Soil organic carbon (SOC) storage over 17 years of organic and conventional farming in central India

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Introduction

Organic farming is advocated to sustain soil fertility and increase carbon storage in intensively managed temperate soils. However, there is limited understanding about soil organic carbon (SOC) storage in clay-rich sub-tropical soils.

Aim

(i) Compare SOC storage over 17 years between **organic** and **conventional** farming systems
(ii) Link **SOC** changes to **cotton yield** and farming practices
(iii) Assess how **physiochemical** soil properties influence SOC build-up

Highlights

Implications:

1. Organic farming practices sequesters more carbon than conventional
2. Conventional systems' higher cotton yield may rely on external inputs (higher N, FYM, and Urea) as SOC doesn't correlate with yield

Organic Farming | SOC correlated with cotton yield

Conventional Farming | SOC uncorrelated with cotton yield

SOC ~ 4 mg g^{-1} increase in SOC after 10+ years

SOC ~ 2 mg g^{-1} increase in SOC after 10+ years

pH Both systems indicate a slightly alkaline soil pH, with fluctuations likely due to changes in input.

Bulk density appears independent of applied management systems

Materials and methods

Study site

Sub-tropical, semi-arid climate, 800 mm rainfall. Sampled in March during dry season, temperature ~36°C. Vertisols in the Narmada belt.

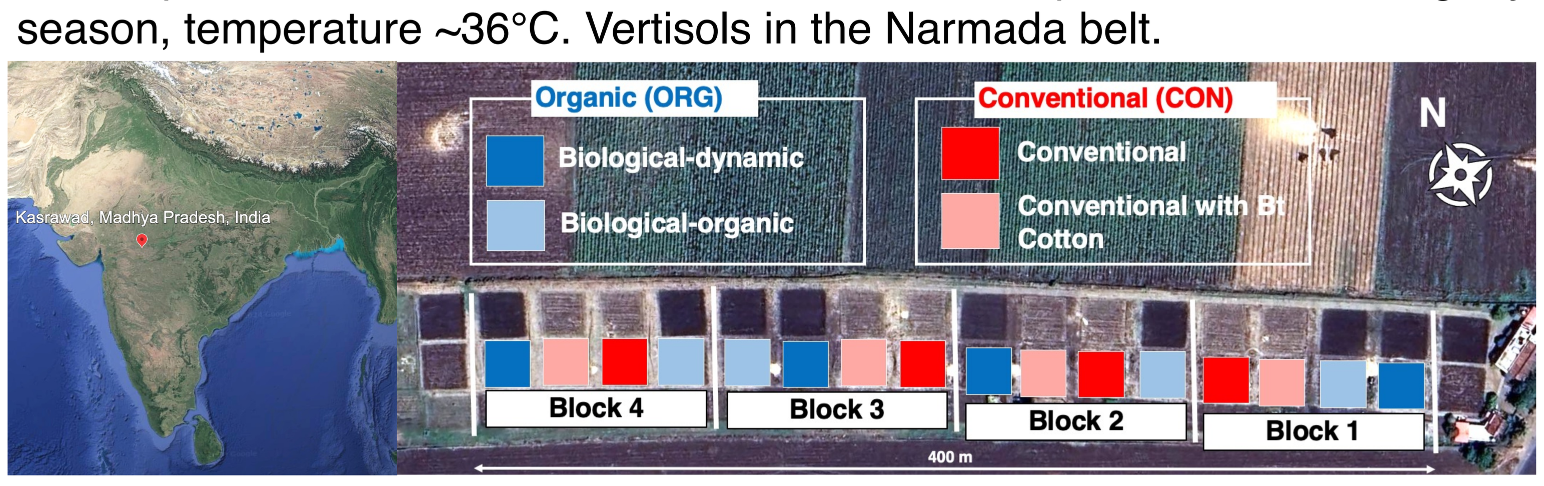


Fig 1: The randomized block design of two organic systems and two conventional systems of the long-term trial by FiBL and BioRe in Madya Pradesh, India (modified based on Google Earth). Each plot is 256 m^2 .

