Carbon farming & agricoltura
Che integra food&energy:
A che punto siamo?

Sistemi colturali per accumulare carbonio nel suolo

Alessia Perego – Università di Milano | DISAA

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13 LUGLIO 2023 PTP SCIENCE PARK | LODI

PSR 2014 2020 LOMBARDIA L'INNOVAZIONE METTE RADICI

Regione Lombardia

Fondo Europeo Agricolo per lo Sviluppo Rurale: l'Europa investe nelle zone rurali

Il carbonio organico nel suolo agrario

Quali sono i fattori che incidono sul suo accumulo?

- Lavorazioni del suolo ridotte
- Residui colturali
- Fertilizzazione organica
- Cover crop

Management category	Management practices to increase soil carbon
Crop management	Soil fertility enhancement Better rotation Erosion control Irrigation
Conservation tillage	Stubble retention Reduced tillage No-tillage
Pasture management	Fertiliser management Grazing management Earthworm introduction Irrigation Improved grass species Introduction of legumes Sown pasture Introduction of perennial pastures
Organic amendments	Animal manure Green manure Recycled organics

[1] Chan, Y. (2008). Increasing soil organic carbon of agricultural land. Primef act, 735, 1-5.

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Geoderma 292 (2017) 59–86

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Uta Stockmann [a], Yiyi Sulaeman [s], Chun-Chih Tsui [f], Tor-Gunnar Vågen [t],
Bas van Wesemael [u], Leigh Winowiecki [t]

Table 1
Management practices that are reported to sequester soil carbon.

Management practices	Country	Depth observed	Carbon sequestration rates[b] t C ha^{-1} yr^{-1}	Average C stock[a] t C ha^{-1}	Period of observation	References
Arable land						
Organic amendment	China	Plough layer, 0–20 cm for dry cropland and 0–15 cm for paddy soil	0.62	24.4	*6 to 25 years, 14.4 years on average	Wang et al. (2010)
Organic amendment	China	Plough layer	0.54	24.4	*3 to 25 years	Jin et al. (2008)
Organic amendment combined with inorganic fertilizer	China	Plough layer, 0–20 cm for dry cropland and 0–15 cm for paddy soil	0.62 0.69 0.89	24.4	*3 to 25 years	Jin et al. (2008); Zhu et al. (2015); Wang et al. (2010)
Compost addition	S. Korea	0–30 cm paddy soils	0.24	40.5	42 years	Lee et al. (2013)
Compost addition with inorganic fertilizer	S. Korea	0–30 cm, paddy soils	0.39	40.5	42 years	Lee et al. (2013)
Compost addition	Taiwan	0–15 cm	0.46–1.00	36	*13–20 years	Wei et al. (2015a); Wei et al. (2015b)
Compost with inorganic fertilizer	Taiwan	0–15 cm	0.40–0.80	37.4	*20 years	Wei et al. (2015a); Wei et al. (2015b)
Farm yard manure	Belgium	0–25 cm	0.45 ± 0.14	50	*20 years	Buysse et al. (2013)
Farm yard manure/crop residue	Nigeria	Topsoil	0.10–0.30	33.4	*50 years	FAO (2004)
Inorganic fertilizer with straw return	Indonesia	0–15 cm, paddy soils	0.52 ± 0.16	17.9	40 years	Minasny et al. (2012)
Straw return with Inorganic fertilizer	Indonesia	0–15 cm, paddy soils	0.47	17.9	*3 years	Sugiyanta (2015)
Inorganic fertilizer	S. Korea	0–15 cm, paddy soils	0.32 ± 0.29	27.3	8 years	Minasny et al. (2012)
Straw return	China	Plough layer	0.57–0.60	27.6	*3 to 25 years	Jin et al. (2008); Lu et al. (2009)

