Carbon depletion by ploughing and its restoration by no-till cropping systems in Oxisols of sub-tropical and tropical agro-ecoregions in Brazil

Solos - LABMOS

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INTRODUCTION

The present study was conducted to test the hypothesis that the intensification of cropping systems by increasing C-input and biodiversity under NT restores SOC pool, increases resilience of degraded agro-ecosystems, and enhances crop yield. The objectives of this research were to: (i) assess the impact of the continuous plough-based CT on SOC stock for sub-tropical and tropical agro ecosystems vis-a-vis the native vegetation (NV) as base line, (ii) compare SOC balance among plough-based CT, NT cropping systems and NV, and (iii) evaluate redistribution of SOC stock in the soil profile in relation to soil resilience and impact on the agronomic productivity in a subtropical and tropical agro-ecoregion in Brazil.

MATERIALS AND METHODS

Sites location, description, experimental design and analyses

Research sites: (i) Ponta Grossa (PG site), in Paraná State, southern Brazil. The experimental design consisted of three tillage treatments: conventional tillage (CT), minimum tillage (MT) and no-till (NT) laid out as whole plots, and (ii) Lucas do Rio Verde (LRV site) in Mato Grosso State (Fig. 1 and table 1). The experiment was designed to compare the standard tillage management of the region represented by one crop per year in the summer under CT, compared with cropping systems involving different biomass-C input under NT (Table 2).

