Profile Soil C and N after 25 Years of Tillage and Soil Amendments

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Introduction

- Soil organic carbon (SOC) and N (SON) in agricultural soils are affected by anthropogenic activities.
- Soil can be a sink or source of atmospheric CO_2 depending upon management.
- Maintaining soil quality is critical to the conservation of the soil resources which is rapidly declining due to the use of unsustainable production practices.
- Adoption of sustainable soil intensification practices such as reduced tillage, and the use of organic and inorganic inputs can potentially improve soil quality.
- Benefits of improved soil quality include reduced greenhouse gas emissions, increased microbial activity, water conservation, reduced cost of production and retention of soil C and N.

Objective

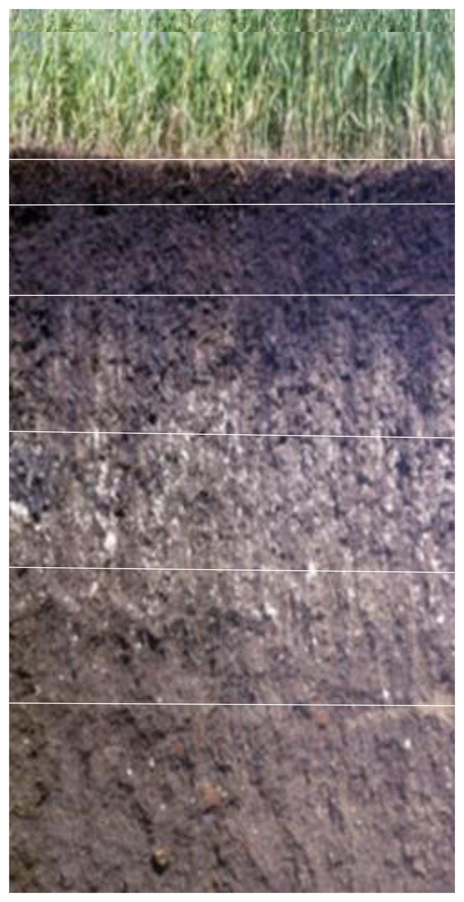
- To assess SOC and SON as affected by tillage and nitrogen source after 25 years

Materials and Methods

- Location: Agronomy North Farm, Manhattan, KS
- Soil Type: Kennebec silt loam
- Experimental Design: Randomized complete block (RCB) in a split plot design initiated in 1990

Treatments

- Main plot: Tillage Systems
  - No-tillage (NT)
  - Conventional tillage (CT) chisel/disk
- Sub plot: N source: commercial N (urea) and organic N
  - Control no N added (C)
  - Compost (OF) (168 kg N ha^{-1})
  - Fertilizer (MF) (168 kg N ha^{-1})
- Soil profile was sampled to a depth of 0-90 cm (1992 and 2014)



cm
0-5 Ap
5-15 Ap
15-30 A
30-45 C
45-60 Ab
60-90 A/Eb –A'b

Fig. 1: Profile of soil at study site

- SOC and SON by dry combustion and soil bulk density
- Soil $\delta^{13}C$
- Stock change in SOC and SON and their rates
- Statistical analysis was done using procmixed in SAS 9.4 at P < 0.1, means separated by Tukey HSD.

Table 1: Analysis of Variance (ANOVA) table

ANOVA	∆ SOC stock (Mg ha^{-1})			∆ SON stock (Mg ha^{-1})		
Depth	0-30cm	0-60cm	0-90cm	0-30cm	0-60cm	0-90cm
Tillage (T)	**0.0751**	0.0504	0.3235	**0.0072**	**0.09**	0.2959
Source (N)	**0.0544**	**0.0175**	0.1288	**0.0377**	**0.0297**	0.2161
TXN	0.1262	0.4982	0.9869	**0.0626**	0.405	0.9302
ANOVA	∆ SOC stock rate (Mg ha^{-1}yr^{-1})			∆ SON stock rate (Mg ha^{-1}yr^{-1})		
Depth	0-30cm	0-60cm	0-90cm	0-30cm	0-60cm	0-90cm
Tillage (T)	**0.0777**	**0.0502**	0.3235	**0.0777**	**0.0502**	0.3235
Source (N)	**0.0556**	**0.0175**	0.1288	**0.0556**	**0.0175**	0.1288
TxN	0.1278	0.4979	0.9869	0.1278	0.4979	0.9869

