Litter decomposition and organic matter turnover by soil fauna in a sustainably managed olive grove

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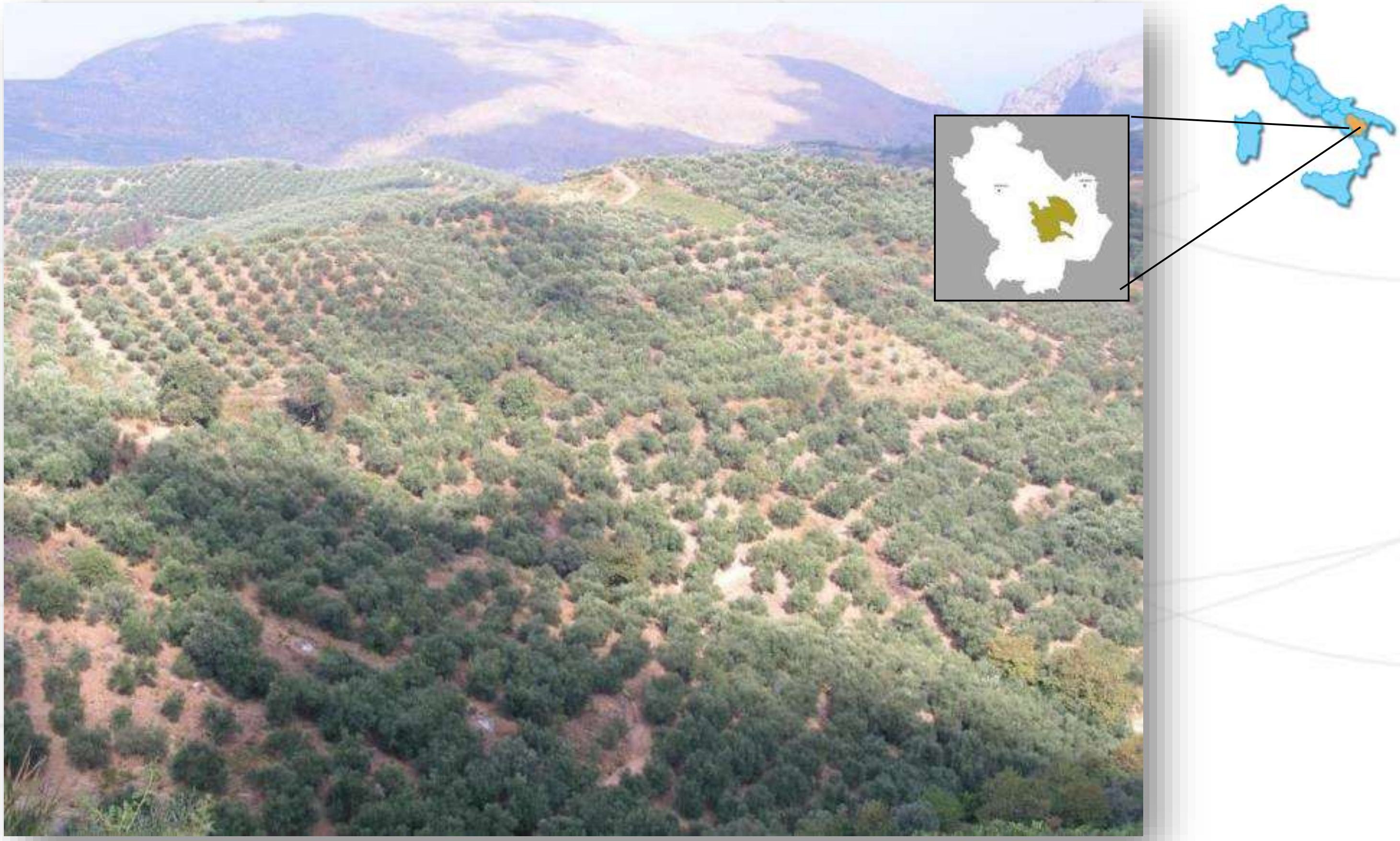
The field site – Ferrandina (Matera province, Italy)



Mature olive orchard (plant age = approximately 100 years)

18 years of differential management: sustainable (1 ha) and conventional (1 ha)

Sustainable system

- No tillage. Spontaneous weeds and grasses mowed at least twice a year. Crop residues were cut and left on the ground as mulch.
- Guided fertilization: fertigation based on a nutrient balance approach which takes into account nutrient input (by wastewater), output (by yield), and recycling/immobilization in the grove system (by pruned material, senescent leaves, cover crops).
- Guided drip irrigation with treated municipal wastewater.
- Light winter pruning was performed each year in order to reach vegetative-reproductive balance of trees. Pruning material was cut and left on the ground as mulch.