Long-term system comparison

- **2007**: FiBL and BioRe initiated trial (year 0)
- **2024:** Fresh and archive samples collected (year 17)
- **Crop rotation**: 1st year: cotton, wheat 1. 2nd year: soybean, chickpea/wheat 2
- **Annual Inputs⁺:**

Chickpea replaced Wheat 2 in organic systems since year 12 (9.25 t ha^{-1} Compost)

	Cotton		Wheat 1		Soybean		Wheat 2	
	ORG	CON	ORG	CON	ORG	CON	ORG	CON
Compost [t ha^{-1}]	13.8	NA	11.6	NA	4.3	NA	10.3	NA
N input [kg ha^{-1}]	100	175	70	150	30	30	50	150
	Year 1				Year 2			

+ 7.1 t ha^{-1} of farmyard manure applied every 2nd year to conventional systems from Year 0 – 11

Soil analysis

- **Elemental analyser**: Total C (combustion), Inorganic C (muffled samples)
- **FiBL data**: Bulk density, pH and cotton yield
- **Size fractionation**: SOC in particulate and mineral-associated and SOM

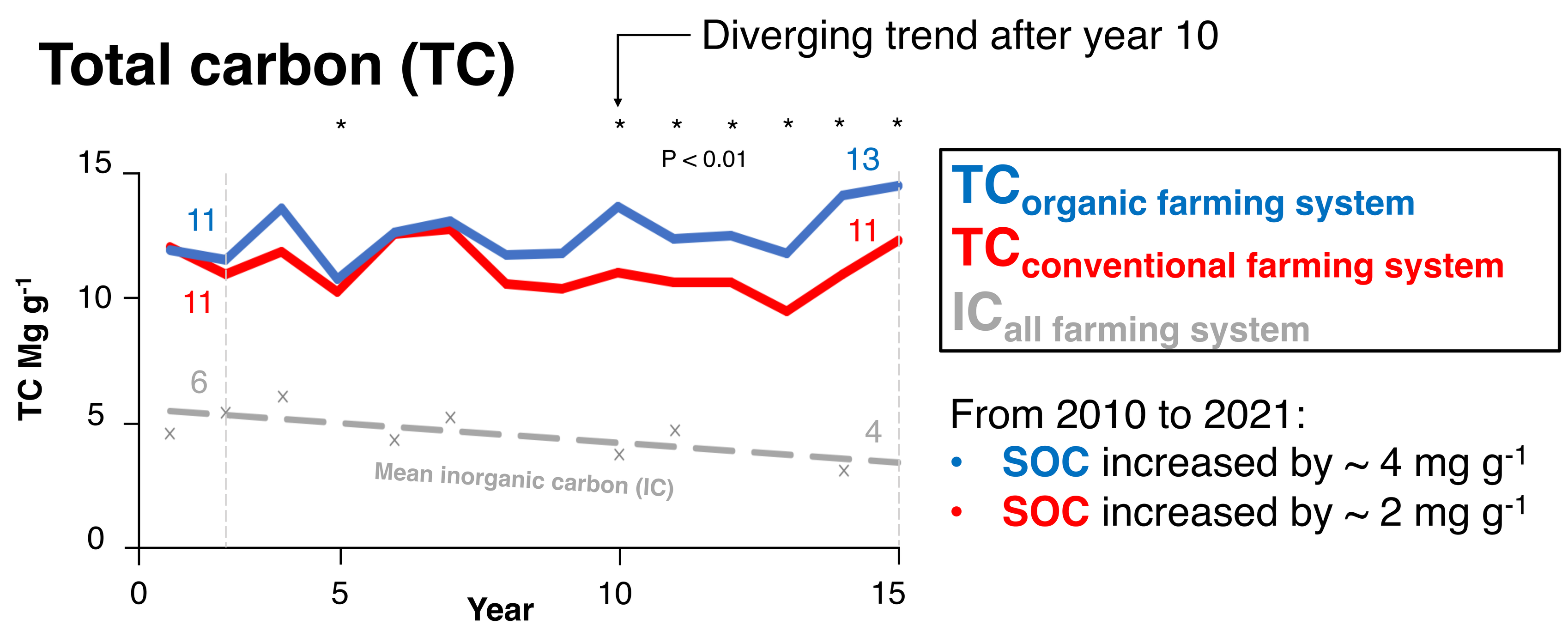
Acknowledgements

We thank the foundation fiat panis for financial support.

