Soil carbon stock and wheat yield in central-eastern and southeastern Brazilians regions

Introduction

Soil carbon stock (SCstock) plays a key role in maintaining wheat productivity. However, inadequate soil management tends to reduce SCstock over time (Lal, 2005). To preserve SCstock in soils, the input of phytomass is important, especially through crop rotations with diverse species and greater root biomass under no-tillage systems (Ardent et al., 2023). It is also essential to recover and maintain soil structural quality. This study aimed to evaluate the relationship between soil carbon stock (SCstock) and wheat yield in Rhodic Ferralsols of medium to clay texture in the central-eastern and southeastern regions of Paraná, Brazil.

Results and discussion

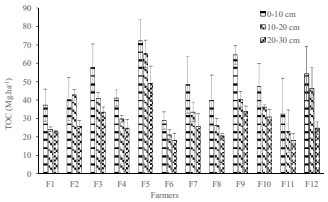


Figure 2. Total organic carbon stocks evaluated at the 0–10 cm, 10–20 cm, and 20–30 cm depths.

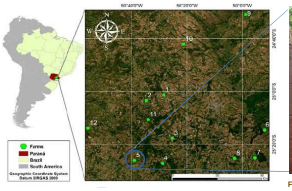
Table 2. Wheat yield in the evaluated properties in the Eastern Central and Southeastern mesoregions of Paraná

Farmer[1]	Municipality	Year				Mean	SD[2]
		2020	2021	2022	2023		
		Wheat yield (kg ha-1)					
F1	Ipiranga	3720	4200	2940	2460	3330	778
F2	Ipiranga	3960	4560	4140	3780	4110	334
F3	Teixeira Soares	3900	4320	3660	2880	3690	605
F4	Teixeira Soares	2970	3222	2730	2700	2906	243
F5	Irati	4140	4920	4260	3600	4230	542
F6	Ponta Grossa	4080	4440	4200	2550	3818	858
F7	Palmeira	4620	5100	4740	4080	4635	422
F8	Palmeira	3960	4080	4200	3720	3990	205
F9	Piraí do Sul	3660	3570	3924	3786	3735	154
F10	Tibagi	3918	4062	4134	3762	3969	165
F11	Imbituva	3600	4320	3660	3540	3780	363
F12	Prudentópolis	3048	3240	2940	2760	2997	201

[1] Farmer: F1-F12; [2] Standard Deviation.

Methods

Study Area



Soil Type

Soil Sample

Sampling in the 12 properties occurred in 2023. Three trenches were dug at each location, covering an area of 1 hectare, spaced 50 meters apart. In each trench, samples were collected for chemical and physical soil evaluations at depths of 0-10, 10-20, and 20-30 cm. Information on wheat yield and crop rotations used from 2020 to 2024 was obtained from participating farmers. Soil physical characterization was performed using volumetric rings (5 cm diameter × 2.5 cm height). Soil bulk density (BD) was determined at the Soil Physics and Water Laboratory of the University of Passo Fundo/RS. Although used for calculating total organic carbon (TOC), BD data are not presented in this study.

Farm 5: Latossolo Vermelho distrofico tipico/Rhodic Ferralsol (Clayic, Dystric, Humic)

Figure 1. Study area, soil type and soil sample.

Table 1. Management and environmental aspects in the Eastern Central and Southeastern mesoregions of Paraná