Conventional system

- Soil tillage (milling at 10 cm soil depth) performed 2-3 times per year in order to keep the soil bare.
- Mineral fertilization carried out empirically once per year in early spring by using granular product applied to the soil.
- Empirical irrigation with conventional water.
- Heavy pruning carried out every two years. Pruned residues burned out of the olive grove.

Aims and hypothesis

- In view of circular economy principles and to capitalize on the natural potential of soils, strategies have to be developed for sustainable land-use practices that optimize nutrient and energy use. This can reduce SOM decline, soil erosion and soil degradation but also promote ecosystem services and foster biodiversity, with consequent benefits to the whole agrosystem stability and its resilience against biotic and abiotic factors.

- The role of soil fauna - and particularly of macrofauna - to ecosystem services has been often overlooked. SOM plays a crucial role and its level is principally determined by the continuous physical and chemical action of soil fauna.

- C/N dynamics and other soil physicochemical parameters, soil macrofauna abundance, bioturbation and litter/SOM decomposition indices in a Mediterranean olive orchard. A sustainable (S_{mng}) and a conventional (C_{mng}) olive orchard were compared. Soil macrofauna, bioturbation and litter/SOM decomposition indices were measured.

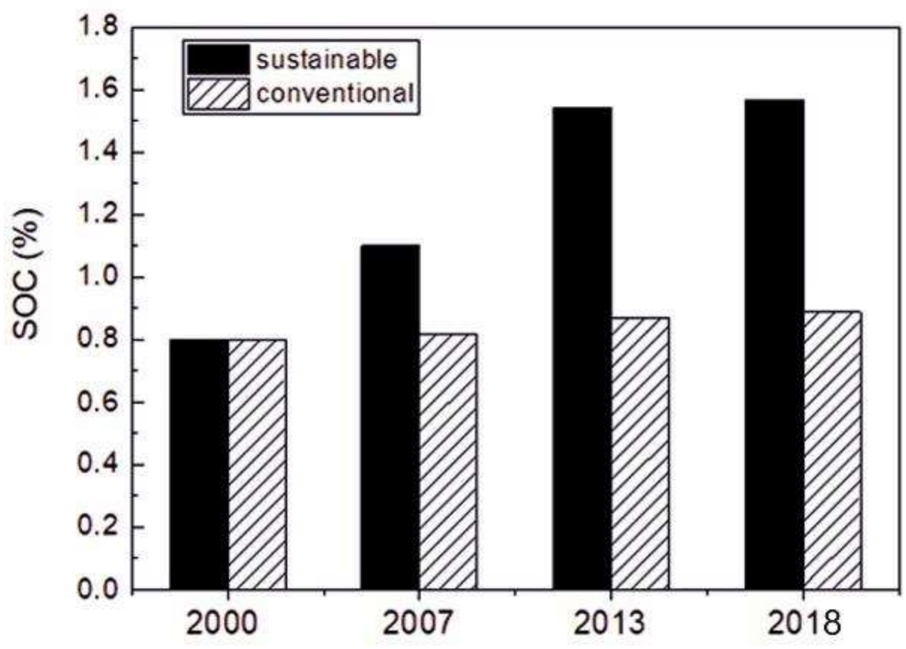
- We hypothesize that the better soil chemical quality deriving from the sustainable agronomic practices adopted (S_{mng} system) could be partly the result of the higher abundance and activity of soil fauna, in terms of enhanced litter decomposition and bioturbation.

