C AND N POOLS IN A BRAZILIAN OXISOL ACCORDING TO TILLAGE SYSTEMS AND N SOURCES

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Introduction

- ✓ Brazil is the fourth largest pig producer and exporter in the world. Recycling pig slurry as fertilizer is the usual fate of this waste in Brazil. Nonetheless, large pig farming operations are adopting biodigestion or composting for pig slurry treatment in response to more stringent environmental regulations.
- ✓ Biodigestion and composting affect recalcitrance and nutrient availability of organic fertilizers (Vivan et al. 2010; Angnes et al., 2014), impacting soil C/N dynamics (Grave et al., 2015; 2018).
- ✓ The application of pig slurry and cattle manure in NT soils was found to promote higher soil C accumulation rates in comparison with mineral fertilizers (Mafra et al., 2014; Nicoloso et al., 2016). However, the application of composted organic waste yield a larger soil C recovery in relation to soils amended with cattle manure (Nicoloso et al., 2016).
- ✓ Pig slurry is usually broadcasted at the soil surface under no-till (NT). However, the incorporation or injection of pig slurry into the soil was show to mitigate ammonia losses and increase grain yields (Aita et al., 2014).
- ✓ We thus assessed the effects of tillage and sources of N on soil C/N stocks in an Oxisol from Southern Brazil. Emphasis was placed to determinate changes on soil C/N pools and C/N concentration within soil aggregates.

Material and Methods

- ✓ The experiment was initiated in 2012 by introducing a maize (Zea mays L.) – black oat (Avena strigosa Scherb.) double cropping system in a grassland area. Lime (2 Mg ha^{-1}) was incorporated with disk plow.
- ✓ Soil was a Rhodic Kandiudox with 250, 460 and 290 g kg^{-1} of clay, silt and sand, respectively. Soil test characteristics (0-10 cm) in 2012 were pH-$H_2O_{(1:1)}$ 5.3, Al^{3+} 0.3 $cmol_c$ dm^{-3}, organic matter 39.0 g kg^{-1}, $P_{Mehlich-I}$ 6.6 mg dm^{-3}, $K_{Mehlich-I}$ 249.6 mg dm^{-3}, CEC 11.9 $cmol_c$ dm^{-3}, and base saturation of 68%.
- ✓ Experimental design was split-plots in randomized blocks with 4 replications. The main plots (10x25m) had NT and conventional tillage (CT). CT consisted of disk plowing (20-25 cm) followed by offset disking (10 cm) in the spring and offset disking in the autumn.
- ✓ Sub-plots (10x5m): 140 kg N ha^{-1} (total N) was applied for maize either as mineral fertilizer (urea; MIN), pig slurry (PS), anaerobically digested pig slurry (ADS) and composted pig slurry (CS), besides a control without fertilization (CTR). P and K was supplied as necessary.
- ✓ C inputs from organic fertilizers and crops aboveground and root biomass (0-30 cm) were determined.
- ✓ Soil samples were collected in the 0-5, 5-10, 10-20, 20-30, 30-40 and 40-60 cm soil layers in 2012 and 2017.
- ✓ C and N pools were isolated (Cambardella and Elliott, 1992) and stocks were compared in equivalent soil masses (Wendt and Hauser, 2013).
- ✓ C and N concentration within >2,000, 250-2,2000, 53-250, and <53 µm water-stable aggregates were determined in the 0-5 cm soil layer from samples collected in 2017 (Gulde et al., 2008).
- ✓ Data was analysed using two-way ANOVA and means were compared with Holm-Sidak test. Results were considered significant at P<0.05.

Results

Table 1. C inputs according to soil tillage and fertilization practices (2012-2017).

Source	Tillage	Fertilization CTR	MIN	PS	ADS	CS	Mean
		C input (Mg ha^{-1} yr^{-1})					
Fertilizer	CT/NT	0.0	0.0	0.7	0.3	2.3	N/C
Maize	CT	4.9	5.5	5.7	5.7	5.1	5.4 **ns**
	NT	4.2	5.3	5.5	5.7	4.6	5.1
	Mean	4.5 **c**[1]	5.4 **ab**	5.6 **a**	5.7 **a**	4.9 **bc**	5.2
Black oats	CT	1.7	1.7	1.8	2.0	1.7	1.8 **ns**
	NT	1.6	1.8	1.8	1.8	1.8	1.8
	Mean	1.7 **ns**	1.7	1.8	1.9	1.8	1.8
Total	CT	6.6	7.2	8.2	8.0	9.1	7.8 **ns**
	NT	5.8	7.1	8.1	7.8	8.7	7.5
	Mean	6.2 **d**[1]	7.1 **c**	8.1 **ab**	7.9 **bc**	8.9 **a**	7.6

CTR: control without fertilization; MIN: mineral fertilization; PS: pig slurry; ADS: anaerobically digested pig slurry; CS: composted pig slurry; CT: conventional tillage; NT: no-tillage; ns: differences were not significant according to the F test; [1]Means followed by the same letter are not different according to the Holm-Sidak test (P<0.05).