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Inorganic fertilizer	India	0–15 cm	0.16	13.3	6–32 years	Pathak et al. (2011)
Inorganic fertilizer + FYM	India	0–15 cm	0.33	13.3	6–32 years	Pathak et al. (2011)
Residue incorporation	Nigeria	0–15 cm	0.24	20	*18 years	Raji and Ogunwole (2006)
Stubble retention	Australia	0–15 cm	0.19 ± 0.08	21.2	*	Sanderman et al. (2010)
Stubble retention	Australia	0–10 cm	0.147 ± 0.059	18.3	*4 to 40 y	Lam et al. (2013)
No till	China	Plough layer	0.16–0.51		3 to 25 years	Jin et al. (2008); Lu et al. (2009); Wang et al. (2009)
No till	France	0–30 cm, Wheat-corn rotation	0.2 ± 0.13	51.6	20 years	Arrouays et al. (2002b)
No till	UK	Topsoil	0.31 ± 0.2	80	5–23 years	Powlson et al. (2012)
No till	USA	0–20 or 0–30 cm	0.4 ± 0.61[c]	53±25.2	12–34 years	Johnson et al. (2005)
No till plus cover crops	USA (southeast)	0–20 cm	0.45 ± 0.04	25.5 ± 0.9	11 ± 1 years	Franzluebbers (2010)
Conventional till to no-till	Canada	0–30 cm	0.05–0.16	75	20 years	VandenBygaart et al. (2008)
Reduced use of summer fallow	Canada	0–30 cm	0.30	75	20 years	VandenBygaart et al. (2008)
Reduced tillage	Australia	0–15 cm	0.34 ± 0.06	21.2	*Various, 4 to 42 years	Sanderman et al. (2010)
Reduced tillage	Belgium	0–60 cm	0		20 years	D'Haene et al. (2009)
Conservation tillage	Australia	0–10 cm	0.15 ± 0.028	18.3	4 to 40 years	Lam et al. (2013)
Conservation tillage	France	0–25 cm	0.10	51.6	28 years	Metay et al. (2009)
Crop rotation	Australia	0–15 cm	0.20 ± 0.04	21.2	Various, 4 to 42 years	Sanderman et al. (2010)
Crop rotation	France	0–30 cm	0.16 ± 0.08	51.6	20 years	Arrouays et al. (2002a,b)
Crop rotation with perennial grasses	Russia	Plough layer	0.03–0.08	32.3	*5 years	Savin et al. (2002)
Conversion to ley farming	England	0–23 cm	0.20	80	30 years	Powlson and Johnston (2015)
Conversion of annual cropping to crop+ley rotation	USA	0–30 cm	0.5	78	30 years	Dick et al. (1998)

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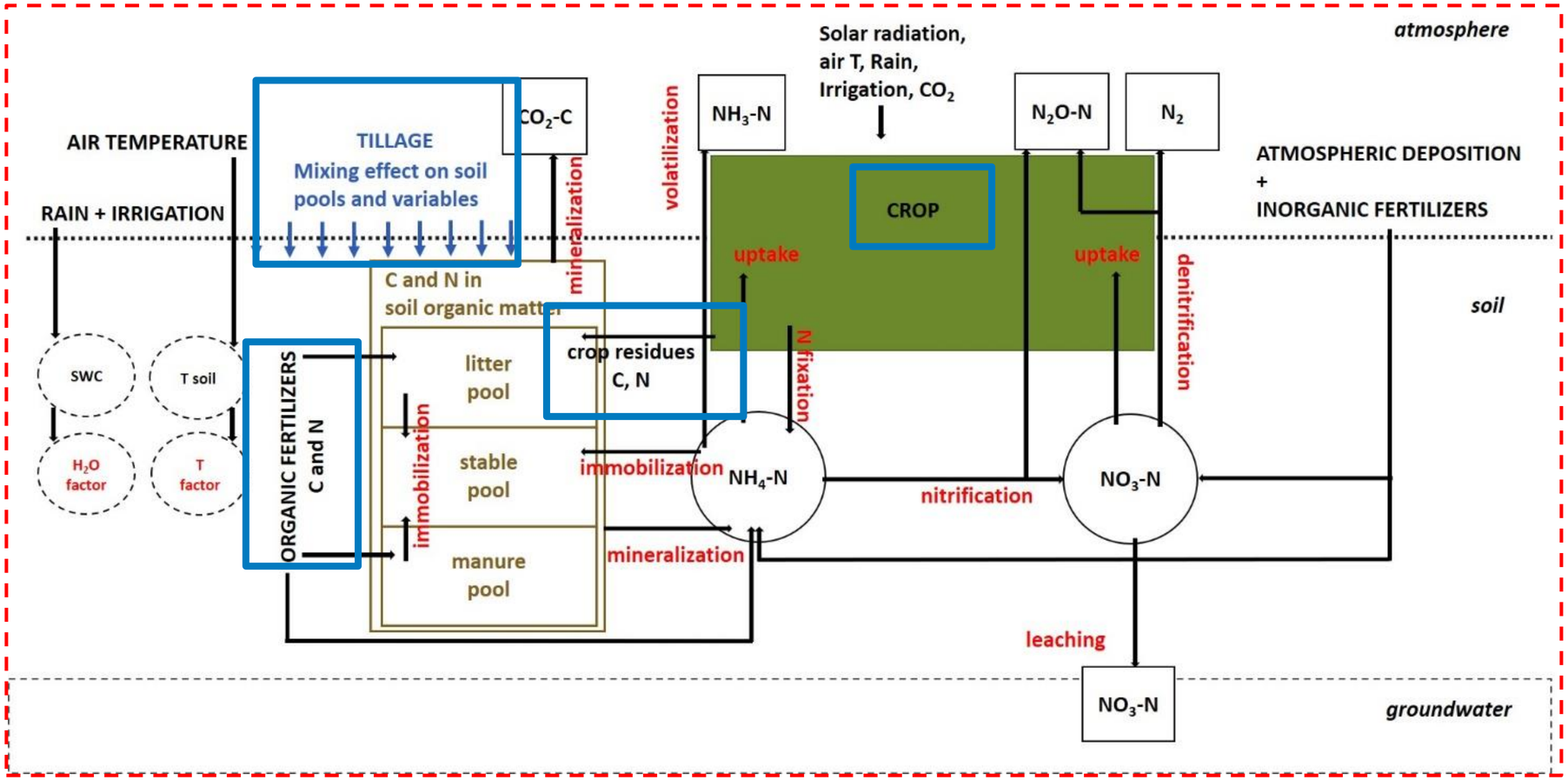
Accumulo del carbonio organico nel suolo agrario

