Long-term phosphorus fertilization and perennial legumes addition impacts on a temperate natural grassland : II . Total and particulate soil organic carbon .

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Introduction Soil organic carbon (SOC) is a critical soil quality indicator and its pools have different functional roles in agroecosystems . Natural grassland improved with perennial legumes and P fertilizers is a rare production system in the world . We evaluated long-term P fertilization and perennial legumes inclusion effects on SOC and particulate organic C (C-POM ; 53-2000 μm) in a natural grassland of Uruguay .

Materials and methods We analyzed a 30 ha experiment in a Typic Argiudol of Uruguay (33° 14′ 58″ S , 54° 29′ 24″ W) . A randomized complete block design with five replications was used . Treatments were : natural grassland (NG) , and natural grassland overseeded with *Trifolium repens* L . and *Lotus corniculatus* L . fertilized with 30 (IP_{30}) , or with 60 kg ha^{-1} yr^{-1} of P_2O_5 (IP_{60}) during 9 yrs . After the 9th year , soil samples were collected to a depth of 0-5 and 5-15-cm , dried , dispersed and passed through sieves of 2000 , 200 and 53 μm (Cambardella and Elliot , 1992) . Soil remaining on the 200 and the 53 m sieves (coarse and fine C-POM , respectively) and the one passing all sieves (mineral-associated organic matter , C-MAOM) was analyzed for total C using the Mebius method (Nelson and Sommers , 1982) . Orthogonal contrasts were used to make comparisons among treatments , NG vs . IP_{30} and IP_{60} average (IP) , and IP_{30} vs . IP_{60} . The level of significance for the statistical test was 0 .1 .

Results and discussions Overall ,there were no treatments effects on SOC at 0-15-cm depth after 9 yrs (mean : 21 .2 g C kg^{-1}) . However , treatments affected SOC by depth and C pools (Table 1) . On average , IP had 8% higher and 11% lower SOC compared to NG at 0-5-cm and 5-15-cm depth , respectively . On the other hand , IP had 40% higher C-POM ($p<0$ .01) and surprisingly 15% lower C-MAOM ($p<0$ .01) than NG at 0-15-cm . As expected , a significant C-POM increase of 40% in the 0-5-cm depth was observed in IP relative to NG . In this layer , C-POM represented 46% of total SOC in IP but only 35% of total SOC in NG . Similarly , C-POM , that represented 21% of the total SOC in IP and only 13% in NG at 5-15-cm , was 40% higher in IP than in NG . Unexpected , IP had 9% and 19% lower C-MAOM than NG at 0-5-cm and 5-15-cm depths , respectively . Finally , no significant differences either on SOC or C pools were found between IP_{30} and IP_{60} at any depth . The SOC stratification , C-POM increase and C-MAOM drop in IP relative to NG , were probably related with the greater biomass production , lower biomass C-N ratio and the changes in the root system distribution observed in IP . These results are in agreement with Palm et al . (2001) and Metherell (2003) that shown that increased availability of nutrients results in increased quality of the litter input and reduces the recalcitrant pool of SOC .

Table 1 Perennial legumes addition and long-term P fertilization (30 and 60 kg P_2O_5 ha^{-1} yr^{-1}) impacts on soil organic carbon (SOC) and particulate organic C fractions (C-POM) in a temperate natural grassland of Uruguay after 9 years .

Soil Depth	(0-5-cm)			(5-15-cm)		
Treatment	SOC	C-POM (2000-200 μm)	C-POM (200-53 μm)	SOC	C-POM (2000-200 μm)	C-POM (200-53 μm)
	g C kg^{-1}					
Natural Grassland	32 .67b†	7 .68b	3 .83b	15 .80a	1 .41b	0 .70b
Improved Pasture 30 kg P_2O_5	36 .02a	11 .44a	5 .15a	13 .96b	1 .75a	1 .33a
Improved Pasture 60 kg P_2O_5	34 .73a	10 .81a	4 .87a	14 .11b	1 .73a	1 .12a

† Means followed by the same letter within a column are not significantly different at $P \leqslant 0$ .1 level .

Conclusion The aggregate of data suggest that for temperate NG on undegraded soils , improved pastures with overseeded legumes and P fertilizers may sustain SOC in the long term . However , excessive SOC stratification , basically due to C-POM rise , and C-MAOM drop on IP are issues that may need further attention in the future .

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