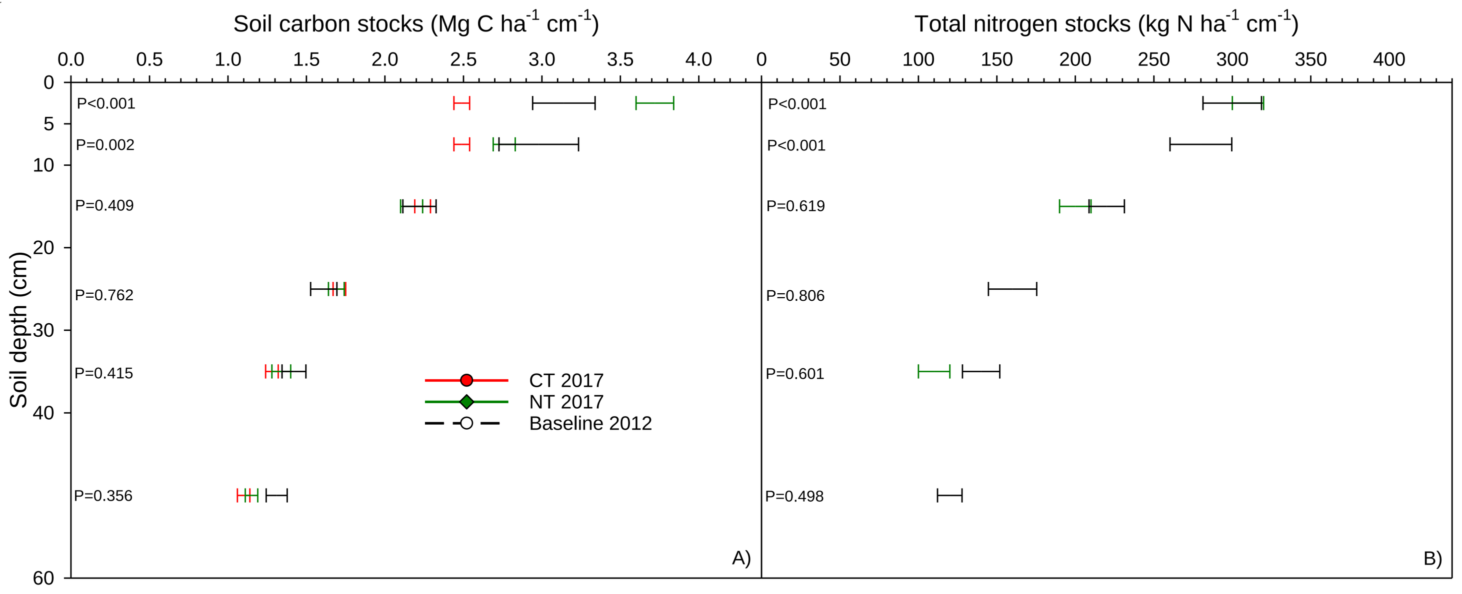

Fig. 1. C and N stocks according to soil tillage.