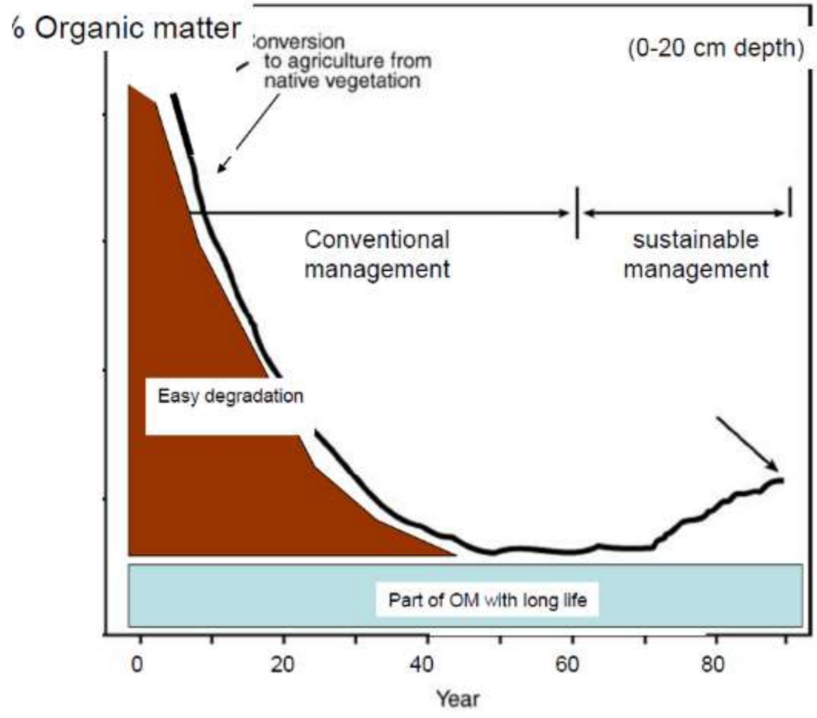
Soil total organic carbon (SOC), total nitrogen (STN), SOC/STN ratio, and pH in soils of the sustainable (S_{mng}) and conventional (C_{mng}) systems measured at different depths.

Soil system	Soil depth (cm)	SOC (g kg^{-1})	STN (g kg^{-1})	SOC/STN	pH
Sustainable (S_{mng})	Litter	43.38 ± 0.95 a	5.90 ± 0.50 a	73.53 ± 19.02 a	-
	0-5	24.19 ± 0.76 b	2.38 ± 0.19 b	10.17 ± 0.12 c	7.61 ± 0.03 e
	5-10	9.25 ± 0.60 d	1.80 ± 0.91 c	6.02 ± 0.27 e	7.70 ± 0.06 c
	10-20	5.84 ± 0.12 e	1.03 ± 0.26 c	5.88 ± 0.33 e	7.80 ± 0.03 bc
Conventional (C_{mng})	0-5	11.99 ± 0.46 c	1.10 ± 0.22 c	11.23 ± 0.06 b	7.85 ± 0.04 b
	5-10	11.42 ± 0.65 cd	1.20 ± 0.07 c	9.51 ± 0.29 d	7.91 ± 0.05 a
	10-20	9.66 ± 0.16 d	1.12 ± 0.06 c	8.65 ± 0.32 d	8.08 ± 0.05 a

Soil C and N dynamics were affected by differential soil management.

SOC changes in the topsoil (0-30 cm)





Adapted from Xiloyannis et al. (2018) and Sofo et al. (2019)

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

Number, total weight and mean weight of (left) earthworms and (right) other macrofauna.

	Earthworms			Other macrofauna		
Soil system	Number	Total weight (g)	Mean weight (g)	Number	Total weight (g)	Mean weight (g)
Sustainable (S_{mng})	7 ± 1 a	4.011 ± 0.702 a	0.540 ± 0.043 a	5 ± 2 a	0.552 ± 0.038 a	0.109 ± 0.016 a
Conventional (C_{mng})	3 ± 1 b	1.397 ± 0.334 b	0.523 ± 0.096 a	3 ± 1 b	0.252 ± 0.072 b	0.075 ± 0.013 b

The adoption of the S_{mng} system significantly increased almost three times the abundance of earthworms and two times that of other soil macrofauna.

The mesh bags with holes for macrofauna access used in the experiment.

Filled with a mixture of 75% sand with 25% kaolin (3:1; w/w) (ARTIFICIAL SOIL).

Weight of biogenic structures in the mesh bags with and without holes.

