Influence of No-Till Practice on Soil Carbon Pools

A. Chatterjee

Department of Soil Science, North Dakota State University, Fargo, ND 58108-6050

UID: 99595

Objectives

1. Comparing changes in basic soil properties in between conventional (CT) and no-till (NT) practices
2. Differences in SOC under CT and NT at different soil depths of profile
3. Shift in surface SOC pools (active and resistant) under long-term CT and NT

Methods

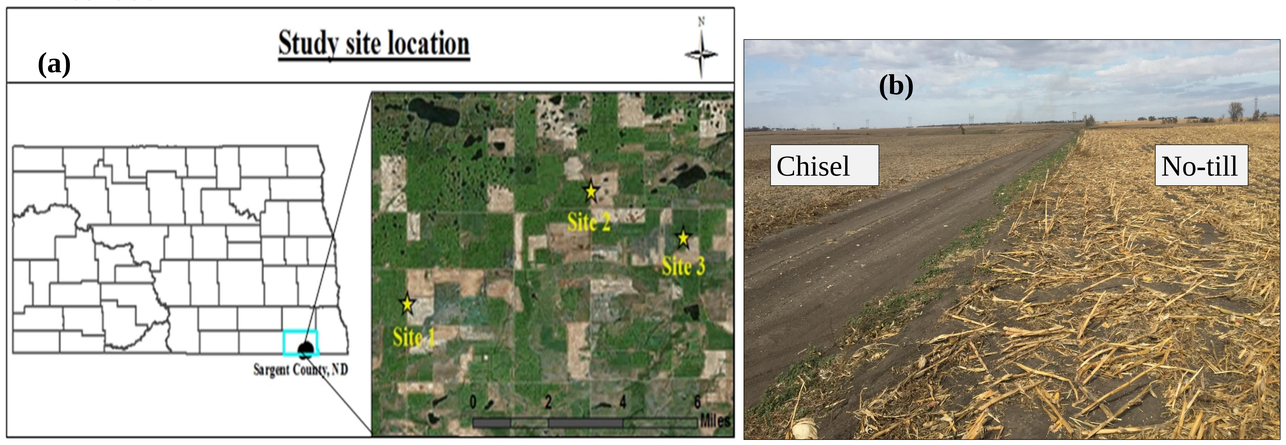

Figure 1. (a) geographic location of study sites, (b) Conventional tillage (left) and no-tillage (right) paired fields at site 2, Sargent County, ND.

- Three soil profile samples (90 cm) and bulk soil samples (0-10 cm) were collected from paired growers' field (Fig. 2) under long-term (>20 yr) chisel plough and no-till practices in southeast ND (Fig. 3).
- Bulk density (BD) of soil depth increments 0-15, 15-30, 30-60, and 60-90 were determined by dividing the oven-dry soil weight with soil core volume.
- Soil samples of each depth increment were processed-air-dried and 2 mm sieved and analyzed for soil organic carbon (SOC) and total nitrogen (N) using automated total CN analyzer
- For 86 days, soil samples of 0-15 cm depth were incubated in quart jars at 50% water holding capacity at 25°C and soil CO_2 efflux was measured using gas chromatograph (Dani-Master GC, Dani Inc., Italy).
- Using three pool constrained model (Paul et al. , SOC pool was separated into (1) active(C_a), (2) slow (C_s) and (3) nonhydrolyzable or C_r pools (determined by digestion with 6M HCl, fractions).

$$C\ mineralization\ rate = C_a * k_a e^{(-ka*days)} + (C_{soc} - C_r - C_a) * k_s e^{(-ks*days)} + C_r * k_r * e^{(-kr*day)}$$

Soil organic C pool sizes (Ca, Cs and Cr) and turnover rates (ka and ks) were determined by the three pool constrained model using SAS PROC NLIN (ver. 9.4, SAS, 2013) separately for each jar. The Cs pool was calculated by subtracting Cr and Ca pools from Csoc. One-way ANOVA was conducted for each site using randomized complete block design with three replications. Treatment means were separated using Fisher's LSD test at 95% significance level. Statistical analysis was performed using PROC ANOVA (SAS 9.4, 2013).