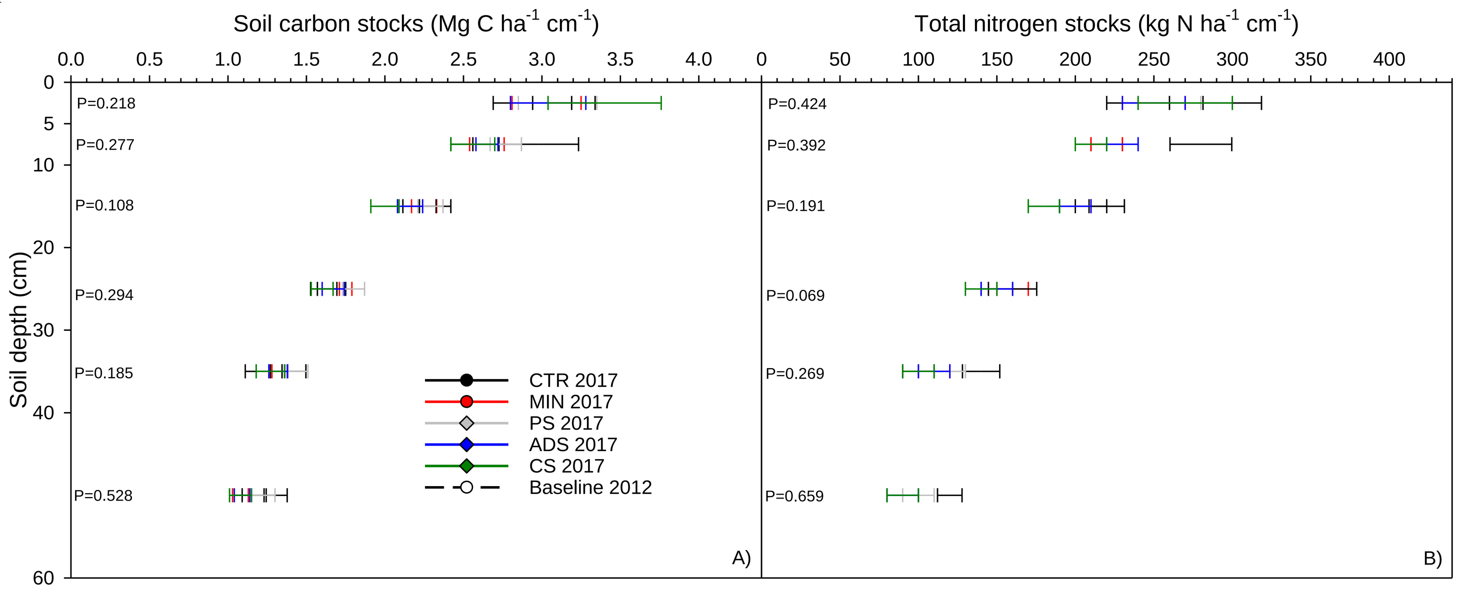

Fig. 2. C and N stocks according to N sources.

