Geophysical Research Abstracts
Vol. 18, EGU2016-4009, 2016
EGU General Assembly 2016

Soil organic carbon assessments in cropping systems using isotopic techniques

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Introduction of improved farming practices are important to address the challenges of agricultural production, food security, climate change and resource use efficiency. The integration of livestock with crops provides many benefits including: (1) resource conservation, (2) ecosystem services, (3) soil quality improvements, and (4) risk reduction through diversification of enterprises. Integrated crop livestock systems (ICLS) with the combination of no-tillage and pastures are useful practices to enhance soil organic carbon (SOC) compared with continuous cropping systems (CCS).
In this study, the SOC and its fractions in two cropping systems namely (1) ICLS, and (2) CCS were evaluated in Southern Santa Fe Province in Argentina, and the use of delta carbon-13 technique and soil physical fractionation were evaluated to identify sources of SOC in these systems.
Two farms inside the same soil cartographic unit and landscape position in the region were compared. The ICLS farm produces lucerne (Medicago sativa Merrill) and oat (Avena sativa L.) grazed by cattle alternatively with grain summer crops sequence of soybean (Glicine max L.) and corn (Zea mays L.), and the farm under continuous cropping system (CCS) produces soybean and corn in a continuous sequence. The soil in the area is predominantly a Typic Hapludoll.
Soil samples from 0-5 and 0-20 cm depths (n=4) after the harvest of grain crops were collected in each system and analyzed for total organic carbon (SOC, 0-2000 μm), particulate organic carbon (POC, 50-100 μm) and mineral organic carbon (MOC, <50 μm). Delta carbon-13 was determined by isotopic ratio mass spectrometry. In addition, a site with natural vegetation (reference site, REF) was also sampled for delta carbon-13 determination. ANOVA and Tukey statistical analysis were carried out for all data.
The SOC was higher in ICLS than in CCS at both depths (20.8 vs 17.7 g kg-1 for 0-5 cm and 16.1 vs 12.7 g kg-1 at 0-20 cm, respectively, $P<0.05$). MOC was similar at both depths, and POC was higher in CCS than in ICLS at 0-5 cm, while at 0-20 cm this trend was opposite. This is probably due to the presence of deep roots under pastures in ICLS.
Delta carbon-13 values for 0-5 cm were -22.9, -21.2 and -19.9 per mil for REF, ICLS and CCS, respectively ($P<0.05$). The lower delta carbon-13 in REF soils is explained by the presence of tree species with high lignin content in natural vegetation. Lignin has lower delta carbon-13 compared to cellulose (dominating in crops and pastures), which is present in greater proportion in plant residues of ICLS and CCS. Delta carbon-13 for 0-20 cm depth was similar for both systems. This means that in CCS there was a higher C input from C4 plants than in ICLS and REF, reflecting corn-plant residue contribution to SOC, meanwhile the main component of SOC in ICLS derived from pasture-plant residues. Results showed that ICLS under no tillage improved SOC levels due to higher plant residue inputs derived mainly from pasture compared to continuous cropping systems.