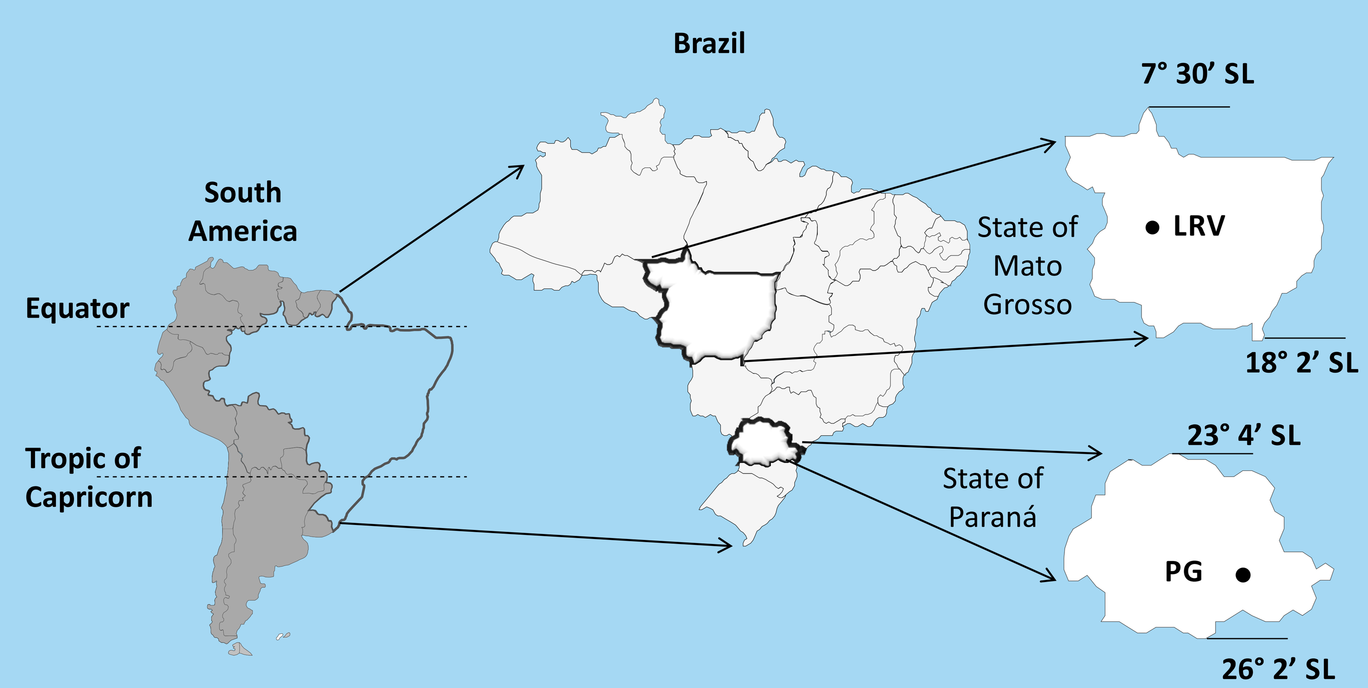

Fig. 1. Location of the experimental sites

Table 1. Sites description: Location, soil type, parent material, climate, land use and management, duration of experiment, samplingdepth

Description	Ponta Grossa – PR (PG site)	Lucas do Rio Verde – MT (LRV site)
Altitude	865 m	380 m
Soil type (FAO)	Red Latosol, Oxisol,	Red Yellow Latosol, Oxisol
Soil Type (Soil Taxonomy)	Rhodic Hapludox	Typic Haplustox
Parent material	Shale	Shale and Sandstone
Climate - type	Mesothermic, Summer and Winter wet, cold winter (Cfa)	Humid tropic, Summer hot and very wet, winter hot and dry (Aw)
Mean annual temperature (MAT)	18.5°C	25.2°C
Mean Annual rainfall (MAR)	1545 mm	1950
Land use †	NV, CT, MT and NT	NV, CT and NT1 to NT6
Sampling depth, cm	0-5, 5-10, 10-20, 20-40, 40-60, 60-80, 80-100	0-5, 5-10, 10-20, 20-40, 40-60, 60-80, 80-100

Table 2. Tillage systems, crop sequence, cumulative and annual C input in the 29 years period at the PG site and 8 years periodat the LRV site.

Site	Tillage systems	Crop sequence	Carbon input Cumulative	Annual
			------ $Mg\ ha^{-1}$ -----	
PG	CT	S/O+V – M/O – S/O – M/O – S/O – M/R – S/V	86.1	3.07
	MT	S/O+V – M/O – S/O – M/O – S/O – M/R – S/V	83.7	2.99
	NT	S/O+V – M/O – S/O – M/O – S/O – M/R – S/V	116.1	4.15
LRV	CT	S/Ct – S/Ct–S/Ct–S/Ct	32.1	4.01
	NT_1	S/M+Brz – S/M+Brz – M – S/Cs	60.8	7.60
	NT_2	S/Fm+Pp – S/Fm+Pp – M – S/M+Cs	58.0	7.25
	NT_3	S/Fm+Pp – S/Fm+Cs – S/Fm+Cs – M – S/G+Cs	54.7	6.84
	NT_4	S/Fm+Cs – S/G+Brz – S/G+Brz – M – S/Sg+Cs	58.7	7.34
	NT_5	S/Sg+Brz – S/Sg+Brz – S/Sg+Brz – M –S/Sg+Brz	67.0	8.38
	NT_6	S/Mt – S/M+Brz – S/M+Brz – M – S/M	59.3	7.41

Total organic carbon concentration, stocks and resilience index (RI)

SOC concentrations : TruSpec CN - LECO. The SOC stocks to 1-m depth (computed on an equivalent soil mass-depth basis). SOC rates ($Mg\ ha^{-1}\ yr^{-1}$): Depletion rate = $(SOC_{NV} - SOC_{CT})/t$; Recovery rate = $(SOC_{NT} - SOC_{CT})/t$; RI = $(SOC_{NT} - SOC_{CT})/(SOC_{NV} - SOC_{CT})$. C converted from crop residues to SOC ($CCCR_{SOC}$): $CCCR_{SOC}$ = (Recovery rate/Annual C-input) x 100