Fattori e processi coinvolti



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Fertilizzanti di origine organica

Effetto sull’accumulo carbonio organico (SOC)

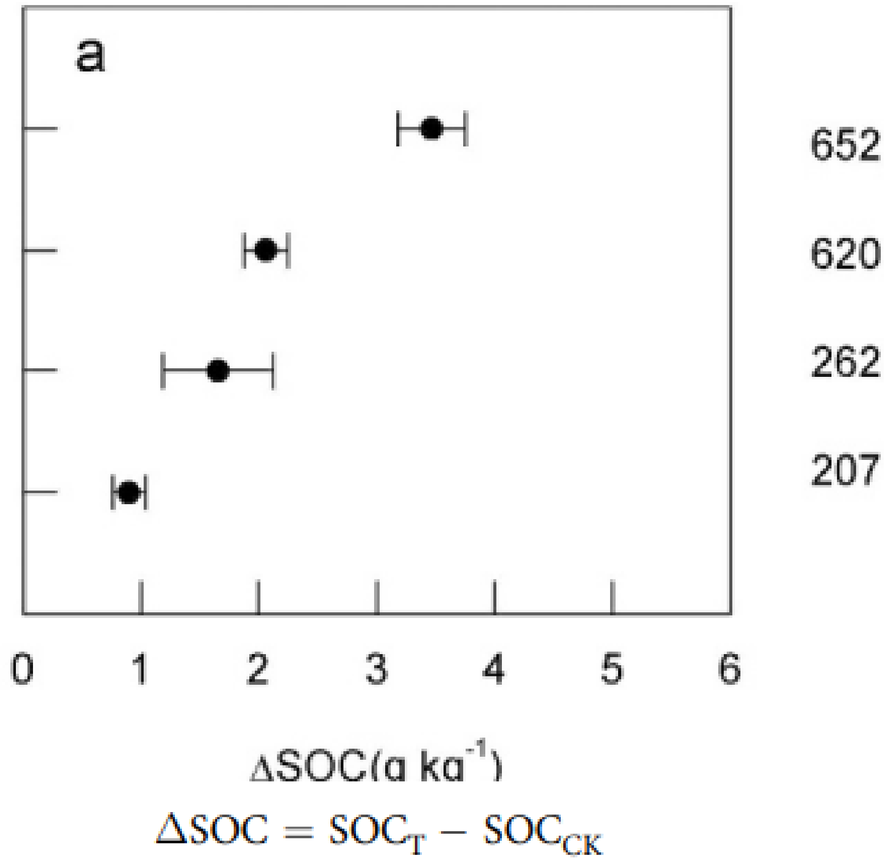
Han, P., Zhang, W., Wang, G., Sun, W., & Huang, Y. (2016). Changes in soil organic carbon in croplands subjected to fertilizer management: a global meta-analysis. Scientific reports, 6(1), 27199.

CONCIMI MIN. + ORG.

CONCIMI MIN. + RESIDUI

CONCIMI MIN. (DOSI OTTIMALI)

CONCIMI MIN. (DOSI SUBOTTIMALI)



$$\Delta SOC = SOC_T - SOC_{CK}$$

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Fertilizzanti di origine organic