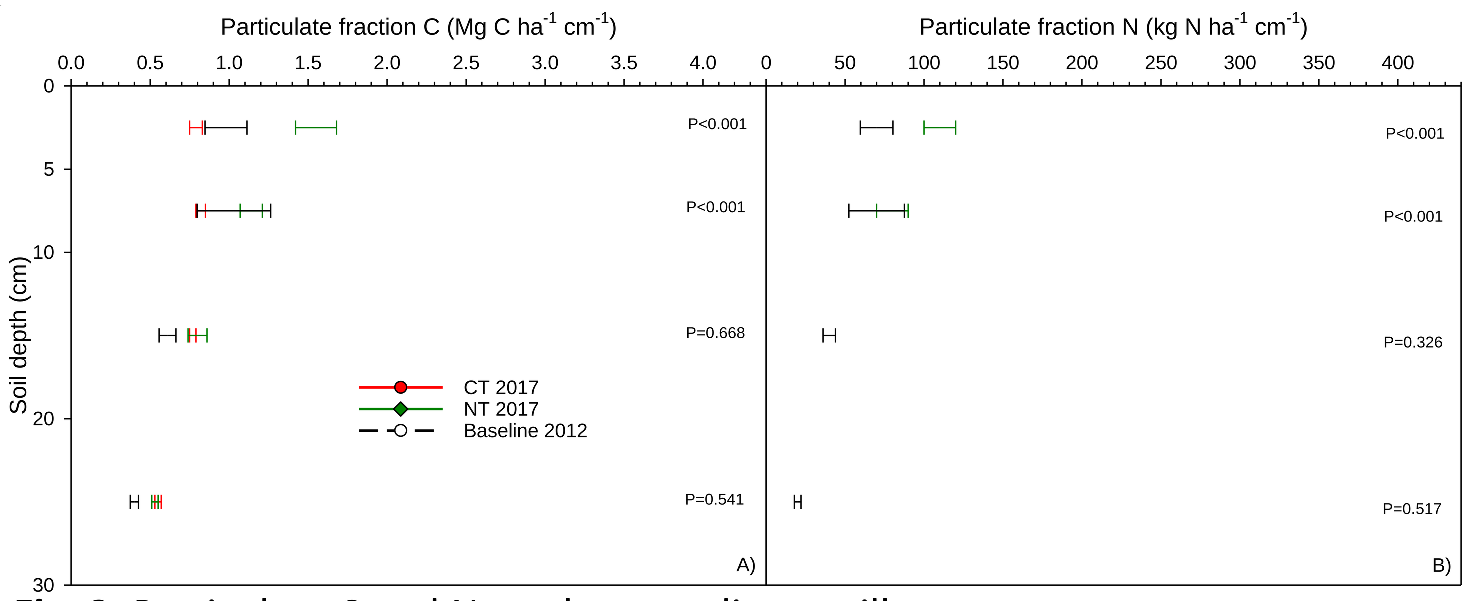

Fig. 3. Particulate C and N stocks according to tillage systems.

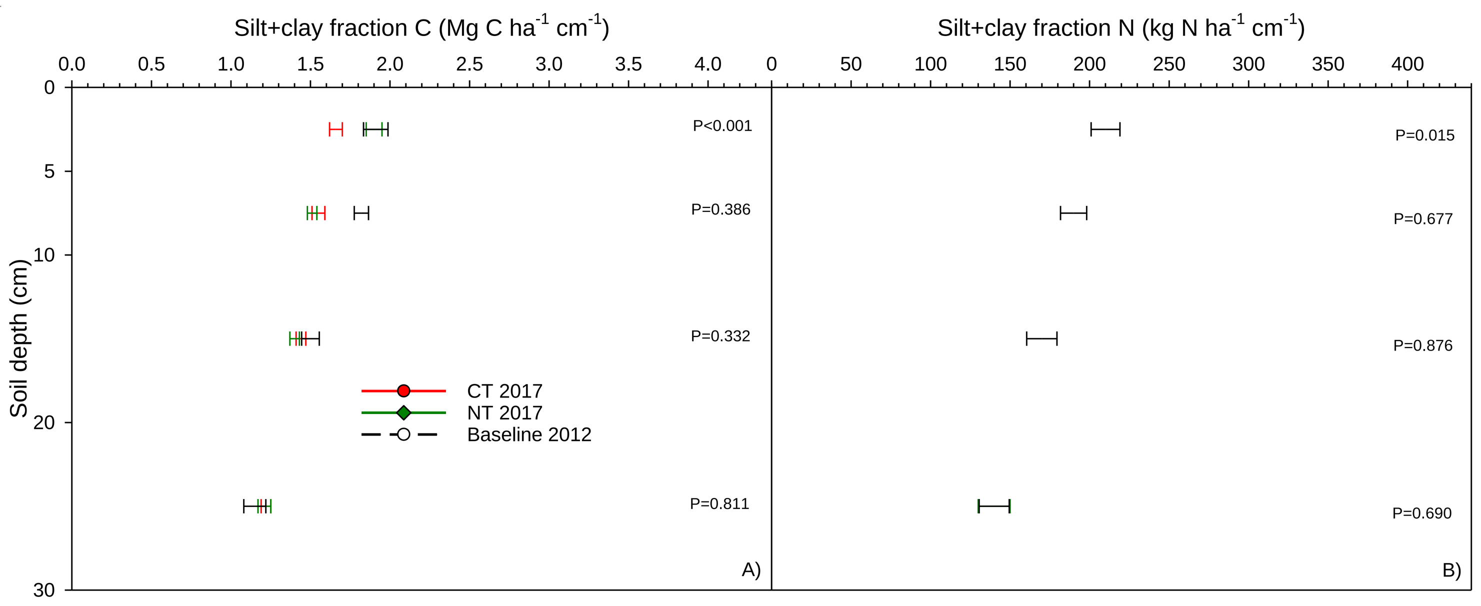

Fig. 4. Silt+clay fraction C and N stocks according to tillage systems.

