



# Exploring the role of deep rooting ability on soil carbon accumulation in pasture-rice rotation systems in a Vertisol

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## Introduction

- ▶ Pasture-crop rotation is an agricultural practice performed to obtain multiple benefits in terms of yield, sustainability and soil health.
- ▶ Rice is the second most important crop in Colombia and the third most important crop in the world. According to the "Colombia National Report: National Map of Soil Organic Carbon Sequestration Potential", a high potential for carbon sequestration has been identified in the areas dedicated to this crop.
- ▶ *Urochloa humidicola* forage grasses are a promising option for rotational systems because of their potential to develop deep and vigorous root systems which have been associated with increased accumulation of soil organic carbon (SOC), and their capacity for high biological nitrification inhibition (BNI).

## Objective

Evaluate the effect of a pasture-rice rotation compared to conventional management (monoculture) on SOC storage in a 4-year field trial, in collaboration with the Bezos Earth Fund.

## Methodology

**Location:** Alliance Bioversity & CIAT campus in Palmira, Colombia (3°30' 12"N - 76°21' 24"W).

**Experimental design:** Randomized complete block (RCB) with eight treatments and three replications.

**Treatments:** ▶ **Four monoculture treatments:** two rice genotypes (HL23057 deep-rooted, Fedearroz 60 shallow rooted), two *U. humidicola* forage grass genotypes (Bh08-1149 shallow rooted, CIAT679 deep rooted).

▶ **Four rice-pasture rotations** using the above four genotypes.

**Experimental unit:** Plot size of 362 m<sup>2</sup> (8×3 = 24 plots).

**Soil baseline:** Measurements were made prior to starting the experiment:

- ▶ **Five soil depths:** 0-5, 5-10, 10-30, 30-60 and 60-100 cm.
- ▶ Composite sample of 9 subsamples per plot and depth.
- ▶ **Variables:** Soil bulk density (cylinder); SOC (Walkley-Black); pH (2:1 water ratio); soil organic matter (SOM)(Walkley-Black); available phosphorus concentration (P)(Bray II); texture (Bouyoucos).

**Variables evaluated:** After first rice crop cycle:

- ▶ **Root variables (40 cm depth):** Carbon (C) and nitrogen (N) concentration (dry combustion), carbon:nitrogen (C:N) ratio, root biomass.