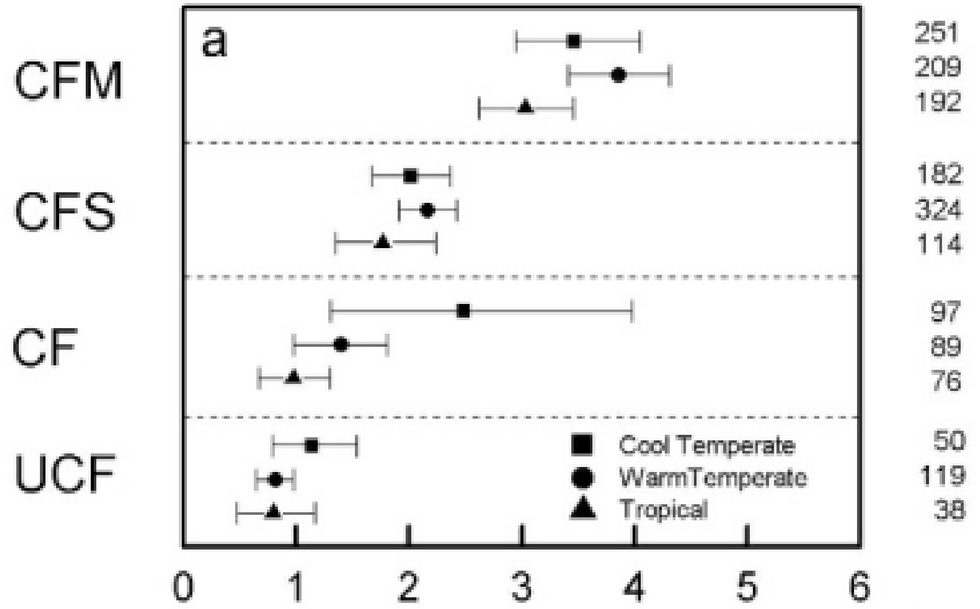
Effetto sull’accumulo carbonio organico (SO

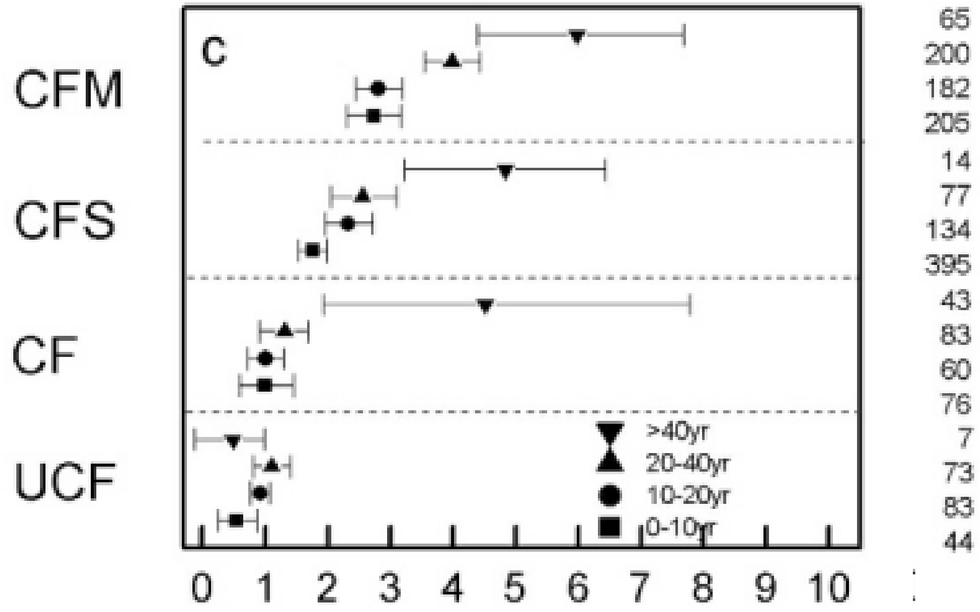
CONCIMI MIN. + ORG. = CFM

CONCIMI MIN. + RESIDUI = CFS

CONCIMI MIN. (DOSI OTTIMALI) = CF

CONCIMI MIN. (DOSI SUBOTTIMALI) = UCF)





Han, P., Zhang, W., Wang, G., Sun, W., & Huang, Y. (2016). Changes in soil organic carbon in croplands subjected to fertilizer management: a global meta-analysis. Scientific reports, 6(1), 27199.