Results

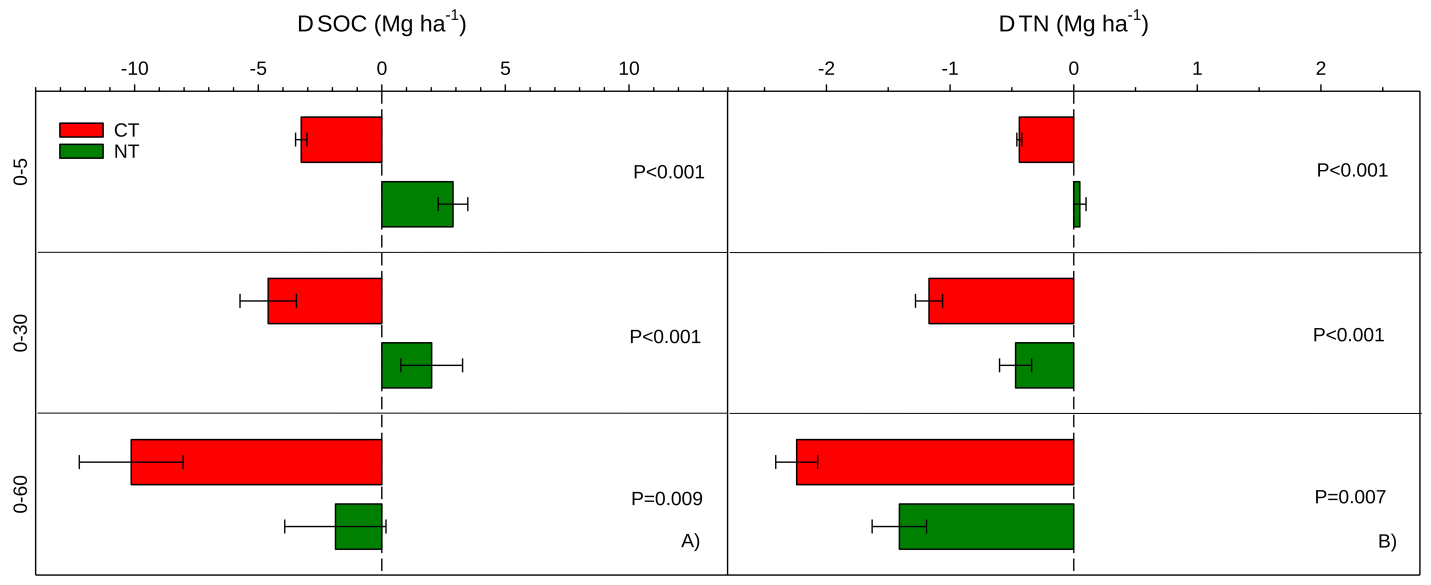

Fig. 5. Changes on C and N stocks according to tillage systems.

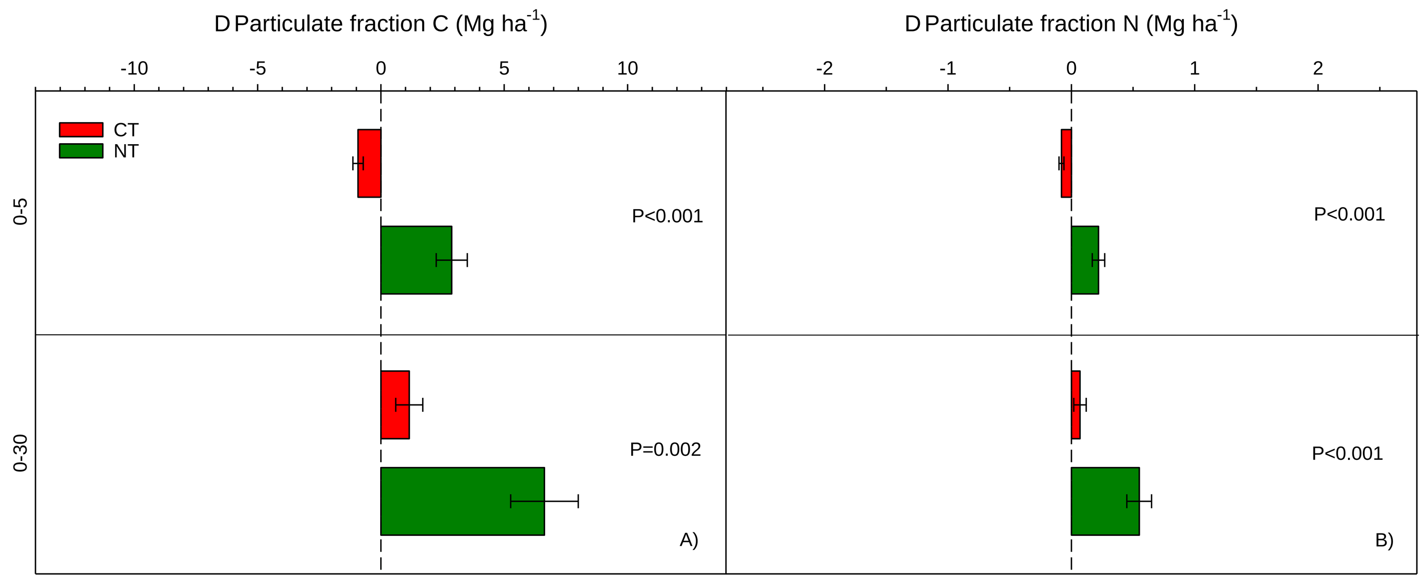

Fig. 6. Changes on particulate C and N stocks according to tillage systems.

