Leguminous green manure can drive the stabilisation of the increased soil organic carbon on dryland

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Modern intensive cropping system induced high emission of greenhouse gases.
Background

What's the connection between changing climate and crop yield?

- Global yield decreased by 3.8%
- Global yield decreased by 5.5%

Source: Internet

Lipper et al., 2014 *Nature Climate Change*
Background

How to balance the demand for food and better environment?
Background

The cropland SOC in both China and Canada is increased through better field management.
Background

- Summer fallow-winter wheat rotation is widely applied;
- Low soil fertility and high synthetic N rate;
- Rich heat and precipitation in summer

High N content, low C/N

No synthetic N is required

SOC sequestration

Synthetic N reduction

- Maintain productivity of the cropland soils;
- Mitigate the environmental impacts due to crop production;
- Propel sustainable development of agriculture.

Source: Chinese National Geography
Background

Background

The stability of OC

Low

Coarse POC

Fine POC

The stability of OC

High

OC associated with free microaggregate or microaggregate within macroaggregate.

OC associated with silt and clay.

OC associated with macroaggregates.

Beneficial effects

The OC associated with silt+clay and microaggregate are considered as **physicochemically protected** C.
Experimental design

### Split-plot design

#### Sub treatments

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#### Main treatments

- **Mung bean** (*Vigna radiata* (Linn.) Wilczek)
- **Huai bean** (*Glycine soja* Sieb. et Zucc)
- **Fallow**
- **Soybean** (*G. max* (L.) Merr.)

No synthetic fertilizer for LGM while synthetic N and P are applied as basal fertilizers before wheat seeding.

- **Synthetic NP**
- **Fallow**
- **Wheat growing period**
- **Early Sep.** — Green manure incorporation
Experimental design

100g bulk soil pass 8 mm sieve

- Large macroaggregate: >2 mm
- Small macroaggregate: 0.25-2 mm
- Microaggregate: 0.053-0.25 mm
- Silt+clay: <0.053 mm

- Wet sieving
- Wet sieving with glass beads
- Microaggregate within macroaggregate
- Density flotation 1.85 g cm\(^{-3}\) NaI

Elliot, 1986; Six et al., 1998; Six et al., 2000

* Sub fractions
Results

- The LGM only affected the soil particle mass distribution at the 0-10 cm soil.
- Huai bean was efficient in increasing the GMD and MWD.

**Fig. 1** Geometric mean diameter and mean weight diameter of the soil at the 0-10 and 10-20 cm soil layers.
Results

Fig. 2 Organic carbon concentration of cPOC, fPOC, iPOC and MOC for free microaggregate (a), small macroaggregate (b) and large macroaggregate (c) at the 0-10 and 10-20 cm soil layers.

- The OC concentration of iPOC in microaggregate was the highest.
- LGM increased the OC concentration of iPOC and MOC in different soil layers.
- For all aggregates, the OC concentration of fPOC was not increased due to the incorporation of LGM.
Results

acellular OC content of different fractions at the 0-10 and 10-20 cm soil layers and the contribution of different soil particles to MOC and iPOC (pie chart).

- LGM increased the OC content of iPOC and MOC in the bulk soil.
- LGM also tended to increase fPOC+cPOC in the bulk soil.
- All aggregates made important contributions to iPOC and MOC while small macroaggregate was the main contributor.
Results

Fig. 4 Total OC content changes of different fractions and their contribution to the total changes of the SOC in the bulk soil (sunburst chart) at the 0-10 and 10-20 cm soil layers due to including LGM in the cropping system.

❖ Protected C (iPOC+MOC) accounted for 69-86% of the increase of the SOC.
❖ The contribution of both iPOC and MOC was important to the increased SOC.
Results

Fig. 5 Correlation matrix of OC content among different fractions and the correlation between the content change of SOC and protected/unprotected OC at the 0-10 (a) and 10-20 cm soil (b).

❖ The SOC of the aggregates were closely related to the corresponding OC content of iPOC and MOC.
❖ The changes of protected C were significantly correlated with the changes of SOC in the bulk soil.
The protected C accounts for 69-86% of the increased SOC.

MOC and iPOC from free microaggregates and microaggregate within macroaggregates

MOC from bulk soil and macroaggregates
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