## Results and discussion

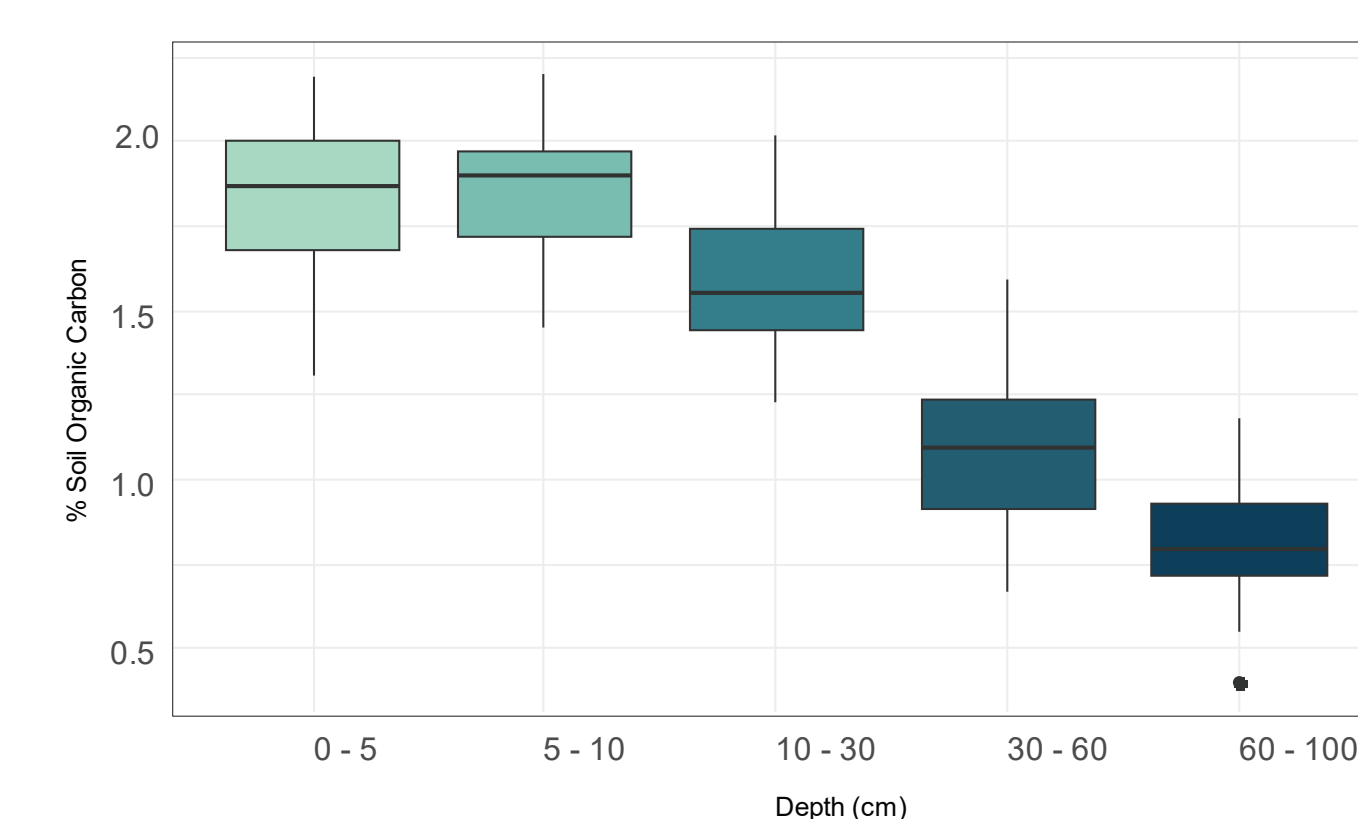
The mean values of soil physical-chemical characteristics for 0-100 cm soil depth were as follows: pH 8.7, SOM 32.43 g/kg; P 47.75 mg/kg; SOC stock 173.45 tons/ha; sand, silt and clay content 8.78, 33.95, and 57.26%, respectively, indicating a clayey soil (Table 1).

**Table 1.** Soil physical-chemical characteristics of vertisol with pasture-rice rotation systems prior to the establishment of the field trial. Values are the mean ± SD (n=24).

