Integrating the animal component into grain crops does not compromise soil carbon and nitrogen stock

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Soil carbon storage is crucial for mitigating climate change and maintaining soil functions. In this context, Integrated Crop-Livestock Systems (ICLS) not only lead to more efficient productive outcomes but also play a significant role in restoring or maintaining the carbon and nitrogen stocks in the soil. We hypothesized that different grazing intensities and ungrazed (UG) cover crops, both under no-till conditions, would exhibit similar soil organic carbon (SOC) and total nitrogen (TN) stocks. The objective of this study was to assess SOC and TN stocks and their temporal dynamics over 22 years in a long-term experiment. The research was conducted at an experimental protocol in Southern Brazil, which consists of a succession of winter pastures grazed by cattle (*Bos taurus*) and soybean grain crops (*Glycine max* (L.) Merr.). The experiment was established as a randomized block design with three replicates. Treatments initially consisted of three grazing intensities defined by different sward heights (10, 20, and 40 cm) of mixed black oats (*Avena strigosa* Schreb.) and annual ryegrass (*Lolium multiflorum* Lam.) under continuous stocking. Shortly after the initial design, two plots were assigned to blocks one and two to serve as UG control treatment, resulting in an unbalanced experimental design. Soil samplings were conducted in four different years across the experimental period (2001 to 2023): in May 2001 before protocol installation, in May 2004, in April 2014, and twenty-two years from the beginning of the experiment in May 2023. The examined soil depth was 20 cm for all evaluated years. Soil samples were processed in the laboratory, and the carbon and nitrogen contents were obtained through dry combustion (Shimadzu VCSH). Stocks were calculated using equivalent soil masses. Data were subjected to analysis of variance and means were compared using Tukey's test at a 5% significance level. No differences were found between the treatments from both SOC and TN stocks in all years of evaluation. However, both elements exhibited significant temporal changes between 2001 and 2004, with significant increases in their stocks (SOC increased from 47.8 to 51.7 Mg ha^{-1} and TN increased from 4.39 to 4.73 Mg ha^{-1}). After this initial phase, SOC and TN stabilized at higher values than at the beginning, with SOC at 51.0 and TN at 4.43 Mg ha^{-1} in 2014, and SOC at 52.0 and TN at 4.44 Mg ha^{-1} in 2023. Our findings suggest that implementing any management approach results in an initial surge in carbon and nitrogen stocks, which eventually stabilize over the long term, with no discernible differences observed among treatments. The ICLS proved to be an effective strategy for preserving soil carbon and nitrogen stocks over the long term.

Keywords: Ecosystem services, mixed crop-livestock, grazing management, climate change mitigation.

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