RESULTS

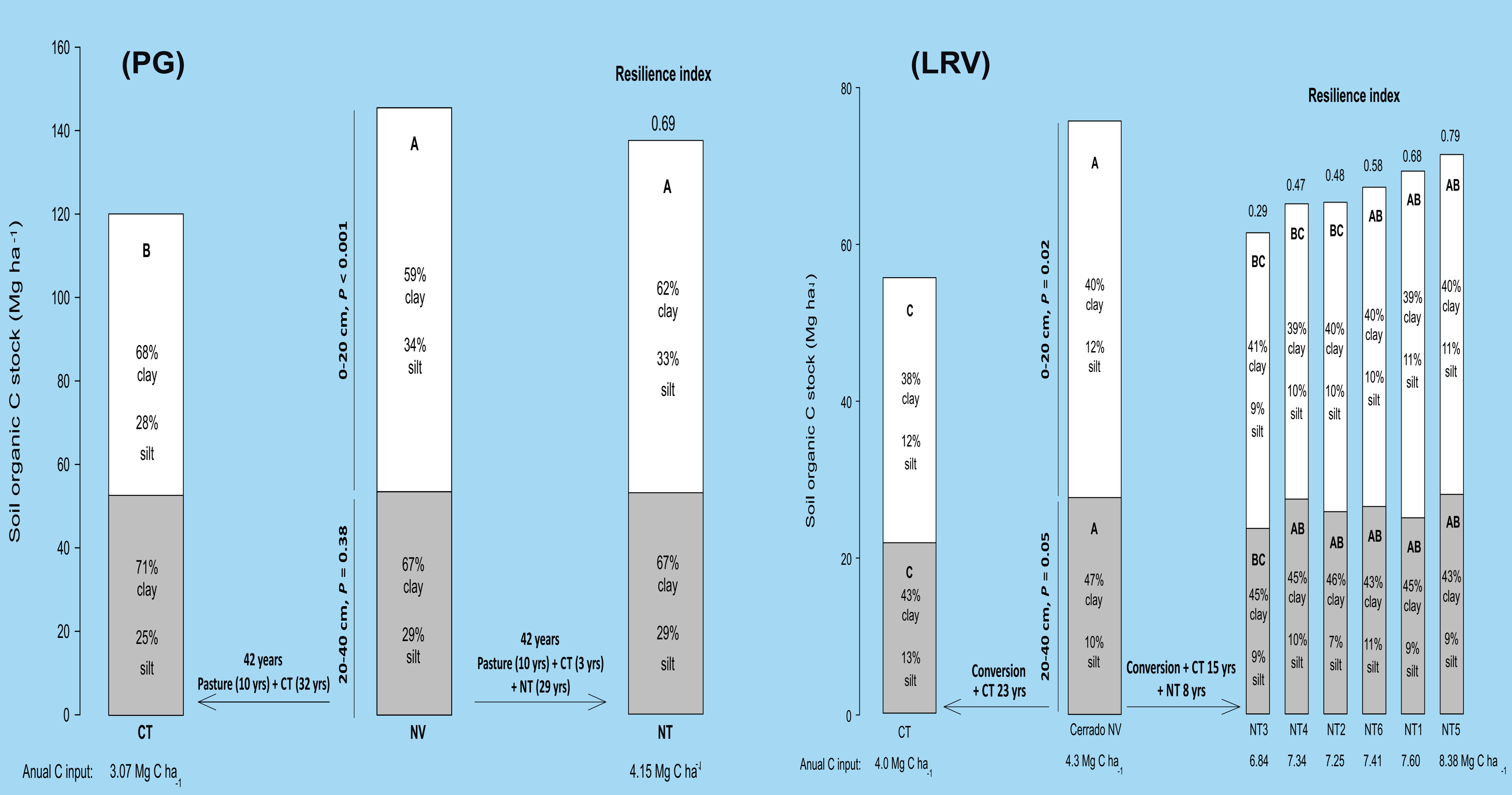

Fig. 2. Effects of continuous CT and conversion from CT to NT cropping systems with contrasting C-inputs on SOC ($Mg\ ha^{-1}$) at the PG and LRV site.