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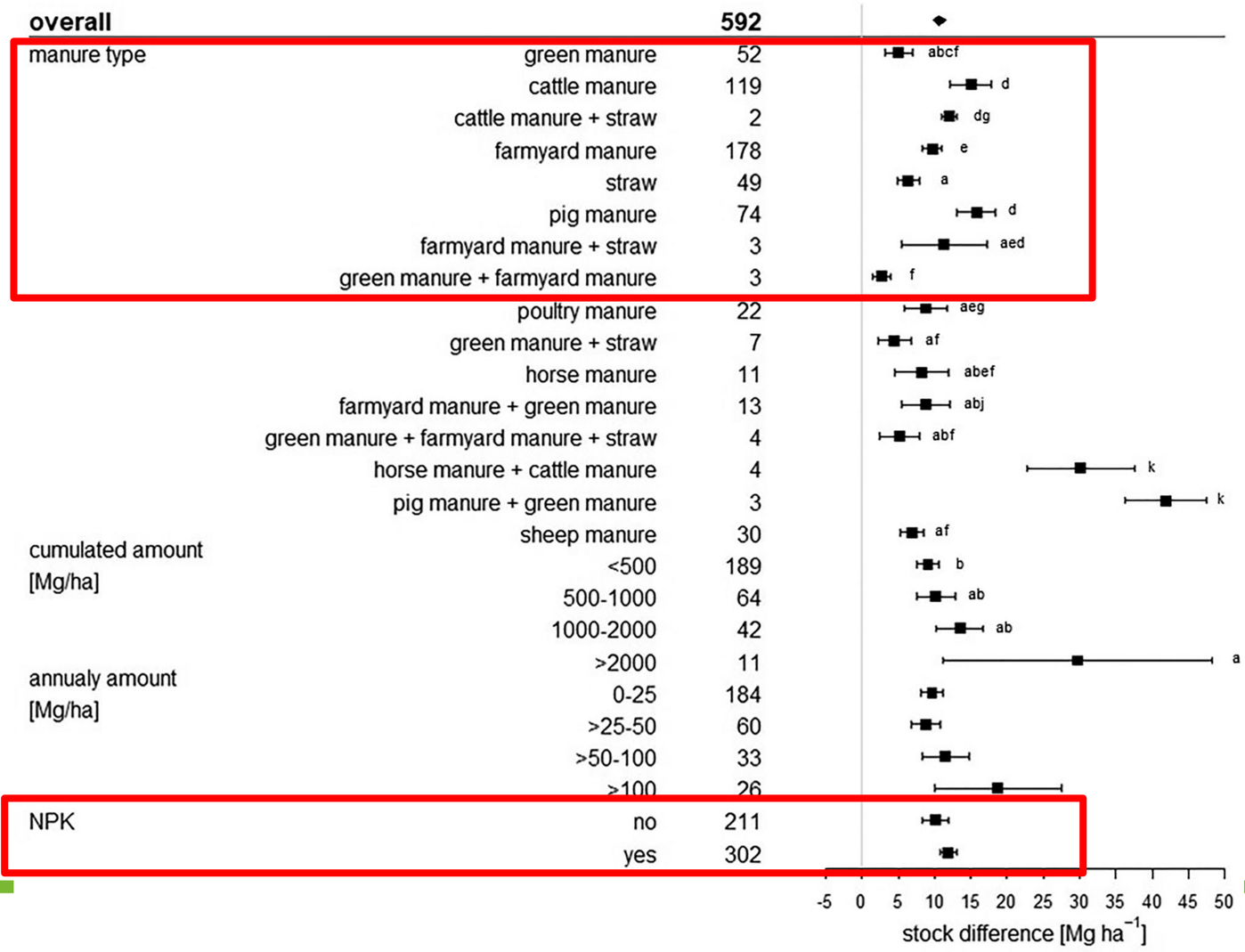
Fertilizzanti di origine organica

Effetto sull’accumulo carbonio organico (SOC)



Gross, A., & Glaser, B. (2021). Meta-analysis on how manure application changes soil organic carbon storage. Scientific reports, 11(1), 5516.

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Applicazione di digestato

Effetto su SOC e GHG. Caso studio Lodi

Lagomarsino, A., Valagussa, M., Scotti, C., Borrelli, L., Becagli, C., & Tosca, A. (2022). Mitigation of GHG Emissions from Soils Fertilized with Livestock Chain Residues. Agronomy, 12(7), 1593.

		Yield	TOC
		Gg ha^{-1}	Gg ha^{-1}
2020	Digestate	16.4 (1) ^{a,b,c}	44 (0.4) ^{d,e,f}
	Digestate + biochar	16.9 (1) ^{a,b,c}	49 (2) ^{c,g}
	Slurry	14.9 (0.2) ^{a,b,c}	39 (0.8) ^{f}
	Slurry + biochar	14.9 (1) ^{a,b,c}	49 (0.6) ^{c,d,g}
	Mineral	13.6 (1) ^{c}	39 (1) ^{f}
	Mineral + biochar	14.2 (0.8) ^{b,c}	56 (3) ^{a,b}
2021	Digestate	16.6 (0.5) ^{a,b,c}	46 (3) ^{d,e,g}
	Digestate + biochar	18.6 (3) ^{a,b}	50 (2) ^{c,g}
	Slurry	16.9 (0.2) ^{a,b,c}	46 (0.8) ^{d,e,g}
	Slurry + biochar	15.6 (3) ^{a,b,c}	59 (3) ^{a}
	Mineral	19.2 (1) ^{a}	42 (1) ^{e,f}
	Mineral + biochar	14.0 (1) ^{c}	54 (1) ^{b,c}

