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Integrated crop-livestock-forestry systems as potential carbon sinks

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Introduction Mixed farming systems have great potential to combine food production with environmental services, including climate change mitigation and biodiversity preservation. This study contributed to the evaluation of integrated crop-livestock (ICL) and crop-livestock-forestry (ICLF) production systems from the point of view of their potential for carbon (C) sequestration in the soil and in the production system as a whole.

Material and Methods The studies focused on the Cerrado biome of Brazil and area considered as transition zone between the Cerrado and the Amazon. The partial C balance was assessed through the net ecosystem exchange of nitrous oxide (N_2O) and carbon dioxide (CO_2). The soil C stock was assessed to 1 m depth, measuring total C and N and $\delta^{13}C$. Soil microbial community structure was evaluated based on PLFA analysis.

Results and Conclusions The main findings were that pasture in rotation with annual crops (soybean, dryland rice and maize) in integrated systems had a net negative balance of CO_2 emission, resulting in net C accumulation in the system. This is in contrast to the partial balance of the grain production phase of ICL, which emitted C to the atmosphere. Thus, the introduction of forage grasses and planning the duration of grain crop cultivation within the integrated system, may offset CO_2 emissions during the annual crop phase. This balance is partial because it was still not possible to assess the contribution of methane (CH_4) emission or removal by the production system. In the ICLF systems, trees showed a significant effect, not only on biomass, but also in the accumulation of total soil organic C. Carbon stocks of soils under the tree rows increased at 1-m depth compared to the time zero reference (degraded pasture). Results of the isotopic signature of the soil C showed that the forest component in ICLF had a significant effect in the soil organic matter build-up in a short term (3 years). The artificial increase of biological diversity above ground, using exotic or native species, affected the functional diversity of microorganisms in the soil. In contrast to the soil under continuous degraded pasture, soils under ICLF showed an increased ratio of fungi to bacteria indicating ecosystems of lower organic matter mineralization rates. Thus, soils under ICLF may have a larger capacity for C retention than soils under simple production systems. The positive net accumulation potential for C in ICL and the accumulation of soil C under ICLF even in a short time, are additional evidences that support integrated systems as a way towards a more sustainable agriculture (soil C enhances soil fertility) with lower C emissions (C sink) in tropical ecosystems. On the bases of the results of the study it will also be possible to make adaptations in integrated systems to improve or optimize their performance in removing C from the atmosphere.

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