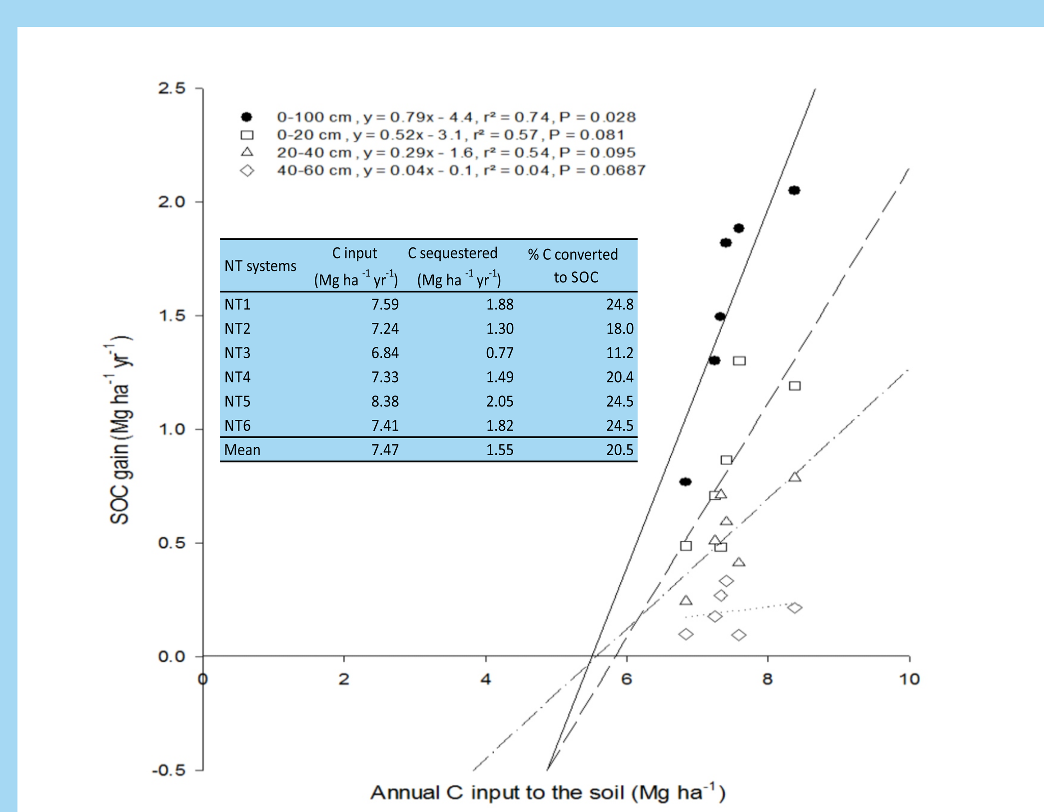

Fig. 3. SOC gain ($Mg\ ha^{-1}\ yr^{-1}$) and annual C input ($Mg\ ha^{-1}\ yr^{-1}$) under NT systems for 0-100 cm, 0-20 cm, 20-40 cm, and 40-60 cm depths at the LRV site.