	Digestate			Slurry		
	2020	2021		2020	2021	
Moisture content (%)	92.1	93.1		94.6	94.7	
Norg content (g kg^{-1})	2.43	1.61		4.32	1.64	
N-NH_4 content (g kg^{-1})	2.57	1.48		0.98	0.46	
Effective N (%)	0.38	0.23		0.31	0.13	
Added dose (Mg ha^{-1})	54	74		45	133	
N added (Kg ha^{-1})	270	229		239	279	
Effective N added (Kg ha^{-1})	205	170		140	173	

	2020						2021					
	Organic vs. Mineral Fertilizer (%)			Biochar Effect (%)			Organic vs. Mineral Fertilizer (%)			Biochar Effect (%)		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Digestate	17 #	+31 *	+202 #	0	+8	+24	+42 ***	−8	+63 #	−21 ***	+58 *	−59 *
Slurry	25 *	+11	−18	0	+24 **	−6	+18 *	+16 #	+11	+6 **	−15	+49
Mineral	–	–	–	−8 *	+7	−57 **	-	–	–	−8 #	+10	−50 #

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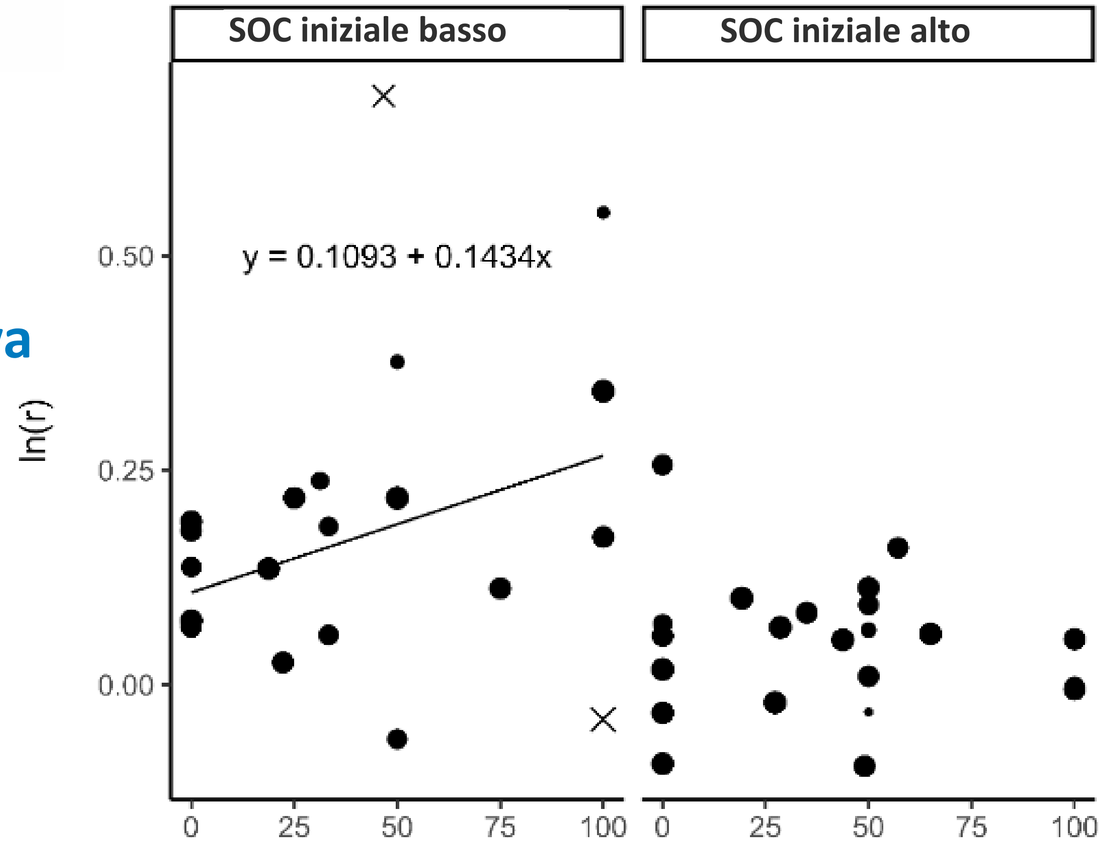
Coservativa vs Convenzionale: Effetto sul SOC

Interazione significativa tra Valore inziale di SOC x Quantità di Residui

Effetto positivo della Conservativa rispetto al Convenzionale



% colture con elevato residuo nella rotazione

Tadiello, T., Acutis, M., Perego, A., Schillaci, C., & Valkama, E. (2023). Soil organic carbon under conservation agriculture in Mediterranean and humid subtropical climates: Global meta-analysis. European Journal of Soil Science, 74(1), e13338.