Results and Discussion

Soil organic C (SOC) and N (SON) stock change and rates

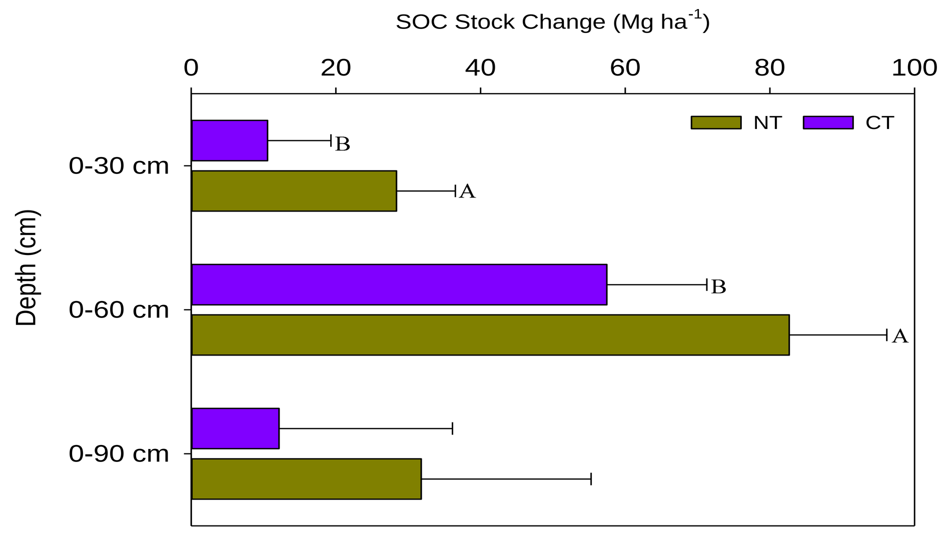


Fig. 2. Soil organic C (SOC) stock change as affected by tillage systems

- SOC stock change was greater with NT compared to CT after 25 years of management

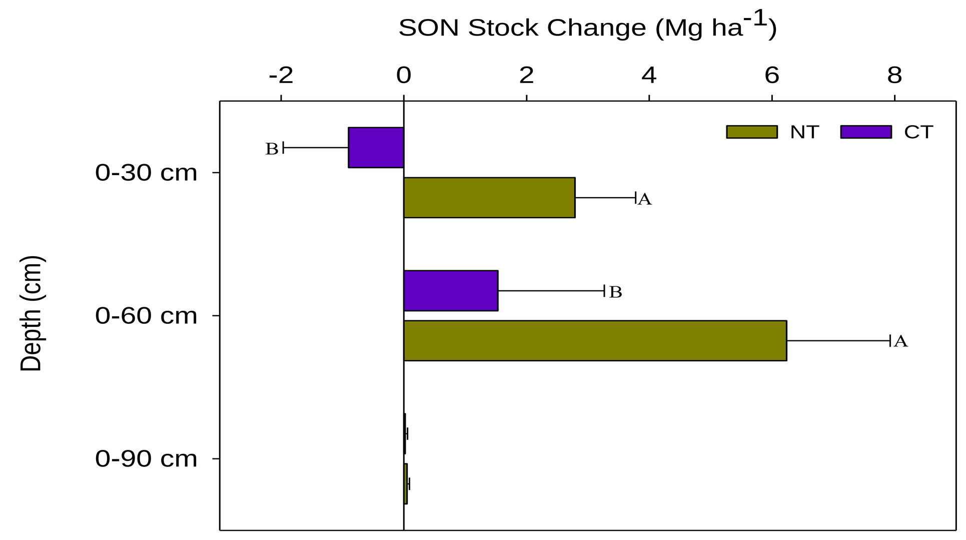


Fig. 3. Soil organic N (SON) stock change as affected by tillage systems

- SON stock change was significantly increased with NT compared CT at 0-30 and 0-60. At 0-30 cm, CT lost some SON due to mining N by roots and excessive tillage.

Table 2. Soil organic C and N rate of change as affected by tillage systems

Depth (0-90 cm)	∆ SOC stock rate (Mg ha^{-1}yr^{-1})			∆ SON stock rate (Mg ha^{-1}yr^{-1})		
Tillage	0-30cm	0-60cm	0-90cm	0-30cm	0-60cm	0-90cm
NT	1.2	3.6 a	1.4	0.05 a	0.14 a	1.1
CT	0.46	2.5 b	0.53	0.02 b	0.10 b	-3.6

- Greater SOC sequestration rate was found under NT (3.6 Mg C ha^{-1} yr^{-1}) compared to CT (2.53 Mg C ha^{-1} yr^{-1}).
- SON sequestration rate was greater for NT. At 0-90 cm depth CT lost SON at -3.6 Mg N ha^{-1} yr^{-1}