		With holes			Without holes		
Soil system	Mesh depth (cm)	Dry weight (g)	Abundance index - roots	Abundance index - fauna	Dry weight (g)	Abundance index - roots	Abundance index - fauna
Sustainable (S_{mng})	0-5	10.058 ± 2.702 a	2	2	3.710 ± 1.098 a	2	2
	5-10	1.739 ± 0.481 b	1	0	0.434 ± 0.150 bc	0	1
	10-20	0.916 ± 0.325 c	0	0	0.634 ± 0.153 bc	0	0
Conventional (C_{mng})	0-5	3.952 ± 0.815 b	0	0	1.392 ± 0.272 b	1	1
	5-10	0.316 ± 0.065 cd	0	0	0.118 ± 0.032 c	0	0
	10-20	0.184 ± 0.026 d	0	0	0.148 ± 0.051 c	0	0

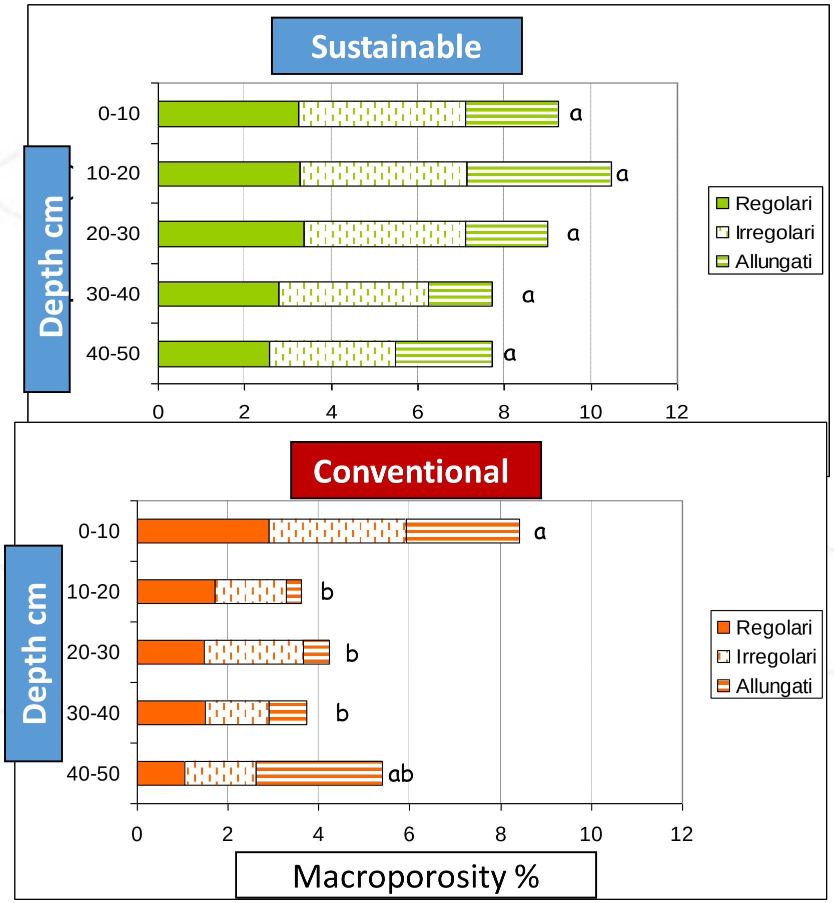
Bioturbation due to soil fauna and roots was significantly higher in the S_{mng} system.

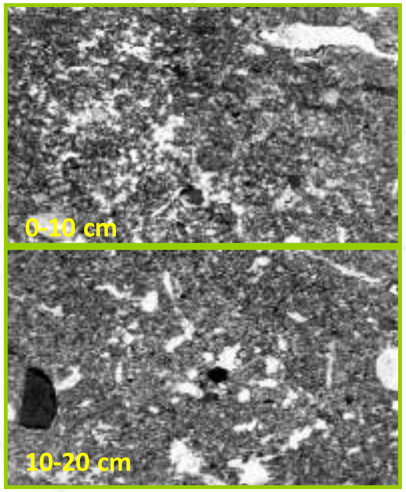
Initial and final dry weight, fraction of remaining local litter (Xl_t), and decomposition constant (z) from the local litter bags kept (left) for one year and (right) for 90 days.