This work has been conducted in the framework of long-term systems comparisons program, which is financially supported by Biovision foundation, Coop Sustainability Fund, Liechtenstein Development Service (LED) and the Swiss Agency for Development and Cooperation (SDC).

Results

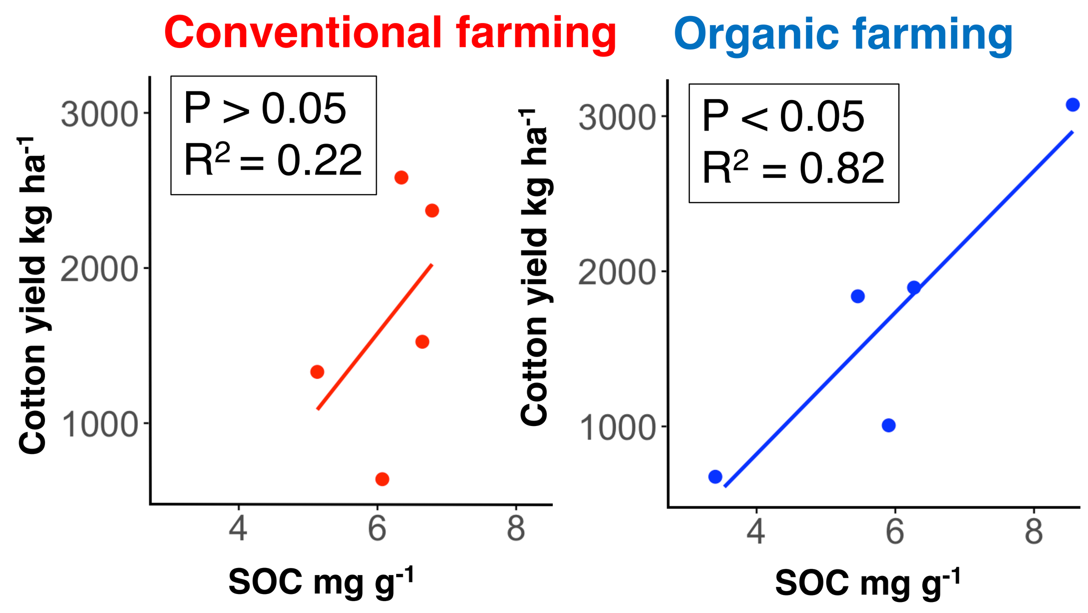
Total carbon (TC)



From 2010 to 2021:
- **SOC** increased by ~ 4 mg g^{-1}
- **SOC** increased by ~ 2 mg g^{-1}

Fig 2: Total carbon (mean, [mg g^{-1}], n=8) across a 14-year timespan under **organic** (blue) and **conventional** (red) farming systems. Mean Linear estimate for Inorganic Carbon (IC) (grey) for all treatments

Soil organic carbon (SOC) and cotton yield

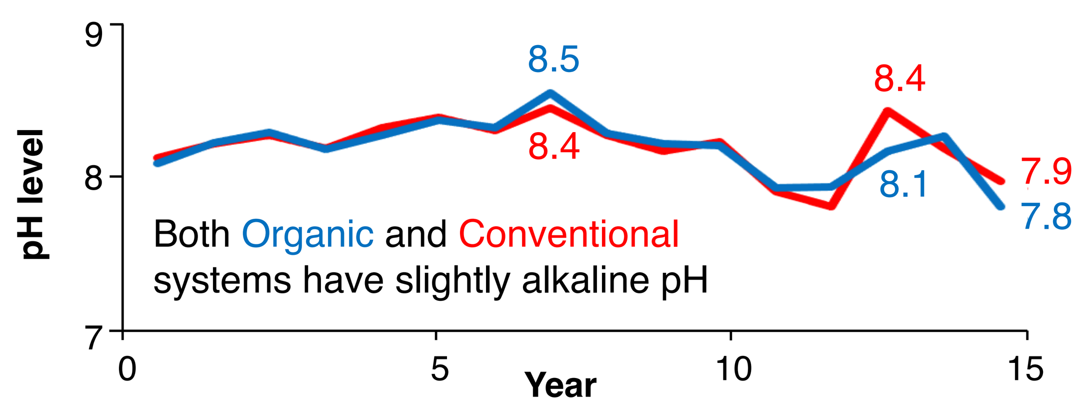


SOC: Weak correlation
- 22% yield variability explained by SOC

SOC: Strong correlation
- 82% yield variability explained by SOC
- Each **1 mg g^{-1}** increase in SOC predicts a **456 kg ha^{-1}** rise in cotton yield

Fig 3 & 4: Correlation between soil organic carbon (mean, [mg g^{-1}]) and cotton yield (mean, [kg ha^{-1}]) from 0-40cm soil depth for years 2010, 2011, 2015, 2019 and 2022.