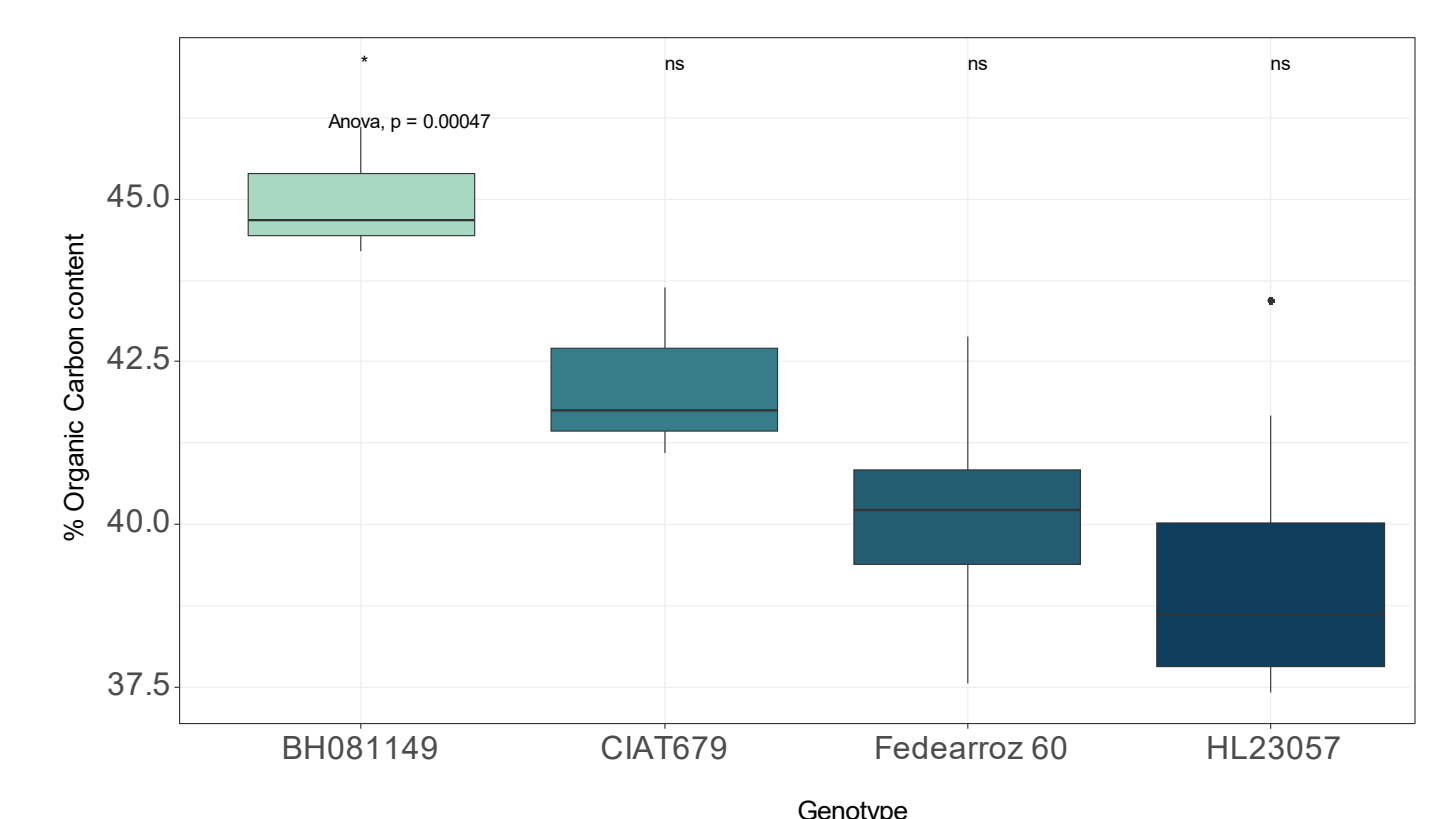
Characteristic	Soil depth (cm)				
	0 - 5	5 - 10	10 - 30	30 - 60	60 - 100
pH	8.02 ± 0.22	8.07 ± 0.18	8.10 ± 0.17	8.30 ± 0.17	8.40 ± 0.14
Soil organic Matter (SOM)(g/kg)	41.70 ± 5.41	41.80 ± 4.44	36.10 ± 4.81	24.40 ± 5.27	18.20 ± 3.98
P (Bray II)(mg/kg)	74.20 ± 14.7	73.80 ± 14	53.00 ± 15.8	23.30 ± 16.5	14.50 ± 18.6
Soil bulk density (g/cm <sup>3</sup> )	1.32 ± 0.09	1.42 ± 0.10	1.55 ± 0.053	1.52 ± 0.08	1.55 ± 0.08
SOC stock (ton/ha)	12.17 ± 1.91	13.05 ± 1.66	49.23 ± 6.95	49.18 ± 11.4	49.83 ± 11.3

The SOC concentration decreases as soil depth increases, and remains stable in the topsoil layers, between 0 and 10 cm (Fig. 1). Similar results have been reported by Yang et al. (2022).

Pasture grass genotypes have a higher root carbon concentration than rice genotypes (Fig. 2). Carbon and nutrients distribution in the plant can affect SOC sequestration (De Deyn et al., 2008). Rice directs 15% of carbon fixed toward root growth, while in grasses ~60% of the net primary productivity is allocated belowground.