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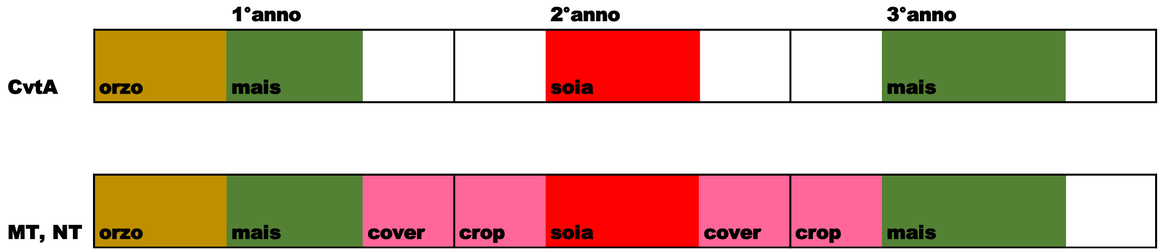
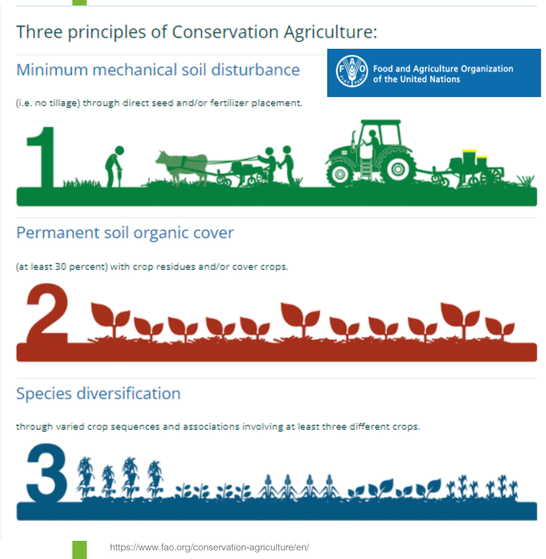
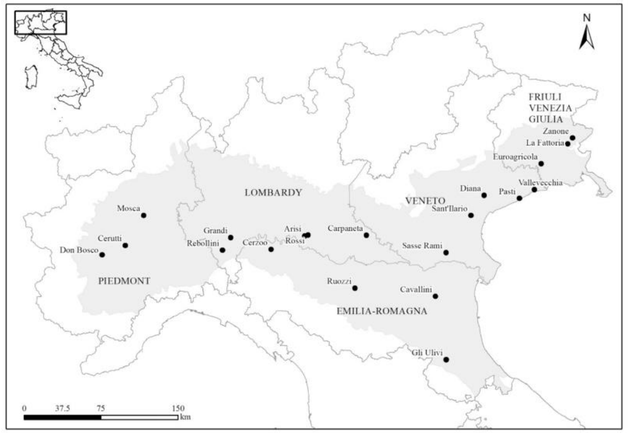
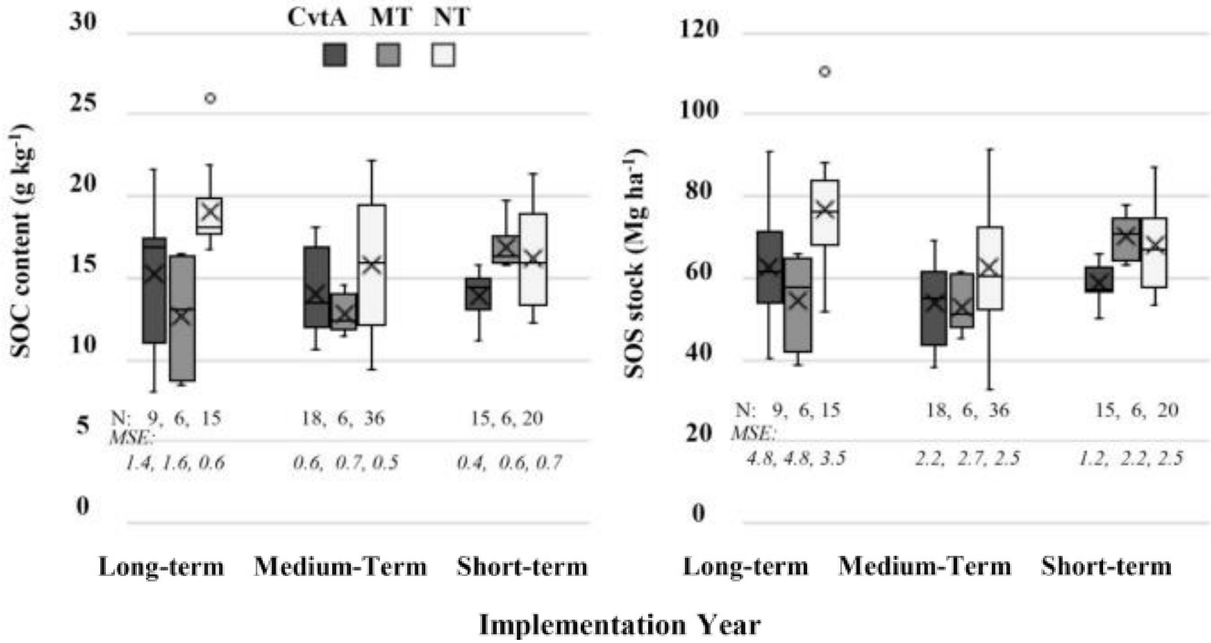
Agricoltura conservativa

