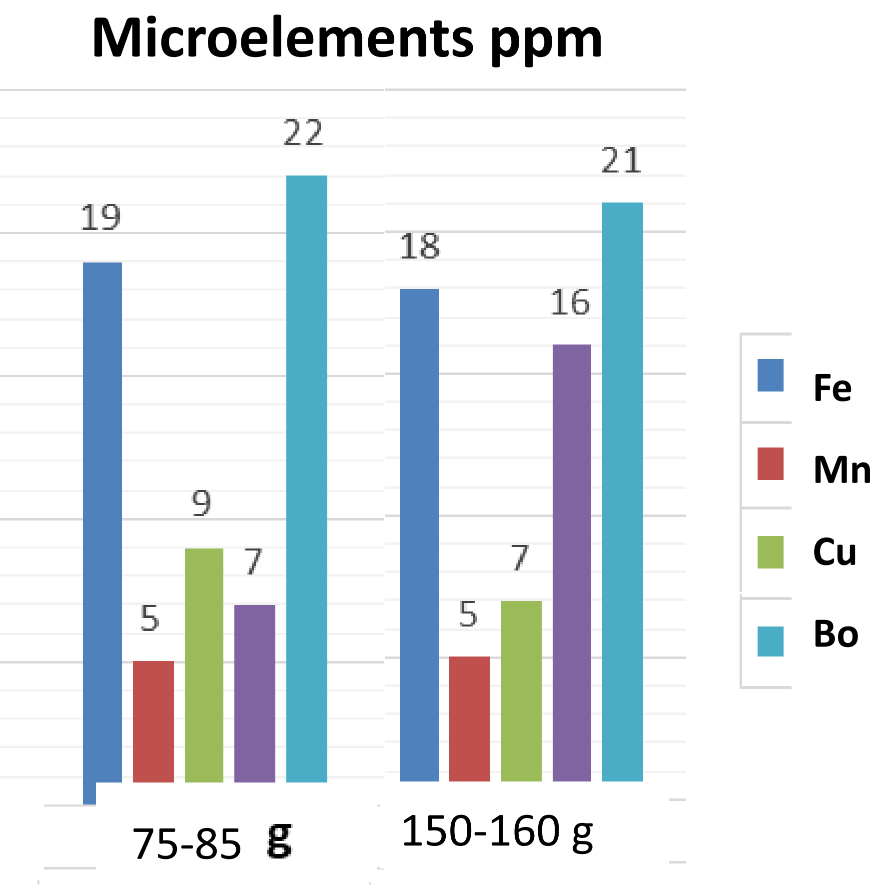
DM 21.48

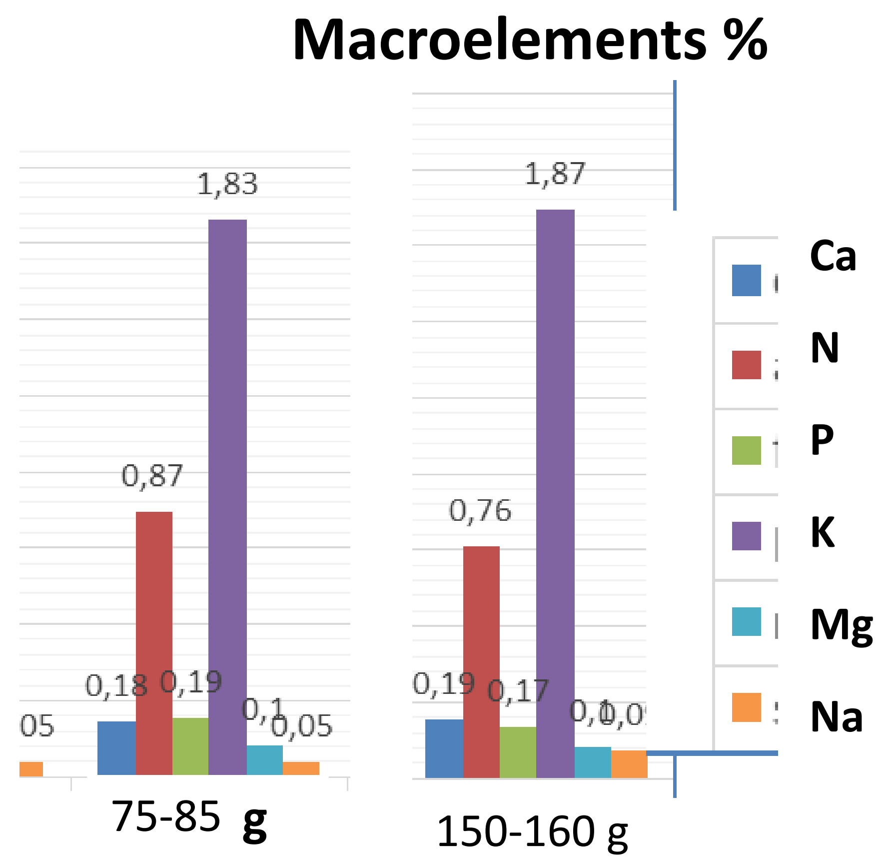
Brix 15

DM 21.51

No differences in quality between sizes!

Mineral content of kiwifruit





No differences between sizes!

United Kingdom: 9 out of 10 retailers promote the sale of imperfect fruits and vegetables

Nel Regno Unito la vendita di **frutta e verdura imperfetta**, cioè quella che normalmente non raggiunge gli scaffali perché ha problemi estetici che però non ne inficiano la qualità, sembra essere promossa a pieni voti... ma con una riserva: quella del pezzo.

Una recente indagine della società di ricerca Blue Yonder - come **riporta Aol** - rivela infatti che 9 responsabili vendite su 10 dei maggiori retailers britannici giudicano positivamente la vendita di frutta e verdura *brutta ma buona* a patto però che, stando ai feedback dei propri clienti, sia venduta sugli scaffali a un prezzo più basso, assimilabile a quello da discount.

Frutta e verdura solitamente scartata per la vendita al dettaglio.

Nel Regno Unito il consumatore si dimostra particolarmente attento alla sostenibilità ambientale, visto e considerato che un recente rapporto del **Global Food Security** del governo britannico rivela che il 40% della frutta e della verdura commestibile non raggiunge nemmeno gli scaffali, proprio per via di difetti esteriori.