Results

Table 1. Site and soil information of three paired fields of NT and CT

Site	Coordinates	No-till for	Tile	Soil Series	Tillage	Crop rotation	Sand	Silt	Clay	Textural Class
							g kg^{-1}			
1	45°58'10.4"N, 97°33'0.47"W	20 yr	Yes	Colvin-Borup Complex	CT	Corn-Soybean	274	451	275	Clay loam
					NT	Winter cereal-corn-soybean-flax/sunflower	407	394	200	Loam
2	45°59'54.6" N 97°28'43.8" W	36 yr	No	Aastad-Forman	CT	Corn-Soybean	278	447	275	Clay loam
					NT	Winter cereal-corn-soybean-flax/sunflower	242	446	313	Clay loam
3	45°59'11.4" N 97°26'35.5" W	20 yr.	Yes	Overly Bearden	CT	Corn-Soybean	382	369	250	Loam
					NT	Winter cereal-corn-soybean-flax/sunflower	292	433	275	Clay loam

Table 2. Basic soil chemical characteristics and nutrient availability within 0-15 cm depth of soils

Site	Treatments	pH(1:2.5)		EC		Inorganic N		Olsen-P		K	
				dSm^{-1}		kg ha^{-1}		µg g^{-1}			
1	CT	7.83	0.06^{A*}	0.77	0.03^{A}	28.4	18.1^{A}	10.3	1.53^{A}	267	55.9^{A}
	NT	7.57	0.06^{A}	0.39	0.08^{B}	23.0	7.45^{A}	11.3	2.52^{A}	232	34.6^{A}
	LSD (P=0.05)	0.29		0.27		31.9		8.96		138	
2	CT	7.77	0.06^{A}	0.79	0.05^{A}	17.07	11.3^{A}	41.3	13.5^{A}	343	36.0^{A}
	NT	6.63	0.78^{A}	0.34	0.11^{B}	14.14	2.66^{A}	45.7	21.9^{A}	375	33.0^{A}
	LSD (P=0.05)	2.07		0.25		17.4		63.4		101	
3	CT	8.00	0.01^{A}	0.46	0.09^{A}	16.04	4.56^{A}	29.3	7.64^{A}	269	35.9^{A}
	NT	7.53	0.15^{B}	0.54	0.18^{A}	13.30	4.02^{A}	33.0	14.9^{A}	313	43.1^{A}
	LSD (P=0.05)	0.38		0.69		12.4		54.5		77.0	