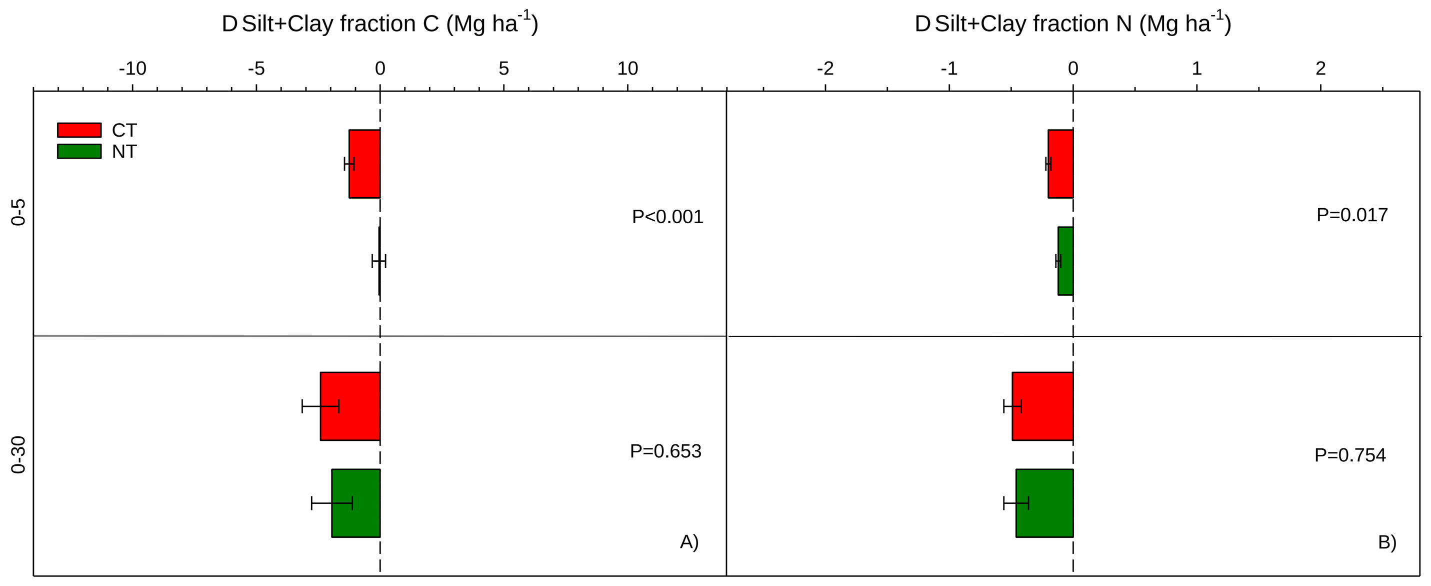

Fig. 7. Changes on silt+clay fraction C and N stocks according to tillage systems.

Table 2. Distribution of water-stable aggregates as affected by tillage system and N sources in the 0-5 cm soil layer of a Oxisol from Sourthern Brazil.

Treatment	Sand-free water-stable aggregates (µm) <53	53-250	250-2,000	>2,000
	g 100 g^{-1} soil			
CT CTR	7.5	14.9	56.8	20.9
CT MIN	7.8	13.7	54.1	24.4
CT CS	6.9	11.8	50.8	30.5
NT CTR	4.3	5.3	39.1	51.3
NT MIN	3.1	3.9	34.1	58.9
NT CS	3.7	7.3	24.7	64.3
CT (mean)	7.4 **a**[1]	13.4 **a**	53.9 **a**	25.3 **b**
NT (mean)	3.7 **b**	5.5 **b**	32.6 **b**	58.2 **a**
CTR (mean)	5.8 **ns**	10.0 **ns**	48.0 **ns**	36.1 **ns**
MIN (mean)	5.5	8.8	44.1	41.6
CS (mean)	5.3	9.5	37.8	47.4

CTR: control without fertilization; MIN: mineral fertilization; CS: composted pig slurry; CT: conventional tillage; NT: no-tillage; ns: differences were not significant according to the F test; [1]Means followed by the same letter are not different according to the Holm-Sidak test (**P**<0.05).