Effetto sullo stock di carbonio nel suolo
Esperienza in pianura Padana









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Perego, A., Rocca, A., Cattivelli, V., Tabaglio, V., Fiorini, A., Barbieri, S., ... & Acutis, M. (2019). Agro-environmental aspects of conservation agriculture compared to conventional systems: A 3-year experience on 20 farms in the Po valley (Northern Italy). Agricultural Systems, 168, 73-87..

Rotazione colturale e gestione agronomica

Effetto sull'evoluzione di SOC

tessitura	**Medio-fine**
Sostanza Organica	**Alta (>2.7%)**

RISULTATI ESPRESSI In t CO_2 eq. ha^{-1} yr^{-1}

(+ emissions – sequestro)

	BASELINE	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4
Coltura	SOIA GIRASOLE FRUMENTO	FRUMENTO SOIA MAIS	FRUMENTO SOIA (II) MAIS	VITE	MIX FIORI
Suolo	+ 2.52	+ 1.79	+ 1.13	+ 0.48	- 0.37
Carburante	+ 0.50	+ 0.80	+ 0.66	+ 1.55	+ 0.00
GHG	+ 0.69	+ 0.87	+ 0.82	+ 0.16	+ 0.47
TOTALE	+ 3.71	+ 3.45	+ 2.61	+ 2.19	+ 0.10
SEQUESTRO (EFFETTO DI MITIGAZIONE)	0	-0.26	-1.11	-1.53	-3.62

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Effetto delle pratiche agronomiche

Bilancio del C

tessitura	**Medio-fine**
Sostanza Organica	**Alta (>2.7%)**

RISULTATI ESPRESSI In t CO_2 eq. ha^{-1} yr^{-1}

(+ emissions – sequestro)

	BASELINE	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO
COLTURA	SOIA GIRASOLE FRUMENTO				SOIA GIRASOLE FRUMENTO COVER CROP	
Gestione Agronomica	*Aratura + Conc. Min. + Residui Frumento Asportati*	*NT + Conc. Min. + Residui Frumento Asportati*	*Aratura + Conc. Org. + Residui Frumento Asportati*	*Aratura + Conc. Min. + Residui Frumento incorporati*	*Aratura + Conc. Min. + Residui Frumento Asportati + Cover Crop*	*NT + Conc Org. +Resi Frumento superficie Cover Cro*
Suolo	+ 2.52	+ 2.37	+ 1.93	+ 1.02	+ 0.42	-1.05
Carburante	+ 0.50	+ 0.22	+ 0.60	+ 0.49	+ 0.57	+ 0.27
GHG	+ 0.69	+ 0.86	+ 0.47	+ 0.59	+ 0.49	+ 0.48
TOTALE	+ 3.71	+ 3.45	+ 3.00	+ 2.10	+ 1.47	- 0.30
SEQUESTRO (EFFETTO DI MITIGAZIONE)	0	-0.26	-0.71	-1.61	-2.24	-4.02

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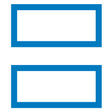
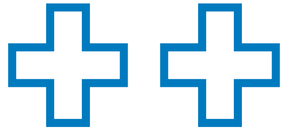
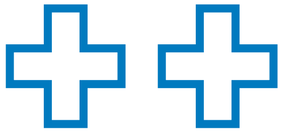
Conclusioni

- **Lavorazioni del suolo ridotte**  **solo con input SO, altrimenti** 
- **Residui colturali** 
- **Fertilizzazione organica** 
- **Cover crop**  **in alternativa, doppia coltura nell’anno**

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Grazie per l’attenzione

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