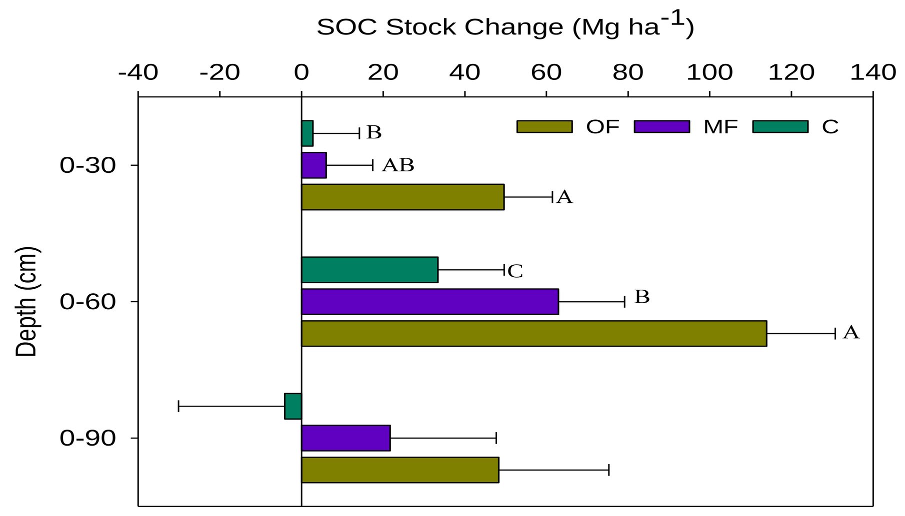


Fig.4. Soil organic C (SOC) stock change as affected by different nitrogen sources

- Compost (OF) sequestered the highest SOC while the control had the least (0-30 and 0-60 cm) and with some SOC lost in 0-90 cm.

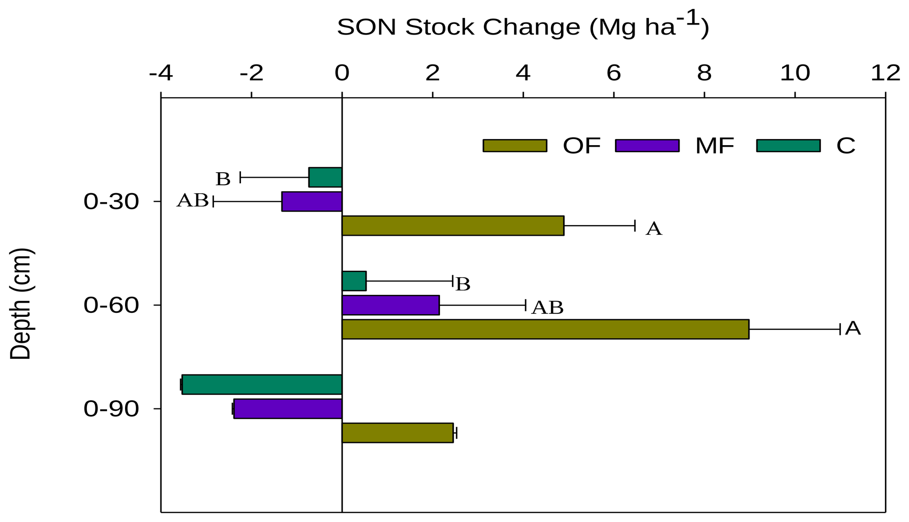


Fig.5. Soil organic N (SON) stock change as affected by different nitrogen sources

- SON stock significantly increased with the use of compost (OF) compared to the other treatments. However, decreased SON stock was observed in the MF and C in the 0-90 cm.

Results and Discussion (cont.)

Table 3: Soil organic C (SOC) and N (SON) stock rate as affected by N sources

Depth (0-90 cm)	∆ SOC stock rate (Mg ha^{-1}yr^{-1})			∆ SON stock rate (Mg ha^{-1}yr^{-1})		
Tillage	0-30cm	0-60cm	0-90cm	0-30cm	0-60cm	0-90cm
OF	2.2 a	5.0 a	2.1	0.09 a	0.2 a	0.08
MF	0.3 ab	2.7 ab	0.94	0.01ab	0.11 ab	0.04
C	0.12 b	1.5 b	-0.18	0.00 b	0.06 b	-0.01

- Compost (OF) significantly increased SOC and SON stock sequestration compared to the control at 0-30 cm and 0-60 cm. The control lost some SOC and SON at 0-90 cm.

