Soil Organic Carbon Sequestration during 12 Years of Poultry Litter Application to Pasture in the Southern Piedmont USA

Alan J. Franzluebbers
USDA–Agricultural Research Service
Watkinsville GA
Tel: 706-769-5631, Email: afranz@uga.edu

John A. Stuedemann
USDA–Agricultural Research Service (retired)
Watkinsville GA
Email: jstuedem@uga.edu

RATIONALE

Grass-based agricultural management systems have great potential to sequester soil organic C, because of:

- undisturbed soil surface
- perennial nature of many plant species
- long growing season of mixed species
- deep and long-lasting rooting system
- efficient water utilization and conversion of CO_2

Long-term, time-series estimates of soil organic C sequestration in pastures are limited, but needed to improve our understanding of management influences on greenhouse gas emissions and soil quality.

OBJECTIVE

Determine soil-profile changes in organic C during 12 years of 'Coastal' bermudagrass and 'Georgia 5' tall fescue management.

METHODS

Environmental characteristics

- Southern Piedmont Major Land Resource Area
- 16.5 °C - mean annual temperature
- 1250 mm - mean annual precipitation
- 1560 mm - mean annual pan evaporation
- Cecil-Madison-Pacolet dominated soils (fine, kaolinitic, thermic Typic Kanhapludults)
- Severely eroded site following decades of tilled cropping

Management variables

- Fertilization regime
  - *Phase I (1994-1998)* - all supplying 200 kg N · ha^{-1} · yr^{-1} to bermudagrass (*Cynodon dactylon*; grazed in summer)
    - (a) inorganic only
    - (b) crimson clover (*Trifolium incarnatum*) + inorganic
    - (c) broiler litter
  - *Phase II (1999-2005)* - all supplying 270 kg N · ha^{-1} · yr^{-1} to tall fescue (*Lolium arundinaceum*)/bermudagrass mixture (grazed year-round)
    - (a) inorganic only
    - (b) low broiler litter (1x) + inorganic
    - (c) high broiler litter (3x)
- Forage harvest strategy
  - (a) unharvested (CRP simulation)
  - (b) low grazing pressure (4 Mg ha^{-1} of available forage)
  - (c) high grazing pressure (2 Mg ha^{-1} of available forage)
  - (d) hayed monthly
- 3 replications in a split-plot factorial arrangement of fertilization (main plot) and harvest strategy (split plot)

Sampling

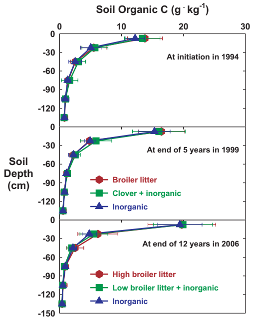
- Soil sampled vertically to a depth of 150 cm in 30 cm increments:
  - (a) at initiation (1994)
  - (b) at end of 5 years (1999)
  - (c) at end of 12 years (2006)
- Soil sampled horizontally in 3 zones:
  - (a) 5 m from shade/water
  - (b) 30 m from shade/water
  - (c) 80 m from shade/water

Thanks to Our Technical Support

Steve Knapp, Dwight Seman,
Eric Elsner, Kim Lyness,
Robert Martin, Ronald Phillips,
Stephanie Steed, Clara Parker,
Heather Hart, Terri Cameron,
David Lovell, Fred Hale

RESULTS

1. Fertilization regime had no effect on soil organic C (SOC), either at the end of 5 years or 12 years. Depth distribution of SOC was highly stratified and became more stratified with years of pasture management.

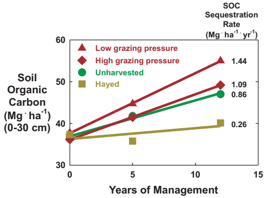


2. Sampling variation increased with depth in the soil profile.

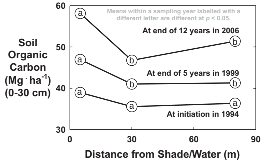
Residual coefficient of variation (%) of SOC concentration by depth and year of sampling.

Depth (cm)	0 years	5 years	12 years
0-15	16	18	17
15-30	28	35	41
30-60	29	34	41
60-90	52	33	40
90-120	47	34	85
120-150	25	28	65

3. Forage harvest strategy greatly affected SOC sequestration during 12 years of management.



4. Cattle grazing caused redistribution of SOC within pastures.



5. Detecting a difference in SOC depended upon sampling depth.

Mean rate of SOC sequestration (Mg ha^{-1} yr^{-1}) during 12 years as affected by harvest strategy and sampling depth.

Depth (cm)	Harvest Strategy H	HGP	LGP	UH
0-15	0.28 *	1.14 ***	1.34 ***	0.85 ***
0-30	0.26	1.09 ***	1.44 ***	0.86 ***
0-60	0.18	0.83 ***	1.31 ***	0.79 **
0-90	-0.28	0.60 *	1.10 ***	0.69 *
0-120	-0.47	0.45	0.97 ***	0.57 *
0-150	-0.59	0.29	0.86 ***	0.42

H is hayed, HGP is high grazing pressure, LGP is low grazing pressure, and UH is unharvested. *, **, and *** indicate $p \leq 0.1$, 0.01, and 0.001, respectively.

6. Sequestration of SOC occurred at the soil surface, but loss of SOC was observed deep in the soil profile.

Mean rate of SOC change (Mg ha^{-1} yr^{-1}) during 12 years by depth increment as affected by forage harvest strategy.

Depth (cm)	Harvest Strategy H	HGP	LGP	UH
0-15	0.28 *	1.14 ***	1.34 ***	0.85 ***
15-30	-0.02	-0.05	0.10	0.02
30-60	-0.24 *	-0.26 **	-0.13	-0.07
60-90	-0.30 ***	-0.23 ***	-0.21 **	-0.11 *
90-120	-0.19 ***	-0.15 **	-0.13 ***	-0.12 **
120-150	-0.12 ***	-0.15 ***	-0.11 ***	-0.15 ***

H is hayed, HGP is high grazing pressure, LGP is low grazing pressure, and UH is unharvested. *, **, and *** indicate $p \leq 0.1$, 0.01, and 0.001, respectively.

IMPLICATIONS

1. Broiler litter contributed no SOC advantage over other fertilization strategies, at least within a decade of agronomic application (ca. 2 Mg C ha^{-1} yr^{-1}) to pasture.
2. Increasing variability in SOC concentration with depth in the soil profile limits our ability to detect sequestration of SOC.
3. How pastures are managed can greatly influence surface accumulation of SOC.
4. Pastures grazed by cattle can lead to SOC sequestration, but redistribution of SOC within the pasture can be expected due to animal behavior.
5. Significant SOC sequestration in pastures can be expected within the typical rooting zone (0-90 cm).
6. Loss of SOC may occur deep in the soil profile, perhaps as a result of a legacy effect from previous land use.

Presented at the Fourth USDA Greenhouse Gas Conference, 6-8 February 2007, Baltimore MD