Soil pH changes over time



- Relatively stable pH level till year 10
- Fluctuating between year 10 and 15, possibly due to management changes

Fig 5: Soil pH levels from 2007 to 2023 in **organic** (blue) and **conventional** (red) farming systems.

Bulk density

- Soil characterized by shrinking and swelling, creating dynamic soil structure
- Lower bulk density in organic farming may relate to higher SOC (years 12 & 17)

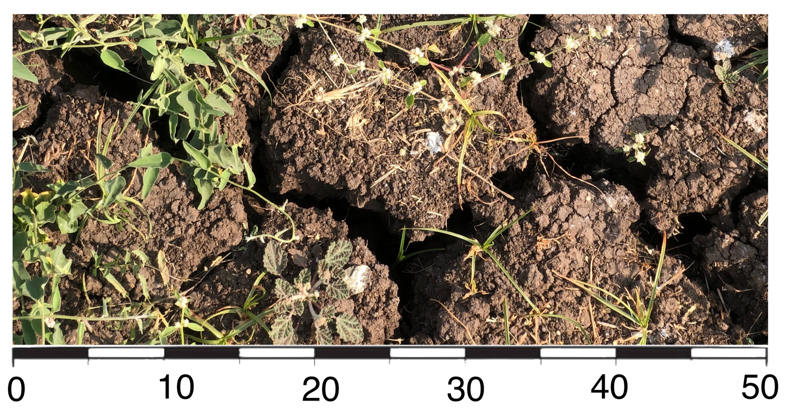


Fig 6: Exemplary image of crack surfaces seen throughout plot site.

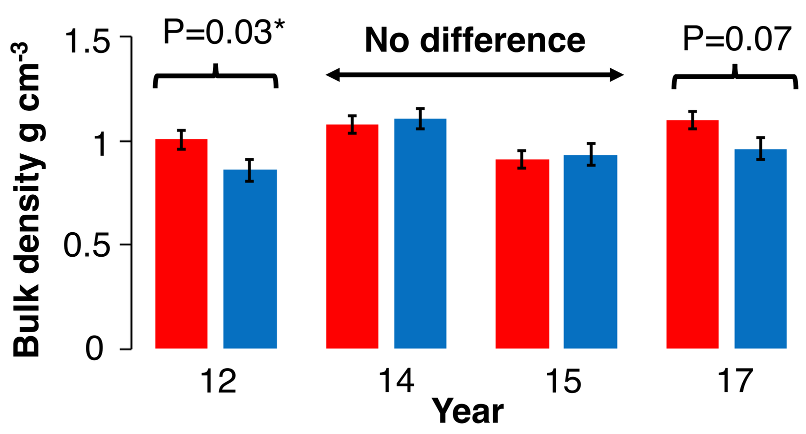
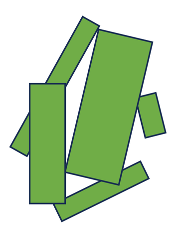


Fig 7: Bulk density (mean [g cm^{-3}] ±SD) for **organic** and **conventional** farming.

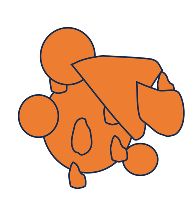
Next steps

Determine **SOC** storage in **particulate (POM)** and **mineral-associated (MAOM)** soil organic matter pools to enable further insights about soil organic matter build-up.



Particulate organic matter

- Plant derived litter particles
- > 20 μm
- **Short-term carbon pool** (1-50 years)
  - Rapid turnover rate



Mineral-associated organic matter

- More microbially processed residues
- < 20 μm
- **Long-term carbon pool** (10-1000 years)
  - Slow turnover rate