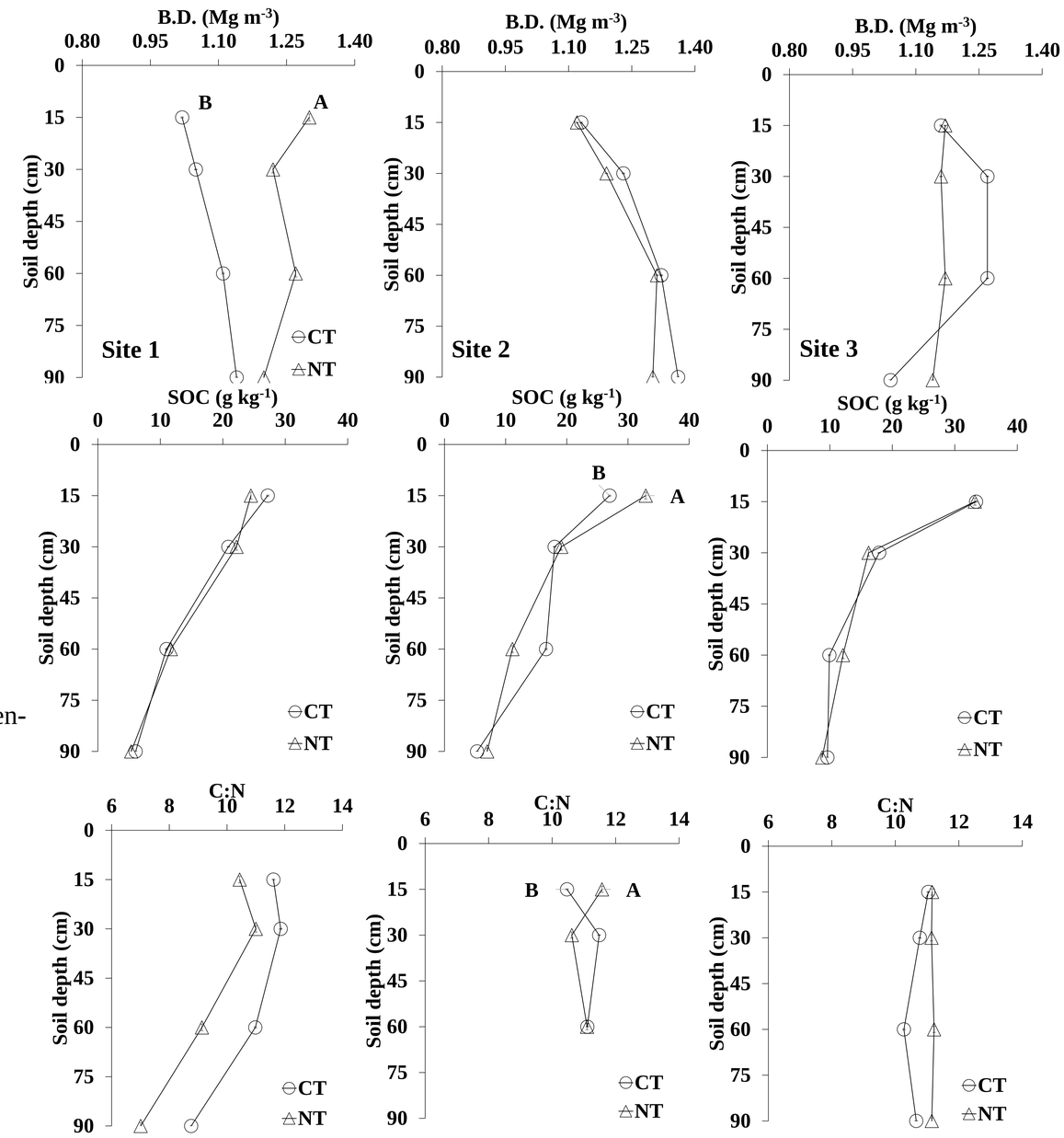

Figure 2. Changes in soil BD (Mg m^{-3}), SOC (Mg ha^{-1}), and C:N ration within 0-90 cm soil depth

Table 3. Changes in cumulative, C_a, C_s, and C_r pools their relative percent contributions to SOC, and mean residence time (MRT) of Ca (days) and Cs (years) within 0-15 soil depths in response to NT and CT

Site	Treatments	Cumulative	C_a	%C_a	Ca-MRT	C_s	%C_s	C_s-MRT	C_r	%C_r
		µg g^{-1}	mg g^{-1}		days	mg g^{-1}		Years	mg g^{-1}	
1	CT	224	0.11	0.40	4.41	17.1	59.6	33.9	12.0	40.0
	NT	323	0.19	0.68	3.23	19.2	70.8	25.0	8.27	28.5
LSD (P=0.05)		594	0.23	0.51	10.8	4.09	41.8	99.0	17.8	41.8
2	CT	247	0.13	0.48	5.52	15.7	59.7	25.7^{A}	10.5^{B}	39.8
	NT	309	0.11	0.35	1.53	17.1	52.6	15.3^{B}	15.2^{A}	47.0
LSD (P=0.05)		261	0.26	0.92	6.47	2.66	10.2	9.67	3.78	9.84
3	CT	185	0.15^{A}	0.44^{A}	8.63^{A}	18.8	54.6	99.0^{A}	15.4	44.9
	NT	167	0.08^{B}	0.25^{B}	3.44^{B}	15.3	46.4	32.5^{B}	17.6	53.4
LSD (P=0.05)		22.8	0.03	0.07	3.20	6.63	15.4	31.3	3.98	15.4

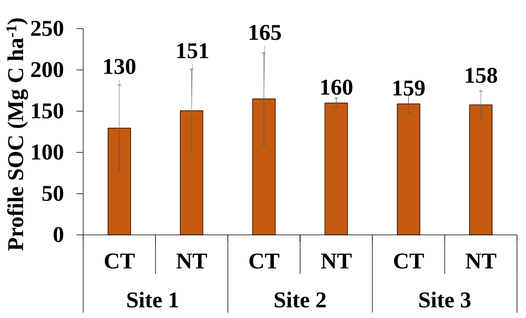

Figure 3. Soil Profile C (Mg ha^{-1}) of 90 cm depth under CT and NT practices

Conclusion

- Significant differences in SOC and its pools were limited within the surface 0-15 cm depth only.
- One out three sites showed significant increases in SOC and C:N ratio under NT than CT. However, profile SOC did not differ between NT and CT.
- Tillage had influence on distributions of biochemical SOC fractions derived from lab incubation study but the effect was not consistent across sites.
- For these sites, either no-till had no influence on SOC or other factors like soil texture and crop rotation had significant interactions with tillage and SOC to makeup the differences in SOC.