Sustainable intensification alternatives to Rice-Pasture system in Uruguay: Impacts on rice yield and soil organic C during the transition.

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Introduction

Soil organic matter (SOM) is key soil quality indicator. Reach high yield is critical to maintain soil quality. In Uruguay, rice typically rotate with perennial pastures (mix of grasses and legumes) used in beef production systems. This allows farmers to sustain high productivity, preserve natural resources, diversify incomes and minimize the use of pesticides and fertilizers (Pittelkow et al., 2016). Rice yield is one of the top in the world, showing a sustained increase from approximately 5 Mg ha^{-1} in the late 80´s to more than 8 Mg ha^{-1} in last years. However, rice farmers have a growing interest to intensify their production systems with the aim to increase profitability. The goal of this study was to evaluate the impact of different rice rotation intensification pathways on rice yield and SOM during the stabilization of a prospect long term experiment.

Material and method

A field-scale long term experiment was initiated in 2012 in a Natraquoll located in eastern Uruguay (33° 16' 23" S; 54° 10' 24" W; 22 MASL). It was used a basic design, in a randomized complete block with three replications and all phases of each rotation presented simultaneously (Patterson, 1964). Treatments were established in a 30 years rice-pasture rotation field and included: 1) Rice-Rice-Long Pasture of *Festuca arundinacea*, *Trifolium repens* and *Lotus corniculatus* (RLP) (5yr); 2) Rice-Short Permanent Pasture of *Lolium multiflorum* and *Trifolium pratense* (RSP) (2yr); Rice-Soybean-Short Permanent Pasture of *Festulolium spp.* and *Lotus corniculatus* (RSySP) (6yr); Rice-Soybean-Rice-Sorghum (RSyRSg) (4yr); Rice-Soybean (RSy) (2yr) and Continuous Rice (CR) (1yr). Cover crops were sown in winter between cash crops in all rotations. Permanent pastures of RLP, RSP and RSySP were grazed with lambs. Crop management practices, including nutrients, pest and weeds control and cultivars seeded were chosen specifically for each rotation, and were not necessarily the same. Rice yield (13%H) was determined in each 1200 m^2 plot, using a combine and a wagon with a digital balance during 2015-16 and 2016-17 season. Soil quality indicators evaluated were: soil organic carbon (SOC), total nitrogen (N), particulate organic carbon and nitrogen (C-POM and N-POM respectively), mineral associated organic carbon and nitrogen (C-MAOM and N-MAOM) in 0-15 cm depth in Sept. 2016 and May 2017. Treatment effect were analyzed with general liner model. Source of variation included, rotation, year, block and their interactions. Rice yield means were separated with a least significant difference ($P \leq 0.05$). Contrasts with Scheffe´s test ($P \leq 0.05$) were used to evaluate rotation effect on soil indicators.

Results and discussion

No differences were found on rice yield between rotations. Average yield was 10.3 Mg ha^{-1}, the highest yield was observed in the RSyRSg (10.7 Mg ha^{-1}) and the lowest in CR (9.7 Mg ha^{-1}). Season 2015-16 had 5.3 % lower yield than season 2016-17 (10.6 Mg ha^{-1}). After five years, no SOC and TN differences were found between rotations (29.3 Mg C ha^{-1} and 3.16 Mg N ha^{-1}). Neither in C-MAOM and N-MAOM, also when RLP was compared with RSP or RSySP no changes were found in C-POM and N-POM.

However, RLP had 18% and 19% grater C-POM and N-POM compared with RSy and RSyRSg (6.06 Mg C ha^{-1} and 0.48 Mg N ha^{-1}; respectively), representing around 23.6% and 20% of SOC for RLP and RSy-RSyRSg, respectively (Table 1).

Table 1. Difference and standard error in particulate organic carbon and nitrogen contents for contrasts evaluated.

Contrasts	C-POM				N-POM			
	Difference		Std. Error	Significance	Difference		Std. Error	Significance
	Mg ha^{-1}							
1) RLP vs RSP	0,91	±	0,37	NS	0,082	±	0,033	NS
2) RLP vs RSySP	0,70	±	0,27	NS	0,037	±	0,024	NS
3) RLP vs (RSyRSg and RSy)	1,07	±	0,27	*	0,089	±	0,024	*
4) (RSyRSg and RSy) vs CR	-0,51	±	0,48	NS	-0,034	±	0,042	NS

*Significative with a p-value ≤ 0,05. NS= no significative. Rice rotating with: long pastures (RLP), short pastures (RSP), with soybean and short pastures (RSySP), with soybean and sorghum (RSyRSg), with soybean (RSy) and under continuous rice (CR).

Probably, the contribution of residues provided for rice straw and roots of high productivity as well as the residues of other crops, cover crops and/or shorter pastures have supplied the input of long pastures substituted in more intensive systems. Higher contents of C-POM and N-POM in RLP respect to RSyRSg and RSy can be explained by the quality and quantity of residues provided for roots of perennial pastures (Benintende et al., 2008).

Conclusion

The results from this study indicated that, for soils under rice-pasture rotations in temperate climates, there are alternatives for soil use intensification that allows sustain productivity without losing SOM at least in the midterm. However, the elimination of perennial pastures from the rice rotation may make SOM more vulnerable to lose and soil less resilient to these changes in the future.

References

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