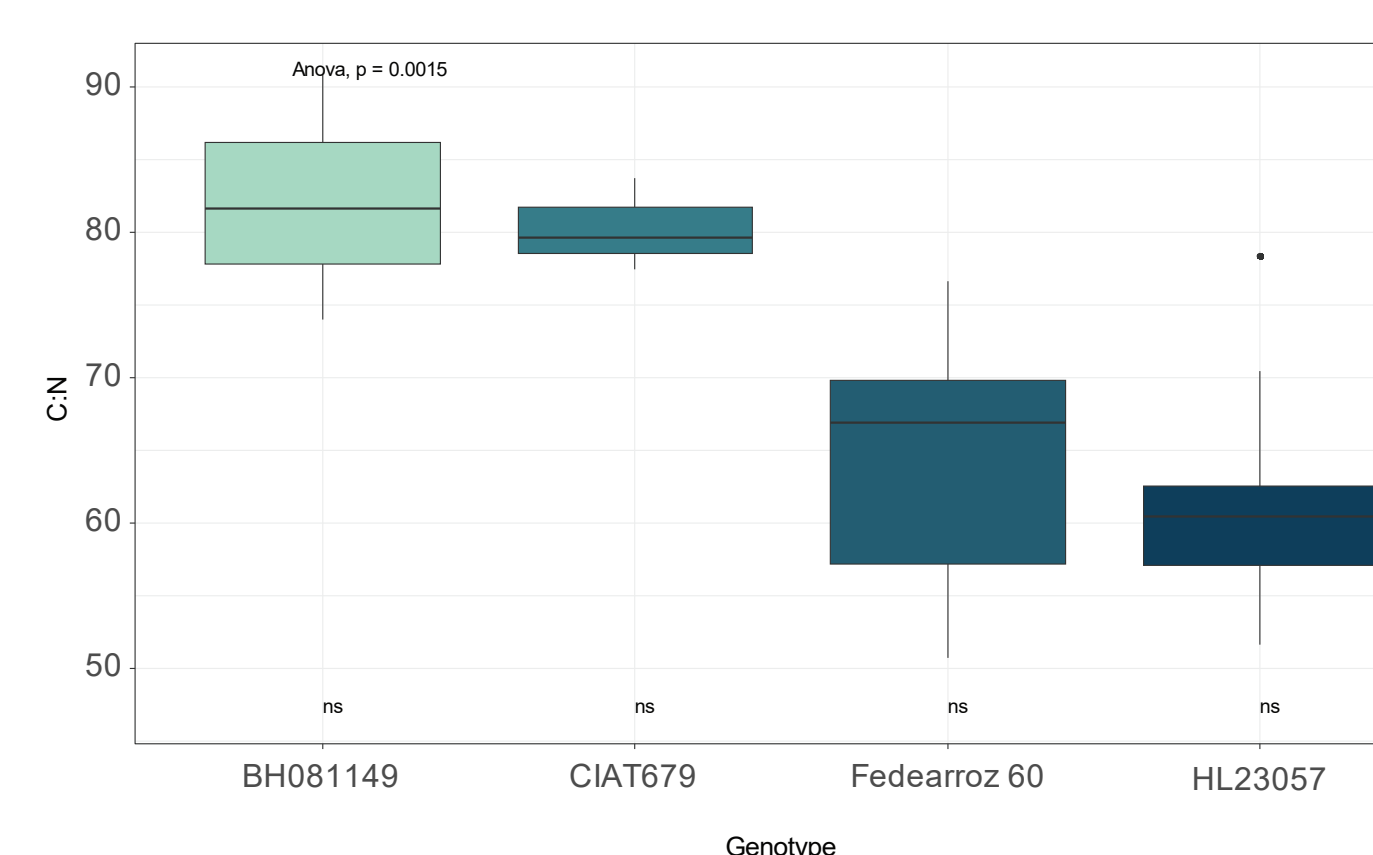
**Figure 1.** SOC concentration in different soil layers of a vertisol of pasture-rice rotation systems prior to the establishment of the trial.