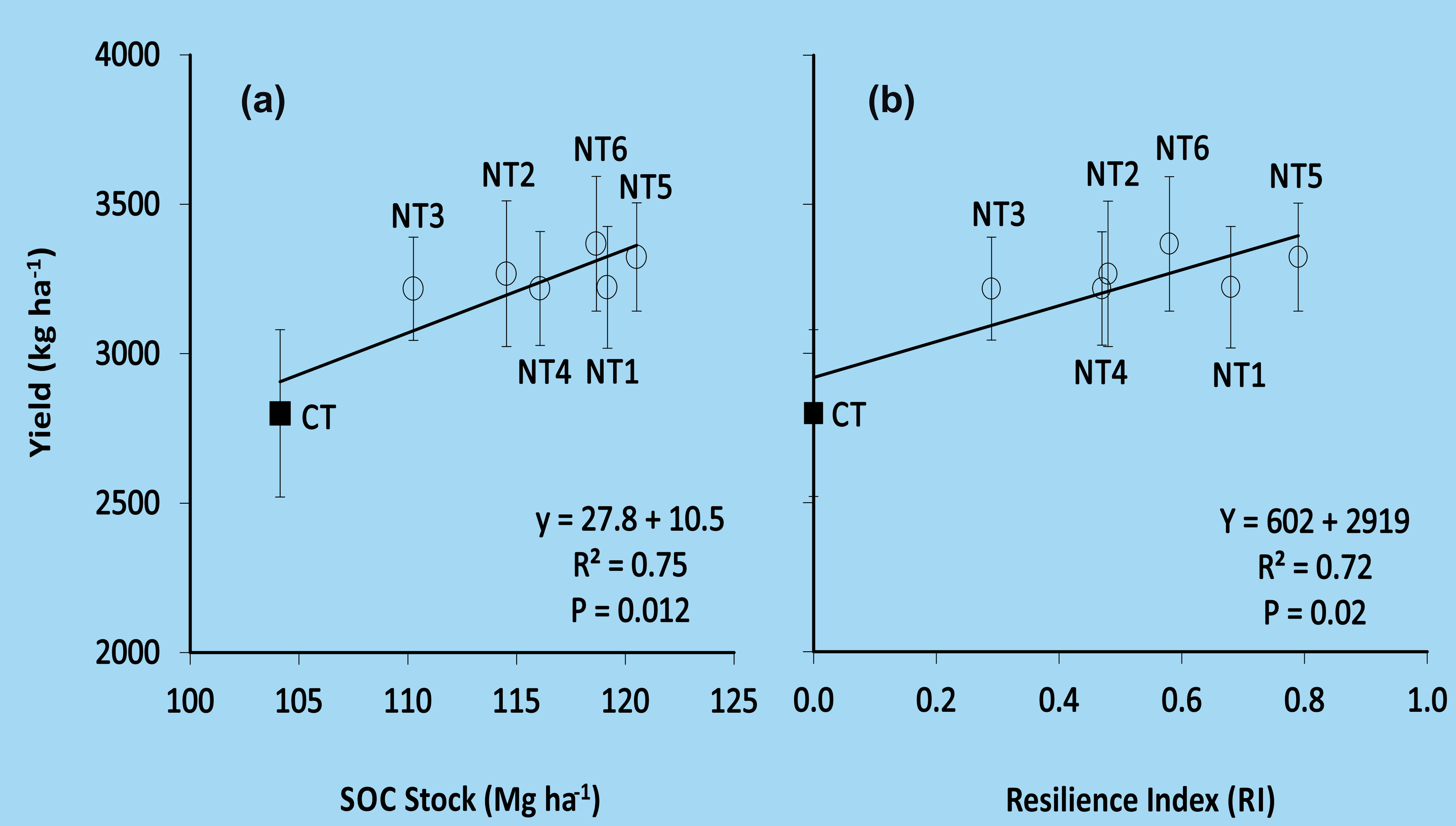

Fig. 4. Relationship between **(a)** SOC stock under NT systems for 0-100 cm and soybean yield, and **(b)** the resilience index and yield at the LRV site.

CONCLUSIONS

The SOC stock is drastically reduced by the conversion of native vegetation to agro ecosystem by a continuous use of CT leading to a depletion of 0.58 and 0.67 $Mg\ C\ ha^{-1}\ yr^{-1}$ in 0-20 cm depth at PG and LRV sites, respectively. The rate of SOC sequestration of 0.59 $Mg\ C\ ha^{-1}\ yr^{-1}$ in sub-tropical region and 0.48 to 1.30 $Mg\ C\ ha^{-1}\ yr^{-1}$ in the tropical Cerrado region. A high SOC resilience under the tropical NT systems indicates a potential to reverse the process of soil degradation and SOC decline by conversion to intensive NT systems.