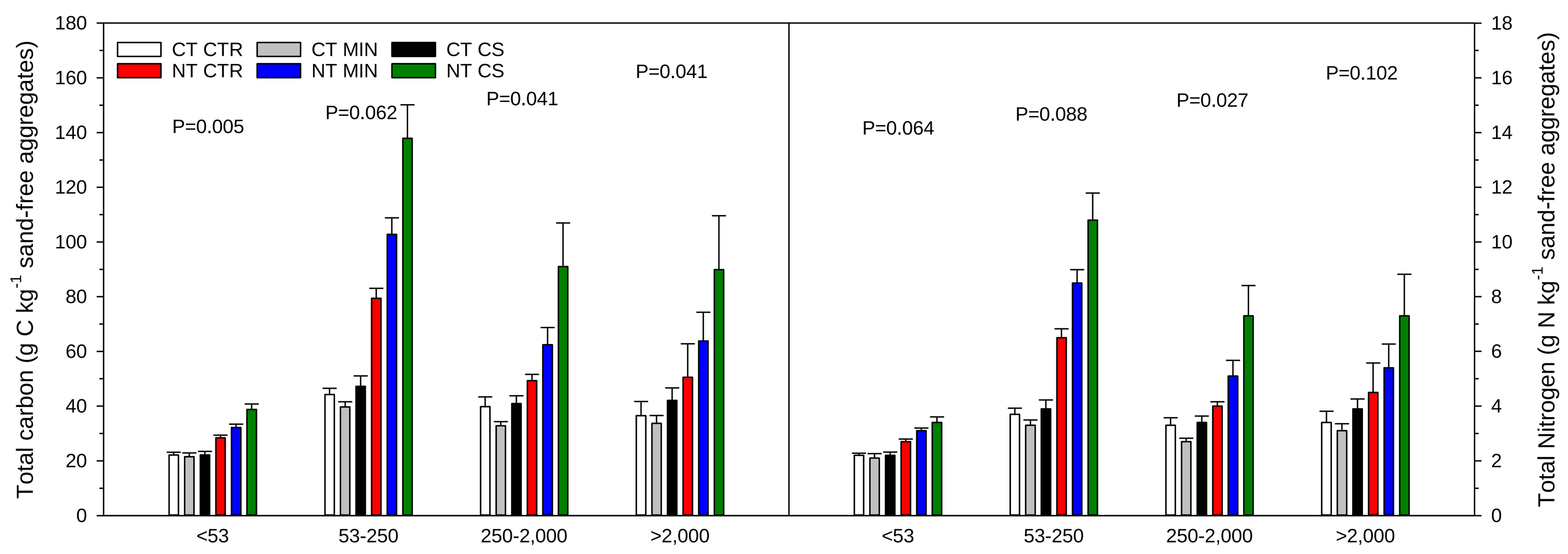

Fig. 8. C and N content within aggregates in the 0-5 cm soil layer of a Oxisol from Southern Brazil according to tillage systems and N sources.

Conclusions

- ✓ C and N stocks were higher in NT than CT soils. Differences in the 0-5 and 5-15cm soil layers were maintained throughout the soil profile (0-60 cm).
- ✓ C and N stocks decreased under CT, regardless of sampling depth. Greater losses occurred within the silt+clay C and N fractions (0-30 cm).
- ✓ C stocks increased in the 0-30 cm soil layer under NT, due to accrual of particulate C. C losses at deeper layers had offset accumulation of C in topsoil.
- ✓ N stocks decreased under NT with the exception of the 0-5 cm soil layer. Greater losses occurred within the silt+clay N fraction (0-30 cm).
- ✓ NT had larger proportion of large macroagregates (>2,000 µm) and higher C and N content within all aggregates sizes than CT soils.
- ✓ External C inputs increased C and N contents within aggregates under NT, remarkably for aggregates > 53 µm.
- ✓ C and N stocks were correlated with on particulate C (R=0.83) and N (R=0.78) within large macroaggregates (R=0.71 and 0.72, respectively).