Imperfect from aesthetic point of view

TERROIR/ AGRICUTLTURAL VOCATION and ORCHARD DESIGN

- CORRECT CHOICE OF THE SPECIES
- NUMBER OF TREES/ha
- RESISTANT/TOLERANT TO WATER SHORTAGE
- CORRECT CHOICE OF TRAINING SYSTEM

3.5m x 1.00m (2857 alb./ha) – Asse centrale

3.5m x 0.35m (8183 alb./ha) – V

(Tratto da Lugli)

Foto Vivai Mazzoni

Filari di "Abate Fétel"/cotogno MC in fioritura, al 5° anno. L'allevamento a V sembra congeniale per gli alberi fitti sulla fila (distanza 0,4 m). Si noti la bassa statura degli alberi.

Species and variety

- Self-fertile varieties
- Low chilling requirements
- High heat requirements to avoid early frost
- Late blooming
- Short interval from blooming to harvesting
- Tolerant to water stress

rootstocks

CORRECT CHOICE OF ROOTSTOCK

- TOLERANT TO WATER STRESS
- EFFICIENT AND RAPID COLONISATION OF THE AVAILABLE SOIL
- GROWTH OF ROOTS IN THE DEEP SOIL LAYERS
- HIGH RATIO BETWEEN ROOTS AND LEAVES
- RESISTANCE/TOLERANCE TO SOIL PATHOGENS
(NEMATODES, PHYTOPHTHORA, ARMILLARIA MELLEA…)

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