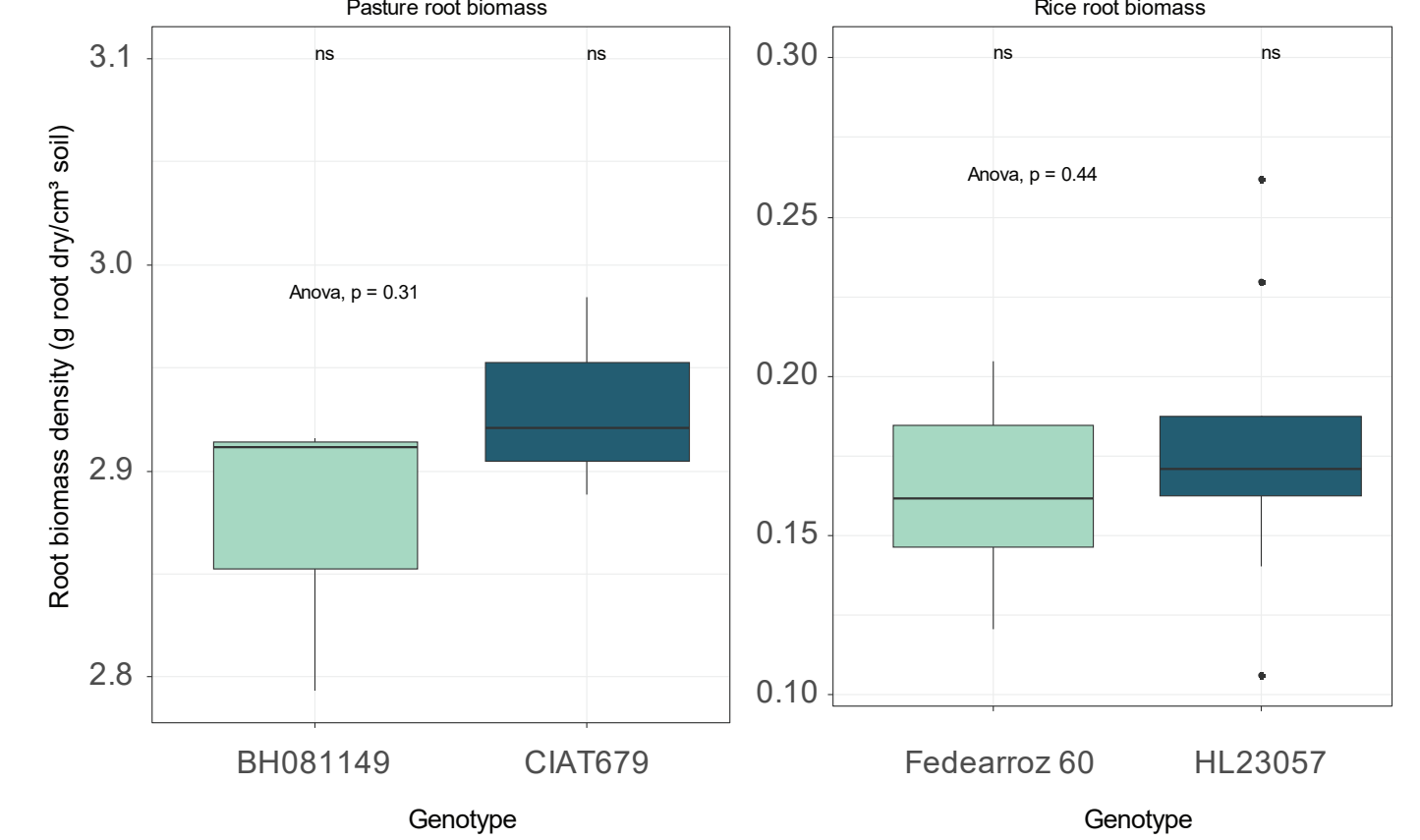
**Figure 2.** The percentage of organic carbon concentration in root dry mass of the four genotypes studied.

The C:N ratio in roots was higher in the two forage genotypes (BH08-1149 and CIAT679) (Fig. 3). A lower C:N ratio in two rice genotypes (HL23057 and Fedearroz 60) facilitates higher rates of SOM mineralization and could become more stable as MAOM in the soil.

The genotypes with the higher values of root biomass were CIAT679 and HL23057 (Fig. 4). However, the shallow rooting genotypes Fedearroz 60 and Bh08-1149 tend to show greater values of carbon concentration and lower values of root biomass, which could depend on the type and quality of the roots. Root growth and turnover and root C:N ratio could impact the proportion of accumulation of particulate organic carbon (POC) and mineral associated carbon (MAOC) in soil (Ayarza et al., 2022).



**Figure 3.** Carbon to nitrogen ratio in root dry mass of the four genotypes studied.



**Figure 4.** Root biomass density for pasture grass and rice genotypes studied.

## Conclusions

- ▶ The first rice crop cycle showed that the two pasture grasses have greater values of root biomass, root C concentration and C:N ratio than the two rice genotypes.
- ▶ The use of pasture-rice rotation management can result in greater accumulation of SOC in the form of both POC and MAOC than rice monoculture treatment.
- ▶ The individual characteristics of the genotypes and their effect on SOC accumulation in a pasture-rice rotation will continue to be evaluated.

## References

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