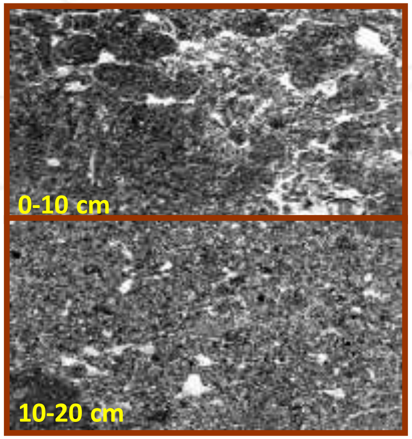
	One year				90 days			
Soil system	Initial dry weight (g)	Final dry weight (g)	Fraction of remaining local litter (Xl_t)	Decomposition constant - z	Initial dry weight (g)	Final dry weight (g)	Fraction of remaining local litter (Xl_t)	Decomposition constant - z
Sustainable (S_{mng})	27.931 ± 4.102 a	17.002 ± 4.431 b	0.626 ± 0.074 b	0.515 ± 0.160 a	6.464 ± 2.549 a	5.907 ± 0.924 b	0.912 ± 0.005 b	0.092 ± 0.006 a
Conventional (C_{mng})	24.880 ± 2.455 a	21.027 ± 0.692 a	0.847 ± 0.054 a	0.168 ± 0.064 b	8.521 ± 2.215 a	7.938 ± 0.586 a	0.931 ± 0.004 a	0.072 ± 0.004 b

A significantly faster SOM decomposition measured in the local litter bags of the S_{mng} system. $Xl_t = Xl_0 e^{-zt}$ (Harmon et al., 1999)

The effects of differential managements on soil macroporosity







Soil water holding capacity and soil erosion

Mechanical tillage reduces water infiltration, causing runoff and erosion processes

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

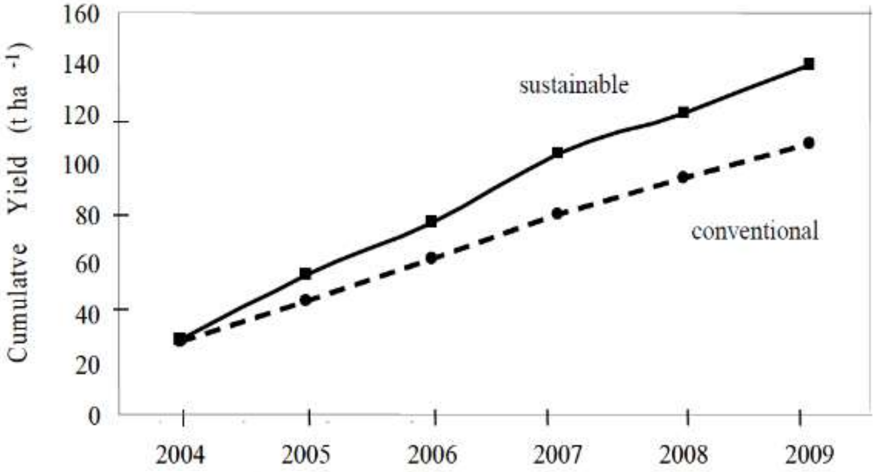
(a soil layer of about 1 cm!!!)

Sustainable management practices increase infiltration rate and water storage in soil

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

Palese et al. (2005)

BENEFITS



COMMERCIAL	ECOLOGICAL	ISTITUTIONAL
external processes, material… soil, litter seq. <u>not</u> considered	Biological carbon sequestration + farmer impact (In OUT)	Accounting Biological carbon sequestration in CROPLAND by 2021 within national GHGs inventory (EC 529/2013)

Benefits for the farmers?

Increasing benefit for growers may boost the adoption of environmental friendly water and soil management (plant status, water and soil quality).

Conclusions

- Soil chemical quality in the S_{mng} system was enhanced by the higher abundance and activity of soil fauna, in terms of enhanced litter decomposition and bioturbation.

- From a productive point of view, in soil fauna-plant interactions both the animal and the plant profit from each other, and these interactions could play an important role in fruit growing, positively affecting plant status, water and nutrient uptake and improving product quality.

- The role of soil fauna should be seriously taken into account in land management strategies not exclusively oriented to fruit yield and quality, but also to soil fertility restoration.

- Soil fauna has a key role in soil quality and fertility of fruit orchards but also provides a wide range of ecosystem services. Land management strategies should be oriented not only to fruit production, but also to soil fertility restoration.

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http://www.agreenment.it/index.php/en/

Thanks for your kind attention!