Impacts of Agricultural Practices on Soil Carbon

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Soil carbon content

Intensive Ag management change begins

Management Changes

Soil improving practices

Soil degrading practices

• Cropland C-Stock in soil
• Management can +/- C stocks
• Magnitude and longevity of C-stock changes are environment and difference sensitive
• Subject to future management changes

(Hristov et al., 2018 – SOCCR2)

Based on Wilhelm et al., 2010

USDA-ARS

Begins

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USDA-ARS
Management choices can cause Ag. practices that leave the land exposed, providing inadequate carbon inputs. This can lead to:

- Compaction & crusting
- Reduced plant growth
- Decrease potential future yield
- Impair soil biology
- Accelerate water & wind erosion
- Degradation of structure & aggregation
- Reduction of soil carbon and soil productivity.
Tillage: erosion and carbon-loss
Build Climate Resilient Healthy Soil

Increase soil carbon
Increase soil biology and function
Improve resilience to Water & wind erosion

Increase yield potential
Improve infiltration
Enhance soil structure & aggregation

Increase Plant and belowground diversity

Conservation-restorative practices, “Climate Smart”, CRP, cover crop, perennials

Or Agricultural Practices can..
**Example: empirical study**

### Rotation history and sampling, all no tillage

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A = Alfalfa, BBS = Big Bluestem, C = corn, SW = Switchgrass, S = Soybean, W = spring wheat.
Soil sampling, GHG sampling occurred all four seasons, crop residue and grasses harvested annually
Study found

• SOC stocks (0-5 cm; P≤0.05) increased under the perennial grasses and in the W+A/A/A rotation but not deeper in the profile.

• SOC storage (10-years) under perennial may not be adequate to offset fertilizer induced N₂O emission.

• N management refinement needed to optimize grass biomass production and minimize N₂O emission.

Johnson and Barbour, 2018
Agricultural management practices for croplands

- **Conservation/ no tillage:**
  - $0.40 \pm 0.61 \text{ Mg C ha}^{-1} \text{ year}^{-1}$ (n=44, average depth 30 cm Midwest USA Johnson et al., 2005)
  - $0.58 \pm 0.71 \text{ Mg C ha}^{-1} \text{ year}^{-1}$ (Eastern USA, n=37; 21 cm, Dell and Novak, 2005)
  - Reduced/No tillage increased SOC stock ~19% (subtropical and tropical soils N= 420, Das et al., 2022)
  - No tillage – without out residue retention less effective at SOC retention (Xiao et al., 2021)
Mean differences SOC stocks in ag. soils according to tillage system, crop frequency and use of legumes as compared pretreatment baselines in the cumulative 0-100 cm soil layer. Meta-Analysis – from 121 studies, 19 countries, 6 continents. Nicoloso and Rice 2021 SSSAJ
Residue management –

- Residue retention promotes C accumulation (Li et al., 2020)
- Harvesting <50% corn residue reduced C-stock loss (Xu et al., 2019)
Crop rotation and cover crops

- Corn provides high plant C-stocks (Mathew et al., 2020)
- Perennials and cover crops > grain only or grain + legume (King and Blesh, 2018)
- Cover crop benefits modulated by type, soil, and climatic
  - 0.32 ± 0.08 Mg C ha⁻¹ year⁻¹; n=139, 37 sites (Poeplau and Don, 2015)
  - 15% increase tropical/subtropical n=248 (Das et al., 2022)
  - Impact on N₂O – equivocal n=106; 26 studies (Basche et al., 2014)
Agricultural management practices

- Residue management –
  - Residue retention promotes C accumulation (Li et al., 2020)
  - Harvesting <50% corn residue reduced C-stock loss (Xu et al., 2019)
  - Harvesting maize residue tended to decrease N\textsubscript{2}O emission (Jin et al., 2014 Bioenergy Res.)
  - Meta-analysis N\textsubscript{2}O increased but nitrate leaching decreased w/residue retention (n=178, temperate soil Li et al., 2021)
Concluding comments

- Empirical studies one-step in the process
- Aggregated via-meta-analyses – expand understanding among regions, environment
- Models, Life-cycle analyses rely on solid studies to inform, validate and calibrate
- Goal – Agricultural practices that provide food, feed, fiber and fuel while increasing soil carbon and healthy resilient soils - for today and tomorrow
Acknowledgements

- Thank-you the organizers for the invitation and opportunity to present.
- Thank-you for your attention
Additional resources