Farmer	Municipality /State	[1]Soil Type	[2]WRB Soil	[3]Crop rotation	Terrain Slope	Plot altitude	Soil profile depth	[4]Clay	[4,5]Soil textural class	[4,6]CEC	[4]OM
					(%)	(m)	(cm)	(g kg-1)		(cmol$_c$ dm-3)	(%)
F1	Ipiranga/PR	Latossolo Vermelho distrófico típico	Umbric Rhodic Ferralsol (Clayic, Dystric)	S/W; B-C/W; S/W; S/W	6 - 13	854	>250	230	3	11	2.6
F2	Ipiranga/PR	Latossolo Vermelho distrófico típico	Umbric Rhodic Ferralsol (Clayic, Dystric)	M-B/W; S/Mi; B/W; M-B/W	8 - 10	882	>250	250	3	10	3.3
F3	Teixeira Soares/PR	Latossolo Vermelho distrófico típico	Rhodic Ferralsol (Clayic, Dystric, Humic)	S/W; S/BO; S/W; M/W	6 - 14	829	>250	287	3	14	4.0
F4	Fernandes Pinheiro/PR	Latossolo Vermelho Amarelo distrófico típico	Haplic Ferralsol/ (Loamic, Dystric, Ochric)	S/W; S/BO; S/W; S/W	9 - 15	834	>250	162	4	9	2.2
F5	Irati/PR	Latossolo Vermelho distrófico típico	Rhodic Ferralsol (Clayic, Dystric, Humic)	S/W; S/By; S/W; M/W	8 - 15	996	>150	260	3	15	4.0
F6	Ponta Grossa/PR	Latossolo Vermelho Amarelo distrófico típico	Haplic Ferralsol (Loamic, Dystric)	S/W; B/WO; S/Mi-W; B/W	7 - 13	1078	60 a 150	200	4	10	2.5
F7	Palmeira/PR	Cambissolo Háplico distrófico típico	Haplic Ferralsol (Clayic, Dystric, Ochric)	S/Mi; S/W; B-S/W; S/W	4 - 10	922	60 a 150	450	2	10	2.2
F8	Palmeira/PR	Cambissolo Háplico distrófico latossólico	Haplic Ferralsol (Clayic, Dystric, Ochric)	S/BO-W; S/Mi; M/W; B/BO-W	7 - 20	878	60 a 150	260	3	7	6.4
F9	Piraí do Sul/PR	Latossolo Vermelho distrófico típico	Rhodic Ferralsol/ (Clayic, Dystric, Humic)	M-B/W; S/Mi; S/W; B/W	4 - 12	672	>150	495	2	21	5.3
F10	Tibagi/PR	Latossolo Vermelho distrófico típico	Umbric Rhodic Ferralsol (Clayic, Dystric)	M-B/W; S/Mi; M/W; S/Mi	7 - 15	854	>250	290	3	15	1.6
F11	Imbituva/PR	Latossolo Vermelho eutrófico típico	Rhodic Ferralsols (Clayic, Oligoeutric, Ochric)	S/BO; B-S/W S/W; B/W	3 - 8	971	60 a 150	260	3	9	1.3
F12	Prudentópolis /PR	Latossolo Vermelho distrófico típico	Umbric Rhodic Ferralsol (Clayic, Dystric)	S/W; S/BO; B-S/W; S/BO	3 - 12	789	>150	290	3	16	3.9

[1] Soil type: Brazilian soil classification system; [2] WRB: World reference base for soil resources;
[3] Crop rotation: B= Bean, By= Barley; W= Wheat, WO=White Oat; S= Soybean, M= Maize; BO= Black Oat; Mi= Cover Crop mixture.
[4] Average values from the 0-20 cm soil layer;

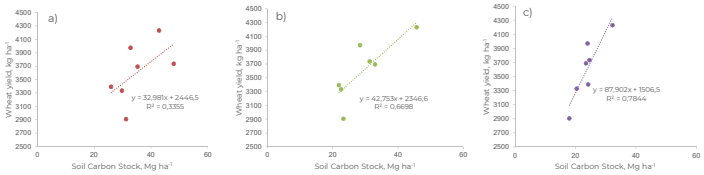


Figure 3. Relationship of Soil Carbon Stock and wheat yield at the 0–10 cm (a), 10–20 cm (b), and 20–30 cm (c) depths on 2020 to 2023 period.

Conclusion

Wheat yield correlated linearly and positively with SCstock, increasing by 33 kg ha^{-1}, 43 kg ha^{-1}, and 88 kg ha^{-1} for each unit increase in SCstock at the 0–10 cm, 10–20 cm, and 20–30 cm soil layers, respectively. The evaluated farmers possess and employ technologies aimed at increasing productivity and improving soil carbon storage. However, it became evident that enhancing crop rotations with greater root biomass is still necessary, as this would lead to increased soil carbon sequestration in deeper layers, thereby contributing to greater resilience to extreme climate events.

AUTHOR(S)

AMARAL, Andre Julio do [1]; GIONGO, Vanderlise [1]; SANTI, Anderson [1]; DENARDIN, Jose Eloir [1]; MARTINS, Tatiane [2]; SILVA, Bruno [2]; COELHO, Maurício [3]

AFFILIATION OF AUTHOR(S)

[1] Embrapa Trigo/Wheat
[2] Moageira Irati SA/Irati Mill AS
[3] Embrapa Solos/Soils

REFERENCES

ARDENTI, F.; CAPRA, F.; LOMMI, M.; FIORINI, A.; TABAGLIO, V. Long-term C and N sequestration under no-till is governed by biomass production of cover crops rather than differences in grass vs. legume biomass quality. Soil & Tillage Research, v. 228, 105630, 2023. DOI: 10.1016/j.still.2023.105630.

LAL, R. Enhancing crop yields in the developing countries through restoration of the soil organic carbon pool in agricultural lands. Land Degradation & Development, West Sussex, v. 17, p. 197-206, 2005. DOI: 10.1002/ldr.696.

ACKNOWLEDGEMENTS

The authors thank the farmers and stakeholders who contributed to the research. The Moageira Irati and FAPEG through the SAIC Project: 10200.19/0028-7, SEI code: 21148.002708/2019-19, IDEARE: 20.23.00.048.00.00.

INDICATION OF THE CORRESPONDING AUTHOR

AMARAL, Andre Julio do [1]
Email adress: andre.amaral@embrapa.br

LATIN AMERICAN & CARIBBEAN
Soil Carbon Research Symposium
Rio de Janeiro, RJ, Brazil
June 25-28, 2025

CO-ORGANISED AND PROMOTED BY

ORGANISED BY

https://proceedings.science/p/203484?lang=en