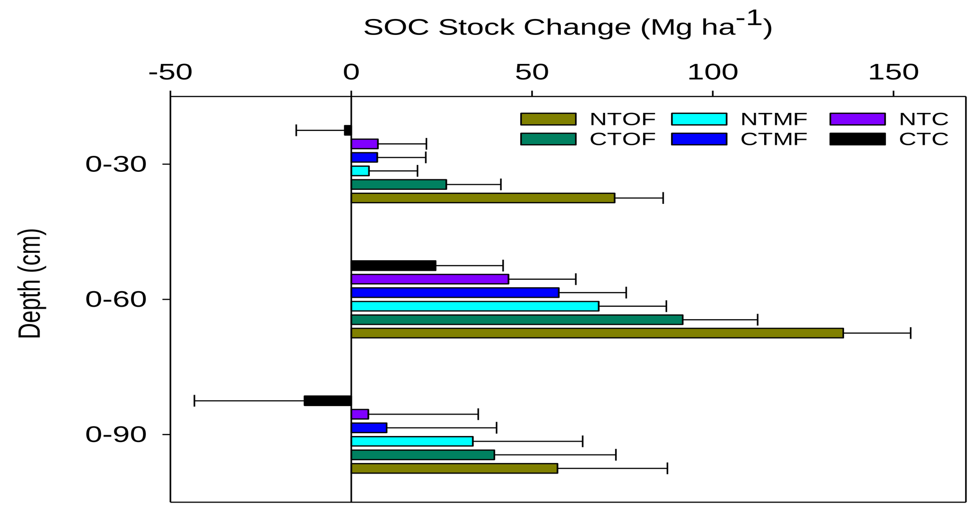


Fig.6. Interaction effect of tillage and N sources on SOC stock change

- Greater SOC stock change was observed in NTOF followed by CTOF, while CTC lost some SOC(Fig.6) after 25 years.

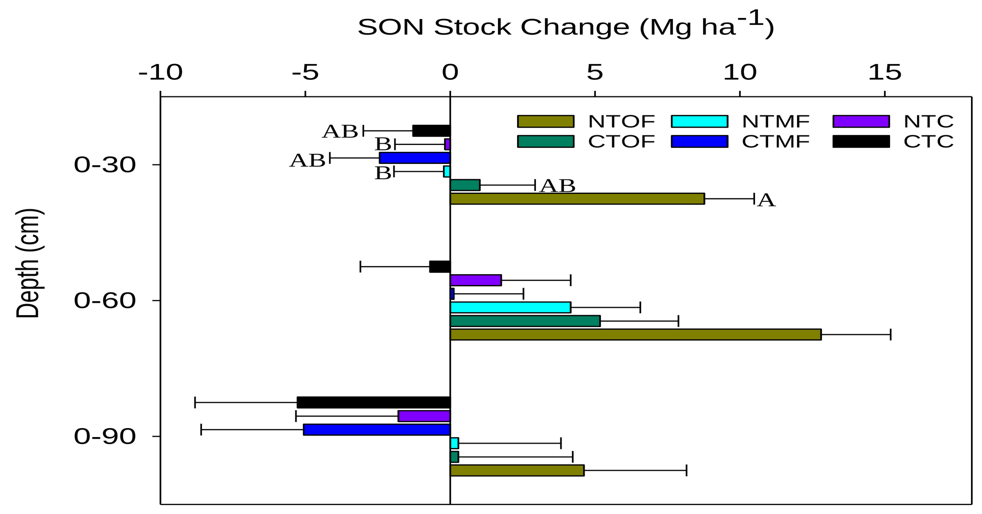


Fig.7. Interaction effect of tillage and N sources on SON stock change

- SON stock change was significantly increased with NTOF in the 0-30 cm depth due to the interaction effect of tillage and N sources (Fig 6.). However, NTC, NTC and CTM generally lost SON at 0-30 and 0-90 cm (Fig. 7.)

Table 4: Interaction effect of tillage and N sources on SOC and SON stock rates

Depth (0-90 cm)	∆ SOC stock rate (Mg ha^{-1}yr^{-1})			∆ SON stock rate (Mg ha^{-1}yr^{-1})		
Interaction effect	0-30cm	0-60cm	0-90cm	0-30cm	0-60cm	0-90cm
NTOF	3.17	5.92	2.48	0.13	0.24	0.1
CTOF	1.14	3.99	1.73	0.05	0.16	0.07
NTMF	0.21	2.98	1.46	0.01	0.12	0.06
CTMF	0.32	2.5	0.42	0.01	0.1	0.02
NTC	0.32	1.89	0.2	0.01	0.08	0.01
CTC	-0.08	1.01	-0.56	0	0.04	-0.02

- No significant interaction of tillage systems and N sources on SOC and SON stock rate was observed although CTC lost soil C and N (Table 4)

Summary

- After 25 years of managements no-till and compost had the greatest impact on SOC and SON stocks.
- Depletion of SON observed under CT with or without mineral fertilizer was due to N mining by corn roots in the buried A horizons.

Acknowledgements

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