Soil structural state in different crop-pasture rotation systems

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Introduction

Soil compaction in no tillage systems is a degrading process that reduces crop productivity and soil quality. On the other hand, pastures have an important role in the creation of pores and in the structural stability of the soil. Understanding the processes that lead to the improvement of the physical condition of the soil is of utmost importance for its management. The methodology "Cultural Profile" (CP) is based on the visual identification of structures with different states of porosity, allowing to make inferences about the quality of the soil (Gautronneau and Manichon, 1987). In this study, we used the CP to evaluate soil structure of a Uruguayan Abruptic Argiudoll after 20 years of contrasting management: continuous cropping and crop-pasture rotation.

Material and methods

Three contrasting cropping systems were analyzed: continuous cropping, crop-pasture rotation (two years of crop and four of perennial pastures), and a no crop system (grazed grassland). Crop-pasture system was analyzed at the end of pasture and crop phase. Therefore, treatments were (n=4): continuous cropping (CC), crop-pasture rotation after two years of crops (R2C), crop-pasture rotation after four years of pastures (R4P), and grassland (G). We followed the CP methodology improved by Boizard et al. (2017) and Sasal (2003). Measurement were performed on pits of 2 m long and 0.6 m deep. On each pit (n=2) we quantified the proportion of the surface occupied by CP structures: Δ, Φ, Γ, and O. On those structures, we considered the main origin of the porosity: root activity (b1) or soil fauna activity (b2). On the same pits we measured, soil strength (SS), soil bulk density (BD), soil structural porosity (SP), and soil textural porosity (TextP). Sampling units were all of the structures described visually. A pocket van tester was used to measure SS, it was applied 5 and 10 times in structures smaller and greater than 0.1 m^2, respectively. The cylinder method was used to measure BD. To calculate TP we used the following equation TP=1-(BD/RD), with RD 2.65 $gr.cm^{-3}$. By kerosene immersion, SP was determined (Sasal, 2003). To calculate TextP we used the following equation TP=SP+TextP. Additionally, root frequency (RF) was evaluated on a grid. Treatment effect on the proportion of CP structures was analyzed using the X^2 test (α=0.05). Within treatments, we compared mean values of SS, BD and SP of CP structures using one-way ANOVA (α=0.05). Among treatments, we compared overall weighted mean of SS, BD and TextP.

Results and discussion

Cropping systems influenced the proportion of structures described by CP (Table N°1). In all treatments Δ structure was found. However, quality of Δ structure was improved in R4P and G, given a greater radicular exploration and biological activity (CΔb2). Moreover, in CC and

R2C the porosity of Δ was low, and associated with root growth (CΔb1). The same behavior was found in Φ structure, the main source of pores was root activity in CC and R2C (CΦb1) and roots activity and fauna in G and R4P (CΦb2). The structure OΓ was only visualized in CC and R2C associated with a sowing bed (Table N°1). Among cropping systems, CC had a higher SS value (88.5 KPa), SS in R4P and G was not significant different (81.6 and 81.7 KPa, respectively). Within cropping systems, structures had differences in SS, regardless of treatment Δ had the highest mean (Table Nº1). Root frequency was 30.3% in G; 31.7% in R4P, 11.8% in R2C and 23.8% in CC. Bulk density ($g.cm^{-3}$) in CC was higher than G and R2C (1.46 >1.41 and 1.38). In R4P, BD was 1.43 ($g.cm^{-3}$). As expected in a soil type, TextP was not different between cropping systems 32.7%. In crop systems the porosity had its origin in the expansion-contraction of soil by weather effects. However, in the systems that presented pastures, the main origin of the macroporosity was associated to the fauna biological activity. Moreover, pastures systems had higher RF and lower BD.

Table N° 1: Percentage of cultural profiles structures in different cropping system, p-value of χ^2 test. Mean soil strength (KPa) according to structures and cropping system, p-value of one way ANOVA. Means followed by the same letter on the same treatment are not significant different according to LSD Fisher test.

	Cultural profile structures (%)						P-value	Soil strength (KPa)						P-value
	OΓ	CΓb2	CΦb1	CΦb2	CΔb1	CΔb2		OΓ	CΓb2	CΦb1	CΦb2	CΔb1	CΔb2	
CC	15	0	60	0	25	0	0,0001	54a	-	76b	-	105c	-	0,0001
R2C	16	0	59	0	25	0		46a	-	73b	-	109c	-	0,0001
R4P	0	0	0	73	0	27		-	-	-	73a	-	87b	0,0001
G	0	5	0	75	15	5		-	64a	-	55a	87b	67a	0,0001

CC: continuous cropping; R2C: crop-pasture rotation after two years of crops; R4P: crop-pasture rotation after four years of pastures and G: grassland.

Conclusion

Soil quality evaluated through CP evidenced a better state in pasture than in crop phase, in a crop-pasture system. The main effect of pastures was macroporosity development that modified compact structures, such as Δ. Furthermore, we found evidence that continuous cropping systems may compromise soil long term sustainability. Practical implications of this study reveal the importance of including perennial pastures in cropping systems.

References

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